RG-RSR Series Router

RGOS Configuration Guide, Release 10.4 (3b13)

Copyright Statement

Exemption Statement

Preface

Thank you for using our products. This manual matches the RGOS Release 10.4(3b13).

Audience

This manual is intended for:

- Network engineers
- Technical support and servicing engineers
- Network administrators

Obtaining Technical Assistance

- Ruijie Networks website: http://www.ruijienetworks.com/
- Online customer services: http://webchat.ruijie.com.cn
- Customer service center: http://www.ruijie.com.cn/service.aspx
- Customer services hotline: +86-4008-111-000
- BBS: http://support.ruijie.com.cn
- Customer services email: Consulting@ruijienetworks.com

Related Documents

Documents	Description
Command Reference	Describes the related configuration commands, including command modes, parameter descriptions, usage guides, and related examples.
Hardware Installation and Reference Guide	Describes the functional and physical features and provides the device installation steps, hardware troubleshooting, module technical specifications, and specifications and usage guidelines for cables and connectors.

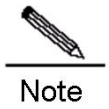
Conventions

This manual uses the following conventions:

Convention	Description
boldface font	Commands, command options, and keywords are in **boldface**.
italic font	Arguments for which you supply values are in *italics*.
[ ]	Elements in square brackets are optional.
{ x | y | z }	Alternative keywords are grouped in braces and separated by vertical bars.

[x | y | z]	Optional alternative keywords are grouped in brackets and separated by vertical bars.

Symbols



Means reader take note. Notes contain helpful suggestions or references.

Means reader be careful. In this situation, you might do something that could result in equipment damage or loss of data.

RGOS Configuration Guide
v10.4(3b13)
Basic Configuration

17. Configuring Flow Platform

Configuring the Command Line Interface

This chapter describes how to configurethe command line interface(CLI) to manage network devices.

Command Mode

The management interface of Ruijie network devices has multiple modes and they determine the commands you can use.

To listusable commands in each mode, enter a question mark (?) at the command prompt.

After setting up a session connection to the network device management interface, you enteruser EXEC mode first. In the user EXEC mode, only a few commands are usable with limited functions, for example, the **show**command. The command results are also not saved.

To use all commands, enter privileged EXEC mode with the privileged password. Then you can use all privileged commands and enter global configuration mode.

Using commands in configuration (for example, global configuration or interface configuration) modewill influence the current configuration. If you have saved the configuration information, these commands will be saved and executed when the system restarts. To enter any of the configuration modes, enter global configuration mode in the first.

The following table describescommand modes, access methods, prompts, and exit methods.Suppose the device is named "Ruijie" by default.

The following table summariesmain command modes.

Command mode	Access method	Prompt	Exit or enter the next mode	Remark
User EXEC	Log in.	Ruijie>	To quit this mode, enter the **exit** command. To enter privileged EXEC mode, enter the**enable**command.	Performs basic tests and showssystem information.
Privileged EXEC	In the user EXEC mode, enter the**enable**command.	Ruijie#	To return touser EXEC mode, enter the**disable**command. To enter global configuration mode, enter command **configure**.	Verifiessettings. This mode is password-protected.
Global configuration	Inprivileged EXEC mode, enter the**configure terminal**command.	Ruijie(config)#	To return to privileged EXEC mode, enter command **end** or **exit** or press Ctrl+C. To access the interface configuration mode, enter command **interface**with an interface specified. To access VLAN configuration mode, enterthe **vlan***vlan_id*command.	Executes commands to configure global parameters influencing the entireswitch.

Command mode	Access method	Prompt	Exit or enter the next mode	Remark
Interface configuration	Inglobal configuration mode, enter the **interface**command.	Ruijie(config-if)#	To return to privileged EXEC mode, enter command **end** orpress Ctrl+C. To return to global configuration mode, enter the**exit**command. Moreover, you need specify an interface in the **interface** command.	Configures various interfaces of the device in this mode.
Config-vlan (Vlan Mode)	Inglobal configuration mode, enter the**vlan** vlan-idcommand.	Ruijie(config-vlan)#	To return to privileged EXEC mode, enter command **end** or pressCtrl+C. To return to global configuration mode, enter the**exit**command.	Configures VLAN parameters in this mode.

Obtaining Help

Enter a question mark(?) at the command prompt to obtain a list of commands that are available for each command mode. You can also obtain a list of command keywords beginning with the same character or parameters of each command. See the following table.

Command	Description
Help	Obtainsthe brief description of the help system under any command mode.

abbreviated-command-entry?	Obtains a list of commands that begin with a particular character. string.
	For example:
	`Ruijie# di?`
	`dir disable`

abbreviated-command-entry <Tab>	Completes a partial command name.
	For example:
	`Ruijie# show conf<Tab>`
	`Ruijie# show configuration`

?	Listskeywordsassociated witha command. For example: `Ruijie# show ?`
command keyword ?	Listsarguments associated witha command. For example: `Ruijie(config)# snmp-server community ?` WORD SNMP community string

Abbreviating Commands

To abbreviate a command, simply enter part of the command that can uniquely identify the command.

For example, **show configuration**can be abbreviated as follows:

```
Ruijie# show conf
```

Using the no Form and the default Form

Most commands have the **no**formthatdisables a feature or function, or performs a reversed action of acommand. For example, the **no shutdown**command turns on aninterface, which is the reversed action of the **shutdown** command. You can use the commands without the keyword**no**to enable the features that have been disabled or are disabled by default.

Most configuration commands have the **default**formthat restoresa command setting to its default. The **default** form is disabled for most commands by default. In this case, the **default** and **no**formsgenerally serve the same purpose. However, the default form is enabled for some commandsby default. In this case, the **default** and **no**formsserve different purposes, where the **default**formenables the command and restores the arguments to the default settings.

Understanding CLI Error Messages

The following table describes the error messages that may occur when you use the CLI to manage devices.

Error Message	Meaning	How to Obtain Help
% Ambiguous command: "show c"	The switch cannot identify the unique command because you have entered insufficient characters.	Re-entersthe command with the question mark (?)next tothe ambiguous word. The possible keywords will be listed.
% Incomplete command.	You have not entered the required keywords or arguments.	Re-entersthe command withthespace followed by thequestion mark (?). The possible keywords or arguments will be displayed.
% Invalid input detected at '^' marker.	The symbol (^)indicates the positions of wrong words when user entersa wrong command.	Entersthequestion mark (?) at the command prompt to show the allowed keywords of the command.

Using Historical Commands

The system records the commands you have entered, whichis very useful when you entera long and complex command again.

To re-execute the commands you have entered, perform the following operations.

Operation	Result
Ctrl-P or **Up**	Allows you to browse the preceding command in the historical command records.You can inquire earlier records by repeating this operationfrom the latest record,.
Ctrl-N or **Down**	Allows you to return to a more recent command in the historical command records. You can inquire laterrecords by repeating this operation.

Caution Arrow keys are supported by standard terminals like VT100 series.

Using Editing Features

Editing Shortcut Keys

The following table describes the editing shortcut keys.

Function	Shortcut Key	Description
Move cursor in an editing line	Left direction key or Ctrl+B	Moves the cursor to left by one character.
	Right direction key or Ctrl+F	Moves the cursor to right by one character.
	Ctrl+A	Moves the cursor to the beginning of the command line.
	Ctrl+E	Moves the cursor to the end of the command line.
Delete the entered characters	Backspace	Deletes the character to the left of the cursor.
	Delete	Deletes the character to the right of the cursor.
Scroll up by one line or one page	Return	Scrolls up one line of the display contents anddisplaythe next line. This is used only before the end of the output.
	Space	Scrolls up one page of the displayed contents anddisplaythe next page appear. This is used only before the end of the output.

Sliding Window of Command Lines

You can use this function to edit acommand that exceeds the width of one line. When the editing cursor closes to the right border, the whole command line will move to the left by 20 characters. In this case, the cursor can still be moved back to the previous character or the beginning of the command line.

The following table describes shortcut keys used in this function:

Function	Shortcut key
Moves the cursor to the left by one character.	Left direction key or Ctrl+B
Moves the cursor to the head of a line.	Ctrl+A
Moves the cursor to the right by one character.	Right direction key or Ctrl+F
Moves the cursor to the end of a line.	Ctrl+E

For example, the contents of the **mac-address-table static** command may exceed the screen width. When the cursor approaches the line end for the first time, the whole line move left by 20 characters, and the hidden beginning part is replaced by the symbol ($) on the screen. The line moves left by 20 characters when the cursor reaches the right border.

access-list 199 permit ip host 192.168.180.220 host

$ost 192.168.180.220 host 202.101.99.12

$0.220 host 202.101.99.12 time-range tr

Now you can press **Ctrl+A** to return to the beginning of the command line. In this case, the hidden ending part is replaced by the symbol ($).

access-list 199 permit ip host 192.168.180.220 host 202.101.99.$

Caution The default line width on the terminal is 80 characters.

Combined with historical commands,the sliding window enables you to invoke complicated commands repeatedly. For details about shortcut keys, see the description about the section"Editing Shortcut Keys".

Filtering and Searching CLI Output Information

Filtering and Searching the Output Information of the show Command

Use the following command to search the specified content in theoutput informationof the **show** command.

Command	Description
Ruijie# **show** any-command |**begin**regular-expression	Searches the specified content in the outputinformation of the **show** command andexportsthe first line that contains the specified content and allinformation after the line.

Caution
- You can execute show command in any mode.
- The information to be searched is case sensitive, and the feature is also effective in the following.

Use the following commands to filter the specified content in the output information ofthe **show** command:

Command	Description
Ruijie# **show** any-command |**exclude**regular-expression	Filters the content inthe output information ofthe **show** command andexportsother information excluding the line that includes the specified content.
Ruijie#**show**any-command |**include**regular-expression	Filters the content inthe output information ofthe **show** command and exports the line that includes the specified content.Other information will be filtered.

Caution To search and filter the contents exportedby the **show** command, you must enter the pipeline sign, which is the vertical bar (|) followed by searchand filterrules and contents (characters or strings). The contents are case sensitive.

Using Command Aliases

The system provides the command alias function.You can specify any word as the alias of a command. For example, you can define the word “mygateway” as the alias of the **ip route 0.0.0.0 0.0.0.0 192.1.1.1** command.The effect of enteringthis word is equal to that of enteringthe entire command.

You can use one word to replace one command by configuring an alias for the command. For example, you can define an alias to represent the firstpart of acommand, and then continue to enter the rest parts.

The command that an alias represents must run under the mode you have defined in the current system. In global configuration mode, you can enter **alias?** to list all command modes that can configure aliases.

```
Ruijie(config)#alias ?
  aaa-gs              AAA server group mode
acl                  acl configure mode
  bgp                  Configure bgp Protocol
config               globle configure mode
......
```

An alias supports help information. An alias appears withtheasterisk (*) before it in the following format:

*command-alias=original-command

For example, in EXEC mode, the alias “s” indicates the **show** command by default. You can enter “s?” to obtain the help information on the command and the aliases beginning with ‘s’.

```
Ruijie#s?
*s=show  show  start-chat  start-terminal-service
```

If the command that an alias represents containsmore than one word, the command will be included by the quotation marks. As shown in the following example, you can configure the alias “sv” to replace the **show version**command in EXEC mode.

```
Ruijie#s?
*s=show  *sv=”show version” show  start-chat
start-terminal-service
```

An alias must begin with the first character of the command line entered without any spacebefore it. As shown in the precedingexample, the alias is invalid if you have entereda spacebefore the command.

```
Ruijie# s?
show  start-chat  start-terminal-service
```

An alias can also be used to obtain the help information of command parameters. For example, the alias “ia" represents the **ip address** commandin interface configuration mode.

```
Ruijie(config-if)#ia ?
  A.B.C.D  IP address
  dhcp    IP Address via DHCP
Ruijie(config-if)#ip address
```

The preceding informationlists the parameter information after the command **ip address**, and replaces the alias with the actual command.

A completealias must be entered for use. Otherwise, it can not be identified.

To view the setting of aliases in the system, use the **show aliases** command.

Accessing the CLI

Before using the CLI, you need to use a terminal or PC to connect toanetwork device. Power on the network device.After initializing the hardware and software, you can use the CLI. If the network device is used for the first time, you can only connect to the network deviceoverthe serial port (Console), which is referred to as out-band management. In addition, you can connect and manage the network device through the virtual terminal of Telnet. In either case, you can access the CLI.

Configuring LINE Mode

Configuring LINE Mode

Entering the LINE mode

After entering the specific LINE mode, you can configure the specified line. Use the following command to enter the specified LINE mode:

Command	Function
Ruijie(config)# **line [aux | console | tty | vty]** *first-line* [*last-line*]	Enters the specified LINE mode.

Increasing/Decreasing LINE VTY

The number of line vty is 5 by default. Use the following commands to increase or decrease line vty. 36 line VTYs are supported at most.

Command	Function
Ruijie(config)# **line vty** *line-number*	Increases the number of LINE VTY to the specified value.
Ruijie(config)# **no line vty** *line-number*	Decreases the number of LINE VTY to the specified value.

Configuring the Protocols to Communicate on the Line

Use this command to limit the communication protocol type supported on the line. By default, VTY supports communication of all protocols while TTY does not support the communication of any protocol.

Command	Description
Ruijie# **configure terminal**	Enters the configuration mode.
Ruijie(config)# **line vty** ***line number***	Enters the line configuration mode.
Ruijie(config-line)# **transport input {all | ssh | telnet | none}**	Configures the protocol to communicate on the line.
Ruijie(config-line)# **no transport input**	Disables the communication of any protocol on the line.
Ruijie(config-line)# **default transport input**	Restores the default value.

Configuring the Access Control List on the Line

Use this command to configure the access control list on the line. No access control list is configured on the line by default.That is, all incoming and outgoing connections are permitted.

Command	Description
Ruijie# **configure terminal**	Enters the configuration mode.
Ruijie(config)# **line vty** *line number*	Enters the line configuration mode.

Command	Description
Ruijie(config-line)# **access-class** *access-list-number* **{in | out}**	Configures the access control list on the line.
Ruijie(config-line)# **no access-class** *access-list-number* **{in | out}**	Removes the configuration.

System Upgrade and Maintenance

Overview

Upgrade and maintenance refers to upgrade the main program or CTRL program or upload and download files on the CLI . There are two ways to upgrade programs: use TFTP through a network interface or use Xmodem protocol through a serial interface.

Upgrade and Maintenance Method

Transferring Files by TFTP

There are two ways to transfer files by TFTP: download files from the host to the equipment, or upload files from the equipment to the host.

In the CLI command mode, download the files by performing the following steps:

Before download, first run the TFTP server software on the local host. Then, select the directory of the file to download. Finally, log in to the equipment. In the privileged mode, download the files by using the following commands. If no location is specified, you need to separately input the IP address of the TFTP server.

Command	Function
Ruijie# **copy tftp:** *//location/filename* **flash:** *filename* [**vrf** *vrfname*]	Download the specified file from the URL on the host to the equipment.

In the CLI command mode, upload the files by performing the following steps:

Before upload, first run the TFTP server software on the local host. Then, select the destination directory for the file to upload at the host. Finally, upload the files by using the following commands in the privileged mode.

Command	Function
Ruijie# **copy flash:** *filename* **tftp:** *//location/filename* [**vrf** *vrfname*]	Upload the specified file from the equipment to the directory specified by the URL on the host. You can also rename the file.

Note It is necessary to put the tftp link in quotes if the filename of the source file has space. For example:

Note **copy tftp:**"//localtion/filename" **flash:**filename [**vrf** vrfname]

Note It is necessary to put the filename in quotes if the filename of the destination file has space. For example:

Note **copy tftp:**//localtion/filename **flash:**"filename" [**vrf** vrfname]

Transferring Files by TFTP IPv6

There are two ways to transfer files by TFTP: download files from the host to the equipment, or upload files from the equipment to the host.

In the CLI command mode, download the files by performing the following steps:

Before download, first run the TFTP server software on the local host. Finally, log in to the equipment. In the privileged mode, download the files by using the following commands.

Command	Function
Ruijie# **copy tftp:** *//location/filename* **flash:** *filename*	Download the specified file from the URL on the host to the equipment.

In the CLI command mode, upload the files by performing the following steps:

Before upload, first run the TFTP server software on the local host. Then, select the destination directory for the file to upload at the host. Finally, upload the files by using the following commands in the privileged mode.

Command	Function
Ruijie# **copy flash:** *filename* **tftp:** *//location/filename*	Upload the specified file from the equipment to the directory specified by the URL on the host. You can also rename the file.

Caution If location is the local link address, use the following command to specify the egress:

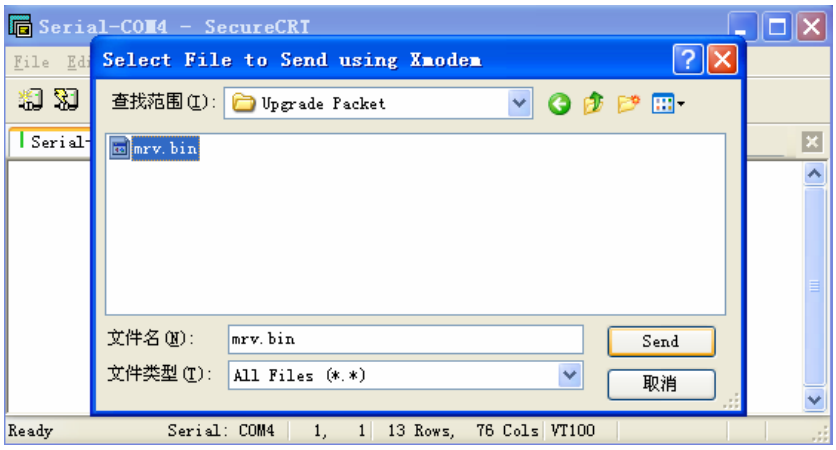
```
Ruijie#copy tftp: flash:
Address of remote host []?fe80::5efe:192.168.195.90
Output Interface: loopback 0
Source filename []?rgos.bin
Extended commands [n]:
Destination filename [rgos.bin]?
```

Transferring Files by XMODEM

There are two ways to transfer files by Xmodem: download files from the host to the equipment, or upload files from the equipment to the host.

In the CLI command mode, download the files by performing the following steps:

Prior to download, first log in to the out-band management interface of the device by using the Windows HyperTerminal. Then, download the files by using the following command in the privileged mode. Finally, select the “Send File” from the “Transfer” menu on the Windows HyperTerminal on the local host, as shown in the following figure:

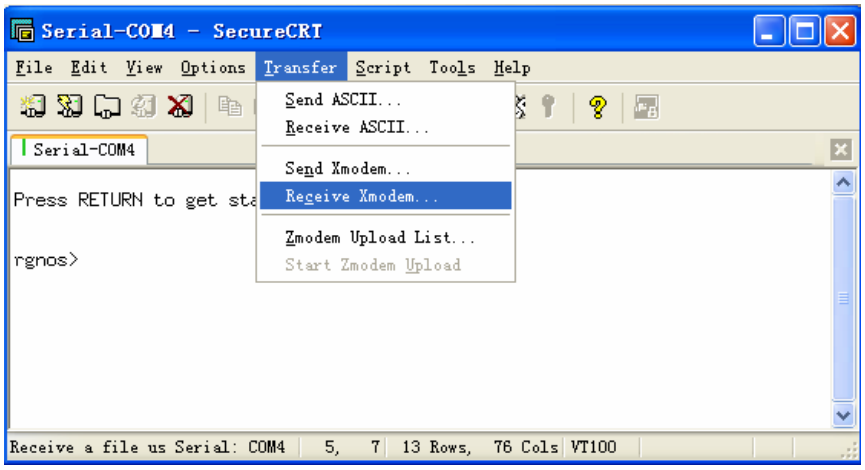


In the pop-up dialog box, select the file to download from the File Name field and Xmodem from the Protocol field. Click “Send”, and the Windows HyperTerminal will show the transmission process and packets.

Command	Function
Ruijie# **copy xmodem flash**:*filename*	Download the file from the host to the equipment and name it *filename*.

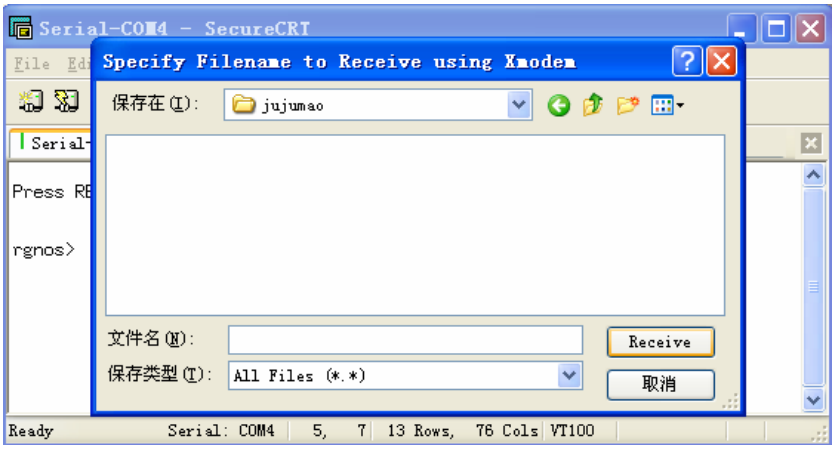
In the CLI command mode, upload the files by performing the following steps:

Prior to upload, first log in to the out-band management interface of the switch by using the Windows HyperTerminal. Then, upload the files by using the following command in the privileged mode. Finally, select the “Receive File” from the “Transfer” menu on the Windows HyperTerminal on the local host. It’s shown in the following figure:



In the pop-up dialog box, select the storage location for the file to upload and select the “Xmodem” as the reception

protocol. Click “Receive”, and the Windows HyperTerminal will further prompt the name of the locally stored file. Click “OK” to start reception. The operation is shown below:



Command	Function
Ruijie# **copy flash**:*filename* **xmodem**	Upload the file from the equipment to the host.

Caution It is necessary to put the filename with space in quotes. For example:

```
copy xmodem flash:”filename” OR copy flash:”filename” xmodem
```

Upgrading System

You can transfer the upgrading file to a device through TFTP or Xmodem, no matter the device is box-mount or chassis-mount. After transmission, restart the device. The upgrading file will automatically check and upgrade the system without manual interference.

The upgrade procedure on the box-mount equipment is slightly different from that on the chassis-mount equipment:

On the box-mount equipment, the upgrading file upgrades only its single supervisor engine. After upgrading, the system automatically resets. The equipment works normally after restart.

The chassis-mount equipment includes supervisor engines, line cards and multi-service cards. To upgrade the whole system with a upgrading file, first upgrade the supervisor engine. The system resets. When the equipment restarts, the automatic version synchronization function runs to upgrade line cards and multi-service cards.

Automatic Upgrade: a function running on the supervisor engine that verifies the version consistency for the slave supervisor engine, line cards and multi-service cards. When it is found that the version is not consistent with the one in the master supervisor engine, the function sends the upgrading files to those blades for upgrading so as to keep the version consistence in the whole system.

Caution Whenever you upgrade the master supervisor engine, the slave one (if any) is upgraded at the same time to

keep the version consistent. The upgrade of a line card will upgrade all the line cards inserted into the device. Do not power off the device before the upgrade is complete. Otherwise, the upgrade program may be lost.


Caution

Before the chassis-mount device is upgraded, you can check whether the software version of all line cards and supervisor engines are consistent with the upgraded object version by the **show version** command. However, you cannot carry out master-slave switch (such as **redundancy force-switchover**). Otherwise, it will cause the upgrade failure and return to the original version.

Upgrade the chassis-mounted device by the upgrade file:

Confirm the filename of the upgrade file to be loaded is rgos.bin.

Download the file to the device by using the copy command.

If there is a slave supervisor engine on the device, you need to first upgrade the main programs of the master and slave supervisor engines successfully. After upgrading the main program successfully, the system prompts:

```
Upgrade Slave CM MAIN successful!!
Upgrade CM MAIN successful!!
```

Reset the equipment.

After reset, the upgrade file will run automatically. The system prompts:

```
Installing is in process ......
Do not restart your machine before finish !!!!!!
......
```

After the upgrade operation is completed, the system prompts:

```
Installing process finished ......
Restart machine operation is permitted now !!!!!!
```

After the operation of the upgrade file is completed, the system resets automatically and prompts:

```
System restarting, for reason 'Upgrade product !'.
```

After reset, the upgrading operation of the supervisor engines is completed. The system will load and operate the upgrade pack of boards. Moreover, it prompts information in Steps 5 to 6. Instead of the information in Step 7, it prompts:

```
System load main program from install package ......
```

Load the main program of the supervisor engine to operate from the upgrade file directly.

After the main program operates normally, the automatic upgrade function starts. If there is the slave supervisor engine or other modules in the chassis-mount device, the system prompts:

```
A new card is found in slot [1].
System is doing version synchronization checking ......
Current software version in slot [1] is synchronous.
System needn't to do version synchronization for this card ......
```

Or, the system prompts:

```
System is doing version synchronization checking ......
Card in slot [3] need to do version synchronization ......
```

Other Printing Information

```
Version synchronization begain ......
Keep power on, don't draw out the card and don't restart your machine before finished !!!!!!
```

Other Printing Information

```
Transmission is OK, now, card in slot [3] need restart ...
Software installation of card in slot [3] is in process ......
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
Software installation of card in slot [3] has finished successfully ......
The version synchronization of card in slot [3] get finished successfully.
```

The former indicates the version of the line card is synchronous and it is not necessary to upgrade again. The latter indicates the version of the line card, and it is necessary to upgrade the line card.

The system will carry out above operation for the slave supervisor engine and each module in turn.

After checking the version consistency on all modules and upgrading, the system will work normally

Caution

During the upgrade or automatic upgrade, the system may prompt that the reboot is not allowed. In this case, neither power off or reset the system nor plug or unplug other modules

Note

Automatic upgrading and checking also applies to the system with hot-plugging modules.

Upgrade the box-mount device by the upgrade file

To upgrade the box-mount device, do Steps 1 to 7, and then the system resets. After that, the equipment runs well.

Configuring Basic Management Features

Overview

Note

For more information about the CLI commands mentioned in this chapter, see the Device Management Command Reference.

Access Control through Command Authorization

Overview

A terminal's network access can be simply managed by using passwords and assigning privileged levels. Passwords restrict access to a netwdydyork or network device. Privileged levels define the commands you can use after logging in to a network device.

For security sake, passwords are stored in a configuration file. Passwords must be kept secure when the configuration file is transmitted, for example, over TFTP or across a network. Passwords are encrypted before they are saved into the configuration file. Plain text passwords becomes cipher text passwords. The **enable secret** command builds on a private encryption algorithm.

Configuring Default Passwords and Privileged Levels

No password at any level is available by default. The default privileged level is 15.

Configuring or Changing the Passwords at Different Levels

Our products provide the following commands for you to configure or change passwords at different levels.

Command	Function
Ruijie(config)# **enable password** [**level** *level*] {*password* | *encryption-type encrypted-password*}	Sets a static password. You can only set a level-15 password when no level-15 security password is configured. If you have set a non-level-15 password, the system will show a message and automatically convert it into a security password. If you have set the same level-15 static password as the level 15 security password, the system will show a warning message. If the encryption type is set to 0, the following password is configured in plain text. If the encryption type is set to 7, the following password is configured in cipher text.

Command	Function
Ruijie(config)# **enable secret** [**level** *level*] {*encryption-type encrypted-password*}	Sets the security password, which provides the same function but a better encryption algorithm than a static password. For security sake, it is recommended you use a security password.
Ruijie(config)#**service password-encryption**	Determines whether to encrypt the related password.
Ruijie# **enable** [*level*], and Ruijie# **disable** [*level*]	Switches between user levels. To move from a lower to a higher level, input the password for the higher level.

When you set a password, the keyword "level" is used to define the password for a specified privileged level. After setting, it only works for the users at that level.

Configuring Multiple Privileged Levels

By default, the system provides only two password-protected levels: normal user (level 1) and privileged user (level 15). You can configure up to 16 hierarchical command levels for each mode. By configuring different passwords at different levels, you can use different sets of commands for different levels.

When no password is set for the privileged user level, you can enter the privileged mode without password authentication. For security, it is recommended you set the password for the privileged user level.

Configuring Command Authorization

To expand the application scope of a command, you can assign it to users at lower levels. On the contrary, to narrow the scope, you can assign it to users at higher levels.

You can use the following commands to authorize users to use a command:

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **service display command privilege**	Enables command-level display. After this function is enabled, you can enter ? to view the level of a command key.
Ruijie(config)# **privilege** *mode* [**all**] {**level** *level* | **reset**} *command-string*	Sets a privileged level for a command. *mode* – The CLI command mode in which you authorize the command. For example, config indicates global configuration mode, exec indicates privileged command mode, and interface indicates interface configuration mode. **all** – Changes the privileges of all the sub-commands of a specified command to the same level. **level** *level* – Authorization level in the range from 0 to 15. **reset**：Restores the command privilege to the default level. *command-string:* Indicates the command you want to authorize.

To restore the configuration for a specified command, use the **no privilege** *mode* [**all**] **level** *level* command in global configuration mode.

Example of Command Authorization Configuration

The following example shows the configuration process that sets the **reload** command and all its sub-commands to level

1, and activates level 1 (by setting the command as "**test**"):

```
Ruijie# configure terminal
Ruijie(config)# service display command privielge
Ruijie(config)# privilege exec all level 1 reload
Ruijie(config)# enable secret level 1 0 test
Ruijie(config)# end
```

Enter level 1, and you can see the command and its subcommands:

```
Ruijie# disable 1
Ruijie> reload ?
  at                  reload at a specific time/date (privilege: 14)
  cancel               cancel pending reload scheme (privilege: 14)
  in                  reload after a time interval (privilege: 14)
  <cr>
```

The following example shows the configuration process that restores the privilege settings of the reload command and all its sub-commands to the default value:

```
Ruijie# configure terminal
Ruijie(config)# privilege exec all reset reload
Ruijie(config)# end
```

Enter the level 1, the privilege setting for the command is removed.

```
Ruijie# disable 1
Ruijie> reload ?
% Unrecognized command.
```

Configuring Line Password Protection

Our products offer password authentication for remote logins (such as Telnet). A password is required for protection. Execute the following command in line configuration mode:

Command	Function
Ruijie(config-line)# **password** [**0** | **7**] *line*	Specifies a line password. 0: The password is configured in plaintext. 7: The password is encrypted by a Ruijie device. Line: the character string of the password to be configured.
Ruijie(config-line)# **secret** { [**0**] *password* | **5** *encrypted-secret* }	Specifies the line's password encrypted by irreversible MD5 **0**: (Optional) specifies the plaintext password text and encrypts it with irreversible MD5 after configuration. *Password*: The password plaintext.. ***5*** *encrypted-secret*: Specifies the password text encrypted by irreversible MD5 and saves it as the encrypted password after configuration.
Ruijie(config-line)# **login**	Enables line password protection.

Note If no login authentication is configured, password authentication on the line layer will be ignored even when a line password is configured. Login authentication will be discussed in the next section.

Note If no login authentication is configured, password authentication on the line layer will be ignored even when a line password is configured. Login authentication will be discussed in the next section.

Supporting Session Locking

Our products allow you to lock the session terminal temporarily using the lock command, so as to prevent unauthorized access. To do so, enable the terminal locking function in the line configuration mode, and lock the terminal using the lock command in terminal EXEC mode: The system prompts you for a password for unlocking when you enter any character on a locked terminal. The terminal is locked when your password is authenticated.

Command	Function
Ruijie(config-line)# **lockable**	Enables the function of locking the line terminal.
Ruijie# lock	Locks the current line terminal.

Login Authentication Control

Overview

The previous section discusses how to control access to network devices by configuring a locally stored password. In addition to line password protection and local authentication, in AAA mode, we can authenticate users' management privilege based on usernames and passwords on some servers when they log in to the switch. Take an RADIUS server for example.

With an RADIUS server, the network device sends encrypted user information to the RADIUS server for authentication instead of authenticating them with locally stored credentials. The RADIUS server configures user information consistently like user name, password, shared key, and access policy to facilitate user access management and control and enhance the security of user information.

Configuring Local Users

Our products support identity authentication system based on a local database for local authentication of the method list in AAA mode and local authentication of line login management in non-AAA mode.

To enable username identity authentication, run the following commands in global configuration mode:

Command	Function

Command	Function
Ruijie(config)# **username** *name* [**password** *password* | *encryption-type encrypted password*]	Enables username identity authentication with encrypted password. Encryption type 0 defines a password in plaintext. Encryption type 7 defines an encrypted password.
Ruijie(config)# **username** *name* **secret** { [**0**] *password* | **5** *encrypted-secret* }	Sets the password encrypted by irreversible MD5 for the local user.
Ruijie(config)# **username** *name* [**privilege** *level*]	Sets the privilege level for the user (optional).

Confining the Simultaneously Online Amount of a Local Username

Ruijie products support local usernames confining the simultaneously online amount. By default, local usernames does not limit the simultaneously online amount.

Run the following commands to limit the simultaneously online amount of a local username:

Command	Function
Ruijie(config)# **username** *name* **online amount** *numbers*	Confines the simultaneously online amount of a local username.
Ruijie(config)# **no username** *name* **online amount**	Cancels the limit on the simultaneously online amount of a local username.

After the simultaneously online amount of a local username is set, the number of clients logging in with the username must be within the specified range. When the number exceeds the limit, the username is not allowed to be used for login.

When the simultaneously online amount of a local username is set to 0, no login is allowed with the username by any client, including console login and remote login through this user.

Confining Username Login Mode

Ruijie products support configuration of local username login mode. Login mode can be one type or several types among aux, console ssh and telnet. By default, when there is no restriction on local username login mode, the local username will not confine user login mode.

Run the following demands in global configuration mode to confine local username login mode:

Command	Function
Ruijie(config)#**username** *name* **login mode** { **aux | console | ssh | telnet** }	Confines local username login mode.
Ruijie(config)#**no username** *name* **login mode** { **aux | console | ssh | telnet** }	Cancels restriction on local username login mode.

This command is used to set local username login mode to one type or several types among aux, ssh and telnet. Only the configured login mode is allowed while the other modes are prevented.

Configuring Line Login Authentication

To enable line login identity authentication, run the following commands in line configuration mode:

Command	Function
Ruijie(config-line)# login local	Sets local authentication for line login in non-AAA mode.
Ruijie(config-line)# login authentication {default | list-name}	Sets AAA authentication for line login in AAA mode. The authentication methods in the AAA method list will be used for authentication, including Radius authentication, local authentication and no authentication.

Note For more information on how to set AAA mode, configure Radius service, and configure the method list, see the sections relating to AAA configuration.

System Time Configuration

Overview

Every switch has its clock, which indicates date (year, month, day) and time (hour, minute, second) and week. When using a switch for the first time, you must configure the clock manually. Of course, you can adjust the clock when necessary. The clock is used for system login that requires you to record the time of an event.

Setting System Time and Date

You can configure the system time on the network device manually. Once configured, the clock will be running continuously even if the network device is powered off. Therefore, unless you need to modify the time, it is not necessary to reconfigure the time.

However, the configuration does not apply to network devices without hardware clock, as the manual time setting actually configures software clock. When the network devices are powered off, you cannot set the time manually.

Caution RSR10 do not provide hardware clock.

☺ **Support** S2026G, S2026F and RSR10 do not provide hardware clock.

Command	Function
Ruijie# **clock set** hh:mm:ss month day year	Sets system date and time.

For example, change the system time to10:10:12, 2003-6-20:

```
Ruijie# clock set 10:10:12 6 20 2003                //Set system time and date.
Ruijie# show clock               //Confirm the modification takes effect.
clock: 2003-6-20 10:10:54
```

Showing System Time and Date

You can show system time and date by using the **show clock** command in privileged mode. The following example shows the format:

```
Ruijie# sh clock   //Show the current system time and date.
clock: 2003-5-20 11:11:34
```

Updating Hardware Clock

Some platforms use hardware clock (calendar) to double as software clock. Since battery enables hardware clock to run continuously, hardware clock still runs even though the device is turned off or restarted.

If hardware clock and software clock are out of sync, software clock prevails. Execute the clock update-calendar command to copy date and time from software clock to hardware clock.

In privileged mode, execute the **clock update-calendar** command for software clock to overwrite hardware clock.

☺ **Support**	S2026G, S2026F and RSR10 do not provide hardware clock.

Command	Function
Ruijie**# clock update-calendar**	Updates hardware clock through software clock.

Execute the following command to copy current date and time from software clock to hardware clock.

```
Ruijie# clock update-calendar
```

Scheduled Restart

Overview

This section describes how to use the **reload** [*modifiers*] command to schedule system restarts at specified time. This feature facilitates your operation in some scenarios (for testing, for example). Modifiers is a set of options provided by the **reload** command to increase the command flexibility. The optional modifiers includes **in**, **at** and **cancel**. See the following examples for details:

- **reload in** *mmm* | *hhh:mm* [*string*]

This command sets up the system to restart at regular intervals in the format of mmm or hhh:mm. string is a help prompt. You can give the scheme a name using the string to indicate its purpose. string is a prompt. For example, to reload the system at intervals of 10 minutes for testing, type r**eload in** *10 test*.

- **reload at** hh:mm month day year [string]

This command sets up the system to restart at a specified future time. The parameter year is optional. The year recorded in the system clock is shown by default if no year is specified. As the time span is limited to 30 days, the current system date generally ranges between January 1 and November 30. Therefore, you do not need to specify the year. However, the restart time you have specified can be sometime next January if the system currently shows December. In this situation, you must specify a year to instruct the system to restart next January rather than this January. The system may fail as the restart time is considered to fall in this January by default. string is used in a similar way. For example, input **reload at** *08:30 11 1 newday* if the current system time is 14:31 on January 10, 2005 and you want the system to reload tomorrow. If the current system time is 14:31 on December 10, 2005 and you want the system to reload at 12:00 a.m. on January 1, 2006, input **reload at** *12:00 1 1 2006 newyear*.

- **reload cancel**

This command deletes a user-defined restart scheme. As mentioned earlier, you have specified the system to reload at 8:30 a.m. tomorrow, the setting will be canceled after you input **reload cancel**.

Note If the system supports clock function, you can use option at. Before the use, it is recommended you configure the system clock as required. If a restart scheme has been set before, subsequent settings will overwrite previous settings. If you have set a restart scheme and you restart the system before the scheme takes effect, the scheme will be lost.

Note The span between the time indicated in the restart scheme to the current time must be within the range of 200 days and must be later than the current system time. Besides, after you have set reload, you should not set system clock. Otherwise, your setting may fail if the system time is later than the reload time.

Specifying the System to Restart at the Specified Time

In privileged mode, you can configure system reload at the specified time using the following commands:

Command	Function
Ruijie# **reload at** *hh:mm month day* [*year*] [*reload-reason*]	Reloads at hh:mm,month day,year. reload-reason (if any); indicates the reason that the system reloads.

The following example shows an example of system reload at 12:00 a.m. January 11, 2005 (suppose the current system clock is 8:30 a.m. January 11, 2005):

```
Ruijie# reload at 12:00 1 11 2005 midday   //Set the reload time and date.
Ruijie# show reload //Confirm the modification takes effect.
Reload scheduled for 2005-01-11 12:00  (in 3 hours 29 minutes)16581 seconds.
At 2005-01-11 12:00
Reload reason: midday
```

Specifying the System to Restart after a Period of Time

In privileged mode, you can configure the system reload at the specified time using the following commands:

Command	Function
Ruijie# **reload in** *mmm* [*reload-reason*]	Configures the system reload in mmm minutes, where the reload reason is described in reload-reason (if entered)
Ruijie# **reload in** *hhh:mm* [*reload-reason*]	Configure the system reload in hhh hours and mm minutes, where the reload reason is described in reload-reason (if entered)

The following example shows how to reload the system in 125 minutes (assume that the current system time is 12:00 a.m. January 10, 2005):

```
Ruijie# reload in 125 test //Set the system reload time
Or
Ruijie# reload in 2:5 test     //Set the system reload time
Ruijie# show reload //Confirm whether the restart time change takes effect
System will reload in 7485 seconds.
```

Immediate Restart

The **reload** command without any parameter will restart the device immediately. In privileged mode, you can restart the system immediately by using the **reload** command.

Deleting the Configured Restart Scheme

In privileged mode, use the following command to delete the configured restart scheme:

Command	Function
Ruijie# **reload cancel**	Deletes the configured restart scheme.

If no reload scheme is used, an error message appears.

Configuring a System Name and Prompt

Overview

For easier management, you can configure a system name for the switch to identify it. If you configure a system name that contains more than 32 characters, the first 32 characters are used as the system prompt. The prompt varies with the system name. The system is named Ruijie by default.

Configuring a System Name

Our products provide the following commands to configure a system name in global configuration mode:

Command	Function
Ruijie(Config)# **hostname** *name*	Sets the system name. The name must contain up to 63 printable characters.

To restore the name to the default value, use the **no hostname** command in global configuration mode. The following example changes the device name to RGOS:

```
Ruijie# configure terminal     //Enter global configuration mode.
Ruijie(config)# hostname RGOS      //Set the equipment name to RGOS
RGOS(config)#                  //The name has been modified successfully.
```

Configuring a Command Prompt

The system name appears as the default if you have not configured any command prompt. (If the system name exceeds 32 characters, the first 32 characters will be blocked.) The prompt varies with the system name. You can use the **prompt** command to configure a command prompt in global configuration mode. The command prompt only applies in EXEC mode.

Command	Function
Ruijie# **prompt** *string*	Sets the command prompt with printable characters. If the name exceeds 32 characters, the first 32 characters are blocked.

To restore the prompt to the default value, use the **no prompt** command in global configuration mode.

Banner Configuration

Overview

When a user logs in to the switch, you may need to give the user useful information through a banner. There are two kinds of banners: message-of-the-day (MOTD) and login banner. The MOTD is unique to users who connect with switches. When users log in, the notification message will appear on the terminal. MOTD allows you to send urgent messages (for example, the system is shutting down) to network users. The login banner also appears on all connected terminals. It provides some common login messages. By default, no MOTD and login banners are configured.

Configuring a Message-of-the-Day

You can create a notification of single or multi-line messages that appears when a user logs in the switch. To configure the message of the day, execute the following commands in global configuration mode:

Command	Function
Ruijie(Config)# **banner motd** *c* *message c*	Specifies the message of the day, with c being the delimiter, for example, a pound sign (&). After entering the delimiter, press Enter. Now, you can type text. You need to input the delimiter and then press Enter. Note that if you type additional characters after the ending delimiter, these characters will be discarded by the system.

Command	Function
	Also note that you cannot use the delimiter in the message and the message can contain a maximum of 255 bytes.

To delete the MOTD, use the no banner motd command in global configuration mode. The following example describes how to configure a MOTD. The # symbol is used as the delimiter, and the text is “Notice: system will shutdown on July 6th.”

```
Ruijie(config)# banner motd #                    //Start delimiter.
Enter TEXT message.  End with the character '#'.
Notice: system will shutdown on July 6th.#            //End delimiter.
Ruijie(config)#
```

Configuring a Login Banner

To configure a login banner, execute the following commands in global configuration mode:

Command	Function
Ruijie(Config)**# banner login** *c* *message c*	Specifies the text of the login banner, with c being the delimiter, for example, a pound sign (&). After entering the delimiter, press Enter. Now, you can start to type text. You need to input the delimiter and then press Enter. Note that if you type additional characters after the end delimiter, these characters will be discarded by the system. Also note that you cannot use the delimiter in the text of the login banner and the text can contain a maximum of 255 bytes.

To delete the login banner, use the **no banner login** command in global configuration mode.

The following example shows how to configure a login banner. The pound sign (#) is used as the starting and end delimiters and the text of the login banner is "Access for authorized users only. Please enter your password."

```
Ruijie(config)# banner login # //Start delimiter
Enter TEXT message. End with the character '#'.
Access for authorized users only. Please enter your password.
#   //End delimiter
Ruijie(config)#
```

Displaying a Banner

A banner is displayed when you log in the network device. See the following example:

```
C:\>telnet 192.168.65.236
 Notice: system will shutdown on July 6th.
 Access for authorized users only. Please enter your password.
 User Access Verification
Password:
```

“Notice: system will shutdown on July 6th." is a MOTD banner and "Access for authorized users only. Please enter your password." is a login banner.

Viewing System Information

Overview

You can check some system information using the show command on the command-line interface, such as version and device information.

Viewing System Information and Version

System information includes description, power-on time, hardware version, software version, BOOT-layer software version, and CTRL-layer software version.This information helps you know the system better. You can show system information using the following commands in privileged mode.

Command	Function
Ruijie# **show version**	Shows system information.

Note For a sequence number, run the **show version** command on the main program interface to view SYSTEMUPTIME in the form of DD:HH:MM:SS.

Note During upgrading, the running software version may differ from the version in the file system. In this case, the main program version shown by running the show version command is the one running in the memory, but the Boot/Ctrl version is the one stored in the flash memory.

Viewing Hardware Entity Information

Hardware information relate to physical devices, slots and modules assembled in a device. The information on a device includes description, number of slots,slot information, slot number, description of the module on the slot (empty description if no module is plugged in the slot), the number of physical ports of the module in the slot, and the maximum number of ports supported in the slot (the number of ports on the plugged module). You may use the following commands to show the information about the device and slots in privileged mode:

Command	Function
Ruijie# **show version devices**	Shows the current device information.
Ruijie# **show version slots**	Shows current information about slots and modules.

Setting Console Rate

Overview

The device provides a console interface for management. When using the switch for the first time, you need to perform configuration through the console interface. You can change the console rate on the device if necessary. Note that the rate of the terminal used to manage the switch must be the same as that of the console interface on the switch.

Setting Console Rate

In line configuration mode, execute the following command to set the console rate:

Command	Function
Ruijie(config-line)# **speed** *speed*	Sets transmission rate in bps on the console interface. For a serial interface, you can only set the transmission rate to any one of the following values: 9600, 19200, 38400, 57600 and 115200 bps, with 9600 bps by default.

This example shows how to configure the baud rate of the serial interface to 57600 bps:

```
Ruijie# configure terminal //Enter global configuration mode.
Ruijie(config)# line console 0     //Enter the console line configuration mode
Ruijie(config-line)# speed 57600   //Set the console rate to 57600bps
Ruijie(config-line)# end       //Return to the privileged mode
Ruijie# show line console 0    //View the console configuration
CON    Type    speed   Overruns
* 0    CON    57600   0
Line 0, Location: "", Type: "vt100"
Length: 25 lines, Width: 80 columns
Special Chars: Escape  Disconnect  Activation
            ^^x    none       ^M
Timeouts:   Idle EXEC   Idle Session
            never         never
History is enabled, history size is 10.
Total input: 22 bytes
Total output: 115 bytes
Data overflow: 0 bytes
stop rx interrupt: 0 times
Modem: READY
```

Configuring Telnet

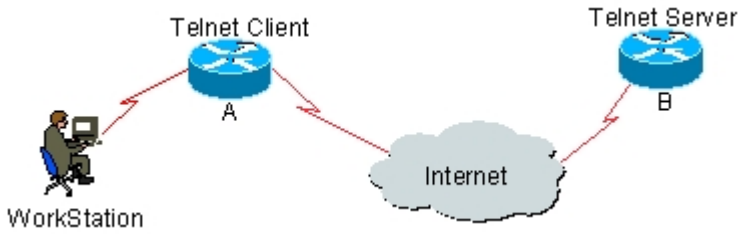
Overview

Telnet, as an application layer protocol in the TCP/IP protocol suite, provides the specifications for remote login and virtual terminal communication. The Telnet Client service is used by a local or remote user who has logged onto the local

network device to work with the Telnet Client program to access other remote system resources on the network. As shown below, after setting up a connection with Switch A through the terminal emulation program or Telnet, you can log in the Switch B for management and configuration using the telnet command.

Ruijie's telnet program supports IPV4 and IPV6 addresses. The telnet server can receive IPV4 and IPV6 telnet connection requests. The telnet client can send connection requests to an IPV4 or IPV6 host.

Figure 1



Using Telnet Client

You can log in to a remote device by using the **telnet** command on the switch.

Command	Function
Ruijie# **telnet** *host* [*port*] [/**source** {**ip** *A.B.C.D* **ipv6** *X:X:X::X* | **interface** *interface-name*}] [/**vrf** *vrf-name*]	Logs in to a remote device via Telnet. host may be an IPv4 or IPv6 host name or an IPv4 or IPv6 address. For optional parameters, refer to relevant Telnet command section in Basic Configuration Management Command.

The following example shows how to establish a Telnet session and manage the remote device with the IP address 192.168.65.119:

```
Ruijie# telnet 192.168.65.119  //Establish the telnet session to the remote device
Trying 192.168.65.119 ... Open
User Access Verification       //Enter into the login interface of the remote device
Password:
```

The following example shows how to establish a Telnet session and manage the remote device with the IPv6 address 2AAA:BBBB::CCCC:

```
Ruijie# telnet 2AAA:BBBB::CCCC //Establish the telnet session to the remote device
Trying 2AAA:BBBB::CCCC ... Open
User Access Verification       //Enter into the login interface of the remote device
Password:
```

Using Telnet Server

Use the following command to enable the Telnet server service for network devices:

Command	Function

Ruijie(config)# **enable service telnet-server**	Enables the Telnet server service. This command enables IPv4 and IPv6 services concurrently.

Setting Connection Timeout

Overview

You can control the connections of a device (including the accepted connections and sessions between the device and a remote terminal) by configuring the connection timeout for the device. When the idle time exceeds the set value and no input or output is found, this connection will be released.

Connection Timeout

When there is no information running through an accepted connection within a specified time, the server will release this connection.

Our products provide commands for you to configure the connection timeout in line configuration mode.

Command	Function
Ruijie(Config-line)**#exec-timeout** *minutes* [*seconds*]	Configures the timeout for the accepted connection. When the configured time is due and there is no input, this connection will be released. *minutes*: timeout in minutes; *seconds*: timeout in seconds.

You can cancel the connection timeout by using the **no exec-timeout** command in line configuration mode.

```
Ruijie# configure terminal //Enter global configuration mode.
Ruijie# line vty 0         //Enter the line configuration mode
Ruijie(config-line)#exec-timeout 20    //Set the timeout to 20min
```

Session Timeout

When there is no input for the session established with a remote terminal over the current line within the specified time, the session will be released and the remote terminal becomes idle.

RGOS provides commands in line configuration mode to configure the timeout for sessions with a remote terminal.

Command	Function
Ruijie(Config-line)**#session-timeout** *minutes* [**output**]	Configures the timeout for the session set up with the remote terminal over the line. If there is no input within the specified time, this session will be released. *minutes*: timeout in minutes; **output**: Determines whether the session has expired using output data.

You can remove the timeout setting for the session set up with the remote terminal by using the **no exec-timeout** command in the line configuration mode.

```
Ruijie# configure terminal //Enter global configuration mode.
Ruijie(config)# line vty 0         //Enter the line configuration mode
Ruijie(config-line)# session-timeout 20    //Set the session timeout to 20min
```

Executing the Commands for Executable Batch Files

During the process of system management, it is sometimes necessary to enter multiple configuration commands to manage a function. It takes a long time to enter all the commands on CLI, causing errors. To solve this problem, you can include all the commands into a batch file by taking configuration steps. Then, you can execute the batch file for configuration when necessary.

Command	Function
Ruijie**# execute** {[**flash**:] *filename*}	Executes a batch file.

For example, the batch file line_rcms_script.text enables the reversed Telnet function on all the asynchronous interfaces as shown below:

```
configure terminal
line tty 1 16
transport input all
no exec
end
```

Result:

```
Ruijie# execute flash:line_rcms_script.text
executing script file line_rcms_script.text ......
executing done
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# line vty 1 16
Ruijie(config-line)# transport input all
Ruijie(config-line)# no exec
Ruijie(config-line)# end
```

Note

The file name and contents of a batch file can be specified. You can send an edited batch file to the flash memory of the network device in TFTP mode. The contents of the batch file will synchronize the input completely. Hence, it is necessary to edit the contents of the batch file in the sequence that CIL commands are configured. For some interactive commands, it is necessary to write corresponding response information into the batch file to ensure that the commands can be executed normally.

Caution Files exceeding 128 KB may cause batch processing to fail. For batch processing, split a large file into a number of files, each of which is smaller than 128 KB.

Setting a Service Switch

During operations, you can adjust services dynamically to enable or disable specified services (SNMP Server/SSH Server/Telnet Server/Web Server).

Command	Function
Ruijie(Config)# **enable service snmp-agent**	Enables SNMP Server.
Ruijie(Config)# **enable service ssh-sesrver**	Enables SSH Server.
Ruijie(Config)# **enable service telnet-server**	Enables Telnet Server.
Ruijie(Config)# **enable service web-server**	Enables http and https servers.

In configuration mode, you can use the **no enable service** command to disable corresponding services.

```
Ruijie# configure terminal            //Enter global configuration mode.
Ruijie(config)# enable service ssh-server  //Enable SSH Server
```

To enable http service only, use the following command:

```
Ruijie(config)# enable service web-server http
```

To enable https service only, use the following command:

```
Ruijie(config)# enable service web-server https
```

Note The **enable service web-server** command can be followed by three optional keywords:
enable service web-server [*http* | *https* | *all*]
If the command is followed by no keyword or by all, the command enables http and https services. Followed by http, the command enables http service only. Followed by https, the command enables https service only. This command and related HTTP service commands discussed later do not necessarily enable you to access the web management page through the browser. These commands only enable the HTTP service and provide an HTTP access channel. To access the web management page, upload a compressed web management work package in upd format to the flash memory of your device. These commands are not designed only for web management. Instead, they support HTTP detection, redirection, and flash file download on the device.

Caution For the HTTP server to work after the HTTP service is enabled, store the server certificate and private key in the root directory of the file system on the device. Name the server certificate httpd_cert.crt and private key file httpd_key.pem, and upload these files to the root directory through a TFTP server.

Setting HTTP Parameters

When using the integrated Web for management, you can adjust HTTP parameters, and specify service ports or login authentication methods.

Command	Function
Ruijie(Config)# **ip http port** *number*	Specifies HTTP service port, 80 by default.
Ruijie(Config)# **ip http authentication** {**enable** | **local**}	Sets Web login authentication method, which is enable by default. **enable**: Uses the password set by the enable password or enable secret command for authentication, where the password must be 15 levels. **local**: Uses the username and password set by the username command for authentication, where the user must be bound with 15-level access rights.

In configuration mode, you can use the **no** form of the command to restore the setting to the default value. The following example enables the HTTP Server, sets the service port to 8080, and uses the local username for login authentication.

```
Ruijie# configure terminal            //Enter global configuration mode.
Ruijie(config)# enable service web-server http    //Enable http Server
Ruijie(config)# username name password pass //Set local user
Ruijie(config)# username name privilege 15    //Bind user right
Ruijie(config)# ip http port 8080          //Set service port
Ruijie(config)# ip http authentication local //Set authentication method
```

Use the following command to configure an HTTPS service port.

Command	Function
Ruijie(Config)# **ip http secure-port** *number*	Specifies the HTTP service port. (default:443)

In configuration mode, you can use the **no** form of the command to restore the setting to the default value. The following example enables the HTTP Server and sets the service port to 4443.

```
Ruijie# configure terminal            //Enter global configuration mode.
Ruijie(config)# enable service web-server https//Enable https Server
Ruijie(config)# ip http secure-port 4443
```

Use the following command to verify the status of WEB server.

```
Ruijie# show web-server status
http server status : enabled
```

```
http server port : 8080
https server status:  enabled
https server port: 4443
```

Caution

Avoid configuring http and https service ports to the same value. If https service is enabled after http service, and the port is configured to the same port as http service, you can only access https service through this port, and http service will be blocked temporarily until https service port is changed or the service is disabled.

Setting Multi-boot Function

Overview

By default, the device searches for the main program file and boots it in the built-in flash memory. If the main program file is damaged due to upgrade failure, formatted flash memory, for example, the device may fail to boot the system.

Some Ruijie products support the multi-boot function, which enables you to boot the device using main program files from local flash memory, a removable disk (USB drive or SD card) or a remote TFTP server. When the device starts, the system boots the main programs by boot pirority in descending order until it boots successfully or all programs are filed. Multi-boot function is mandatory for some environments with higher demands on reliability and availability.

Product support	Only the RSR20, RSR30, R2700 V5.0, RSR50, RSR50E and NPE50 series of routers and the S86 series of switches currently support the multi-boot function. Unless otherwise stated, this section applies to the above products.

This following examples describe how to use multi-boot for redundant backup of the main program.

Configuring the Main boot program

You can use the following command to configure the main boot program and specify the boot priority. The system will boot the main program based on priority in descending order with 1 being the highest and 10 being the lowest priority.

Command	Function
Ruijie(Config)**#boot system** *priority* prefix:/[directory/] filename	Sets the main boot program and specify its priority. The boot priority is in the range of 1 to 10, with 1 being the highest.

Caution

Using URL prefix to locate a file is only supported in 10.4(2) and higher versions. For details, refer to the File System Configuration Guide. Path is used to locate a file in a version lower than 10.4(2), for example, usb0:/backup/rgos.bin represents rgos.bin in the backup directory on the first USB device.
flash:/rgos.bin indicates the rgos.bin file under the Flash root directory.


Caution Supported URL prefixes vary with platforms. To show the currently supported URL prefixes, run the following command:

```
Ruijie (config) # boot system 2 ?
  flash:   Boot from flash: file system
  tftp:    Boot from tftp server
  usb0:   Boot from usb0: file system
  usb1:   Boot from usb1: file system
```


Caution Multi-boot is not allowed during ISSU operations (see “Upgrading ISSU”).

By default, the bootable main program is flash:/rgos.bin with the priority of 5.


Caution Since the system uses this command in the early stage of booting, the configuration is saved in the Boot ROM rather than in the configuration file.

Specifying a file in local flash memory

The following example sets the file on the local flash memory as the main program.

```
Ruijie(config)# boot system 5 flash:/rgos.bin
```


Note When you specify a local file through prefix, the path following “:” must be an absolute path.

When you configure the boot system command, the system will check the validity of the main program in the local flash memory. You can configure the command successfully only when the main program meets the following requirements.

- The main program must exist.
- The main program is a legal RGOS main program.
- The main program is complete and passes CRC check.

If any requirement is unmet, the systme will dispay an error message, for example:

```
Ruijie(config)# boot system 5 flash:/foo.bin
Set boot system file error:[ flash:/foo.bin] does not exist!
```

In addition, a priority can be set for more than one main program. Otherwise, the system will display an error message and print the current main program list for your selection. For instance:

```
Ruijie(config)# boot system 5 flash:/rgos.bin
Ruijie(config)# boot system 5 flash:/rgos_bak.bin
Set boot system file error: priority 5 has been assigned to file [ flash:/rgos.bin].
Boot system config:
=====================================================
Prio     Size            Modified  Name
---- --------- ------------------- -----------------
  1
  2
  3
  4
  5    3205120 2008-08-26 05:22:46 flash:/rgos.bin
  6
  7
  8
  9
 10
=====================================================
Ruijie(config)# boot system 6 flash:/rgos_bak.bin
```

Specifying a file on a removable storage device

The same procedure applies for saving the main program as a file on a removable storage device and in the local flash memory. The only difference is that the system does not check the file for existence or validity when you save it on a removable storage device.

Caution The file is not checked so that you can configure the device remotely without having to insert a USB drive containing a valid main program into the device. However, you must enter a correct filename.

Do as follows to set up the device to boot from a USB drive:

```
Ruijie(config)# boot system 1 usb1:/rgos.bin
```

Note Currently, the device cannot start a RGOS installation package earlier than 10.4 (3) from a USB drive.

Specifying a file on a remote TFTP server

Do as follows to set up the device to boot from a TFTP server:

```
Ruijie(config)# boot system 2 tftp://192.168.7.24/rgos.bin
```

Note Currently, the device cannot start a RGOS installation package earlier than 10.4 (3) from a TFTP server.

For the device to download the main program through the TFTP protocol during the boot process, use the boot ip command to configure a correct local IP address used for TFTP address:

Command	Function
Ruijie(config)# **boot ip** *local-ip*	Configures a local IP address for TFTP transfer during the boot process.
Ruijie(config)# **no boot ip**	Clear the boot ip configuration.

Caution This configuration is stored in the Boot ROM rather than in a configuration file, as the system must use the configuration early in the boot process.

Caution Ensure that the built-in flash memory contains sufficient free space for the boot file when booting from a TFTP server. During the boot process, the file is hidden in the flash memory. Clear it before the next boot.

Do as follows to configure the IP address for the device to boot up:

```
Ruijie(config)# boot ip 192.168.7.11
```

If no boot ip address is specified, the device cannot load main program files from the TFTP server during the boot process due to communication failure. The following message appears on the screen:

```
Load program file: [tftp://192.168.7.24/rgos.bin]
[Failed] (Boot IP was not assigned)
Load program file: [/rgos.bin]
[OK]
Executing program, launch at: 0x00010000
......
```

Modifying the Boot Priority of Main Program

The **boot system** command can also be used to modify the boot priority of the main program. Aussme that the configured boot main program list is shown as follows:

```
Ruijie# show boot system
Boot system config:
=====================================================
Prio     Size            Modified  Name
---- --------- ------------------- ------------------
  1
```

```
 2
 3
 4
 5    3205120 2008-08-26 05:22:46 flash:/rgos.bin
 6
 7
 8    3205120 2008-08-26 05:25:09 flash:/rgos_bak.bin
 9
10
=====================================================
```

To set the boot priority of flash:/rgos_bak.bin to 1, run the following command:

```
Ruijie(config)# boot system 1 flash:/rgos_bak.bin
File [flash:/rgos_bak.bin] has been configured with priority 8,
Change the priority to [1]? [yes] yes
```

The result is as follows:

```
Ruijie# show boot system
Boot system config:
=====================================================
Prio     Size            Modified  Name
---- --------- ------------------- -----------------
 1    3205120 2008-08-26 05:25:09 flash:/rgos_bak.bin
 2
 3
 4
 5    3205120 2008-08-26 05:22:46 flash:/rgos.bin
 6
 7
 8
 9
10
=====================================================
```

Deleting the Main boot program

You can use the following command to delete the main boot program.

Command	Function
Ruijie(Config)**# no boot system** [*priority*]	Deletes the main boot program. The boot priority is in the range of 1 to 10. If no priority is specified, all the main boot programs will be reset.

Use the following command to delete the main program with the prioirty of 8. During the process of deletion, the system displays the corresponding main program name and prompts you for confirmation.

```
Ruijie(config)# no boot system 8
Delete boot system config: [Priority: 8; File Name: flash:/rgos_bak.bin]? [no] yes
```

Use the following command to clear all the main boot programs.

```
Ruijie(config)# no boot system
Clear ALL boot system config? [no] yes
```

Caution If you have not configured the main boot program after using the **no boot system** command to clear all main boot programs, the system will automatically restore to the default setting during the next booting process (the bootable main program is flash:/rgos.bin with the priority of 5).

Showing the Configuration of Multi-boot

You can use the following command to show the configuration of multi-boot.

Command	Function
Ruijie# **show boot system**	Show the configuration of the main boot program.
Ruijie# **show boot ip**	Shows the local IP address used by the device during the boot process.

The local IP address for booting up the device is shown as follows:

```
Ruijie# show boot ip
System boot ip: [192.168.7.11]
```

Use the following command to show the main program and its boot priority.

```
Ruijie# show boot system
Boot system config:
======================================================
Prio     Size            Modified  Name
---- --------- ------------------- -----------------
  1
  2
  3
  4
  5    3205120 2008-08-26 05:22:46 flash:/rgos.bin
  6
  7
  8    3205120 2008-08-26 05:25:09 flash:/rgos_bak.bin
  9
 10
======================================================
```

Note The size and modification time are not shown for files on a remote TFTP server. The size and modification time are shown as N/A for such files.

Note If the related main program does not exist when you run the **show boot system** command, the size and modification time of the file is also shown as N/A.

Configuration Example

The following example shows how the device boots up:

- The device boots from the USB drive in USB port 1 that contains a legal main program file in its root directory;
- The device boots from rgos.bin in the root directory of the built-in flash memory if no USB drive is available;
- The device will boot from the backup main program file rgos_bak.bin if rgos.bin is damaged or lost;
- The device will download and boot from a main program file from the remote TFTP server if the backup main program file fails possibly because the built-in flash memory is formatted.

Step 1: Configure the default main program.

```
Ruijie(config)# boot system 5 flash:/rgos.bin
```

Since the device is configure with the main program flash;/rgos.bin with priority of 5 during intialization, this step can be skipped.

Generally, it is recommended that you set the priority of an active main program to medium so that you can configure other main programs with a higher or lower priroity.

Step 2: configure the backup main program.

The backup main program should have a priority slightly lower than the active main program.

```
Ruijie(config)# boot system 8 flash:/rgos_bak.bin
```

Step 3: Configure the name of the main program for booting from a remote TFTP server and the boot IP address.

Normally, the device is set up to boot from a remote TFTP server only when its built-in flash memory is damaged. Therefore, boot from TFTP is set to the lowest priority:

```
Ruijie(config)# boot ip 192.168.7.11
Ruijie(config)# boot system 10 tftp://192.168.7.24/rgos.bin
```

Step 4: Configure the name of the main program for USB boot.

Boot from a USB drive applies when a temporary version must be quickly deployed for trial run.

For a device to boot first from a USB drive, insert the USB drive that contains only the temporary software version and restart the device. To clear the temporary version, remove the USB drive and restart the device. The device will automatically boot from the main program in the built-in flash memory. Booting from a USB drive simplifies the deployment of a temporary version and shortens the downtime due to version upgrade.

Do as follows to configure the name of the main program and set up the device to boot first from a USB drive:

```
Ruijie(config)# boot system 1 usb1:/rgos.bin
```

Step 5: Check the main program name and boot priority.

You can run the **show boot** system command to view confiugration.

```
Ruijie# show boot system
Boot system config:
=====================================================
Prio     Size             Modified  Name
---- --------- ------------------- -----------------
  1
  2
  3
  4
  5     3205120 2008-08-26 05:22:46 flash:/rgos.bin
  6
  7
  8     3205120 2008-08-26 05:25:09 flash:/rgos_bak.bin
  9
 10         N/A                N/A tftp://192.168.7.24/
                                   rgos.bin
=====================================================
```

Setting Startup Configuration File

Some Ruijie products can speficy a startup configuration file, which is stored in the flash memory, on a removable storage device (for example, USB drive, SD card) or remote TFTP server.

Once configured, a device can obtain a file from a specified location as the startup configuration file.

Product support	Only the RSR20, RSR30, R2700 V5.0, RSR50, RSR50E and NPE50 series of routers and the S86 series of switches currently support this function. Unless otherwise stated, this section applies to the above products.

This following examples describe how to specify a startup configuration file.

Configuring the Startup Configuration File

You can use the following command to configure the startup configuration file.

Command	Function

Command	Function
Ruijie(Config)#**boot config** *prefix:/ [directory/] filename*	Sets the startup configuration file.
Ruijie(Config)#**no boot config**	Clears the startup configuration file.

Note You can view the configuration file using the command line help, for example:

```
Ruijie(config)#boot config ?
  flash:   Startup-config filename
  usb0:   Startup-config filename
  usb1:   Startup-config filename
```

The system loads a configuration file as follows:

- If the **service config** command is absent, configuration files are loaded in the following order: the startup configuration file specified by the **boot config** command, /config.text, the network startup configuration file configured by the **boot network** command, and the default factory configuration (null configuration).
- If the **service config** command is present, configuration files are loaded in the following order: the network startup configuration file configured by the **boot network** command, the startup configuration file specified by the **boot config** command, /config.text, and the default factory configuration (null configuration).
- While loading configuration files in order, the system will not load another configuration files until one configuration file is loaded successfully.

Caution For the service config and boot config commands, refer to the following examples.
Because the system needs to use the configuration of this command in the early stage of booting, this configuration is stored in Boot ROM rather than in the configuration file.

When using the **write [memory]** command to store the startup configuration file, the system will save it as follows:

- If the **boot config** command is not used, the system stores the configuration in the flash:/config.text file in the built-in flash memory by default.
- If the **boot config** command is used to configure a startup configuration file and the file exists, the system stores the configuration in the startup configuration file.
- If the **boot config** command is used to configure a startup configuration file but the configuration file does not exist, then:
- If the device where the configuration file is located exists, the system will automatically create the specified configuration file and store it into the system configuration.
- If the device where the configuration file is located does not exist (for instance, the start cofniguration file is stored on

a removable storage device such as a USB drive or SD card, but the device is not loaded when the system runs the **write [memory]** command), the system will prompt you whether to save the configuration into the default startup configuration file flash:/config.text and act as required.

The following example sets a file on the USB drive as the startup configuration file and demonstrates how to run the write command before and after removing the USB drive.

Set the file on the USB drive as the startup configuration file.

```
Ruijie(config)# boot config usb1:/config.text
```

Run the **write** command before removing the USB drive to save the current configuation into the file specified by the boot config command.

```
Ruijie# write
Building configuration...
Write to boot config file: [usb1:/config.text]
[OK]
```

Run the **write** command after removing the USB drive. The system will prompt you whether to save the current configuration into the default start configuraiton file /config.

```
Ruijie# usb remove 1
0:1:1:38 Ruijie: USB-5-USB_DISK_REMOVED: USB Device <USB Mass Storage Device> Removed!
Ruijie# write
Building configuration...
Write to boot config file: [usb1:/config.text]
[Failed]
The device [usb1] does not exist, write to the default config file [flash:/config.text]? [no]
yes
Write to the default config file: [flash:/config.text]
[OK]
```

Configuring the Network Start Configuration File

You can use the following command to configure the network startup configuration file.

Command	Function
Ruijie(Config)**# boot network tftp** :// *location* / *filename*	Configures the network startup configuration file.
Ruijie(Config)**#no boot network**	Clears the network startup configuration file.

When the device starts, the system loads the configuration file as follows;

- If the service config command is absent, configuration files are loaded in the following order: the startup configuration file specified by the boot config command, /config.text, the network startup configuration file cofnigured by the boot network command, and the default factory configuration (null configuration).
- If the service config command is present, configuration files are loaded in the following order: the network startup

configuration file configured by the boot network command, the startup configuration file specified by the boot config command, /config.text, and the default factory configuration (null configuration).

- While loading configuration files in order, the system will not load another configuration files until one configuration file is loaded successfully.

Caution The system can obtain remote files through TFTP only after you run the bootip command to configure the local IP address of the device used for initiation. Otherwise, TFTP transmission may fail during initiation. Because the system needs to use the configuration of this command in the early stage of booting, this configuration is stored in Boot ROM rather than the configuration file.

The following figure sets the boot IP address of the device and designates the network startup configuration file.

```
Ruijie(config)# boot ip 192.168.7.11
Ruijie(config)# boot network tftp://192.168.7.24/config.text
```

Configuring Preferrably Using the Network Start Configuration File

By default, the device loads the local startup configuration file specified by the **boot config** command. In some cases, if the device needs to use the network startup configuration file, run the **service config** command.

Command	Function
Ruijie(Config)# **service config**	Enables the device to preferably load the startup configuration file from the remote network server.
Ruijie(Config)#**no service config**	Disables the device to preferably load the startup configuration file from the remote network server.

This command should use in conjunction with the **boot config** and **boot network** commands.

When the device starts, the system loads the configuration file as follows;

- If the **service config** command is absent, configuration files are loaded in the following order: the startup configuration file specified by the boot config command, /config.text, the network startup configuration file configured by the boot network command, and the default factory configuration (null configuration).
- If the **service config** command is present, configuration files are loaded in the following order: the network startup configuration file configured by the boot network command, the startup configuration file specified by the boot config command, /config.text, and the default factory configuration (null configuration).
- While loading configuration files in order, the system will not load another configuration files until one configuration file is loaded successfully.

Caution Because the system needs to use the configuration of this command in the early stage of booting, this configuration is stored in Boot ROM rather than the configuration file.

The following example loads the configuration file from a remote network server and configures the network startup configuration name.

```
Ruijie(config)# service config
Ruijie(config)# boot network tftp://192.168.7.24/config.text
```

Showing the Configuration of Start Configuration File

You can use the following command to show the configuration of a startup configuration file.

Command	Function
Ruijie# **show boot config**	Shows the configuration of a startup configuration file.
Ruijie# **show boot network**	Shows the configuration of a network startup configuration file.

The following example shows the configuration of a startup configuration file.

```
Ruijie# show boot config
Boot config file: [flash:/config_main.text]
Service config: [Disabled]
```

The following example shows the configuration of a network startup configuration file.

```
Ruijie# show boot network
Network config file: [tftp://192.168.7.24/config.text]
Service config: [Enabled]
```

Configuration Example

The following example sets up the device to first obtain the configuration file from a remote TFTP server and to use the backup configuration file in built-in flash memory when loading fails.

Step 1: Configure the device to first load the configuration file from a network server and configure the boot IP address.

```
Ruijie(config)# service config
Ruijie(config)# boot ip 192.168.7.11
```

Step 2: Configure the network startup configuration file.

```
Ruijie(config)# boot network tftp://192.168.7.24/router_1.text
```

Step 3: Configure the local startup configuration file.

```
Ruijie(config)# boot config flash:/router_1.text
```

Step 4: Show the configuration.

```
Ruijie# show boot network
Network config file: [tftp://192.168.7.24/router_1.text]
Service config: [Enabled]
Ruijie# show boot config
```

```
Boot config file: [flash:/router_1.text]
Service config: [Enabled]
```

Configuring SMM

Understanding SMM

Overview

Short Message Management (SMM) is used for auxiliary management of mass-deployed 3G routers through short message channels. Below is a general description of SMM.

When plenty of 3G routers are deployed on a network, the following issues arise with the conventional way of managing 3G routers based on SNMP:

1) For a 3G router used for the first time without any configuration file, technical support personnel have to be on site to configure the 3G router. This, however, causes a great waste of time and labor.
2) When a device is faulty and accordingly the IP network becomes abnormal, it is impracticable to manage the device through SNMP. If another channel is available, it would be a very good choice.
3) Because an administrator cannot monitor NMS software all the time, he or she can not immediately learn the abnormality when the NMS software detects that a device is abnormal. If the NMS software remotely notifies the administrator of the abnormality, the administrator will be able to greatly improve his or her work efficiency.
4) Because a 3G router uses an SIM card, overdue payments may occur, thereby causing service interruption. If the balance is periodically queried through short messages and the administrator is notified in the event of an insufficient balance so as to recharge the SIM card in time, service interruption can be avoided.

Considering the preceding issues, a way of combining a short messaging service (SMS) and IP-based SNMP may help 3G router management and resolve these issues. SMS and IP-based SNMP can supplement each other to manage 3G routers in an efficient, real-time, and reliable manner.

Basic Concepts and Features

SMS

SMS is a telecommunications service that comes with a digital mobile communication system. As a non-real-time and non-voice data communication service, it transmits information in the form of text or numbers through signaling channels and signaling networks of the mobile communications system. In terms of the technical means for implementing the SMS function, users mostly send and receive point-to-point messages through mobile terminals. This, however, is not the only means, as fixed phones, the personal handy phone system (PHS), and the Internet are becoming new tools and carriers.

The short message service protocol is a multimedia protocol. Currently, there are three major types of short message services: SMS, enhanced messaging service (EMS), and multimedia messaging service (MMS).

SMS is the most primitive short message service and also a short message service mostly popularized. It enables a mobile phone to send or receive short messages to or from another mobile phone. The content of a short message is

mostly text, number data, or binary non-text data. Currently, the length of such a short message is limited to 140 bytes. Thanks to its easy use, SMS is favored by a wide range of users and rapidly popularized. It, however, is a first-generation wireless data service and subjects to technical standard limitations in terms of content and applications.

SMS was first applied in European GSM systems in 1991. As a value-added service of GSM systems, SMS gained rapid development along with the widening of GSM network coverage. Featuring numerous merits such as fast transmission, low cost, and no need for occupying voice communications channels, SMS has been widely applied in remote intelligent control systems.

SMM

Short Message Management (SMM) is used for auxiliary management of mass-deployed 3G routers through short message channels.

A short message channel is a channel completely independent of the IP channel of a 3G router. Therefore, when the IP channel fails, some urgent and important commands can be executed through the short message channel, so as to obtain relevant location information or restore the running of the device.

Working Principle

The following figure shows the topology of the solution for managing 3G routers based on SMS and IP channels.

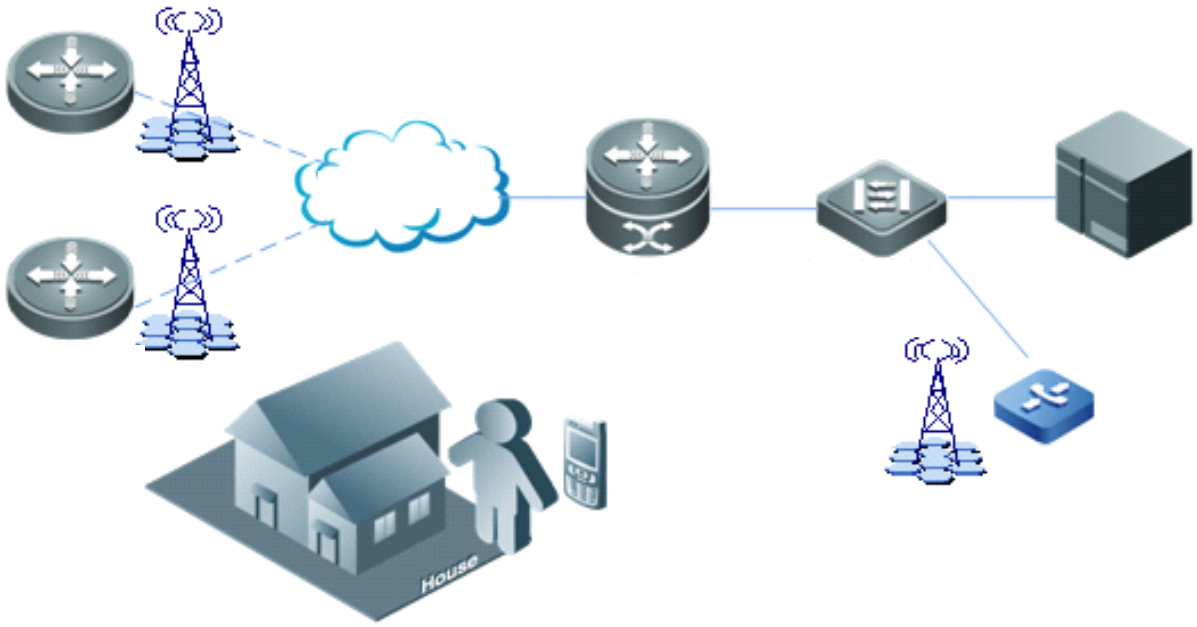


Figure 1 Topology of the Solution for Managing 3G Routers Based on SMS and an IP Network

The devices cooperate with one another in the following way:

5) In this solution, the SNC server supports the SMM function, in addition to the conventional NMS function (based on SNMP and using IP transmission channels), and serves as the control center of SMM. Short messages are sent and received through the SMS gateway. The SNC server communicates with the SMS gateway through Ethernet transmission channels.

6) The SMS gateway serves as a bridge for short message communications between the SNC server and devices (the 3G router and the administrator's mobile phone). It supports China Unicom WCDMA networks and China Telecom CDMA 2000 networks.
7) For a 3G router used for the first time, the SNC server delivers a configuration file in the form of short messages to the 3G router.
8) Each 3G router can only passively receive and execute control or inquiry commands from the SNC server, and gives corresponding replies. There is no active reporting mechanism for the 3G routers. The IP network or the short message channel is used as the transmission channel. The short message channel only serves as the standby channel of the IP network. That is, the IP network is preferred.
9) After receiving fault information about a 3G router, the SNC server sends an alarm in the form of a short message to the administrator through the SMS gateway.
10) The SNC server supports the traffic management function. When a device is to be in overdue payment, the SNC server sends an alarm to the administrator's mobile phone.

Protocol Specification

None.

Default Configuration

The default SMM configuration is shown in the following table.

Feature	Default Setting
Enabling the SMS gateway function on the device	When the device is not configured as the SMS gateway, it is a 3G router by default.
Configuring the SMS gateway to support communications with SIM cards of different systems	The SMS gateway does not support communications with SIM cards of different systems.
Configuring the response timeout period of the SMS gateway	The SMS gateway calculates the response timeout period according to the size of the data carried in the management command by default.
Setting TEXT Mode as the preferred mode to the short message sending mode	N/A

Configuring the SMS Gateway

The SMS gateway involves the following configuration items (the 3G routers do not require configuration):

- (Mandatory) Enabling the SMS gateway function on a device so that the device serves as the SMS gateway

- (Optional) Configuring the SMS gateway to support sending short messages to SIM cards of different systems
- (Optional) Configuring the response timeout period of the SMS gateway
- Displaying configurations

(Mandatory) Enabling the SMS Gateway Function on the Device

You can use the **no** form of the following command to disable the SMS gateway function:

Ruijie(config)**#no smm-role gateway**

	Command	Function
Step 1	**smm-role gateway**	Enables the SMS gateway function on the device and enters SMS gateway configuration mode. After the SMS gateway function is enabled, the device performs the SMS gateway function.

😐**Product Support**	RSR10-02E, RSR20-04E, RSR20-14E, RSR20-14F, RSR30-44, RSR810

The following example enables the SMS gateway function on the preceding devices (see Product Support):

```
Ruijie#configure terminal
Ruijie(config)#smm-role gateway
Ruijie(config-sms-gateway)#
```

(Optional) Configuring the SMS Gateway to Support Sending Short Messages to SIM Cards of Different Systems

This command can be executed in SMS gateway configuration mode only.

This command acts only when a management command is sent to a 3G router (the SMS gateway and the 3G router can use SIM cards of China Unicom and China Telecom only). It does not act when a short message is sent to an authorized number such as the administrator's mobile phone number.

To diable the SMS gateway's support for sending short messages to SIM cards of different systems, use the **no** form of this command or the following **default** command. The **no** form of this command and the **default** command has the same effect.

Ruijie(config-sms-gateway)# **no diff-carrier-comm support**

Ruijie(config-sms-gateway)# **default diff-carrier-comm support**

Command	Function

diff-carrier-comm support	Configures the SMS gateway to support sending short messages to SIM cards of different systems. After this function is enabled, the SMS gateway can send management commands to SIM cards of different systems on 3G routers.

😐**Product Support**	RSR10-02E, RSR20-04E, RSR20-14E, RSR20-14F, RSR30-44, RSR810

The following example enables the SMS gateway on the preceding devices (see Product Support) to send short messages to SIM cards of different systems:

```
Ruijie#configure terminal
Ruijie(config)#smm-role gateway
Ruijie(config-sms-gateway)#diff-carrier-comm support
```

(Optional) Configuring the Response Timeout Period of the SMS Gateway

This command can be executed in SMS gateway configuration mode only.

After sending a management command, the SMS gateway needs to wait for a response to the management command. The management command can be sent in multiple short messages, depending on the size of the data carried in the management command. If no management response is received within a certain time period (in which retries are made), the SMS gateway returns a response timeout message to the SNC server. The maximum waiting time (response timeout period) is calculated according to the size of the data carried in the management command by default. When the network is not in good condition, you can specify the response timeout period through a configuration command instead of using the timeout period calculated by software.

To diable the user-specified timeout period and restore the timeout period calculated by software, use the **no** form of this command or the following **default** command.

Ruijie(config-sms-gateway)**#no wait-resp-timeout**

Ruijie(config-sms-gateway)**#default wait-resp-timeout**

Command	Function
wait-resp-timeout *timeout*	Sets the response timeout period of the SMS gateway. The value range is 600 to 7200 seconds. Note: The minimum timeout period is 600 seconds, because if the timeout period is smaller than 600 seconds, it may be smaller than or equal to the retry timeout period of a management command, causing the SMS gateway to return a response timeout message to the SNC server before the management command is retried.

😐**Product Support**	RSR10-02E, RSR20-04E, RSR20-14E, RSR20-14F, RSR30-44, RSR810

The following example sets the response timeout period of the SMS gateway on the preceding devices (see Product Support):

```
Ruijie#configure terminal
Ruijie(config)#smm-role gateway
Ruijie(config-sms-gateway)#wait-resp-timeout 1800
```

Displaying Configurations

Command	Function
show *running-config*	Displays the current configurations.

If the SMS gateway function is enabled on the device:

```
Ruijie#show running-config
……
webmaster level 0 username admin password 7 14134e00281c
webmaster level 2 username guest password 7 122010175919
!
!
!
!
!
smm-role gateway
!
!
diffserv domain default
……
```

If the SMS gateway has been configured to support sending short messages to SIM cards of different systems:

```
Ruijie#show running-config
……
webmaster level 0 username admin password 7 14134e00281c
webmaster level 2 username guest password 7 122010175919
!
!
!
!
!
smm-role gateway
 diff-carrier-comm support
!
!
diffserv domain default
!
……
```

If the response timeout period of the SMS gateway has been set:

```
Ruijie#show running-config
……
webmaster level 0 username admin password 7 14134e00281c
webmaster level 2 username guest password 7 122010175919
!
!
!
!
!
smm-role gateway
 wait-resp-timeout 800
!
!
diffserv domain default
……
```

Configuring Short Message Sending Mode

The configuration of Short Message Sending Mode involves the following configuration items (Can be applied for both SMS gateway and 3G router):

(Operational) Set TEXT Mode as the preferred mode to the short message sending mode

Displaying configurations

(Operational) Set TEXT Mode as the preferred mode to the short message sending mode

Run this command on a SMS gateway or a 3G router.

This command is required in the scenario where the ISP does not support SMS PDU mode. About the details of the network environment, contact the local ISP of the SIM card. Please do not configure this command without inquiring the local ISP.

Disable TEXT Mode before disabling Short Message Sending Mode, use the no form of this command or the following default command to remove this configuration. The no form of this command and the default command has the same effect.

Ruijie(config)# **no sms-code-prefer text**

Ruijie(config)# **default sms-code-prefer text**

Command	Function
sms-code-prefer text	Set TEXT Mode as the preferred mode to the short message sending mode. When this command is executed, the device prefers to send and receive short message in the TEXT mode.

😐**Product Support**	RSR10-02E, RSR20-04E, RSR20-14E, RSR20-14F, RSR30-44, RSR810

The following example set the TEXT mode as the preferred mode to the short message sending mode on the preceding devices (see Product Support):

```
Ruijie#configure terminal
Ruijie(config)# sms-code-prefer text
```

Displaying Configurations

Command	Function
show *running-config*	Displays the current configurations.

If the TEXT Mode is set as the preferred mode:

```
Ruijie(config)#sh ru
……
webmaster level 0 username admin password 7 06073a0e261b
webmaster level 2 username guest password 7 0344221d152a
sms-code-prefer text
!
!
```

Configuration Examples of the SMS Gateway

Network Requirements

11) SMS gateway: The available devices are the RSR10-02E, RSR20-14E, RSR20-04F, RSR20-14F, RSR30-44, and RSR810
12) 3G router: The available devices are the RSR10-02E, RSR20-14E, RSR20-04F, RSR20-14F, RSR30-44, and RSR810
13) Other devices: They include the convergence router, SNC server, and LAN switches.

Networking Topology

See Figure 1.

Configuration Tips

14) Select a 3G router device where the SMS gateway function can be enabled. After the SMS gateway function is enabled on the device, the device can serve as the SMS gateway.
15) On the device where the SMS gateway function is enabled, configure the SMS gateway to support sending short messages to SIM cards of different systems.
16) Set the response timeout period of the SMS gateway.

Configuration Steps

17) Enable the SMS gateway function on the device.

```
Ruijie#configure terminal
Ruijie(config)#smm-role gateway
```

18) Configure the SMS gateway to support sending short messages to SIM cards of different systems.

```
Ruijie#configure terminal
Ruijie(config)#smm-role gateway
Ruijie(config-sms-gateway)#diff-carrier-comm support
Set the response timeout period of the SMS gateway.
Ruijie#configure terminal
Ruijie(config)#smm-role gateway
Ruijie(config-sms-gateway)#wait-resp-timeout 800
```

Verification

Check the current configurations as follows:

```
Ruijie#show running-config
……
webmaster level 0 username admin password 7 14134e00281c
webmaster level 2 username guest password 7 122010175919
!
!
!
```

```
!
!
smm-role gateway
 diff-carrier-comm support
 wait-resp-timeout 800
!
!
diffserv domain default
……
```

Configuring Network Communication Detection Tools

Ping Connectivity Test

To test the connectivity of a network, many network devices support the **Echo** protocol. The protocol sends a special packet to a specified network address and waits for a response. This allows you to evaluate the connectivity, delay and reliability of a network. The ping tool provided by RGOS can effectively help users diagnose and locate the connectivity problems in a network.

The **Ping** command runs in ordinary user mode and privileged user mode. In ordinary user mode, only basic ping functions are available. However, in privileged user mode, extended ping functions are available.

Command	Function
Ruijie# **ping** [vrf *vrf-name*] [ip] [*address* [**length** *length*] [**ntimes** *times*] [data *data*][**source** *source*] [**timeout** *seconds*] [df-bit] [validate]]	Tests the network connectivity.

The basic ping function can be performed in either ordinary user mode or privileged user mode. By default, this command sends five 100-byte packets to the specified IP address. If the system receives a response within the specified time (2 seconds by default), it shows "!" . Otherwise, it shows ".". Finally, the system shows statistics. The following example shows an ordinary **ping**:

```
Ruijie# ping 192.168.5.1
Sending 5, 100-byte ICMP Echoes to 192.168.5.1, timeout is 2 seconds:
< press Ctrl+C to break >
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/10 ms
```

The extended ping function can be performed in privileged user mode only. This function allows you specify the number of packets, packet length, and timeout time. As with the basic ping function, the extended ping also shows statistics. The following example shows an extended **ping**:

```
Ruijie ping 192.168.5.197 length 1500 ntimes 100 data ffff source 192.168.4.190 timeout 3
Sending 100, 1000-byte ICMP Echoes to 192.168.5.197, timeout is 3 seconds:
  < press Ctrl+C to break >
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!
Success rate is 100 percent (100/100), round-trip min/avg/max = 2/2/3 ms
```

Ping IPv6 Connectivity Test

To test the connectivity of a network, many network devices support the **Echo** protocol. The protocol sends a special packet to a specified network address and waits for a response. This allows you to evaluate the connectivity, delay and reliability of a network. The ping tool provided by RGOS can effectively help users diagnose and locate the connectivity problems in a network.

The **Ping ipv6** command runs in ordinary user mode and privileged user mode. In ordinary user mode, only basic ping IPv6 functions are available. However, in privileged user mode, extended ping IPv6 functions are available.

Command	Function
Ruijie# **ping ipv6** [*address* **[length** *length*] [**ntimes** *times*] [**data** *data*] [**source** *source*] [**timeout** *seconds*]]	Tests the network connectivity.

The basic ping function can be performed in either ordinary user mode or privileged user mode. By default, this command sends five 100-byte packets to the specified IP address. If the system receives a response within the specified time (2 seconds by default), it shows "!" . Otherwise, it shows ".". If the response does not match the request, the system shows “C” and outputs statistics. The following example shows an ordinary **ping**:

```
Ruijie# ping ipv6 2000::1
Sending 5, 100-byte ICMP Echoes to 2000::1, timeout is 2 seconds:
< press Ctrl+C to break >
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/10 ms
```

The extended ping function can be performed in privileged user mode only. This function allows you specify the number of packets, packet length, and timeout time. As with the basic ping function, the extended ping also shows statistics. The following example shows an extended **ping**:

```
Ruijie# ping ipv6 2000::1  length 1500 ntimes 100 data ffff source 2000::2 timeout 3
Sending 100, 1000-byte ICMP Echoes to 2000::1, timeout is 3 seconds:
  < press Ctrl+C to break >
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!
Success rate is 100 percent (100/100), round-trip min/avg/max = 2/2/3 ms
```

Traceroute Connectivity Test

The **Traceroute** command is mainly used to check the network connectivity. It show all the gateways that a packet passes through from the source address to the destination address and exactly locates the fault when the network fails.

One of the network transmission rules is that the number in the TTL field in the packet will decrease by 1 every time when a packet passes through a gateway. When the number in the TTL field is 0, the gateway will discard this packet and send an address unreachable error message back to the source. According to this rule, the execution of the **traceroute** command is as follows: At first, the source sends a packet whose TTL is 1 to the destination address. The first gateway sends an ICMP error message back, indicating that this packet cannot be forwarded for TTL timeout. Then, the first gateway re-sends the packet after the TTL domain adds 1. Likewise, the second gateway returns a TTL timeout error and the process lasts until the packet reaches the destination address. By recording every address returning the ICMP TTL timeout message, you can draw the entire path passed by the IP packet from the source address to the destination address.

The **traceroute** command can run in ordinary user mode and privileged user mode. The command format is as follows:

Command	Function

Command	Function
Ruijie# **traceroute** [**vrf** *vrf-name* | **ip**] [*address* [**probe** *probe*] [**ttl** *minimum maximum*] [source *source*] [**timeout** *seconds*]]	Traces the path that a packet passes through.

The following are two examples that apply **traceroute**. In one example, network connectivity is good. In another example, some gateways in a network are not connected.

traceroute example where network connectivity is good:

```
Ruijie# traceroute 61.154.22.36
  < press Ctrl+C to break >
Tracing the route to 61.154.22.36
1     192.168.12.1      0 msec  0 msec  0 msec
2     192.168.9.2       4 msec  4 msec  4 msec
3     192.168.9.1       8 msec  8 msec  4 msec
4     192.168.0.10      4 msec  28 msec  12 msec
5     202.101.143.130   4 msec  16 msec  8 msec
6     202.101.143.154  12 msec  8 msec   24 msec
7     61.154.22.36     12 msec   8 msec   22 msec
```

As you can see, to access the host with an IP address of 61.154.22.36, the network packet passes throuth gateways 1 to 6 from the source address. Meanwhile, you can know the time that the network packet spennds to reach a gateway. This is very useful for network analysis.

19) **traceroute** example where some gateways in a network are not connected:

```
Ruijie# traceroute 202.108.37.42
< press Ctrl+C to break >
Tracing the route to 202.108.37.42
1     192.168.12.1      0 msec      0 msec      0 msec
2     192.168.9.2       0 msec      4 msec      4 msec
3     192.168.110.1     16 msec     12 msec     16 msec
4     *  *  *
5     61.154.8.129          12 msec     28 msec     12 msec
6     61.154.8.17           8 msec      12 msec     16 msec
7     61.154.8.250          12 msec     12 msec     12 msec
8     218.85.157.222        12 msec     12 msec     12 msec
9     218.85.157.130        16 msec     16 msec     16 msec
10    218.85.157.77         16 msec     48 msec     16 msec
11    202.97.40.65          76 msec     24 msec     24 msec
12    202.97.37.65          32 msec     24 msec     24 msec
13    202.97.38.162         52 msec     52 msec     224 msec
14    202.96.12.38          84 msec     52 msec     52 msec
15    202.106.192.226       88 msec     52 msec     52 msec
16    202.106.192.174       52 msec     52 msec     88 msec
17    210.74.176.158        100 msec    52 msec     84 msec
18    202.108.37.42         48 msec     48 msec     52 msec
```

As you can see, to access the host with an IP address of 202.108.37.42, the network packet passes through gateways 1 to 17 from the source address and there is failure in gateway 4.

Traceroute IPv6 Connectivity Test

The **Traceroute ipv6** command is mainly used to check the network connectivity. It shows all the gateways that a packet passes through from the source address to the destination address and exactly locates the fault when the network fails.

For network transmission rules, refer to the previous section.

The **traceroute ipv6** command can run in ordinary user mode and privileged user mode. The command format is as follows:

Command	Function
Ruijie**# traceroute ipv6** [*address* [**probe** *probe*] [**ttl** *minimum maximum*] [**source** source] [**timeout** *seconds*]]	Traces the path that a packet passes through.

The following are two examples that apply **traceroute ipv6**. In one example, network connectivity is good. In another example, some gateways in a network are not connected.

traceroute ipv6 example where network connectivity is good:

```
Ruijie# traceroute ipv6 3004::1
  < press Ctrl+C to break >
Tracing the route to 3004::1
1     3000::1       0 msec  0 msec  0 msec
2     3001::1       4 msec  4 msec 4 msec
3     3002::1       8 msec  8 msec  4 msec
4     3004::1       4 msec  28 msec  12 msec
```

As you can see, to access the host with an IP address of 3004::1, the network packet passes throuth gateways 1 to 4 from the source address. Meanwhile, you can know the time that the network packet spennds to reach a gateway. This is very useful for network analysis.

traceroute ipv6 example where some gateways in a network are not connected:

```
Ruijie# traceroute ipv6 3004::1
  < press Ctrl+C to break >
Tracing the route to 3004::1
1     3000::1       0 msec  0 msec  0 msec
2     3001::1       4 msec  4 msec 4 msec
3     3002::1       8 msec  8 msec  4 msec
4     * * *
5     3004::1       4 msec  28 msec  12 msec
```

As you can see, to access the host with an IP address of 3004::1, the network packet passes through gateways 1 to 5 from the source address and there is failure in gateway 4.Configuring File System

Configuring File System

Understanding File System

Overview

The chapter describes the file system management on RGOS. The RGOS file management offers an unified cross-platform management function, providing the unified file management interface for different kinds of devices, storages and file transmission protocols.

Locally, there are many kinds of storage medias, for instance, Universal Serial BUS (USB) and FLASH, which can be distributed on different boards like primary and secondary management boards. Users can exchange files with remote devices through xModem and TFTP protocols. These functions can be realized using the same command.

Not all types of devices and file systems support all file system commands described here, because they support different types of file operations. The Help command shows the storage media and protocols supported by the file operation commands.

Basic Features

The file system management on a RGOS device offers an unified command interface for operations of various files on the device.

Using URL to Locate A File

The file system of RGOS uses Uniform Resource Locators (URLs) to uniformly locate files and directories in storage media on the local device or remote device. For example, you can copy a file from one place to another using the **copy** *source-url destination-url* command. The destination can be on the local device or a remote server.

URL representation varies by commands. The following sections describe URL usage:

- Locate a file on the server.
- Locate a local file.
- Description of URL prefixes

Locate a file on the server

To locate a file on the server, use the following command:

- **tftp:**[[//location]/directory]/filename

location: IP address or host name. *Path (directory and file name):* position for file transmission. For instance, the file transission directory specified by the TFTP server is C:\download, the file path specified by the device is the one under C:\download. tftp://192.168.0.1/binary/rgos.bin refers to the c:\download\binary\rgos.bin file on the TFTP server with the IP address of 192.168.0.1.


Caution TFTP can only transmit files smaller than 32M. To transmit files larger than 32M, use the FTP protocol. Set a device as the FTP server to upload files to or download files from the server.

Locate a local file

Use the [*prefix*]:[*directory/*]*filename* syntax to locate a local file on FLASH, USB and the FLASH of the management board of the device.

For example:

flash:/config.text: the configuration file on the local FLASH

usb0:/backup/rgos.bin.bak: the file on the first USB

slave:/rgos.bin: files under the root directory of the secondary management board


Note Without prefix, the syntax refers to the file system type on the current path, for instance, if the current path is under the root directory of usb0, the syntax indicates usb0 if the file system does not specify prefix.


Caution When you use a prefix to specify a local file, the path after ":" must be an absolute path.

Description of URL prefixes

URL prefixes are used to specify file systems. Different devices and file operation commands can run different file systems. You can show the file systems supported on the device by the **show file system** command.

The following table shows the URL prefixes:

Prefix	Description
flash:	FLASH storage media, which can be used on all devices. The startup program is generally stored in the FLASH of a device when the device is delivered.
Tftp:	TFTP network server
xmodem:	Receives and sends files through xModem.
slave:	FLASH on the secondary management board of the chassis-based device
Usb0:	The first USB device
Usb1:	The second USB device
sd0:	The first SD card
sw1-m1-disk0:	Management board on the M1 slot of the chassis with switch id 1 in the VSU mode.
sw1-m2-disk0:	Management board on the M2 slot of the chassis with switch id 1 in the VSU mode.
sw2-m1-disk0:	Management board on the M1 slot of the chassis with switch id 2 in the VSU mode.
sw2-m2-disk0:	Management board on the M2 slot of the chassis with switch id 2 in the VSU mode.

Note

Different file system commands and different platforms support different types of file systems. For details, use the help information in the command line, for example:

```
Ruijier#copy ?
WORD          Copy from current file system
  flash:          Copy from flash: file system
  running-config   Copy from current system configuration
  slave:         Copy from slave: file system
  startup-config   Copy from startup configuration
  tftp:           Copy from tftp: file system
  usb0:         Copy from usb0: file system
  usb1:         Copy from usb1: file system
sd0:            Copy from sd0: file system
  xmodem:       Copy from xmodem: file system
```

Note

Given the limitation of xModem, files transmitted through xModem will be slightly larger than the real one.

Note

For chassis-based devices, the **slave:** prefix is supported and the **sw1-m1-disk0:** series prefixes are not supported in non-VSU modes, while in VSU mode, the **sw1-m1-disk0:** series prefixes are supported and the **slave:** prefix is not. In VSU mode, **copy flash:/file1 sw1-m1-disk0:/file2** and **copy sw1-m1-disk0:/file1 flash:/file2** are supported (the copy between the FLASH on the primary and secondary management boards of the VSU system), and **copy sw1-m1-disk0:/file1 sw1-m1-disk0:/file2** is also supported (the copy on the same management board: the primary or secondary management boards of the VSU system), but neither **copy sw1-m1-disk0:/file1 sw2-m2-disk0:/file2** nor **copy usb0:/file1 sw1-m1-disk0:/file2** is supported (only the combination with the **flash:** prefix is supported).

In VSU mode, you can operate file systems on the primary and secondary management boards of the VSU system using commands such as **dir sw1-m1-disk0:/**. The secondary management board on VSU master and slave chassis can only be used to increase bandwidth. Currently, you cannot operate file systems on the secondary management boards of VSU master and slave chassis on the primary management board of the VSU system.

Showing the File System Information

This command shows all the file systems supported on the device and their available spaces.

In privileged EXEC mode, use the following command:

```
Ruijie#show file systems

File Systems:
       Size(b)       Free(b)       Type     Flags     Prefixes
```

```
   ------------   ------------   ---------   -------   ----------
*      33488896       16191488       flash        rw       flash:
              -              -       flash        rw        usb0:
              -              -       flash        rw        usb1:
              -              -       flash        rw         sd0:
              -              -       flash        rw       slave:
              -              -     network        rw        tftp:
              -              -     network        rw      xmodem:
------------------------------------------------------------------
```

In this informatin, "*" means the active file system, **Size** means the space of the file system and **Free** means the available space.


Caution

Free means the idle status of the file system, not the size of files that can be stored. Since the file system has its own management overhead, the size of files that the system finally can store is slightly smaller than the free space.

Managing Local Files

Local files refer to ones stored in various storage media on the device, for instance, FLASH, and USB. System files such as main program, configuration files, logs and web files are stored generallly in FLASH. Some devices come with USB interfaces. Management of files on the flash disk is also local file management. For a chassis-based device with two management boards, you can manage files in the FLASH of the secondary management board with the **slave** prefix of URL.

For local files, you can:

- Copy files
- Move files
- Delete files
- Create directories
- Delete directories
- Show directories
- Show the current working path
- Modify the working path

These operations apply to slave-, USB-, or FLASH-type file systems and can copy files between these file systems.


Caution

File name is case sensitive on the FLASH- and slave- file systems. For example, abc.txt and Abc.txt are

different. The file name must be entered correctly to locate the corresponding file. On USB-type file system, however, file name is not case sensitive, namely abc.txt and Abc.txt are considered the same.


Caution

Number and size of files will affect the startup and operation speed of files considerably. Storing too many or large files in FLASH will slow down startup of the device and update of the system. When the device starts for the first time, using the **dir** command will result in longer waiting time. Generally, we recommend a file system space of less than 128M. When necessary, we recommend storing a large number of files on a flash disk. We recommend clearing some old and useless files manually on a regular basis.

For chassis-based devices, a timeout failure may occur when the file system on the secondary management board (or the secondary management board of the VSU system in the VSU mode) is operated if too many files are stored on the secondary management board, the device is just started or for the first time. In such case, wait for a while according to the prompt and try again later.


Caution

Some files are vital for the system to work properly. Deleting these files will cause malfunction. These system files include:

- RCMS configuration file (/rcms_config.ini)
- Web management package (/web_management_pack.upd)
- Main program files (for multi-boot-supported devices, the main program includes all the files in the boot system configuration)

The system will automatically recognize these files and alarm you before you delete them. If you need to delete system files, the system will print WARN-level logs as below:

Ruijie**# delete** *rgos.bin*

File [rgos.bin] is a system file. System may not work properly without it.

Are you sure you want to delete it? [no] yes

0:1:1:38 Ruijie: FS-4-SYSTEM_FILE_DELETED: System file [rgos.bin] deleted!


Note

The file name with a path should be no more than 4096 bytes. Wildcard is not supported for file name and path.

Transmitting Files through Communication Protocols

- Transmitting files through TFTP:

You can upload and download files to and from the TFTP server.

In CLI privileged EXEC mode, use the following command to download files:

```
Ruijie# copy tftp:[[//location]/directory]/filename destnation-url
```

In CLI privileged EXEC mode, use the following command to upload files:

```
Ruijie# copy source-url  tftp:[[//location]/directory]/filename
```

- Transmitting files through xModem:

In CLI privileged EXEC mode, use the following command to download files:

```
Ruijie# copy xmodem:  destnation-url
```

In CLI privileged EXEC mode, use the following command to upload files:

```
Ruijie# copy source-url xmodem:
```

Working Principles

None

Protocols Specifications

None

Default Configuration

None

Typical Configuration Example

Downloading Files from TFTP Server

The following example shows how to download a.dat from directory c:\download\ of the TFTP server to the local device:

1) Run the TFTP Server on the host and select C:\download where the file to be downloaded is located.

2) Use the **ping** command to test the connection between the device and the TFTP server.

3) Log on the device, enter privileged EXEC mode and run the following command:

```
Ruijie#copy tftp://192.168.201.54/a.dat flash:
Destination filename [a.dat]?
Accessing tftp://192.168.201.54/a.dat
!!!!!!!!!!!!!!!!!!!!!
Transmission finished, file length 343040
```

4) Run the **dir** command to show the files on the device.

```
Ruijie#dir
Directory of flash:/
   Mode Link     Size             MTime Name
-------- ---- --------- ------------------- ------------------
          1   343040 2009-01-01 02:02:59 a.dat
          1  10838016 2009-01-01 00:08:38 rgos.bin
          1      399 2009-01-01 00:01:37 config.text
-----------------------------------------------------------------
3 Files (Total size 11181455 Bytes), 9 Directories.
```

```
Total 33030144 bytes (31MB) in this device, 20492288 bytes (19MB) available.
```

Uploading Files to TFTP Server

The following example shows how to upload a.dat to the c:\download\ of TFTP server:

1) Run the TFTP Server on the host and select directory C:\download where the file to be uploaded is located.

2) Use the **ping** command to test the connection between the device and the TFTP server.

3) Log on the device, enter privileged EXEC mode and run the following command:

```
Ruijie#copy flash:/a.dat tftp://192.168.201.54/a.dat
Accessing flash:a.dat...
!!!!!!!!!!!!!!!!!!!!!!
 Transmission finished, file length 343040
```

4) Check whether a.dat exists under C:\download on TFTP server.

Downloading Files through xModem

The following example shows how to download config.txt from PC to the local device through xModem:

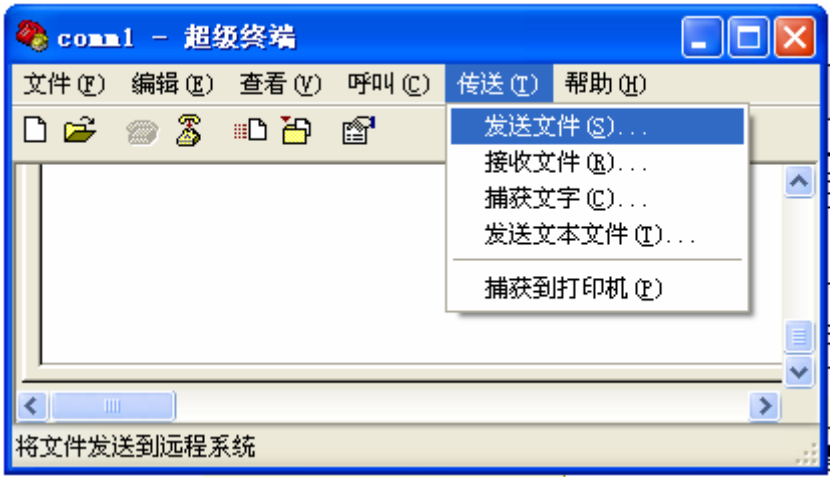
1) Use a serial cable to connect the seiral interface of PC to the serial interface of the device.

2) Run hyperterminal of Windows to connect to the console of the device.

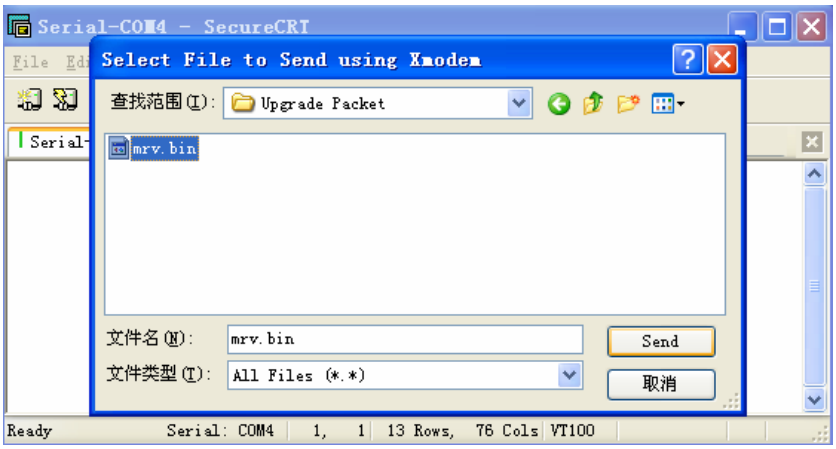
3) In privileged EXEC mode, use the following command to download the file:

```
Ruijie# copy xmodem: flash:/config.text
```

4) In the Windows hyperterminal of local deivce, select Transmit files of Transmit menu, as shown below:



5) In the pop-up dialog box, select the file to download and xModem and click Transmit. The Windows hyperterminal shows the transmission progress and packets.



6) Run the **dir** command to show the files on the device.

```
Directory of flash:/
    Mode Link     Size             MTime Name
-------- ---- --------- ------------------ -----------------
           1    343040 2009-01-01 02:02:59 a.dat
           1  10838016 2009-01-01 00:08:38 rgos.bin
           1       399 2009-01-01 00:01:37 config.text
-----------------------------------------------------------------
3 Files (Total size 11181455 Bytes), 0 Directories.
Total 33030144 bytes (31MB) in this device, 20492288 bytes (19MB) available.
```

Uploading Files through xModem

The following example shows how to upload config.txt from the local device to C:\Documents and Settings\ju of PC through xModem:

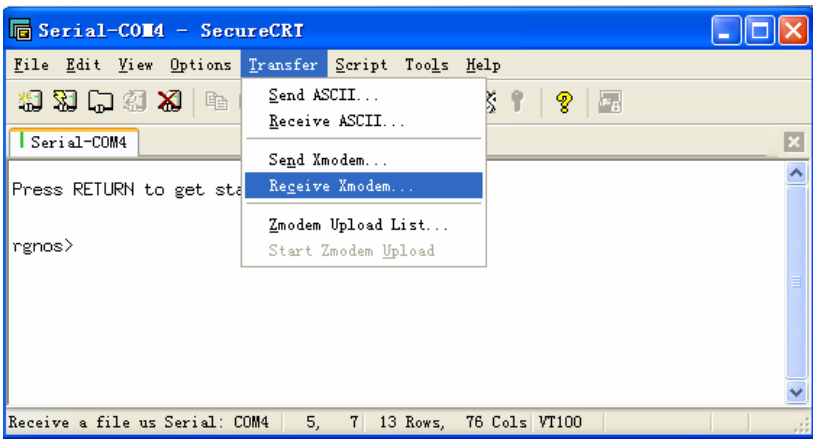
1) Use a serial cable to connect the serial interface of PC and the serial interface of the device.

2) Run the hyperterminal of Windows to connect to the console of the device.

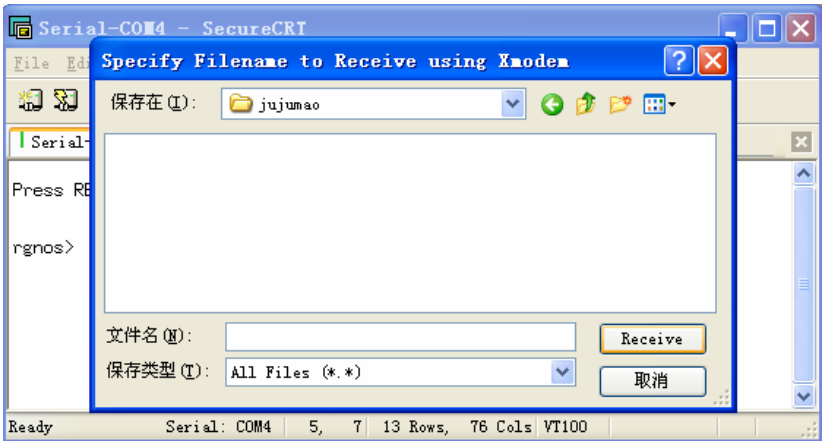
3) In privileged EXEC mode, use the following command to upload file:

```
Ruijie# copy flash:/config.text xmodem
```

4) In the Windows hyperterminal of local deivce, select Receive files of Transmit menu, as shown below:



5) In the pop-up dialog box, select the directory to save the uploaded file and xModem. Click Receive. The Windows hyperterminal prompts to set the name used to store the file. Click OK.



6) Check whether config.text exists under C:\Documents and Settings\ju on PC.

Moving Files from FLASH to USB Device

The following example shows how to move config.txt from FLASH to flash disk on USB0 and save it in the **backup** directory of flash disk:

```
Directory of flash:/
   Mode Link     Size             MTime      Name
-------- ---- --------- ------------------- ------------------
          1    343040 2009-01-01 02:02:59    a.dat
          1  10838016 2009-01-01 00:08:38    rgos.bin
          1       399  2009-01-01 00:01:37    config.text
----------------------------------------------------------------
3 Files (Total size 11181455 Bytes), 0 Directories.
Total 33030144 bytes (31MB) in this device, 20492288 bytes (19MB) available.
```

Enter the root directory of flash disk:

```
Ruijie#cd usb0:/
```

Confirm the current path:

```
Ruijie#pwd usb0:/
```

Create **backup** directory on flash disk:

```
Ruijie#mkdir backup
```

Copy the file to the flash disk:

```
Ruijie#copy flash:/config.text config.text
```

Check the result.

```
Ruijie#dir backup
Directory of usb0:/backup
```

```
   Mode Link     Size             MTime     Name
-------- ---- --------- ------------------ ------------------
          1      399    2009-01-01 00:01:37  config.text
------------------------------------------------------------
Total 33030144 bytes (31MB) in this device, 20488192 bytes (19MB) available.
```

Moving Files from FLASH to SD Card

The following example shows how to move config.txt from FLASH to SD card and save it in the **backup** directory of SD card:

```
Directory of flash:/
   Mode Link     Size             MTime     Name
-------- ---- --------- ------------------ ------------------
          1    343040 2009-01-01 02:02:59    a.dat
          1  10838016 2009-01-01 00:08:38    rgos.bin
          1      399  2009-01-01 00:01:37     config.text
------------------------------------------------------------
3 Files (Total size 11181455 Bytes), 0 Directories.
Total 33030144 bytes (31MB) in this device, 20492288 bytes (19MB) available.
```

Enter the root directory of SD card:

```
Ruijie#cd sd0:/
```

Confirm the current path:

```
Ruijie#pwd sd0:/
```

Create **backup** directory on the SD card:

```
Ruijie#mkdir backup
```

Make sure that the directory is created:

```
Ruijie#dir
Directory of sd0:/
   Mode Link     Size             MTime     Name
-------- ---- --------- ------------------ ------------------
   <DIR>   1    343040 2009-01-01 02:02:59    backup
------------------------------------------------------------
3 Files (Total size 11181455 Bytes), 0 Directories.
Total 33030144 bytes (31MB) in this device, 20492288 bytes (19MB) available.
```

Copy the file to the SD card:

```
Ruijie# copy flash:/config.text backup/config.text
```

Check the result:

```
Ruijie#dir backup
Directory of sd0:/backup
```

```
   Mode Link     Size             MTime     Name
-------- ---- --------- ------------------ ------------------
          1      399   2009-01-01 00:01:37  config.text
-----------------------------------------------------------
Total 33030144 bytes (31MB) in this device, 20488192 bytes (19MB) available.
```

Copying Files between USB and SD Card

The following example shows how to copy rgos_10_4.bin from flash disk to SD card:

Check the available space on the SD card:

```
Ruijie#dir sd0:/
Directory of sd0:/
   Mode Link     Size             MTime Name
-------- ---- --------- ------------------ ------------------
  <DIR>    2        0 2035-02-11 23:24:34 backup/
          1   7650112 2035-02-11 23:42:25 rgos.bin
-----------------------------------------------------------
1 Files (Total size 7650112 Bytes), 1 Directories.
Total 528482304 bytes (504MB) in this device, 475058176 bytes (453MB) available.
```

Copy the file from flash disk to SD card:

```
Ruijie#copy usb0:/rgos_10_4.bin sd0:/rgos_10_4.bin
[OK 7,650,112 bytes]
```

Check the result:

```
Ruijie#dir sd0:/
Directory of sd0:/
   Mode Link     Size             MTime Name
-------- ---- --------- ------------------ ------------------
  <DIR>    2        0 2035-02-11 23:24:34 backup/
          1   7650112 2035-02-11 23:42:25 rgos.bin
          1   7650112 2035-02-11 23:47:36 rgos_10_4.bin
-----------------------------------------------------------
2 Files (Total size 15300224 Bytes), 1 Directories.
Total 528482304 bytes (504MB) in this device, 459571200 bytes (438MB) available.
```

Copy the file from SD card to flash disk:

```
Ruijie#copy sd0:/rgos_10_4.bin usb0:/new_rgos.bin
[OK 7,650,112 bytes]
```

Check the result:

```
Ruijie#dir usb0:/
Directory of usb0:/
   Mode Link     Size             MTime Name
```

```
-------- ---- --------- ------------------- ------------------
          1   7650112 2035-02-11 23:49:21 new_rgos.bin
          1   7650112 2035-02-11 23:45:42 rgos_10_4.bin
-----------------------------------------------------------
2 Files (Total size 15300224 Bytes), 0 Directories.
Total 528482304 bytes (504MB) in this device, 451784704 bytes (430MB) available.
```

Copying Files from Primary Management Board to Secondary Management Board

The following example shows how to copy rgos_10_4.bin from primary management board to secondary management board:

Check the FLASH space on secondary management board:

```
Ruijie#dir slave:/
Directory of slave:/
   Mode Link     Size             MTime     Name
-------- ---- --------- ------------------- ------------------
           1   11014633  2006-01-01 08:00:46  rgos.bin
           1    399      2006-01-01 08:01:37  config.text
-----------------------------------------------------------
2 Files (Total size 11181455 Bytes), 0 Directories.
Total 33030144 bytes (31MB) in this device, 20488192 bytes (19MB) available.
```

Copy rgos_10_4.bin from primary management board to the secondary one:

```
Ruijie#copy rgos_10.4.bin slave:/
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!! [ok 10,234,345 bytes]
```

Check the result:

```
Ruijie#dir slave:/
Directory of slave:/
   Mode Link     Size               MTime     Name
-------- ---- --------- ------------------- ------------------
          1     11014633   2006-01-01 08:00:46  rgos.bin
          1     11025788   2008-01-01 08:00:46  rgos_10.4.bin
          1     399        2006-01-01 08:01:37  config.text
-----------------------------------------------------------
3 Files (Total size 11181455 Bytes), 0 Directories.
Total 33030144 bytes (31MB) in this device, 9563693 bytes (9MB) available
```

Deleting Directories

The following example shows how to delete a non-empty aaa directory:

Show the current directory status:

```
Ruijie#dir
Directory of flash:/
   Mode Link     Size                MTime     Name
-------- ---- --------- ------------------- ------------------
          1      11014633 2006-01-01 08:00:46  rgos.bin
 <dir>    1      0        2006-01-01 08:00:00 aaa/
          1      399      2006-01-01 08:01:37 config.text
----------------------------------------------------------------
2Files (Total size 11015032 Bytes), 1 Directories
Total 33030144 bytes (31MB) in this device, 9563693 bytes (9MB) available
```

Check whether there is any file under the directory:

```
Ruijie#dir aaa
Directory of flash:/aaa
   Mode Link     Size                MTime     Name
-------- ---- --------- ------------------- ------------------
         1         149  2006-01-01 08:01:37 backup.txt
----------------------------------------------------------------
1Files (Total size 149 Bytes), 0 Directories
Total 33030144 bytes (31MB) in this device, 9563693 bytes (9MB) available
```

Delete a non-empty directory:

```
Ruijie# delete recursive aaa
```

Delete an empty directory:

```
Ruijie# rmdir aaa
```

Note

The devices locating files through URL such as S86 and S12000 distributed devices support URL parameters (to locate files) and does not support deleting the non-null directory recursively (recursive parameters are not supported)

Check the result:

```
Ruijie#dir
Directory of flash:/
   Mode Link     Size                MTime     Name
-------- ---- --------- ------------------- ------------------
         1     11014633 2006-01-01 08:00:46  rgos.bin
         1     399      2006-01-01 08:01:37 config.text
----------------------------------------------------------------
2Files (Total size 11015032 Bytes), 0 Directories
```

```
Total 33030144 bytes (31MB) in this device, 9563693 bytes (9MB) available
```

Configuring Syslog

Overview

During the operation of a device, there are various state changes, such as the link status up/down, and various events occurring, such as receiving abnormal messages and handling exceptions. Our product provides a mechanism to generate messages of fixed format (log message) in case of status change or event occurring. These messages can be displayed in related windows (console, VTY, etc.) or recorded in related media (memory buffer, FLASH), or sent to a group of log servers in the network for the administrators to analyze and locate problems. Meanwhile, in order to make it easy for administrators to read and manage log messages, these log messages can be labeled time stamps and serial numbers, and is graded according to the priority of log information.

Log Message Format

The format of the our log message is as follows:

```
<priority> seq no: timestamp sysname: %severity
%ModuleName-severity-MNEMONIC: description
```

Their meanings are as follows:

Command	Meaning
<priority>	Priority, priority value = Device value x 8 + Severity
seq no	System serial number, a six-digit integer. You can disable this information output by commands.
timestamp	Timestamp, local time by default. In the format of Mmm dd hh:mm:ss, Mmm indicates the English abbreviations of the 12 months. From January to December, they are abbreviated as: Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, and Dec.
sysname	System name, you can disable this information output by commands.
ModuleName	Abbreviation of functional module name.
severity	Log severity level.
MNEMONIC	Information abbreviation
description	Information description

For example:

```
<189> 226:Mar  5 02:09:10 Ruijie %SYS-5-CONFIG_I: Configured from console by console
```

Caution The priority field is not attached to the log messages that are printed in the user window. It only appears in the log messages that are sent to the syslog server.

Log Configuration

Log Switch

The log switch is turned on by default. If it is turned off, the device will not print log information in the user window, or send log information to the syslog server, or record the log information in the related media (memory buffer, flash).

To turn on or off the log switch, run the following command in global configuration mode:

Command	Function
Ruijie(config)# **logging on**	Turns on the log switch
Ruijie(config)# **no on**	Turns off the log switch


Caution Do not turn off the log switch in general case. If it prints too much information, you can reduce it by setting different displaying levels for device log information.

Configuring the Device for Displaying the Log Information

When the log switch is turned on, the log information will be displayed on the console and also sent to different displaying devices. To configure different displaying devices to receive logs, run the following commands in global configuration mode or privileged user level:

Command	Function
Ruijie(config)# **buffered** [*buffer-size* | *level*]	Records log in memory buffer
Ruijie**# termninal monitor**	Allows log to be displayed on VTY window
Ruijie(config)# **logging server** *host*	Sends log information to the syslog sever on the network
Ruijie(config)# **logging file flash:***filename* [*max-file-size*] [*level*]	Records log on extended FLASH. This command creates a file based on the specified file name on the FLASH to store logs. The file size increases with the log size, but its upper limit is subject to the configured max-file-size.

Buffered will record log information in the memory buffer. The memory buffer for log is used in recycled manner. That is, when it is full, the oldest information will be overwritten. To show the log information in the memory buffer, run the **show logging** command at privileged user level. To clear the log information in the memory buffer, run the **clear logging** command at privileged user level.

Terminal monitor allows log information to be displayed on the current VTY (such as the telnet window).

Logging server host specifies the address of the syslog server that will receive the log information. Our product allows the configuration of at most 5 syslog servers. The log information will be sent to all the syslog servers at the same time. The configuration of the **logging host** command has the same results.


Caution To send the log information to the syslog server, it is required to turn on the timestamp switch or serial

number switch of the log information. Otherwise, log information will not be sent to the syslog server.

Logging file flash: Records log information in FLASH. The filename for log shall not have any extension to indicate the file type. The extension of the log file is fixed as txt. Any configuration of extension for the filename will be refused.

More flash: The **filename** command shows the contents of the log file in the flash.

Caution Some devices support extended FLASH. If the device has extended FLASH, the log information will be recorded there. If the device has no extended FLASH, the log information will be recorded in the serial FLASH.

Enabling the Log Timestamp Switch of Log Information

To add or delete timestamp in log information, run the following command in global configuration mode:

Command	Function
Ruijie(config)# **service timestamps** [*message-type* [**uptime** | **datetime** [**msec**] [**year**]]]	Enables the timestamp in the log information
Ruijie(config)# **no service timestamps** [*message-type*]	Disables the timestamp in the log information

The timestamp are available in two formats: device uptime and device datetime. Select the type of timestamp as required.

Message type: log or debug. The "log" type means the log information with severity levels 0-6. The "debug" type means that with severity level 7.

Caution If the current device has no RTC, the configured time is invalid, and the device automatically uses the startup time as the timestamp for the log information. If the device has an RTC, the device time is used as the timestamp for the log information by default.

Enabling System Name Switches in Log System

By default, the system name is not included in the log information. To add or remove the system name in the log information, run the following commands in global configuration mode.

Command	Function
Ruijie(config)# **no service sysname**	Removes the system name in the log message.
Ruijie(config)# **service sysname**	Adds a system name to the log message.

Enabling Log Statistics

By default, the log statistics function is disabled. To enable or disable the log statistics function, run the following commands in global configuration mode.

Command	Function

Ruijie(config)# **no logging count**	Disables the log statistics function and delete the statistics about the log information.
Ruijie(config)# **logging count**	Enables the log statistics function.

Ruijie# show logging count

```
Module Name    Message Name     Sev Occur   Last Time
=============================================================
LINEPROTO     UPDOWN            5   2      Aug 20 01:41:19
-------------------------------------------------------------
LINEPROTO TOTAL                       2
LINK          CHANGED           5   1      Aug 20 01:41:19
-------------------------------------------------------------
LINK TOTAL                            1
SYS           CONFIG_I          5   1      Aug 20 01:40:55
-------------------------------------------------------------
SYS TOTAL                             1
```

Ruijie **#config**

```
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie (config)#no logging count
Ruijie (config)#end
Ruijie #show logging count
Module Name    Message Name           Sev Occur   Last Time
=============================================================
```

Enabling the Serial Number Switch of Log Information

By default, the log information has no serial number. To add or delete the serial number in log information, run the following command in global configuration mode:

Command	Function
Ruijie(config)# **no service sequence-numbers**	Deletes the serial number in the log messages.
Ruijie(config)# **service sequence-numbers**	Adds a serial number to the log messages.

Note

The log serial number is a long integer, which increases in ascending order when a log is added. However, since only five digits of the serial number is displayed, when it increases from 1 to 100000 or reaches 2^32, a turnover occurs, that is the serial number is displayed from 00000 again.

Configuring Synchronization Between User Input and Log Output

By default, user input is asynchronous with log output. User input is interrupted if the log is output when the user is keying in characters. As following shows, the status of FastEthernet 0/12 changes and a log is printed after the user entered **vlan**, so that the user forgot which character he was entering previously, affecting the coherence of command entering.

```
Ruijie(config)#vlan Aug 20 16:46:49 %LINK-5-CHANGED: Interface FastEthernet 0/12, changed
state to down
Aug 20 16:46:49 %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet 0/12, changed
state to DOWN
% Incomplete command.
```

While after the synchronization function is configured, the contents that the user entered previously will be displayed even though a log is printed when the user is entering a command, ensuring integrity and coherence. As following shows, the status of FastEthernet 0/1 changes and a log is printed after the user entered **vlan**, but the log module automatically prints **vlan** after the log is printed for the user to continue.

```
Ruijie(config)#vlan
*Aug 20 10:05:19: %LINK-5-CHANGED: Interface GigabitEthernet 0/1, changed state to up
*Aug 20 10:05:19: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet 0/1,
changed state to up
Ruijie(config)#vlan
To configure synchronization between user input and log output, run the following commands
in line configuration mode:
```

Command	Function
Ruijie(config-line)# **logging synchronous**	Sets synchronization between user input and log output.
Ruijie(config)# **no logging synchronous**	Removes synchronization between user input and log output.

Configuring Log Rate Limit

By default, log rate is not limited. However, when there are massive logs, no log rate limit will cause burden on the system. To configure log rate limit, run the following commands in global configuration mode:

Command	Function
Ruijie(config)# **logging rate-limit** *number*	Sets log rate limit on the log information.
Ruijie(config)# **no logging rate-limit**	Removes the setting of log rate limit.

Configuring the Log Information Displaying Level

Users can set the severity level of log information that is allowed to be displayed to view the log information of a specific severity level.

To configure the log information displaying level, run the following commands in global configuration mode:

Command	Function
Ruijie(config)# **logging console** [*level*]	Sets the level of log information that is allowed to be displayed on the console.
Ruijie(config)# **logging monitor** [*level*]	Sets the level of log information that is allowed to be displayed on the VTY window (such as telnet window).
Ruijie(config)# **logging buffered** [*buffer-size*] [*level*]	Sets the level of log information that is allowed to be recorded in memory buffer.

Ruijie(config)# **logging file flash:***filename* [*max-file-size*] [*level*]	Sets the level of log information that is allowed to be recorded in extended flash.
Ruijie(config)# **logging trap** [*level*]	Sets the level of log information that is allowed to be sent to syslog server.

The log information of Ruijie Networks products is classified into the following 8 levels:

Level Keyword	Level	Description
Emergencies	0	Emergency case, system cannot run normally
Alerts	1	Problems that need immediate remedy
Critical	2	Critical conditions
Errors	3	Error message
Warnings	4	Alarm information
Notifications	5	Information that is normal but needs attention
Informational	6	Descriptive information
Debugging	7	Debugging messages

Lower value indicates higher level. That is, level 0 indicates the information of the highest level.

When the level of log information that can be displayed is set for the specified device, the log information that is at or below the set level will be displayed. For example, after the **logging console *6*** command is executed, all log information at or below level 6 will be displayed on the console.

The log information that is allowed to be displayed on the console is at level 7 by default.

The log information that is allowed to be displayed on the VTY window is at level 7 by default.

The log information that is allowed to be sent to the syslog server is at level 6 by default.

The log information that is allowed to be recorded in the memory buffer is at level 7 by default.

The log information that is allowed to be recorded in the extended flash is at level 6 by default.

You can use the **show logging** command in privileged mode to show the level of log information allowed to be displayed on different devices.

Configuring the Device Value of the Log Information

The device value is one of the parts that form the priority field in the messages sent to the syslog server, indicating the type of device that generates the information.

To configure the log information device value, run the following command in global configuration mode:

Command	Function
Ruijie(config)# **logging facility** *facility-type*	Configures the device value of the log information.
Ruijie(config)# **no logging facility** *facility-type*	Restores the device value of the log information to the default value.

The meanings of various device values are described as below:

```
Numerical Code      Facility
         0           kernel messages
```

```
1           user-level messages
2           mail system
3           system daemons
4           security/authorization messages
5           messages generated internally by syslogd
6           line printer subsystem
7           network news subsystem
8           UUCP subsystem
9           clock daemon
10          security/authorization messages
11          FTP daemon
12          NTP subsystem
13          log audit
14          log alert
15          clock daemon
16          local use 0  (local0)
17          local use 1  (local1)
18          local use 2  (local2)
19          local use 3  (local3)
20          local use 4  (local4)
21          local use 5  (local5)
22          local use 6  (local6)
23          local use 7  (local7)
```

The default device value of Ruijie products is 23.

Configuring the Source Address of Log Messages

By default, the source address of the log messages sent to the syslog server is the address of the port that sends the messages. You can fix the source address for all log messages through commands.

It is possible to directly set the source IP address of the log messages or the source port of the log messages.

To configure the source address of the log messages, run the following command in global configuration mode:

Command	Function
Ruijie(config)# **logging source interface** *interface-type interface-number*	Configures the source port of log information.
Ruijie(config)# **logging source** {**ip** *ip-address* | **ipv6** *ipv6-address*}	Configures the source IP address of log messages.

Note

If the configured source IP address of the log message is not configured on any interface of the device, the source IP address of the log message is this inexistent address. However, it is not recommended to perform such configuration in actual use.

Setting and Sending User Log

Command	Function
Ruijie(config)# **logging userinfo**	Sets user login/logoff log.
Ruijie(config)# **logging userinfo command-log**	Send a log when a configuration command is executed.

Log Monitoring

To monitor log information, run the following commands in privileged user mode:

Command	Function
Ruijie# **show logging**	Views the log messages in memory buffer as well as the log statistics.
Ruijie# **show logging count**	Views the statistics of logs in every module.
Ruijie# **clear logging**	Clears the log messages in the memory buffer.
Ruijie# **more flash:***filename*	Views the log files in the extended flash.

Caution The format of the timestamp in the output result of the **show logging count** command is the format in the latest log output.

Examples of Log Configurations

Here is a typical example to enable the logging function. Connect the device to the log server, whose IP address is 192.168.200.2. Perform the following configuration to make all logs carry timestamps and allow logs of all levels to be sent to the log server:

```
Ruijie(config)# service timestamps debug datetime   //Enable debug information timestamp, in date format
Ruijie(config)# service timestamps log datetime    //Enable log information timestamp, in date format
Ruijie(config)# logging 192.168.200.2      //Specify the syslog server address
Ruijie(config)# logging trap debugging     //The log information of all levels will be sent to the syslog server
Ruijie(config)# end
```

Configuring Device Fault Management

Overview of Device Fault Management Module

Purpose

The device fault management module manages device faults, which generates alarms to alert router faults, protects devices against exceptions and adds some methods of preventing faults, such as displaying working status of various basic hardware devices, to enhance safe router running level.

Requirements and Notes

Hardware Requirements

Because fault alarms are closely related to hardware, many functions of the device fault management module are directly related to hardware. For example, hardware must support the detection of power voltage.


Caution

The device fault management module version 1.0 (DFM1.0) cannot display power voltage, fan performance and operating inlet temperature, and fails to allow MIB to search for this information.

System Support

Not all devices support alarm generation by interruption in the case of a device fault. As a result, scheduled detection is required. Here, the detection results obtained last time are used as displayed information and detection interval is set to five seconds that cannot be modified by users.

Running Mode

At present, all configuration of the device fault management module is carried out in privilege mode. As a result, to run the commands mentioned in this document, enter privilege mode first.

Checking Status Information

The command tree of status displaying of the total fault management:

Command	Function
show environment [alarms | all | fans | hardware | powers]	Displays environment of the managed faulty device.

Displaying Exception Alarm

Command	Function
show environment alarms	Displays information about alarm processing. For example, fans should be checked in the case of excessively high temperature

The following information is displayed for this command:

```
Ruijie# show environment alarms
Warning!!!
Power supplies have been changed since the router start, please check them
Warning!!!
Fans have been changed since the router start, please check them.
Warning!!!
Temperature is high, please check powers and fans.
Ruijie#
```

Displaying Operating Temperature

Command	Function
show temperature	Displays temperature of the current operating environment, namely temperature inside the chassis. Currently, inlet temperature cannot be detected.

The following information is displayed for this command:

```
Ruijie#show temperature
Device    Temperature(C)
------    -----------
 CM          43
```

Displaying Fan Information

Command	Function
show environment fans	Displays running situations and status information on one or multiple fans, including whether fans run normally and the number of fans. Currently, performance detection is not supported.

The following information is displayed for this command:

```
Ruijie# show environment fans
Environmental status update at 11:31:37 Jan 9, 1944.
Data is 13 second old, refresh in 20 second(s).
Fans working status:
Fan 0 is on.
Fan 1 is on.
Fan 2 is on.
Fan 3 is on.
Fan 4 is on.
Fan 5 is on.
Fan 6 is on.
Fan 7 is on.
```

Displaying Power Supply Information

Command	Function
show environment powers	Displays the current status information on the power supply, including rated operating voltage, the number of power supplies, and whether each power supply works normally. At present, the current operating voltage and threshold cannot be detected.

The following information is displayed for this command:

```
Ruijie# show environment powers
Environmental status update at 11:28:50 Jan 9, 1944.
Data is 10 second old, refresh in 20 second(s).
Power Supplies:
Power supply 1 is present. Unit is on.
Power supply 2 is present. Unit is on.
Power supply 3 is present. Unit is on.
```

Displaying Information Related to Hardware

Command	Function
show environment hardware	Displays the current status information on the hardware, including CPU name and speed.

The following information is displayed for this command:

```
Ruijie#show environment hardware
  Environmental status update at 16:25:26 2011-01-20.
  Data is 13 second old, refresh in 20 second(s).
  Hardware:
       CPU name: BCM1250.
       CPU Speed : 800M
```

Displaying All Information on Fault Management

Command	Function
show environment all	Displays device status information in the current device fault management.

The following information is displayed for this command:

```
Ruijie#show environment all
  Environmental status update at 16:26:46 2011-01-20.
  Data is 18 second old, refresh in 20 second(s).
  Power Supplies:
       Power supply 1 is not present. Unit is off.
       Power supply 2 is present. Unit is on.
       Power supply 3 is not present. Unit is off.
  Fans working status:
       Fan 1 is on.
```

```
      Fan 2 is on.
      Fan 3 is on.
      Fan 4 is on.
      Fan 5 is on.
      Fan 6 is on.
Hardware:
      CPU name: BCM1250.
      CPU Speed : 800M
```

Configuring Management Ethernet Interface

☑ This chapter describes how to configure and use the Ethernet interfaces on the S8600, S12000, S9600, and NPE80 series.

Introduction to Management Ethernet Interface

Overview

☑ The Ethernet interfaces on the panels of the Ruijie S8600, S12000, S9600 series, and NPE80 are separated from the forwarding panels inside the devices, and are not involved in the forwarding panel and control panel functions. Data communication for the Ethernet interfaces is separated from that on the devices, which is called out-of-band communication. The interfaces can manage the devices, which is similar to the management of the console interface. The Ethernet interfaces are only used to mange devices but do not forward packets. They are usually called MGMT interfaces.

For the Ethernet interface on the panel of Ruijie S86 series, S96 series, NPE40, NPE60 and EG series products, due to the limitations in internal structure, the interface is actually separated from the internal data forwarding module of the device, and will not participate in data forwarding and controlling. The data communication on such interface is independent from the service communication running on the device, and is therefore called "out-of-band communication". We can use this interface to manage the device in the same way as we do with Console port. The management Ethernet interface is only used to device management. It cannot support data forwarding and is always called MGMT (Management) interface.

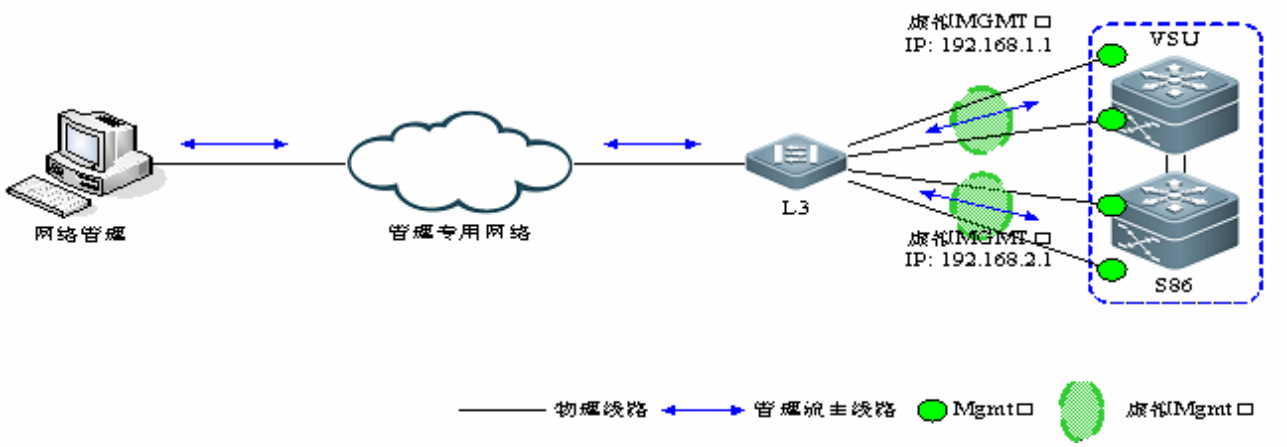
Due to the difference in hardware composition, the MGMT interface could be 100M Ethernet interface or Gigabit Ethernet interface.

MGMT Interface Virtualization

☑ The management board on the S8600 and S12000 series provides one MGMT physical interface, so the each system of the S8600 and S12000 series provides up to two MGMT physical interfaces. The VSU system of the S8600 and S12000 series provides up to 2*N MGMT physical interfaces. By using the virtual MGMT interface technology, the S8600 and S12000 series support out-of-band management through any MGMT physical interface.

A virtual MGMT interface is composed of two physical MGMT interfaces of a chassis, and preferentially uses the MGMT physical interface of the primary management board. If the primary management board fails, it uses the MGMT physical interface of the standby management board. As shown in the Figure 1-1, the VSU system provides two virtual MGMT interfaces. You can access the device through the IP address of the virtual MGMT interface.

Figure 1 Virtual MGMT interface



MGMT Interface Troubleshooting

The troubleshooting checks whether an MGMT interface is usable, and switches the service to the standby MGMT interface when the primary MGMT interface fails. The faults of the MGMT interface are divided into the following categories:

- Hardware failure
- Network cable connection failure
- Carrier plate failure
- IP link failure

Follow these methods to troubleshoot the MGMT interface:

- GRTD detection

GRTD is a unified hardware detection platform to diagnosis whether the device hardware works normally, so MGMT interface failure can be easily detected.

- Link state detection

Link state detection checks the connection status of a network interface at the link layer. The connection status is link up or link down, so the network cable connection of the MGMT interface is easily detected.

- Carrier state detection

This function sets the MGMT interface in the invalid state when you perform hot swapping and primary-standby switchover on the primary management board of the MGMT interface.

- RNS detection

This function checks whether the peer device sends response packets to monitor the peer-to-peer connection. Because only the IP address of the primary MGMT interface takes effect, this functions is only applicable to the detection of primary MGMT interfaces.

MGMT Interface Applications

An MGMT interface supports the following applications:

- You can use the ping and tracert commands to test whether the IP address of the MGMT interface is reachable, and

use the command on the interface to test whether a remote IP address is reachable. Therefore, MGMT interfaces support ICMP.

- You can log in to the MGMT interface through Telnet, SSH, SNMP, or web to manage the device. The MGMT interface supports AAA, including RADIUS and TACACS+, for login authentication and supports TACACS+ authorization for running commands.
- The interface can also send logs and alarms of the device to the log server of the network administrator.
- The MGMT interface supports Telnet clients and TFTP clients.
- The MGMT interface can send and receive NTP and SNTP packets to synchronize network time.
- The MGMT interface supports static ARP binding.

Configuring MGMT Interface

From the dimension of network communication, the MGMT interface has no essential difference from other LAN interface. Since it doesn't support data forwarding, it provides less configurable functions than other LAN ports do. Some commands shall be specially noted that they are used for out-of-band communication.

The MGMT interface could be 100M Ethernet interface or Gigabit Ethernet interface. For 100M Ethernet interfaces, related configuration commands are listed in the following table:

Command	Function
Ruijie# **configure terminal**	Enter configuration mode
Ruijie(config)**#interface mgmt** *0*	Enter interface configuration mode
Ruijie(config-if)**#ip address** *ip-address subnet-mask*	Configure the IP address and subnet mask of interface.
Ruijie(config-if)**#gateway** *A.B.C.D*	Configure the gateway of management network
Ruijie(config-if)# **mtu** *mtu-value*	Configure the maximum transmission unit (MTU) of interface
Ruijie(config-if)# **speed** {**10** | **100** | **1000** | **auto**}	Configure the speed of interface (default: auto)
Ruijie(config-if)# **duplex** { **full** | **half** | **auto** }	Configure the duplex of interface (default: auto)
Ruijie(config-if)# **flowcontrol**	Flow control of interface (default: enable)
Ruijie(config-if)# **description** *text*	Add descriptions for the interface
Ruijie(config-if)**#shutdown**	Shut down MGMT interface

☑ When the MGMT interface of the S7600 series is link up, but you configure the **shutdown** command on the interface, the data link of the interface will be down, but the LED is steady on until you configure the **no shutdown** command on the interface.

☑ When the MGMT interface of the S86CMII-Lite management board works at the half-duplex mode, the LED is off.

☑ When the MGMT interface of the S86CMII management board works at the 10 Mbps mode, the LED is off.

Configuration Example

Configure an IPv4 address and gateway address for the MGMT interface.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface mgmt 0
```

```
Ruijie(config-if)#ip address 192.168.1.1 255.255.255.0
Ruijie(config-if)# gateway 192.168.200.1
```

☑ This feature is supported on the S7600, S8600, S12000, S9600, and NPE series.

Network Management Tools

To facilitate management and the debugging of network communication, the system has provided the following tools for network management, including:

- Ping
- Traceroute
- Track/RNS
- Telnet
- SNMP
- Radius
- TACACS+
- Syslog Server
- NTP/SNTP

ping

Use the **ping** command in the privilege mode to check the connectivity between the device and a node on the management network.

Command	Function
Ruijie> **enable**	Enter the privilege configuration mode.
Ruijie# **ping oob** *ipv4-address*	Use the **ICMP echo request** command to check the reachability of a host on the management network.

Configuration Example

Ping the host (192.168.1.2) from the MGMT interface.

```
Ruijie# ping oob 192.168.1.2
Sending 5, 100-byte ICMP Echoes to 192.168.1.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent, round-trip min/avg/max = 4/4/4 ms
```

traceroute

Use the **traceroute** command in the privilege mode to trace the routes to a node on the management network.

Command	Function
Ruijie> **enable**	Enter the privilege configuration mode.
Ruijie# **traceroute oob** *ipv4-address*	Check the routes to a host on the management network.

Configuration Example

Trace the routes to the host on the management network.

```
Ruijie# traceroute oob 192.168.9.1
Tracing route to 192.168.9.1 over a maximum of 30 hops
1   <10 ms   <10 ms   <10 ms  192.167.201.1
2     1 ms     1 ms     1 ms  192.168.201.1
3     1 ms   <10 ms   <10 ms  10.10.24.1
4   <10 ms   <10 ms   <10 ms  192.168.9.1
```

Track/RNS

Use the **track** and **RND** commands to test the connectivity to the IP address of the MGMT interface.

Command	Function
Ruijie(config)# **ip rns** *operation-number*	Configure an IP RNS object.
Ruijie(config-ip-rns)#**icmp-echo destination-hostname [source-ipaddr** *ip-address*]	Configure an IP RNS object to send an ICMP packet.
Ruijie(config-ip-rns-icmp-echo)#**oob**	Set the MGMT interface as the outgoing interface of the ICMP packet.
Ruijie(config)#**track** *object-number* **rns** *entry-number*	Trace the status of the IP RNS object and enter the track mode.
Ruijie(config-track)# **delay {u**p *seconds* **[down** *seconds*] | [**up** *seconds*] **down** *seconds*}	(Optional) Specify a period time. The state of the track object changes after the time expires. No delay is specified by default.
Ruijie(config)# **interface mgmt 0**	Enter the interface mode.
Ruijie(config-if)#**virtual-mgmt track** *object-number*	Configure track of the MGMT interface.

Configuration Example

Trace the reachability of the host (192.168.0.1) from the MGMT interface.

```
Ruijie(config)#ip rns 1
Ruijie(config-ip-rns)#icmp-echo 192.168.0.1
Ruijie(config-ip-rns-icmp-echo)#oob
Ruijie(config)#track 1 rns 1
Ruijie(config-track)#delay up 30
Ruijie(config)#interface mgmt 0
Ruijie(config-if)#virtual-mgmt track 1
```

telnet

You can telnet devices on the management network through the MGMT interface.

Command	Function
Ruijie(config)# **telnet oob** *host*	Telnet a host on the management network.

Note

The arguments of the **telnet oob** command have the same definition as those of the **telnet** command. For related configuration, see configuration guide and command reference of the fundamental configuration management.

Configuration Example

Telnet the host (192.168.9.1) on the management network through the MGMT interface.

```
Ruijie#telnet oob 192.168.9.1
User Access Verification
Password:
```

SNMP

You can use the MGMT interface to manage SNMP hosts as other LAN interfaces.

Command	Function
Ruijie(config)# **snmp-server host oob** *host-addr* **traps** [**vrf** *vrfname*] [**version {1|2c |3 [auth	noauth	priv]}**] *community-string* [*udp-port port-num*] [**type**]	Specify an IP address, a host port, VRF options, message type, an authentication name (username under the SNMPv3), and a security level for the SNMP host, on the management network.

Note

The arguments of the **snmp-server host oob** command have the same definition as those of the **snmp-server host** command. For related configuration, see SNMP configuration guide and command reference.

Configuration Example

Configure an SNMP user for the management network.

```
Ruijie(config)#snmp-server host oob 192.168.12.219 public snmp
```

☑ This feature is supported on the S8600 and S12000 series.

RADIUS

You can use the MGMT interface to access the RADIUS services on the management network as other LAN interfaces.

Command	Function
Ruijie(config)# **radius-server host oob** *ip-address* [**auth-port** *port*] [**acct-port** *port*]	Configure the RADIUS server on the management network.

Note

The arguments of the **radius-server host oob** command have the same definition as those of the **radius-server host** command respectively. For related configuration, see RADIUS configuration guide and command reference.

Configuration Example

Specify a RADIUS server in an IPv4 environment.

```
Ruijie(config)# radius-server host oob 192.168.12.1
```

☑ This feature is supported on the S8600 and S12000 series.

Tacacs+

You can use the MGMT interface to access the TACACS+ services on the management network as other LAN interfaces.

Use the **tacacs-server host oob** command to specify an address of the TACACS+ server for the device on the management network.

Command	Function
Ruijie(config)# **tacacs-server host oob** *ip-address* | [**port** *integer*] **[timeout** *integer*] [**key** *string*]	Configure the TACACS+ server on the management network.
Ruijie(config)# **aaa group server tacacs+** *group-name*	Configure a TACACS+ server group to assign TACACS+ servers to different groups.
Ruijie(config-gs-tacacs)# **server** *ip-address*	Configure IP addresses for the servers in the TACACS+ server group.
Ruijie(config-gs-tacacs)# **ip oob**	Enable out-of-band communication for the TACACS+ server group.

Note

The arguments of the **tacacs-server host oob** command and the **ip oob** command have the same definition as those of the **tacacs-server host** command and the **ip vrf forwarding** *vrf-name* command. For related configuration, see TACACS+ configuration guide and command reference.

Configuration Example

Specify a TACACS+ server.

```
Ruijie(config)# tacacs-server host oob 192.168.12.1
```

Specify the name tac1 for the TACACS+ server group and configure a TACACS+ server with the IP address 1.1.1.1.

```
Ruijie(config)# aaa group server tacacs+ tac1
Ruijie(config-gs-tacacs+)# server 1.1.1.1
```

```
Ruijie(config-gs-tacacs+)# ip oob
```

Syslog Server

You can use the MGMT interface to send logs to the syslog server on the management network as other LAN interfaces.

Command	Function
Ruijie(config)# l**ogging serve**r **oob** *host*	Send logs to the syslog server on the management network.

Note The arguments of the **logging server oob** command have the same definition as those of the **logging server** command. For related configuration, see syslog configuration guide and command reference.

Configuration Example

Specify an IP address (202.101.11.1) for the syslog server.

```
Ruijie(config)#logging server oob 202.101.11.1
```

DNS Server

You can configure DNS on the MGMT interface as other LAN interfaces.

Command	Function
Ruijie(config)# **ip name-server oob** *ip-address*	Specify an IP address for the DNS server. You can add a DNS server each time you execute the command. If you cannot obtain a domain name from the first DNS server, the device tries to send DNS requests to other servers until it receives an correct DNS reply.
Ruijie(config)**#no ip name-server oob** *ip-address*	Delete the IP address of the DNS server.

Note The arguments of the **ip name-server oob** command have the same definition as those of the **ip name-server** command. For related configuration, see DNS configuration guide and command reference.

Configuration Example

Specify an IP address (202.101.11.1) for the DNS server.

```
Ruijie(config)#ip name-server oob 202.101.11.1
```

NTP/SNTP

You can synchronize network time through the MGMT interface.

Configure the NTP server for the management network:

Command	Function
ntp server oob *ip-addr* [**version** *version*][**source** *if-name number*]**[key** *keyid*][prefer]	Configure an NTP server for the management network.
no ntp server oob *ip-addr*	Delete the NTP server.
sntp server oob <*ip-addr*>	Configure an SNTP server for the management network.
no sntp server	Delete the SNTP server.

Note The arguments of the **ntp server oob** command and the **sntp server oob** command have the same definition as those of the **ntp server** command and the **sntp server** command respectively. For related configuration, see NTP/SNTP configuration guide and command reference.

Configuration Example

Configure an IPv4 NTP server for the management network.

```
Ruijie(config)#ntp server oob 192.168.210.222
```

Configure an SNTP server for the management network.

```
Ruijie(config)#sntp server oob 192.168.210.222
```

File Management

The system allows file copying between management network and the device, but the file copying to the management network shall be specifically designated. The "url" in the **copy** command can contain the prefix of "tftp". Since TFTP protocol is used to copy files, if the file is copied from a node on management network, the prefix shall be changed to "oob_tftp".

Command	Function
Ruijie> **enable**	Enter the privilege configuration mode.
Ruijie**# copy oob_tftp://***source-url destination-url*	Copy the file from the URL specifed by the *source-url* argument to the URL specified by the *destination-url* argument.

Configuration example:

File copying

```
Ruijie#copy oob_tftp://192.168.1.2/ngsa-compress.bin flash:file.bin
Accessing tftp://192.168.1.2/ngsa-compress.bin...
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
Success : Transmission success,file length 1183856
```

Download a file from an IPv4 host on the management network to the file system of the flash.

```
Ruijie# copy oob_tftp://192.168.1.2/ngsa-compress.bin
flash:file.bin
Accessing tftp://192.168.1.2/ngsa-compress.bin...
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
Success : Transmission success,file length 1183856 bytes
```

Caution To prevent attacks to the MGMT interface, fix the rate of the MGMT interface to 192 Kbps and always enable flow control for the interface. To avoid the loss of frames, enable flow control on the peer device of the MGMT interface.

Configuring Device Security

Configure static ARP bindings and CPU attack prevention to ensure the security of MGMT devices. CPU attacks include CPP and NFPP. For more information, see CPP configuration guide and command reference.

Static ARP Binding

Configure static ARP bindings to avoid the attacks of ARP spoofing on the management network.

Command	Function
Ruijie**#configure terminal**	Enter the configuration view.
Ruijie(config)**#arp oob** *ip-address mac-address arp-type*	Define a static ARP binding. The *arp-type* argument can only be ARPA.

Note The **oob** keyword of the **arp oob** command is mutual exclusive with the **vrp** keyword. The arguments of the **arp oob** command have the same definition as those of the **arp** command. For related configuration, see IPv4 configuration guide and command reference.

Configuration Example

Configure a static ARP binding for the VSU on the MGMT interface.

```
Ruijie(config)#arp oob 1.1.1.1 4e54.3800.0002 arpa
```

View Configurations

Command	Function
show interfaces mgmt 0	Display information about the virtual MGMT interface.
show mgmt virtual	Display member status and statistics about the virtual MGMT interface.

Note Commands of other LAN interface for displaying interface interfaces are applicable for MGMT interfaces. For detailed commands and features, see interface configuration guide and command reference.

Configuring SNMP

SNMP Overview

Introduction

As the abbreviation of Simple Network Management Protocol, SNMP has been a network management standard (RFC1157) since the August, 1988. So far, the SNMP becomes the actual network management standard for the support from many manufacturers. It is applicable to the situation of interconnecting multiple systems from different manufacturers. Administrators can use the SNMP protocol to query information, configure network, locate failure and plan capacity for the nodes on the network. Network supervision and administration are the basic function of the SNMP protocol.

As a protocol in the application layer, the SNMP protocol works in the client/server mode, including three parts as follows:

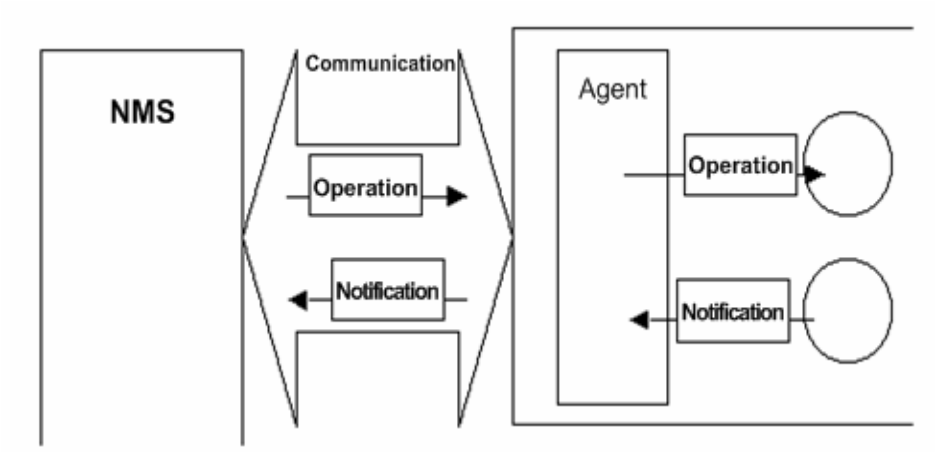
- SNMP network manager
- SNMP agent
- MIB (management information base)

The SNMP network manager, also referred to as NMS (Network Management System), is a system to control and monitor the network using the SNMP protocol.

The SNMP Agent is the software running on the managed devices. It receives, processes and responds the monitoring and controlling messages from the NMS, and also sends some messages to the NMS.

The relationship between the NMS and the SNMP Agent can be indicated as follows:

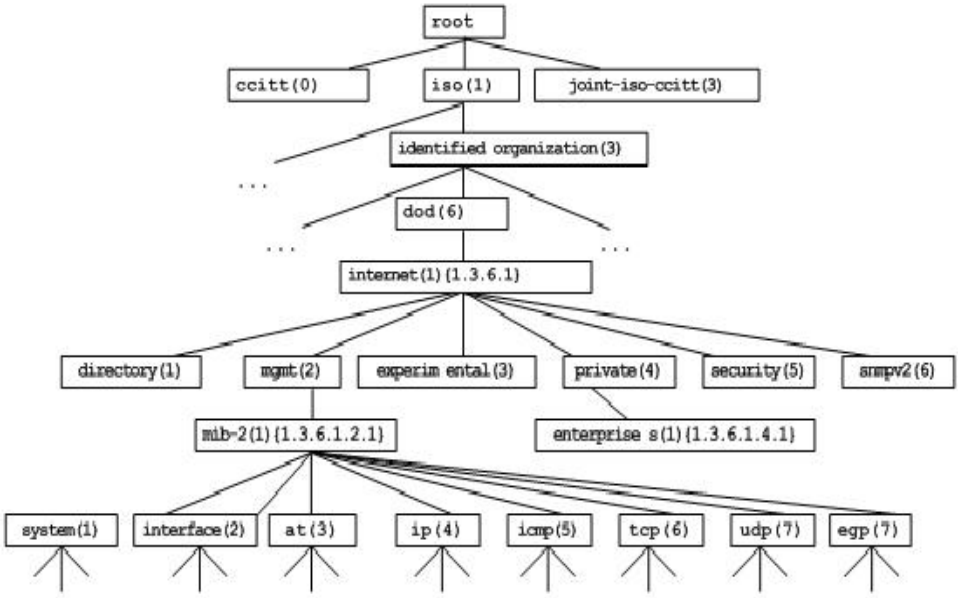
Figure 1 Relationship between the NMS and the SNMP Agent



The MIB (Management Information Base) is a virtual information base for network management. There are large volumes of information for the managed network equipment. In order to uniquely identify a specific management unit in the SNMP message, the tree-type hierarchy is used to by the MIB to describe the management units in the network management equipment. The node in the tree indicates a specific management unit. Take the following figure of MIB as an example to name the objectives in the tree. To identify a specific management unit **system** in the network equipment uniquely, a series of numbers can be used. For example, the number string {1.3.6.1.2.1.1} is the object identifier of a management

unit, so the MIB is the set of object identifiers in the network equipment.

Figure 2 Tree-type MIB hierarchy



SNMP Versions

This software supports these SNMP versions:

- SNMPv1: The first formal version of the Simple Network Management Protocol, which is defined in RFC1157.
- SNMPv2C: Community-based Administrative Framework for SNMPv2, an experimental Internet protocol defined in RFC1901.
- SNMPv3: Offers the following security features by authenticating and encrypting packets:

7) Ensure that the data are not tampered during transmission.

8) Ensure that the data come from a valid data source.

9) Encrypt packets to ensure the data confidentiality.

Both the SNMPv1 and SNMPv2C use a community-based security framework. They restrict administrator's operations on the MIB by defining the host IP addresses and community string.

With the GetBulk retrieval mechanism, SNMPv2C sends more detailed error information type to the management station. GetBulk allows you to obtain all the information or a great volume of data from the table at a time, and thus reducing the times of request and response. Moverover, SNMPv2C improves the capability of handing errors, including expanding error codes to distinguish different kinds of errors, which are represented by one error code in SNMPv1. Now, error types can be distinguished by error codes. Since there may be the management workstations supporting SNMPv1 and SNMPv2C in a network, the SNMP agent must be able to recognize both SNMPv1 and SNMPv2C messages, and return the corresponding version of messages.

SNMP Management Operations

For the information exchange between the NMS and the SNMP Agent, six types of operations are defined:

10) Get-request: The NMS gets one or more parameter values from the SNMP Agent.

11) Get-next-request: The NMS gets the next parameter value of one or more parameters from the SNMP Agent.

12) Get-bulk: The NMS gets a bulk of parameter values from the SNMP Agent.

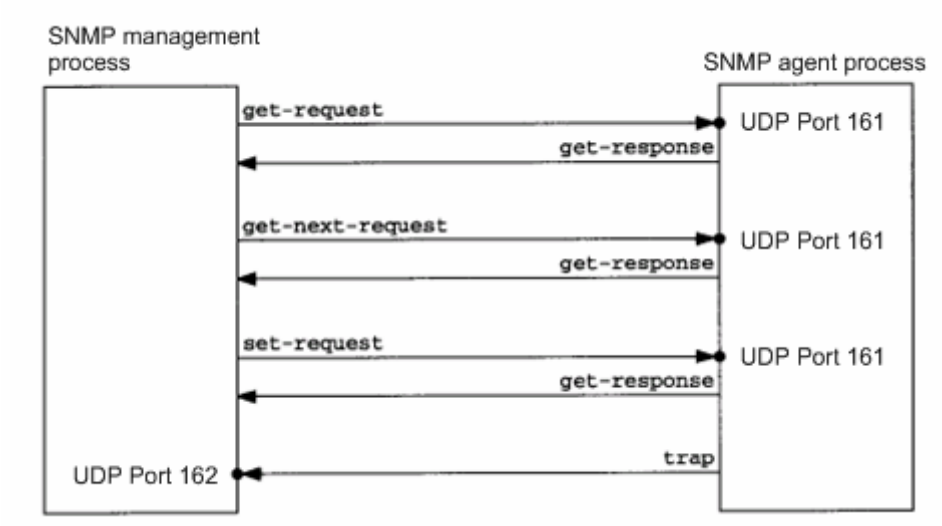
13) Set-request: The NMS sets one or more parameter values for the SNMP Agent.

14) Get-response: The SNMP Agent returns one or more parameter values, the response of the SNMP Agent to any of the above 3 operations of the NMS.

15) Trap: The SNMP Agent proactively sends messages to notify the NMS that some event will occur.

The first four messages are sent from the NMS to the SNMP Agent, and the last two messages are sent from the SNMP Agent to the NMS (Note: SNMPv1 does not support the Get-bulk operation). These operations are described in the following figure:

Figure 3 Message types in SNMP



NMS sends messages to the SNMP Agent in the first three operations and the SNMP Agent responds a message through the UDP port 161. However, the SNMP Agent sends a message in the Trap operation through the UDP port 162.

Caution When managing the R2700 switching card (NM2-24ESW/NM2-16ESW) via SNMP, NM2-16ESW obtains the inexistent error message of port 17-26, while NM2-24ESW obtains the inexistent error message of port 25-26.

SNMP Security

Both SNMPv1 and SNMPv2 use the community string to check whether the management workstation is entitled to use MIB objects. In order to manage devices, the community string of NMS must be identical to a community string defined in the devices.

A community string features:

- Read-only: Authorized management workstations are entitled to read all the variables in the MIB.
- Read-write: Authorized management workstations are entitled to read and write all the variables in the MIB.

Based on SNMPv2, SNMPv3 can determine a security mechanism for processing data by security model and security level. There are three types of security models: SNMPv1, SNMPv2C and SNMPv3.

The table below describes the supported security models and security levels.

Model	Level	Authentication	Encryption	Description
SNMPv1	noAuthNoPriv	Community string	None	Ensures the data validity through community string.
SNMPv2c	noAuthNoPriv	Community string	None	Ensures the data validity through community string.
SNMPv3	noAuthNoPriv	User name	None	Ensures the data validity through user name.
SNMPv3	authNoPriv	MD5 or SHA	None	Provides HMAC-MD5 or HMAC-SHA-based authentication mechanism.
SNMPv3	authPriv	MD5 or SHA	DES	Provides HMAC-MD5 or HMAC-SHA-based authentication mechanism and CBC-DES-based encryption mechanism.

SNMP Engine ID

The engine ID is designed to identify a SNMP engine uniquely. Every SNMP entity contains a SNMP engine, a SNMP engine ID identifies a SNMP entity in a management domain. So every SNMPV3 entity has a unique identifier named SNMP Engine ID.

The SNMP Engine ID is an octet string of 5 to 32 bytes, which is defined in RFC3411:

- The first four bytes indicate the private enterprise number of an enterprise (assigned by IANA) in hex system.
- The fifth byte indicates how to identify the rest bytes.

0: Reserved

1: The following 4 bytes indicate an IPv4 address.

2: The following 16 bytes indicate an IPv6 address.

3: The following 6 bytes indicate an MAC address

4: Texts of up to 27 bytes defined by manufacturers

5: A hexadecimal value of up to 27 bytes defined by manufacturers

6-127: Reserved

128-255: In the format specified by manufacturers.

SNMP Configuration

The SNMP configuration is performed in global configuration mode on network devices. To configure SNMP, enter the global configuration mode.

Setting the Community String and Access Authority

SNMPv1 and SNMPv2C adopt community string-based security scheme. The SNMP Agent supports only the management operations from the management workstations of the same community string. The SNMP messages without matching the community string will be discarded. The community string serves as the password between the NMS and the SNMP Agent.

- Configure an ACL rule to allow the NMS of the specified IP address to manage devices.
- Set the community's operation permission,: ReadOnly or ReadWrite.
- Specify a view for view-based management. By default, no view is configured. That is, the management workstation is allowed to access to all MIB objects.
- Indicate the IP address of the NMS who can use this community string. If it is not indicated, any NMS can use this community string. By default, any NMS can use this community string.

To configure the SNMP community string, run the following command in global configuration mode:

	Command	**Function**
Step 1	Ruijie(config)# **snmp-server community** *string* [**view** *view-name*] [**ro** | **rw**] [**host** *host-ip*] [**ipv6** *ipv6-aclname*][*aclnum* | *aclname*]	Sets the community string and its right.

One or more coummnity strings can be specified for the NMS of different rights. To remove the community name and its right, run the **no snmp-server community** *string* command in global configuration mode.

Configuring MIB Views and Groups

With view-based access control model, you can determine whether the object of a management operation is in a view or not. Only the management objects in a view are allowed to be accessed. For access control, generally some users are associated with a group and then the group is associated with a view. The users in a group have the same access right.

- Set an inclusion view and an exclusion view.
- Set a Read-only view and a Read-write view for a group.
- Set security levels, whether to authenticate, and whether to encrypt for SNMPv3 users.

To configure the MIB views and groups, run the following commands in global configuration mode:

	Command	Function
Step 1	Ruijie(config)# **snmp-server view** *view-name oid-tree* **{include | exclude}**	Creates a MIB view to include or exclude associated MIB objects.
Step 2	Ruijie(config)# **snmp-server group** *groupname* {**v1 | v2c |v3 {auth | noauth | priv**}} [read *readview*] [**write** *writeview*] [**access** {[**ipv6** *ipv6_aclname*] [*aclnum* | *aclname*] }]	Creates a group and associate it with the view.

You can delete a view by using the **no snmp-server view** *view-name* command, or delete a tree from the view by using the **no snmp-server view** *view-name oid-tree* command. You can also delete a group by using the **no snmp-server group** *groupname* {**v1 | v2c | v3**} command.

Configuring SNMP Users

User-based security model can be used for security management. In this mode, you should configure user information first. The NMS can communicate with the SMP Agent by using a valid user account.

For SNMPv3 users, you can specify security level, authentication algorithm (MD5 or SHA), authentication password, encryption algorithm (only DES now) and encryption password.

To configure a SNMP user, run the following commands in global configuration mode:

Command	Function
Ruijie(config)# **snmp-server user** *username roupname* {**v1 | v2c | v3 [encrypted] [auth { md5|sha }** *auth-password*] **[priv des56** *priv-password*] } [**access {[ipv6** *ipv6_aclname*] [*aclnum* | *aclname*] }]	Configures the user information.

To remove the specified user, use the **no snmp-server user** *username groupname* {**v1 | v2c | v3**} command.

Configuring Host Address

In special cases, the SNMP Agent may also proactively send messages to the NMS.

To configure the NMS host address that the SNMP Agent proactively sends messages to, run the following commands in global configuration mode:

Command	Function
Ruijie(config)# **snmp-server host** { *host-addr* | ipv6 *ipv6-addr* } [**vrf** *vrfname*] [**traps**] [**version { 1 | 2c | 3 { auth | noauth | priv** }] *community-string* [**udp-port** *port-num*] [*notification-type*]	Sets the SNMP host address, host port, vrf options, message type, community string, (user name in SNMPv3) and security level (only supported in SNMPv3).

Configuring SNMP Agent Parameters

You can configure the basic parameters of the SNMP Agent, including contact, device location and sequence number. With these parameters, the NMS knows the contact, location and other information of the device.

To configure the SNMP agent parameters, run the following commands in global configuration mode:

Command	Function
Ruijie(config)# **snmp-server contact** *text*	Configures the contact for the system.
Ruijie(config)# **snmp-server location** *text*	Configure the location of the system.
Ruijie(config)# **snmp-server chassis-id** *number*	Configure the sequence number of the system.

Defining the Maximum Message Size of the SNMP Agent

In order to reduce influence on network bandwith, you can configure the maximum packet size of the SNMP Agent. To configure the maximum packet size of the SNMP Agent, run the following command in global configuration mode:

Command	Function
Ruijie(config)# **snmp-server packetsize** *byte-count*	Sets the maximum packet size of the SNMP Agent.

Shielding the SNMP Agent

The SNMP Agent service is a service provided by Ruijie product and it is enabled by default. You can shield the SNMP agent service and related configuration by executing the following command in global configuration mode:

Command	Function
Ruijie(config)# **no snmp-server**	Shields the SNMP agent service.

Disabling the SNMP Agent

Ruijie products provide a different command from the shield command to disable the SNMP Agent. This command will directly disable all SNMP services (the SNMP agent function is disabled, no message is received and no response or Trap message is sent) instead of shielding the configuration information of the SNMP Agent. To disable the SNMP agent service, run the following command in global configuration mode:

Command	Function
Ruijie(config)# **no enable service snmp-agent**	Disables the SNMP agent service.

Configuring the SNMP Agent to Send the Trap Message to the NMS Initiatively

The TRAP message is a message automatically sent by the SNMP Agent to the NMS, and is used to report some critical and important events. By default the SNMP Agent is not allowed to automatically send the TRAP message. To enable it, run the following command in global configuration mode:

Command	Function
Ruijie(config)# **snmp-server enable traps** [*type*] [*option*]	Allows the SNMP Agent to send the TRAP message proactively.
Ruijie(config)# **no snmp-server enable traps** [*type*] [*option*]	Forbids the SNMP Agent to send the TRAP message proactively.

Configuring LinkTrap Policy

You can configure whether to send the LinkTrap message on an interface. When this function is enabled and the link

status of the interface changes, the SNMP will send the LinkTrap message. Otherwise, it will not. By default, this function is enabled.

Command	Function
Ruijie(config)# **interface** *interface-id*	Enters interface configuration mode.
Ruijie(config-if)# **[no] snmp trap link-status**	Enables or disables sending the LinkTrap message on the interface.

The following example configures not to send LinkTrap message on the intereface:

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if)# no snmp trap link-status
```

Configuring the Parameters for Sending the Trap Message

To set the parameters for the SNMP Agent to send the Trap message, run the following commands:

Command	Function
Ruijie(config)# **snmp-server trap-source** *interface*	Specifies the source port sending the Trap message.
Ruijie(config)# **snmp-server queue-length** *length*	Specifies the queue length of each Trap message.
Ruijie(config)# **snmp-server trap-timeout** *seconds*	Specifies the interval at which the Trap message is sent.

Configuring SNMP Attack Protection

Enable SNMP attack protection by confining limited times of failed SNMP consecutive authentications and specifying the solution after consecutive authentications fail. After SNMP authentications fail, the system will blacklist the source IP. When the failed times exceed the limit, the system will restrict the source IP address according to the solutions configured by the device:

- The source IP address that is prevented from authentication permanently cannot try access authentication again unless it is relieved by the administrator manually.
- The source IP address that is prevented from authentication for a while can try access authentication again when the **lock-time** times out or it is relieved by the administrator manually.
- When you try access authentication again, the non-restricted source IP address will pass it as long as you use correct community (for SNMPv1and SNMPv2c) or username (for SNMPv3)..

Run this command in global configuration mode to limit the times of failed SNMP consecutive authentications and specify the solution after consecutive authentications fail.

Command	Function

Command	Function
Ruijie(config)# **snmp-server authentication attempt** *times* **exceed** { **lock** | **lock-time** *minutes* | **unlock** }	Sets limited times of failed SNMP consecutive authentications and specifies the solution after authentications fail. **attempt** *times*: The limit of failed SNMP authentications. **Lock**: The source IP address is prevented from access authentication permanently. It is blacklisted unless relieved by the administrator manually. **lock-time** *minutes*: The source IP address is prevented from access authentication for a while and then allowed to be authenticated again. *minutes* refers to the period when the source IP address is prevented. **unlock**: The source IP address continues to be allowed after consecutive authentications fail, similar to the case that SNMP attack protection is not enabled.

Run the **no snmp-server authentication attempt** command to restore SNMP attack protection. By default, the solution taken after consecutive authentications fail is **unlock**. Namely, the IP address is allowed to try access authentication.

SNMP Monitoring and Maintenance

Checking the Current SNMP Status

To monitor the SNMP status and troubleshoot SNMP configurations, Ruijie product provides monitoring commands for SNMP, with which it is possible to easily check the SNMP status of the current network device. In privileged user mode, run the **show snmp** command to check the current SNMP status.

```
Ruijie# show snmp
Chassis: 1234567890 0987654321
Contact: wugb@i-net.com.cn
Location: fuzhou
2381 SNMP packets input
   5 Bad SNMP version errors
   6 Unknown community name
   0 Illegal operation for community name supplied
   0 Encoding errors
   9325 Number of requested variables
   0 Number of altered variables
   31 Get-request PDUs
   2339 Get-next PDUs
```

```
   0 Set-request PDUs
2406 SNMP packets output
   0 Too big errors (Maximum packet size 1500)
   4 No such name errors
   0 Bad values errors
   0 General errors
   2370 Get-response PDUs
   36 SNMP trap PDUs
SNMP global trap: disabled
SNMP logging: enabled
SNMP agent: enabled
.
```

The above statistics is explained as follows:

Showing Information	Description
Bad SNMP version errors	SNMP version is incorrect.
Unknown community name	The community name cannot be identified.
Illegal operation for community name supplied	Illegal operation
Encoding errors	Code error
Get-request PDUs	Get-request message
Get-next PDUs	Get-next message
Set-request PDUs	Set-request message
Too big errors (Maximum packet size 1500)	Too large response message
No such name errors	The specified management unit does not exist.
Bad values errors	Specified value type error
General errors	General error
Get-response PDUs	Get-response message
SNMP trap PDUs	SNMP trap message

Checking the MIB Objects Supported by the Current SNMP Agent

To check the MIB objects supported by the current SNMP Agent, run the **show snmp mib** command in privileged user mode:

```
Ruijie# show snmp mib
sysDescr
sysObjectID
sysUpTime
sysContact
sysName
sysLocation
sysServices
sysORLastChange
snmpInPkts
snmpOutPkts
```

```
...
```

Viewing SNMP Users

To view the SNMP users configured on the current SNMP agent, run the **show snmp user** command in privileged user mode:

```
Ruijie# show snmp user
User name: test
Engine ID: 8000131103000000000000
storage-type: permanent    active
Security level: auth priv
Auth protocol: SHA
Priv protocol: DES
Group-name: g1
```

Viewing SNMP Views and Groups

To view the group configured on the current SNMP agent, run the **show snmp group** command in privileged user mode:

```
Ruijie# show snmp group
groupname: g1
securityModel: v3
securityLevel:authPriv
readview: default
writeview: default
notifyview:
groupname: public
securityModel: v1
securityLevel:noAuthNoPriv
readview: default
writeview: default
notifyview:
groupname: public
securityModel: v2c
securityLevel:noAuthNoPriv
readview: default
writeview: default
notifyview:
```

To view the view configured on the current SNMP agent, run the **show snmp view** command in privileged user mode:

```
Ruijie# show snmp view
default(include) 1.3.6.1
test-view(include) 1.3.6.1.2.1
```

Viewing Host Information

To view the host information configured on the SNMP agent, run the **show snmp host** command in privileged user mode:

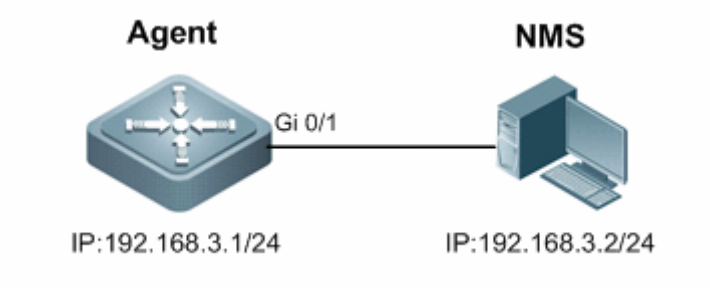
```
Ruijie# show snmp host
Notification host: 192.168.64.221
udp-port: 162   type: trap
user: public    security model: v1
Notification host: 2000:1234::64
udp-port: 162   type: trap
user: public    security model: v1
```

Typical SNMP Configuration Example

SNMP v1/v2 Configuration Example

Topological Diagram

Figure 4 Topology for SNMP v1/2 application



Application Requirements

The Network Management Station (NMS) manages the network device (Agent) by applying the community-based authentication model, and the network device can control the operation permission (read or write) of the community to access the specified MIB objects. For example, community "user1" can only read and write objects under System (1.3.6.1.2.1.1) node.

The network device can only be managed by NMS with a specific IP (i.e., 192.168.3.2/24).

The network device can actively send messages to NMS.

The NMS can acquire the basic system information of the device, such as contact, location, and ID.

Configuration Tips

By creating MIB view and associating authentication name (Community) and access permission (Read or Write), the first application need can be met.

While configuring the community string and access permission, associate ACL or specify the IP of administrator using this

community string to meet the second application need (this example associates the ACL).

Configure the address of SNMP host and enable the Agent to actively send Trap messages.

Configure the parameters of SNMP agent.

Configuration Steps

Step 1: Configure MIB view and ACL.

! Create an MID view named "v1", which contains the associated MIB object (1.3.6.1.2.1.1).

```
Ruijie(config)#snmp-server view v1 1.3.6.1.2.1.1 include
```

! Create an ACL named "a1" to permit the IP address of 192.168.3.2/24.

```
Ruijie(config)#ip access-list standard a1
Ruijie(config-std-nacl)#permit host 192.168.3.2
Ruijie(config-std-nacl)#exit
```

Step 2: Configure community string and access permission.

! Configure Community of "user1", associate write permission for MIB view of "v1", and associate the ACL of "a1".

```
Ruijie(config)#snmp-server community user1 view v1 rw a1
```

Step 3: Configure the Agent to actively send messages to NMS.

! Configure the address of SNMP host as 192.168.3.2, message format as Version 2c and community string as "user1".

```
Ruijie(config)#snmp-server host 192.168.3.2 traps version 2c user1
```

! Enable the Agent to actively send traps.

```
Ruijie(config)#snmp-server enable traps
```

Step 4: Configure parameters of SNMP agent.

! Configure system location.

```
Ruijie(config)#snmp-server location fuzhou
```

! Configure system contact.

```
Ruijie(config)#snmp-server contact ruijie.com.cn
```

! Configure system serial number.

```
Ruijie(config)#snmp-server chassis-id 1234567890
```

Step 5: Configure the IP address for the Agent.

! Configure the IP address of Gi 0/1 as 192.168.3.1/24.

```
Ruijie(config)#interface GigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)#ip address 192.168.3.1 255.255.255.0
```

```
Ruijie(config-if-GigabitEthernet 0/1)#exit
```

Verification

Step 1: Display configurations of the device.

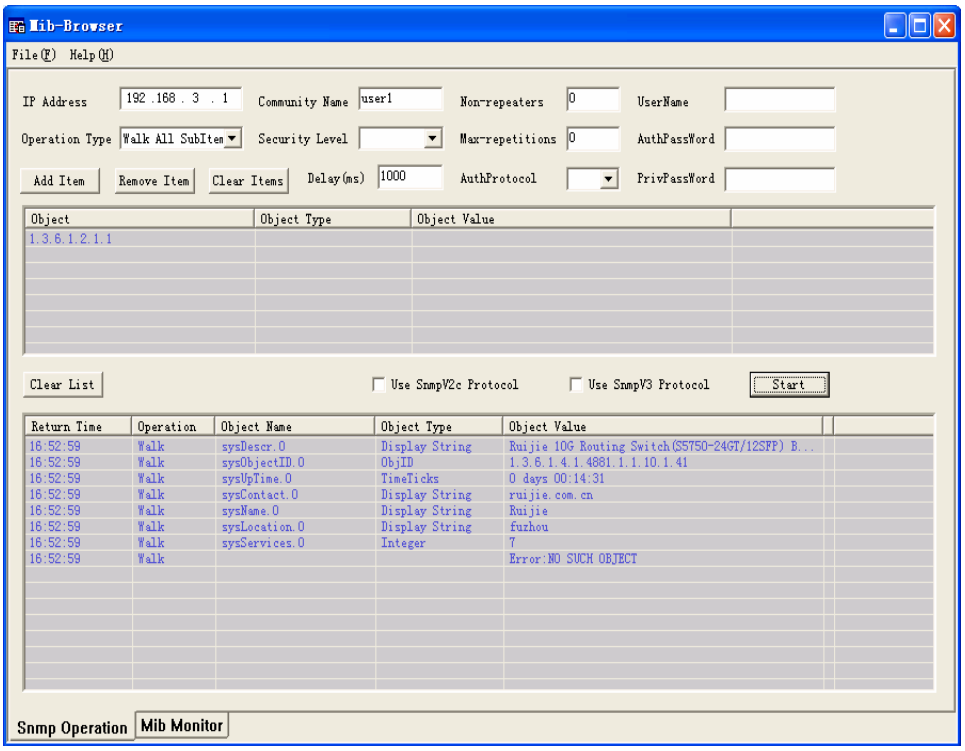
```
Ruijie#show running-config
!
ip access-list standard a1
 10 permit host 192.168.3.2
!
interface GigabitEthernet 0/1
 no ip proxy-arp
 ip address 192.168.3.1 255.255.255.0
!
snmp-server view v1 1.3.6.1.2.1.1 include
snmp-server location fuzhou
snmp-server host 192.168.3.2 traps version 2c user1
snmp-server enable traps
snmp-server contact ruijie.com.cn
snmp-server community user1 view v1 rw a1
snmp-server chassis-id 1234567890
```

Step 2: Display information about SNMP view and group.

```
Ruijie#show snmp view
v1(include) 1.3.6.1.2.1.1                //define MIB object of “v1”
default(include) 1.3.6.1                 //default MIB object
Ruijie#show snmp group
groupname: user1                  //Configure Community as SNMP group
securityModel: v1
securityLevel:noAuthNoPriv
readview: v1
writeview: v1
notifyview:
groupname: user1
securityModel: v2c
securityLevel:noAuthNoPriv
readview: v1
writeview: v1
notifyview:
```

Step 3: Install MIB-Browser. Type in device IP of "192.168.3.1" in the field of IP Address; type in "user1" in the field of Community Name; click **Add Item** button and select the specific management unit for MIB query, such as the System shown below. Click **Start** to implement MIB query of network device. The query result is shown in the bottommost box:

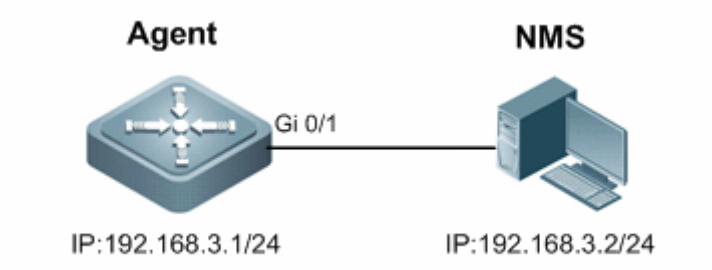
Figure 5



SNMP v3 Configuration Example

Topological Diagram

Figure 6 SNMPv3 application topology



Application Requirements

Network Management Station manages the network device (Agent) by applying user-based security model. For example: the user name is "user1", authentication mode is MD5, authentication key is "123", encryption algorithm is DES56, and the encryption key is "321".

The network device can control user's permission to access MIB objects. For example: "User1" can read the MIB objects under System (1.3.6.1.2.1.1) node, and can only write MIB objects under SysContact (1.3.6.1.2.1.1.4.0) node.

The network device can actively send authentication and encryption messages to the network management station.

Configuration Tips

Create MIB view and specify the included or excluded MIB objects.

Create SNMP group and configure the version as "v3"; specify the security level of this group, and configure the read/write permission of the view corresponding to this group.

Create user name and associate the corresponding SNMP group name to further configure the user's permission to access MIB objects; meanwhile, configure the version number as "v3" and the corresponding authentication mode, authentication key, encryption algorithm and encryption key.

Configure the address of SNMP host, configure the version number as "3" and configure the security level to be adopted.

Configuration Steps

Step 1: Configure MIB view and group.

! Create an MIB view of "view1" and include the MIB object of 1.3.6.1.2.1.1; further create an MIB view of "view2" and include the MIB object of 1.3.6.1.2.1.1.4.0.

```
Ruijie(config)#snmp-server view view1 1.3.6.1.2.1.1 include
Ruijie(config)#snmp-server view view2 1.3.6.1.2.1.1.4.0 include
```

! Create a group named "g1" and select the version number of "v3"; configure security level to "priv" to read "view1" and write "view2".

```
Ruijie(config)#snmp-server group g1 v3 priv read view1 write view2
```

Step 2: Configure SNMP user.

! Create a user named "user1", which belongs to group "g1"; select version number of "v3" and configure authentication mode as "md5", authentication key as "123", encryption mode as "DES56" and encryption key as "321".

```
Ruijie(config)#snmp-server user user1 g1 v3 auth md5 123 priv des56 321
```

Step 3: Configure the address of SNMP host.

! Configure the host address as 192.168.3.2 and select version number of "3"; configure security level to "priv" and associate the corresponding user name of "user1".

```
Ruijie(config)#snmp-server host 192.168.3.2 traps version 3 priv user1
```

! Enable the Agent to actively send traps to NMS.

```
Ruijie(config)#snmp-server enable traps
```

Step 4: Configure the IP address of Agent.

! Configure the IP address of Gi 0/1 as 192.168.3.1/24.

```
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)#ip address 192.168.3.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/1)#exit
```

Verification

Step 1: Display configurations of device.

```
Ruijie#show running-config
!
interface GigabitEthernet 0/1
 no ip proxy-arp
 ip address 192.168.3.1 255.255.255.0
!
snmp-server view view1 1.3.6.1.2.1.1 include
snmp-server view view2 1.3.6.1.2.1.1.4.0 include
snmp-server user user1 g1 v3 encrypted auth md5 7EBD6A1287D3548E4E52CF8349CBC93D priv des56
D5CEC4884360373ABBF30AB170E42D03
snmp-server group g1 v3 priv read view1 write view2
snmp-server host 192.168.3.2 traps version 3 priv user1
snmp-server enable traps
```

Step 2: Display SNMP user.

```
Ruijie# show snmp user
User name: user1
Engine ID: 800013110300d0f8221120
storage-type: permanent    active
Security level: auth priv
Auth protocol: MD5
Priv protocol: DES
Group-name: g1
```

Step 3: Display SNMP view.

```
Ruijie#show snmp view
view1(include) 1.3.6.1.2.1.1
view2(include) 1.3.6.1.2.1.1.4.0
default(include) 1.3.6.1
```

Step 4: Display SNMP group.

```
Ruijie# show snmp group
groupname: g1
securityModel: v3
securityLevel:authPriv
readview: view1
writeview: view2
notifyview:
```

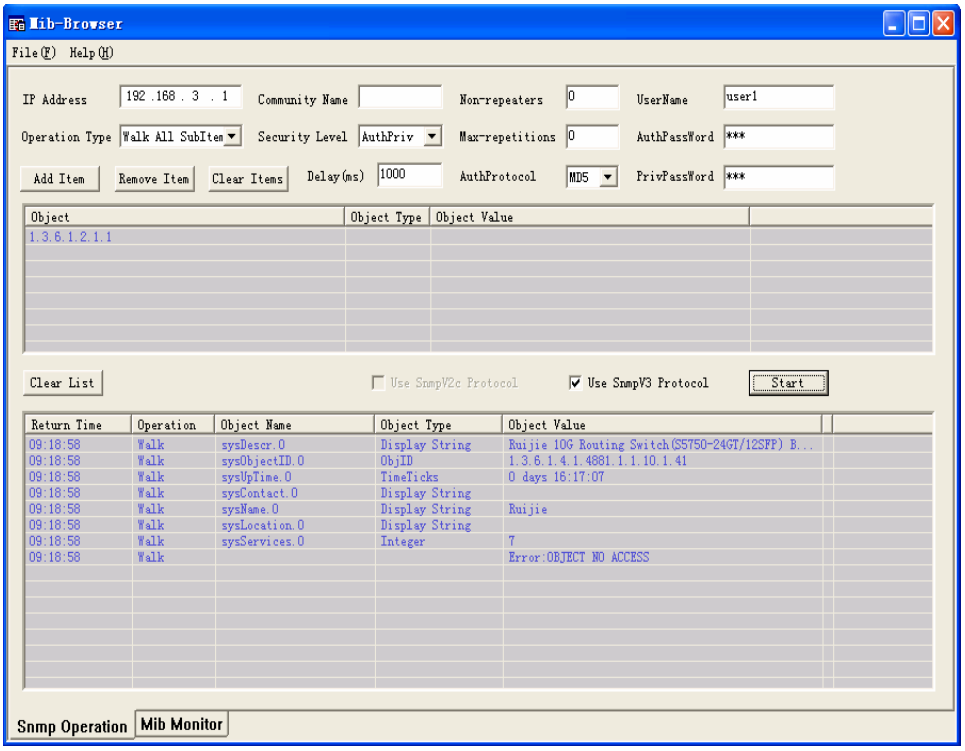
Step 5: Display host information configured by the user.

```
Ruijie#show snmp host
```

```
Notification host: 192.168.3.2
udp-port: 162
type: trap
user: user1
security model: v3 authPriv
```

Step 6: Install MIB-Browser. Type in device IP of "192.168.3.1" in the field of IP Address; type in "user1" in the field of UserName; select "AuthPriv" from Security Level; type in "123" in the field of AuthPassWord; select "MD5" from AuthProtocol; type in "321" in the field of PrivPassWord. Click **Add Item** button and select the specific management unit for querying MIB, such as the System shown below. Click **Start** to implement MIB query of network device. The query result is shown in the bottommost box:

Figure 7



Configuring USB/SD

Overview

This document describes usage of USB/SD storage devices (mainly U disk/SD). The system only recognizes the U-disk/SD card partitioned by FAT. Other file systems cannot be identified.

After inserting a U disk/SD, the system prompts that U disk/SD is found. The files in this U disk/SD card can be positioned and accessed through URL, such as **usb0:/abc/1.txt** or **sd0:/abc/1.txt**.

Caution

Version 10.4 (2) and the later versions support the access to U disk/SD by URL. For earlier software, use the mount path of the file system to position and access U disk/SD, such as using /mnt/usb0 to access the USB device on port 0, and using /mnt/sd to access the SD card. The mount path is prompted when the device is inserted, or is displayed when users run the **show usb** command.
The USB mobile disk (USB-HDD) is not supported.

Inserting the Device

Just insert a USB device into the USB slot. Messages as below are displayed if the system finds the device and loads the driver.

```
*Jan  1 00:09:42: %USB-5-USB_DISK_FOUND: USB Disk <Mass Storage> has been inserted to USB port 0!
*Jan  1 00:09:42: %USB-5-USB_DISK_PARTITION_MOUNT: Mount usb0 (type: FAT32), size: 1050673152B (1002MB)
<USB Mass Storage Device> is the name of the found device; usb0: is the first USB device, and size is the partition size. This U-disk has 1002 MB space.
```

Just insert an SD card into an SD slot. Messages as below are displayed if the system finds the device and loads driver.

```
*Jan  1 00:09:42: %USB-5-USB_DISK_PARTITION_MOUNT: Mount sd (type: FAT32), size: 1050673152B (1002MB)
```

SD: is the first SD partition and **size** is the partition size. This SD card has 1002 MB space.

Using the Device

After loading U disk/SD card to the system, directly run file system commands (dir, copy, del, and others) to operate U disk/SD card. Operations below show how to copy the file of U disk/SD card to flash.

Access the U disk partition.

```
Ruijie# cd usb0:/
Access the SD card partitiom.
Ruijie# cd sd0:/
```

Copy the **a.txt** file in the U disk to root directory of the device.

```
Ruijie# copy usb0:/a.txt  flash:/b.txt
```

Copy the a.txt file in the SD card to device's the root directory of the device.

```
Ruijie# copy sd0:/a.txt  flash:/b.txt
```

Run the **dir** command. The result shows that the b.txt file has been added to the USB/SD card.

For other operation commands, see the "File System Management" section.

Caution If there are multiple partitions in U disk/SD card, only the first FAT partition can be accessed through the device.

Note Only the version 10.4(2) and the later versions allow users to access U disc/SD card by URL. For the earlier versions, use path to position and access the device. For example:
Access the U disk partition:
Ruijie# cd /mnt/usb0
Access the SD card partition:
Ruijie# cd /mnt/sd0

Copy the a.txt file under root directory to U disk.
Ruijie# **copy** flash:/a.txt usb0:/a.txt
Copy the a.txt file under root directory to SD card.
Ruijie# **copy** flash:/a.txt sd0:/a.txt

Showing USB Device/SD Card Information

Command	Function
Ruijie# **show usb**	Shows the USB device information of the system
Ruijie# **show sd**	Shows the SD device information of the system

In CLI command mode, use the **show usb** or the **show sd** command to view the USB / SD device information of the system. The displayed information is as follows:

```
Ruijie# show usb
Device: Mass Storage:
ID: 0
URL prefix: usb0
Disk Partitions:
usb0(type:FAT32)
```

```
Size : 131,072,000B(125MB)
Available size: 1,260,020B (1.2MB)

Ruijie# show sd

Device: Mass Storage:
ID: 1
URL prefix: sd0
Disk Partitions:
SD(type:FAT32)

Size : 131,072,000B(125MB)
Available size: 1,260,020B (1.2MB)
```

USB Mass Storage Device is the name of the device.

URL means which prefix can be used by U disk/SD card to access U disk/SD card.

Size means the available space in U disk/SD card that can be accessed.

Available size means the remaining space in U disk/SD card.

Unplugging USB Device/SD Card

Before pulling out USB device/SD card, run the command on the CLI to uninstall the device in case system is using the USB device/SD card to avoid an error.

Command	Function
Ruijie# **usb remove** *Device_ID*	Uninstalls the USB device with ID Device_ID

Command	Function
Ruijie# **sd remove** *Device_ID*	Uninstalls the SD device with ID Device_ID

As shown above, IDO indicates a USB device, and ID1 indicates an SD card. The commands below can uninstall the corresponding USB device and SD card.

```
Ruijie# usb remove 0
After the uninstall command is used, the system will print:
OK, now you can pull out the device 0.
*Jan  1 00:18:16: %USB-5-USB_DISK_REMOVED: USB Disk <Mass Storage> has been removed from USB port 0!
Ruijie# sd remove 1
After the uninstall command is used, the system will print:
OK, now you can pull out the device 1
Now, you can pull out the USB device/SD card.
```

Sometimes, it may lead to failure to uninstall the device for the device is being used. Wait a while, and then run the uninstall command to pull out the device.

Caution Be sure to uninstall the device first and then unplug the device to prevent the system error.

USB/SD Faults

When the system prints the following message:

```
*Jan 2 00:00:39: %USB-3-OHCI_ERR: USB1.0 controller is not available now.
```

USB/SD 1.0 controller is not available, while USB/SD card 2.0 is still available. In this case, reset the whole system to use corresponding version U disk/SD card.

When the system prints the following message:

```
*Jan 2 00:00:39: %USB-3-EHCI_ERR: USB2.0 controller is not available now.
```

USB/SD 2.0 controller is not available, while U disc/SD card 1.0 is still available. In this case, reset the whole system to use corresponding version U disk/SD card.

Configuring System Management

Basic System Management

Showing CPU Utilization

Use the **show cpu** command to show the total CPU utilization of the system and the CPU utilization of each process:

Command	Function
Ruijie# **show cpu**	Shows CPU utilization.

By default, the device name is **Ruijie**.

The following example shows the output result of this command.

```
Ruijie#show cpu
=====================================
    CPU Using Rate Information
CPU utilization in five seconds: 25%
CPU utilization in one minute: 20%
CPU utilization in five minutes: 10%
  NO   5Sec   1Min   5Min   Process
  0     0%     0%     0%    LISR INT
  1     7%     2%     1%    HISR INT
  2     0%     0%     0%    ktimer
  3     0%     0%     0%    atimer
  4     0%     0%     0%    printk_task
  5     0%     0%     0%    waitqueue_process
  6     0%     0%     0%    tasklet_task
  7     0%     0%     0%    kevents
  8     0%     0%     0%    snmpd
  9     0%     0%     0%    snmp_trapd
 10     0%     0%     0%    mtdblock
 11     0%     0%     0%    gc_task
 12     0%     0%     0%    Context
 13     0%     0%     0%    kswapd
 14     0%     0%     0%    bdflush
 15     0%     0%     0%    kupdate
 16     0%     3%     1%    ll_mt
 17     0%     0%     0%    ll main process
 18     0%     0%     0%    bridge_relay
 19     0%     0%     0%    d1x_task
 20     0%     0%     0%    secu_policy_task
 21     0%     0%     0%    dhcpa_task
```

```
22    0%    0%    0%    dhcpsnp_task
23    0%    0%    0%    igmp_snp
24    0%    0%    0%    mstp_event
25    0%    0%    0%    GVRP_EVENT
26    0%    0%    0%    rldp_task
27    0%    2%    1%    rerp_task
28    0%    0%    0%    reup_event_handler
29    0%    0%    0%    tpp_task
30    0%    0%    0%    ip6timer
31    0%    0%    0%    rtadvd
32    0%    0%    0%    tnet6
33    2%    0%    0%    tnet
34    0%    0%    0%    Tarptime
35    0%    0%    0%    gra_arp
36    0%    0%    0%    Ttcptimer
37    8%    1%    0%    ef_res
38    0%    0%    0%    ef_rcv_msg
39    0%    0%    0%    ef_inconsistent_daemon
40    0%    0%    0%    ip6_tunnel_rcv_pkt
41    0%    0%    0%    res6t
42    0%    0%    0%    tunrt6
43    0%    0%    0%    ef6_rcv_msg
44    0%    0%    0%    ef6_inconsistent_daemon
45    0%    0%    0%    imid
46    0%    0%    0%    nsmd
47    0%    0%    0%    ripd
48    0%    0%    0%    ripngd
49    0%    0%    0%    ospfd
50    0%    0%    0%    ospf6d
51    0%    0%    0%    bgpd
52    0%    0%    0%    pimd
53    0%    0%    0%    pim6d
54    0%    0%    0%    pdmd
55    0%    0%    0%    dvmrpd
56    0%    0%    0%    vty_connect
57    0%    0%    0%    aaa_task
58    0%    0%    0%    Tlogtrap
59    0%    0%    0%    dhcp6c
60    0%    0%    0%    sntp_recv_task
61    0%    0%    0%    ntp_task
62    0%    0%    0%    sla_deamon
63    0%    3%    1%    track_daemon
64    0%    0%    0%    pbr_guard
65    0%    0%    0%    vrrpd
66    0%    0%    0%    psnpd
```

```
 67    0%    0%    0%   igsnpd
 68    0%    0%    0%   coa_recv
 69    0%    0%    0%   co_oper
 70    0%    0%    0%   co_mac
 71    0%    0%    0%   radius_task
 72    0%    0%    0%   tac+_acct_task
 73    0%    0%    0%   tac+_task
 74    0%    0%    0%   dhcpd_task
 75    0%    0%    0%   dhcps_task
 76    0%    0%    0%   dhcpping_task
 77    0%    0%    0%   dhcpc_task
 78    0%    0%    0%   uart_debug_file_task
 79    0%    0%    0%   ssp_init_task
 80    0%    0%    0%   rl_listen
 81    0%    0%    0%   ikl_msg_operate_thread
 82    0%    0%    0%   bcmDPC
 83    0%    0%    0%   bcmL2X.0
 84    3%    3%    3%   bcmL2X.0
 85    0%    0%    0%   bcmCNTR.0
 86    0%    0%    0%   bcmTX
 87    0%    0%    0%   bcmXGS3AsyncTX
 88    0%    2%    1%   bcmLINK.0
 89    0%    0%    0%   bcmRX
 90    0%    0%    0%   mngpkt_rcv_thread
 91    0%    0%    0%   mngpkt_recycle_thread
 92    0%    0%    0%   stack_task
 93    0%    0%    0%   stack_disc_task
 94    0%    0%    0%   redun_sync_task
 95    0%    0%    0%   conf_dispatch_task
 96    0%    0%    0%   devprob_task
 97    0%    0%    0%   rdp_snd_thread
 98    0%    0%    0%   rdp_rcv_thread
 99    0%    0%    0%   rdp_slot_change_thread
100    4%    2%    1%   datapkt_rcv_thread
101    0%    0%    0%   keepalive_link_notify
102    0%    0%    0%   rerp_msg_recv_thread
103    0%    0%    0%   ip_scan_guard_task
104    0%    0%    0%   ssp_ipmc_hit_task
105    0%    0%    0%   ssp_ipmc_trap_task
106    0%    0%    0%   hw_err_snd_task
107    0%    0%    0%   rerp_packet_send_task
108    0%    0%    0%   idle_vlan_proc_thread
109    0%    0%    0%   cmic_pause_detect
110    1%    1%    1%   stat_get_and_send
111    0%    1%    0%   rl_con
```

```
112    75%    80%    90%    idle
```

As shown in the above list, the first three lines indicate the total CPU utilization in the last 5 seconds, 1 minute, and 5 minutes respectively, including the CPU utilization of LISRs, HISRs and tasks, followed by the CPU utilization of various processes. The parameters in the columns are described as follows:

- **No**: number
- **5Sec**: CPU utilization in the last 5 seconds
- **1Min**: CPU utilization in the last 1 minute
- **5Min**: CPU utilization in the last 5 minutes
- **Process**: process name

The first two lines indicate the CPU utilization of all LISRs and all HISRs respectively. All the lines starting from the third line indicate the CPU utilization of processes. The last line indicates the CPU utilization of idle processes. As with **System Idle Process** in the Windows operating system, it indicates an idle status. The above example shows that the CPU utilization of idle processes in the last 5 seconds is 75%, meaning that 75% of the CPU resources are available.

Configuring CPU Utilization Log Thresholds

Use the following command to configure CPU utilization log thresholds.

Command	Function
cpu-log log-limit *low_num high_num*	Configures the high and low thresholds for triggering CPU utilization logs.

By default, the high threshold is 100% and the low threshold is 90%.

The following example sets the low threshold to 70% and the high threshold to 80%.

```
Ruijie# configure terminal                  // Enter the global configuration mode.
Ruijie(config)# cpu-log log-limit 70 80    // Configure the thresholds for triggering CPU logs.
```

If the CPU utilization is higher than 80%, the following information is displayed:

Oct 20 15:47:01 %SYSCHECK-5-CPU_USING_RATE_LOG: CPU utilization rate in one minute: 95%. rl_con occupied most CPU utilization rate: 94%.

If the CPU utilization is lower than 70%, the following information is displayed:

Oct 20 15:47:01 %SYSCHECK-5-CPU_USING_RATE_LOG: CPU utilization rate in one minute: 68%. rl_con occupied most CPU utilization rate: 60%.

Oct 20 15:47:01 %SYSCHECK-5-CPU_USING_RATE_LOG: The CPU utilization ratio has been decreased.

Configuring System Memory Display

Showing the Usage of System Memory

Use the **show memory** command to show the usage and status of system memory:

Command	Function
Ruijie# **show memory**	Shows the usage of system memory.

The switch name is Ruijie by default.

Below is the result of executing this command:

```
Ruijie#show memory
System Memory Statistic:
  Free pages: 174164
    watermarks : min 2012, lower 4024, low 6036, high 9048
  System Total Memory : 1024MB, Current Free Memory : 740580KB
  Used Rate : 29%
```

The above information includes:

Parameter		Description
Free pages		The total free pages of all areas.
watermarks	min	Memory resources are extremely insufficient. It can only keep the kernel running. All application modules fails to run if the minimum watermark has been reached.
	lower	Memory resources are severely insufficient. One route protocol will auto-exit and release the memory if the lower watermark has been reached. For the details, see the **memory-lack exit-policy** command.
	low	Memory resources are insufficient. The route protocol will be in OVERFLOW state if the low watermark has been reached. In the overflow state, the routers do not learn new routes any more. The commands are not allowed to be executed when the memory lacks.
	high	There is plenty of memory resources. Each route protocol restores the state from OVERFLOW to normal.
System Total Memory		System total memory
System Free Memory		System free memory, including free pages space and all free space in the cache pool
Used Rate		Memory utilization rate

Configuring MIB

MIB Lists

The followings are the supported standard MIBs:

- BRIDGE-MIB (RFC1493)
- EtherLike-MIB(RFC1643)
- IF-MIB(RFC2863)
- RFC1213-MIB
- RMON1-MIB(supports RMON etherStats, etherHistory,alarms, events)
- SNMPv2-MIB
- SNMPv3-MIB(supports USM, VACM)

The followings are the private MIBs:

- RUIJIE-AAA-MIB
- RUIJIE -ENTITY-MIB
- RUIJIE -RIP-MIB
- RUIJIE -MEMORY-MIB

You can use the **show snmp mib** command to view the supported MIBs in the current system:

```
Ruijie# show snmp mib
sysDescr
sysObjectID
sysUpTime
sysContact
sysName
sysLocation
sysServices
sysORLastChange
ifNumber
ifEntry
ifEntry.ifIndex
ifEntry.ifDescr
ifEntry.ifType
ifEntry.ifMtu
ifEntry.ifSpeed
ifEntry.ifPhysAddress
ifEntry.ifAdminStatus
ifEntry.ifOperStatus
ifEntry.ifLastChange
ifEntry.ifInOctets
ifEntry.ifInUcastPkts
ifEntry.ifInNUcastPkts
ifEntry.ifInDiscards
ifEntry.ifInErrors
```

```
ifEntry.ifInUnknownProtos
ifEntry.ifOutOctets
ifEntry.ifOutUcastPkts
ifEntry.ifOutNUcastPkts
ifEntry.ifOutDiscards
ifEntry.ifOutErrors
ifEntry.ifOutQLen
ifEntry.ifSpecific
......
```

Obtaining the MIB Files

You can obtain the standard MIB information on the http://ietf.org/rfc.html.
You can obtain the private MIB information on the website.

Configuring One-click Upgrade

Understanding One-click Upgrade

Basic Concepts

One-click upgrade means that a user presses the **FUNC** key on the device panel to reset the system. Before the system reset, the user can individually upgrade the software version or configuration file by using the files stored in an SD card or USB drive or upgrade the software version and configuration file at the same time. Specifically, one-click upgrade provides the following functions:

- One-click system reset
- One-click upgrade of software version and configuration file

One-click System Reset

When no SD card or USB drive is inserted into the device or when an SD card or a USB drive is inserted but no appropriate software version or configuration file is available in the SD card or USB drive for upgrade, the user resets the system by pressing the **FUNC** key to the original software version.

One-click Upgrade of Software Version and Configuration File

When an SD card or a USB drive is inserted into the device and the user presses the **FUNC** key, the system scans for the installation package and configuration file in turn in the root directory of the SD card or USB drive. After finding the installation package and configuration file, the system first performs a validity check and then upgrades the device by using the installation package and configuration file if the installation package and configuration file are valid. After the upgrade is complete, the system resets by using the new software version and configuration file.

Though old line cards do not provide the **FUNC** key, so long as the corresponding software is available, one-click upgrade of the software version and configuration file can be triggered through a configuration command. The upgrade triggered by using a configuration command is the same as that by pressing the **FUNC** key. The system scans for the installation package and configuration file in turn in the root directory of the SD card or USB drive. After finding the installation package and configuration file, the system first performs a validity check and then upgrades the device by using the installation package and configuration file if the installation package and configuration file are valid. After the upgrade is successful, the system resets.

Note When scanning the inserted storage media, the system scans the SD card in preference. If no SD card is inserted or the SD card does not store an appropriate installation package or configuration file, the system scans the USB drive. If the inserted SD card and USB drive do not store an appropriate installation package or configuration file, the software version and configuration file of the device are not upgraded and only the system resets. The system still starts by using the original software version and configuration file.

Caution

- The installation package supports the following four filename formats:
  - *rgos.bin*
  - *Product name_project name_serial number_install.bin*
    For example: RSR77_10.4(3b21)_R166400_install.bin
  - *P product name V1_project name_serial number_install.bin*
    For example: PRSR77V1_10.4(3b21)_R166400_install.bin
  - *P product name v1-version number-install.bin*
    For example: prsr77v1-101939-install.bin
- A product name consists of digits, uppercase, lowercase, and '-'; a version number consists of digits; a project name consist of digits, lowercase, '(', and ')'; a serial number consists of "R" and the version number. The product name in an old installation package is case-insensitive; in a new installation package, the product name is case-sensitive and the configuration file is provided in the form of an encrypted file, for example, **config.des**.
- If a **rgos.bin** file exists, the system uses the file in preference; otherwise, the system uses the first scanned installation package that meets the naming rules in preference.
- The system scans only for the installation package and configuration file in the root directory of the SD card or USB drive and always scans the SD card in preference.
- It is recommended that only one installation package be stored in the root directory of the SD card of USB drive. If multiple installation packages are stored, the system randomly scans for the installation package and takes the first scanned installation package for upgrade, which cannot ensure the correct sequence of searching for the software version.
- The installation package and configuration file must be stored on the same storage medium. If the installation package and configuration file are located in the SD card and USB drive respectively, only the file in the SD card is upgraded.
- Before upgrading the configuration file, you must ensure that the flash memory has sufficient space for storing the configuration file to be upgraded. The size of the configuration file depends on the configuration and is generally not smaller than 1 MB.
- Before upgrading the installation package, you must ensure that the flash memory has sufficient space for storing the installation package to be upgraded. The size of the installation package is generally not smaller than 30 MB.
- Before performing the **FUNC** key triggered one-click upgrade, you must ensure that all line cards are started, that is, the **SYS** indicators of boards become green. For specific positions of **SYS** indicators, see the *Hardware Installation Manual*.
- When using one-click upgrade based on the **FUNC** key, you must ensure that an SD card or USB drive is inserted and the device detects the SD card or USB drive, that is, the indicator of the SD card or USB drive becomes green. For the specific position of the indicator, see the *Hardware Installation Manual*.
- After one-click upgrade is complete, the device resets automatically. If one-click upgrade fails, the indicator of the SD card or USB drive is off and the status indicator becomes red for three seconds. No matter whether the device is upgraded successfully or not, if the SD card or USB drive stores a file that can be used for upgrade, the system generates a Syslog file whose format is "product name-update.log" in the root directory of the SD card or USB drive.
- The function of triggering one-click upgrade through a configuration command requires the software version to be 10.4(3b21) or later.

When scanning the inserted storage media, the system scans the SD card in preference. If no SD card is inserted or the inserted SD card does not store an appropriate installation package or configuration file, the system scans the USB drive. If the inserted SD card and USB drive do not have an appropriate installation package or complete configuration file, the software version and configuration file of the device are not upgraded and only the system resets. The system still starts by using the original software version and configuration file.

Encryption of Configuration File

The configuration file contains confidential information of the user. Therefore, security protection measures must be taken to avoid disclosure of the information. Ruijie's one-click upgrade function provides a tool on the PC side to realize file encryption. That is, the configuration file is encrypted during transmission. When the device performs one-click upgrade, the device reads the encrypted configuration file in the SD card or USB drive and decrypts the configuration file. After successfully decrypting the configuration file, the device upgrades the configuration file; when the device fails to decrypt the configuration file, the configuration file is used incorrectly or the file is damaged during transmission. In this case, the device does not upgrade the configuration file.

For instructions on the encryption tool on the PC side for Ruijie's one-click upgrade function, see the *PC Client Configuration for One-click Upgrade*.

Backup of Configuration File

Upgrading the configuration file is an irreversible operation. If you find an error in upgrading the configuration file and want to restore to the previous configuration, you must upgrade the configuration file again. To help the user obtain the configuration file before upgrade, before one-click upgrade is performed, the configuration file is encrypted and stored in an SD card or USB drive as follows: root directory/update_backup/date_time_config.des (if the same file is found in the directory, the file is overwritten). The configuration file of the device is backed up only when the SD card or USB drive stores the available installation package or configuration file. If the SD card or USB drive does not store any installation package or configuration file for upgrade, the configuration file of the device is not backed up. Before using this function, ensure that the SD card has enough space to store the configuration file. The required storage space depends on the configuration and is generally not smaller than 1 MB.

When you find that the configuration file is upgraded incorrectly, copy the **date_time_config.des** file in **/update_backup** under the root directory of the device to the root directory of the SD card or USB drive, rename it **config.des**, and perform one-click upgrade once again to restore the previous configuration.

The configuration file that is backed up can be used by only the device that generates the configuration file to ensure that the backed up configuration file is not incorrectly used on other devices.

Synchronization of Configuration File

The configuration file running on the device must be the same as the configuration file stored in the SD card or USB drive so that the device is replaced directly and the network is restored quickly for the user by using one-click upgrade when the device is faulty. To meet this requirement, when you modify and save the configuration, the device automatically encrypts the configuration file and synchronizes it to the **config.des** file in the root directory of the SD card. If the file already exists

in the root directory, the file is overwritten. Before applying this function, ensure that the SD card has enough space to store the configuration file. The required storage space depends on the configuration and is generally not smaller than 1 MB.

The configuration file is synchronized only when you save the configuration. When you modify the device configuration in other modes (for example, rename the existing configuration file and copy other configuration files to the flash memory), the device does not synchronize the configuration file.

The synchronized configuration file can be used on any device that supports one-click upgrade, but you need to ensure that the configuration is applicable to the device.

Synchronization of Installation Package

The configuration file running on the device must be consistent with the configuration file stored in the SD card or USB drive so that the device can be replaced directly and the network can be restored quickly by using one-click upgrade when the device is faulty. To meet this requirement, when you upgrade the installation package, the device automatically synchronizes the installation package to the **rgos.bin** file in the root directory of the SD card. If the file already exists in the root directory, the file is overwritten. Before using this function, ensure that the SD card has enough space to store the installation package. The required storage space depends on the size of the installation package and is generally not smaller than 50 MB.

The installation package is synchronized only when you run the **copy tftp** command. When you upgrade the installation package in other modes (for example, rename the existing installation package and copy files in other SD cards or USB drives to the flash memory), the device does not synchronize the installation package.

Working Principle

The **FUNC** key is available on the device panel. If you press the **FUNC** key, the system interrupts the current task and executes the corresponding task. During execution of the task triggered by the **FUNC** key, the system checks whether an SD card or a USB drive is inserted into the current device. If not, the system resets directly. Otherwise, the system first checks whether an SD card is inserted prior to a USB drive. Each time when the system scans a storage medium (SD card or USB drive), the system checks whether an installation package matching the specified file format exists in the root directory of the storage medium and whether the **config.des** file exists in the root directory. If the file exists, the system decrypts the file and performs a validity check on the file. If the check on the installation package and configuration file is successful, the system upgrades the software version and configuration file of the device and then resets by using the new software version and configuration file after the upgrade is complete. If no applicable installation package or configuration file exists or the installation package and configuration file do not pass the validity check, the system does not upgrade the installation package or configuration file and directly resets by using the original software version and configuration file.

According to the preceding description, in addition to the default one-click system reset based on the **FUNC** key, the one-click upgrade function also supports upgrading the software version and configuration file of a device by using a new software version and configuration file stored in an SD card or a USB drive. This provides another convenient means for the user to reset the system and upgrade the software version.

Different from the traditional mode in which the user logs in to the device through the console port or telnet to perform reset and upgrade, one-key upgrade enables users to reset the device and upgrade the software version and

configuration file, without knowing fundamental knowledge about the device. Therefore, users in remote areas without any technical basis can operate and use access routers. When the original software version and configuration file need to be upgraded, only an SD card or a USB drive storing the installation package and configuration file of the new software version needs to be delivered. The customer even without knowing fundamental knowledge about the device can perform the operation and technical personnel do not need to operate on site. This greatly saves the cost of maintenance and the time of technical personnel.

Protocols and Standards

None

Default Configuration

None

Configuring One-click Upgrade

Triggering One-click Upgrade by Using a Command

Command	Function
Ruijie**#onekey**	Enables one-click upgrade.

☑ RSR77 series of version 10.4(3b21) and later support this function.

Displaying Configuration

None

Configuration Example 1

One-click system reset

Networking Requirements

None

Networking Topology

None

Configuration Tips

None

Configuration Steps

Press the **FUNC** key to reset the system when all the **SYS** indicators of boards are green.

Verification

After the system resets, run the **show version** command to check whether the software version of the system is the same as that before the system resets.

Configuration Example 2

One-click upgrade of software version and configuration file

Networking Requirements

None

Networking Topology

None

Configuration Tips

None

Configuration Steps

1) Insert the SD card or USB drive storing the installation package of the new software version into the device (pay attention to the file format. For details, see “One-click Upgrade of Software Version and Configuration File”).
2) Press the **FUNC** key when the **SYS** indicators of all boards are green. The system performs software upgrade and then resets.

Verification

If the SD card or USB drive stores an appropriate configuration file or installation package and the upgrade is successful, the device resets automatically after the upgrade is complete.

If the SD card or USB drive does not store an appropriate configuration file or installation package, as a result of which the upgrade fails, the **SYS** indicators of the device become red for three seconds and then the device resets. For specific positions of **SYS** indicators, see the *Hardware Installation and Reference Guide*.

After the system resets, run the **show version** command to check whether the software version of the system is updated.

Configuring Flow Platform

Understanding the Flow Platform

Overview

The flow platform achieves a perfect combination of services and performance, because services (such as QoS, ACL, NAT, and PBR) enabled on a service processing board have nearly no impact on forwarding performance.

Basic Concepts

Service packets based on Layer 3 usually can be abstracted as flows. A flow identifies a sequence of packets from a specific source to a specific destination. Generally, a flow is indentified by a sextuplet, which includes a source address, a destination address, a source port ID, a destination port ID, a transport layer protocol, and VRF.

Working Principle

When the first packet is forwarded through an entire routing process and service processing, the sextuplet of the packet identifies a flow. If a packet received later matches the sextuplet, it is forwarded in the same way as the first packet. The sextuplet and an outbound interface of the packet compose a flow entry. Packets that match the flow entry are forwarded directly without experiencing the entire routing process or service processing any longer. Therefore, enabled services (such as QoS, ACL, NAT, and PBR) have nearly no impact on forwarding performance.

Protocols and Standards

None.

Typical Application

When services (such as QoS, ACL, NAT, and PBR) are enabled, the flow platform is automatically enabled to accelerate service processing.

Configuring the IPv4 Function of the Flow Platform

Default Configuration

The following table describes the default configuration of the flow platform.

Feature	Default Setting
Flow platform	Disabled

Flow overflow alarm interval of the flow platform	5 seconds
Flow overflow alarm threshold of the flow platform	95%
Maximum number of flow entries in the IPv4 flow table	180,223

Prerequisites

When service modules (such as QoS, ACL, NAT, and PBR service modules) that rely on the flow platform are configured, the flow platform is automatically enabled.

Configuration Steps

Step	Configuration Task	Description
Step 1	Configure service modules.	(Mandatory) You can configure service modules such as QoS, ACL, NAT, and PBR.
Step 2	Configure the maximum number of flow entries in the IPv4 flow table.	(Optional) This step is performed if you need to change the memory occupied by the flow table.
Step 3	Configure the IPv4 flow overflow alarm interval of the flow platform.	(Optional) This step is performed if you need to change the flow overflow alarm interval.
Step 4	Configure the IPv4 flow overflow alarm threshold of the flow platform	(Optional) This step is performed if you need to change the flow overflow alarm threshold.

Configuring ACL to Enable the Flow Platform

Command	Function

Ruijie(config)# **access-list** *id* { **deny | permit** } { src *src-wildcard* | **host** *src* | **any** } [**time-range** *tm-rng-nam e*] [**log**]	Defines an ACL.
Ruijie(config)# **interface** *interface*	Specifies the interface to which the ACL is applied.
Ruijie(config-if)# **ip access-group** *id* { in | out } [**unreflect**]	Applies the ACL to the specific interface.

The following example enables the ACL function on the port GigabitEthernet 0/1.

```
Ruijie# configure terminal

Enter configuration commands, one per line. End with CNTL/Z.

Ruijie(config)# access-list 101 permit tcp 192.168.12.0 0.0.0.255 any

Ruijie(config)# interface GigabitEthernet 0/1

Ruijie(config-if)# ip address 192.168.12.1 255.255.255.0

Ruijie(config-if)# ip access-group 101 in
```

Configuring the Maximum Number of Flow Entries in the IPv4 Flow Table

Command	**Function**
Ruijie(config)# **ip fpm flow max-entries** *flow-number*	Configures the maximum number of flow entries in the IPv4 flow table.

The following example configures the maximum number of IPv4 flow entries as 120,000.

```
Ruijie# configure terminal

Enter configuration commands, one per line.  End with CNTL/Z.

Ruijie(config)# ip fpm flow max-entries 120000

FPM subsystem is reinitializing...

Ruijie(config)#*Oct  6 17:35:21: %FPM-5-RESTARTED: The device IPv4 flow max-entries changed.
```

Configuring the IPv4 Flow Overflow Alarm Interval of the Flow Platform

Command	Function
Ruijie(config)# **ip fpm flow alert interval** *seconds*	Configures the IPv4 flow overflow alarm interval of the flow platform.

The following example configures the IPv4 flow overflow alarm interval of the flow platform as 120s.

```
Ruijie# configure terminal

Enter configuration commands, one per line. End with CNTL/Z.

Ruijie(config)# ip fpm flow alert interval 120
```

Configuring the IPv4 Flow Overflow Alarm Threshold of the Flow Platform

Command	Function
Ruijie(config)# **ip fpm flow alert threshold** *percent-value*	Configures the IPv4 flow overflow alarm threshold of the flow platform.

The following example configures the IPv4 flow overflow alarm threshold of the flow platform as 80%.

```
Ruijie# configure terminal

Enter configuration commands, one per line. End with CNTL/Z.

Ruijie(config)# ip fpm flow alert threshold 80
```

Configuring the IPv6 Function of the Flow Platform

Default Configuration

The following table describes the default configuration of the flow platform.

Feature	Default Setting
Flow platform	Disabled

Flow overflow alarm interval of the flow platform	5 seconds
Flow overflow alarm threshold of the flow platform	95%
Maximum number of flow entries in the IPv6 flow table	81,920

Prerequisites

When service modules (such as QoS v6, ACLv6, NAT64, and PBRv6 service modules) that rely on the flow platform are configured, the flow platform is automatically enabled.

Configuration Steps

Step	Configuration Task	Description
Step 1	Configure service modules.	(Mandatory) You can configure service modules such as QoS v6, ACLv6, NAT64, and PBRv6.
Step 2	Configure the maximum number of flow entries in the IPv6 flow table.	(Optional) This step is performed if you need to change the memory occupied by the flow table.
Step 3	Configure the IPv6 flow overflow alarm interval of the flow platform.	(Optional) This step is performed if you need to change the flow overflow alarm interval.
Step 4	Configure the IPv6 flow overflow alarm threshold of the flow platform.	(Optional) This step is performed if you need to change the flow overflow alarm threshold.

Configuring ACLv6 to Enable the Flow Platform

Command	Function
Ruijie(config)# **ipv6 access-list** *name*	Enters ACL configuration mode.

Ruijie (config-ipv6-nacl)#[*sn*] {**permit** | **deny** } *port* { *src-ipv6-prefix/prefix-len* | **host** *src-ipv6-addr* | **any** } { *dst-ipv6-pfix/pfix-len* | **any** | **host** *dst-ipv6-addr* } [**dscp** *dscp*] [**flow-label** *flow-label*] [**fragments**] [**range** lower upper] [**time-range***tm-rng-name*]	Adds an entry to the ACL. For details about the command, see the Command Reference.
Ruijie(config-exp-nacl)# **exit**	Exits ACL configuration mode.
Ruijie(config)# **interface** *interface*	Specifies the interface to which the ACL is applied.
Ruijie(config-if)# **ipv6 traffic-filter** *name* { **in** | **out** }	Applies the ACL to the specific interface.

The following example enables the ACL function on the port GigabitEthernet 0/1.

```
Ruijie# configure terminal

Enter configuration commands, one per line. End with CNTL/Z.

Ruijie(config)# ipv6 access-list v6-list

Ruijie(config-ipv6-acl)# permit ipv6 2001:db8:1::1/64 any

Ruijie(config-ipv6-acl)# deny ipv6 any any

Ruijie(config-ipv6-acl)# exit

Ruijie(config)# interface GigabitEthernet 0/1

Ruijie(config-if)# ipv6 traffic-filter v6-list in
```

Configuring the Maximum Number of Flow Entries in the IPv6 Flow Table

Command	**Function**
Ruijie(config)# **ipv6 fpm flow max-entries** *flow-number*	Configures the maximum number of flow entries in the IPv6 flow table.

The following example configures the maximum number of flow entries in the IPv6 flow table as 70,000.

```
Ruijie# configure terminal
```

```
Enter configuration commands, one per line. End with CNTL/Z.

Ruijie(config)# ipv6 fpm flow max-entries 70000

FPM subsystem is reinitializing...

Ruijie(config)#*Oct  6 17:35:21: %FPM-5-RESTARTED: The device IPv6 flow max-entries changed.
```

Configuring the IPv6 Flow Overflow Alarm Interval of the Flow Platform

Command	Function
Ruijie(config)**#ipv6 fpm flow alert interval** *seconds*	Configures the IPv6 flow overflow alarm interval of the flow platform.

The following example configures the IPv6 flow overflow alarm interval of the flow platform as 120s.

```
Ruijie# configure terminal

Enter configuration commands, one per line. End with CNTL/Z.

Ruijie(config)#ipv6 fpm flow alert interval 120
```

Configuring the IPv6 Flow Overflow Alarm Threshold of the Flow Platform

Command	Function
Ruijie(config)# **ipv6 fpm flow alert threshold** *percent-value*	Configures the IPv6 flow overflow alarm threshold of the flow platform.

The following example configures the IPv6 flow overflow alarm threshold of the flow platform as 80%.

```
Ruijie# configure terminal

Enter configuration commands, one per line. End with CNTL/Z.

Ruijie(config)# ipv6 fpm flow alert threshold 80
```

Monitoring and Maintaining the Flow Platform

Command	Function
Ruijie**#clear ip fpm counters**	Clears IPv4 packet statistics of the flow platform.
Ruijie**#clear ip fpm flows**	Clears the IPv4 flow table of the flow platform.
Ruijie(config)# **ip fpm flow alert interval** *seconds*	Configures the IPv4 flow overflow alarm interval of the flow platform.
Ruijie(config)# **ip fpm flow alert threshold** *percent-value*	Configures the IPv4 flow overflow alarm threshold of the flow platform.
Ruijie(config)**#ip fpm flow max-entries** *flow-number*	Configures the maximum number of flow entries in the IPv4 flow table.
Ruijie(config)**#ip fpm frq** *queue-number*	Configures the number of concurrent IPv4 fragment reassembly queues.
Ruijie(config)**ip fpm session filter** *acl-number*	Protects the IPv4 flow table against attacks.
Ruijie**#show ip fpm counters**	Displays IPv4 packet counters of the flow platform.
Ruijie**#show ip fpm flows** [**filter** *protocol-number src-ip src-mask dst-ip dst-mask*]	Displays the IPv4 flow table.
Ruijie**#show ip fpm statistics**	Displays IPv4 statistics of the flow platform.
Ruijie**#show ip fpm users**	Displays the number of IPv4 user connections of the flow platform.
Ruijie**#clear ipv6 fpm flows**	Clears the IPv6 flow table of the flow platform.
Ruijie**#clear ipv6 fpm statistics**	Clears IPv6 statistics of the flow platform.

Ruijie(config)**ipv6 fpm flow alert interval** *seconds*	Configures the IPv6 flow overflow alarm interval of the flow platform.
Ruijie(config)**ipv6 fpm flow alert threshold** *percent-value*	Configures the IPv6 flow overflow alarm threshold of the flow platform.
Ruijie(config)**ipv6 fpm flow max-entries** *flow-number*	Configures the maximum number of flow entries in the IPv6 flow table.
Ruijie(config)**ipv6 fpm frq** *queue-number*	Configures the number of concurrent IPv6 fragment reassembly queues.
Ruijie(config)**ipv6 fpm session filter** *acl-name*	Protects the IPv6 flow table against attacks.
Ruijie**#show ipv6 fpm statistics**	Displays IPv6 statistics of the flow platform.
Ruijie**#show ipv6 fpm statistics fragment**	Displays IPv6 fragment reassembly statistics of the flow platform.
Ruijie**#show ipv6 fpm flows** [**filter** *protocol-number src-ip dst-ip*]	Displays the IPv6 flow table.

Configuration Examples

Example of IPv4 Configuration of the Flow Platform

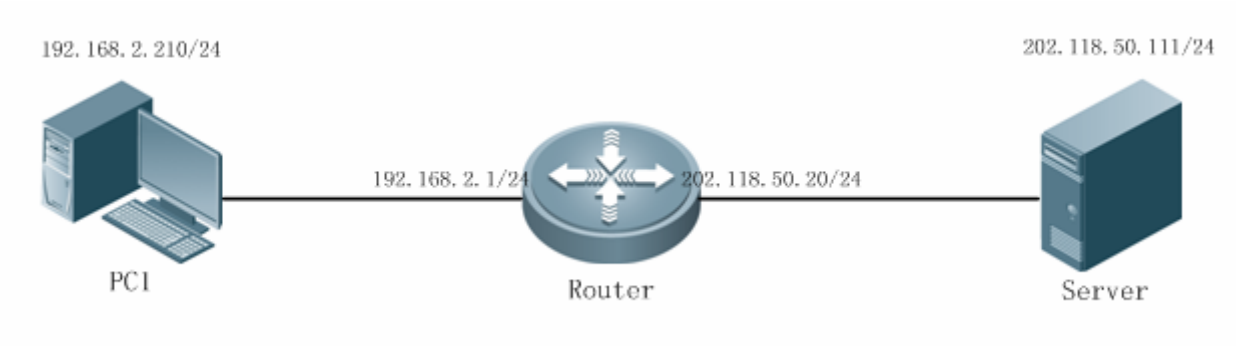
Networking Requirements

As shown in Figure 1-1, a router is connected to a PC and a server. Configure the ACL function on the router to implement the following functions:

- Enable the flow platform on the router.
- Adjust the maximum number of flow entries in the IPv4 flow table of the flow platform on the router.
- Protect the IPv4 flow table on the router by allowing flow establishment for only IP packets from the network segment 192.168.2.0/24 instead of packets from other network segments.
- Configure the IPv4 flow overflow alarm interval as 30s and the IPv4 flow overflow alarm threshold as 80% on the router.

Networking Topology

Figure 1-1 Example of IPv4 Configuration of the Flow Platform



Configuration Tips

None.

Configuration Steps

- Apply the ACL function to the loopback interface on the router to enable the flow platform.

```
Ruijie # configure terminal

Ruijie(config)# ip access-list standard 1

Ruijie(config-std-nacl)# permit any

Ruijie(config-std-nacl)# exit

Ruijie(config)# interface Loopback 0

Ruijie(config-if-Loopback 0)# ip access-group 1 in

Ruijie(config-if-Loopback 0)# exit
```

- Configure the maximum number of flow entries in the IPv4 flow table as 100,000.

```
Ruijie(config)#  ip fpm flow max-entries 100000

FPM subsystem is reinitializing...

Ruijie(config)#*Oct  6 17:35:21: %FPM-5-RESTARTED: The device IPv4 flow max-entries changed.
```

- Configure an ACL numbered 2 on the router so as to protect the IPv4 flow table against attacks.

```
Ruijie(config)#  ip access-list standard 2

Ruijie(config-std-nacl)# permit 192.168.2.0 0.0.0.255
```

```
Ruijie(config-std-nacl)# exit

Ruijie(config)# ip fpm session filter 2
```

- Configure the IPv4 flow overflow alarm interval as 30s and the IPv4 flow overflow alarm threshold as 80% on the router.

```
Ruijie(config)# ip fpm flow alert interval 30

Ruijie(config)# ip fpm flow alert threshold 80
```

Verification

Run the **ping 202.118.50.111 ntimes 1** command on PC 1.

```
C:\>ping 192.168.50.1 -n 1

Pinging 202.118.50.111 with 32 bytes of data:

Reply from 202.118.50.111: bytes=32 time=1ms TTL=64

Ping statistics for 202.118.50.111:

   Packets: Sent = 1, Received = 1, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

   Minimum = 1ms, Maximum = 1ms, Average = 1ms
```

Run the **show ip fpm flows** command on the router. A flow entry is generated during the ping operation.

Construct a packet with a source IP address in another network segment on PC 1, and send the packet to 202.118.50.111. No corresponding flow entry can be seen in the flow table on the router.

Example of IPv6 Configuration of the Flow Platform

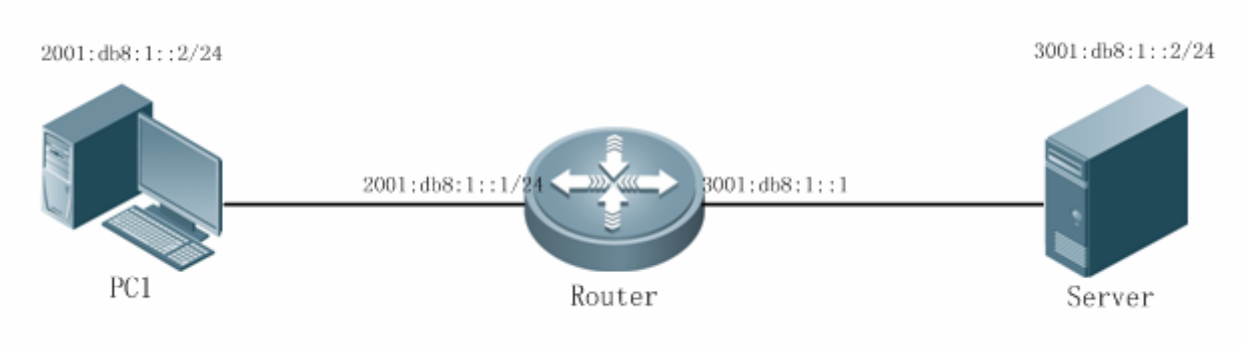
Networking Requirements

As shown in Figure 1-2, a router is connected to a PC and a server. Configure the ACL function on the router to implement the following functions:

- Enable the flow platform on the router.
- Adjust the maximum number of flow entries in the IPv6 flow table of the flow platform on the router.
- Protect the IPv6 flow table on the router by allowing flow establishment for only IP packets from the network segment 2001:db8:1::2/64 instead of packets from other network segments.
- Configure the IPv6 flow overflow alarm interval as 30s and the IPv6 flow overflow alarm threshold as 80% on the router.

Networking Topology

Figure 2-1 Example of IPv6 Configuration of the Flow Platform



Configuration Tips

None

Configuration Steps

3) Apply the ACL function to the loopback interface on the router to enable the flow platform.

```
Ruijie # configure terminal

Ruijie(config)# ip access-list standard 1

Ruijie(config-std-nacl)# permit any

Ruijie(config-std-nacl)# exit

Ruijie(config)# interface Loopback 0

Ruijie(config-if-Loopback 0)# ip access-group 1 in

Ruijie(config-if-Loopback 0)# exit
```

4) Configure the maximum number of flow entries in the IPv6 flow table as 100,000.

```
Ruijie(config)# ipv6 fpm flow max-entries 100000

FPM subsystem is reinitializing...

Ruijie(config)#*Oct  6 17:35:21: %FPM-5-RESTARTED: The device IPv6 flow max-entries changed.
```

5) Configure an IPv6 ACL named "virus_filter" on the router to protect the IPv6 flow table against attacks.

```
Ruijie(config)# ipv6 access-list virus_filter
```

```
Ruijie(config-ipv6-acl)# permit ipv6 2001:db8:1::/64 any

Ruijie(config-ipv6-acl)# permit icmp 2001:db8:1::/64 any

Ruijie(config)# ipv6 fpm session filter virus_filter
```

6) Configure the IPv6 flow overflow alarm interval as 30s and the IPv6 flow overflow alarm threshold as 80% on the router.

```
Ruijie(config)# ipv6 fpm flow alert interval 30

Ruijie(config)# ipv6 fpm flow alert threshold 80
```

Verification

Run the **ping 3001:db8:1::2 ntimes 1** command on PC 1.

```
Ruijie#ping 3001:db8:1::2 ntimes 1

Sending 1, 100-byte ICMP Echoes to 3001:db8:1::2, timeout is 2 seconds:

  < press Ctrl+C to break >

!

Success rate is 100 percent (1/1), round-trip min/avg/max = 10/10/10 ms
```

Run the **show ipv6 fpm flows** command on the router. A flow entry is generated during the ping operation.

Construct a packet with a source IP address in another network segment on PC 1, and send the packet to 3001:db8:1::2. No corresponding flow entry can be seen in the flow table on the router.

RGOS Configuration Guide

v10.4(3b13)

Interface Configuration

Configuring Interfaces

Interface Overview

RSR series devices supports two types of interfaces: physical interfaces and logical interfaces. A physical interface is an interface that has a corresponding physical hardware port on the device, for example, an Ethernet interface, sync serial interface, async serial interface, or ISDN interface.

A logical interface is an interface that has no corresponding physical hardware port on the device. A logical interface can be associated with a physical interface or independent of a physical interface. For example, dialer interfaces, Null interfaces, loopback interfaces, and sub-interfaces are logical interfaces. For network protocols, physical interfaces and logical interfaces are treated in the same way.

Ruijie series devices support the following types of interfaces:

Interface Type	Interface Configuration Name	Standard Compliance
Async serial port	Async	EIA/TIA RS-232
Sync serial port	Serial	V.24, V.35, EIA/TIA-449, X.21, EIA-530
Fast Ethernet interface	FastEthernet GigabitEthernet Aggregateport	IEEE802.3, RFC894
E1/CE1 port	E1	G.775, G.704, G.706, G.732
ISDN S/T port	BRI	ITU-T I.430
ISDN U port	BRI	G.961, ANSI T1.601
Dialer interface	dialer	—
Loopback interface	Loopback	—
NULL interface	NULL	—
Sub-interface	Serial0.1 (example)	—
Async serial port group	Group-Aync	—

Configuring Common Interfaces

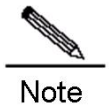
Entering Interface Configuration Mode

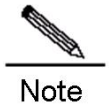
Before you configure an interface, use the following commands to first enter global configuration mode and then enter interface configuration mode.

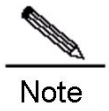
Command	Function
Ruijie(config)# **interface** *interface-type interface-number*	Creates an interface and enters interface configuration mode.
Ruijie(config)# **no interface** *interface-type interface-number*	Deletes the specified interface.

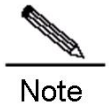
For example, to enter port 0 of slot 0 of the Fast Ethernet, perform the following steps:

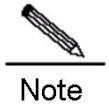
```
Ruijie# config terminal
Ruijie(config)# interface FastEthernet 0/0
```


Note For the names of various interface types, see the interface type table above.


Note For a sync, Ethernet, or ISDN port, the interface number consists of a slot number and a port number. For example, the third port of the sync interface module in slot 2 is represented as Serial 2/3.


Note For E1/CE1 interfaces, the interface number consists of a slot number, port number and a channel number. For example, the first channel group of the third port of the E1/CE1 module in slot 2 is represented as serial 2/3:1.


Note Both the sync serial port and auxiliary port belong to Async interfaces. The interfaces are numbered in a way that the auxiliary interfaces come after the async serial ports. For example, when one 8-async port subcard is inserted into the device, async ports 1-8 are numbered from Async 1 to Async 8 and the auxiliary port is numbered Async 9. If there is not any async serial port module on the device, the number of the auxiliary port is Async 1.


Note Some interfaces have features. When you create and enter such an interface, you can specify its features. For example, to enter the frame relay point-to-point sub-interface, use the interface serial 1/0.1 point-to-point command.

Configuring IP Addresses

Except the NULL interface, every interface has its own IP address. Therefore, you must configure an IP address for an interface before you use the interface.

Use the following commands to configure or delete the IP address of an interface.

Command	Function
Ruijie(config-if)# **ip address** *ip-address ip-mask*	Configures the IP address of an interface.
Ruijie(config-if)# **no ip address**	Deletes the IP address of the interface.

For the details about IP address configuration, see the related chapter in the *IP Address and Service Configuration Guide*.

Configuring Interface Descriptions

Interface descriptions are used to identify interfaces.

Use the following commands to configure an interface description in interface configuration mode.

Command	Function
Ruijie(config-if)# description *interface-description*	Describes the purpose of the specified interface, which is a string of up to 80 characters.
Ruijie(config-if)# no description	Deletes the description of the interface.

Setting the Maximum Transmit Unit (MTU)

The MTU is a feature of IP packets. It ranges from 64 to 65535 bytes depending on the interface type. Use the following commands to set the MTU.

Command	Function
Ruijie(config-if)# **mtu** *bytes*	Configures the MTU size.
Ruijie(config-if)# **no mtu**	Restores the default value of the MTU.

Configuring Bandwidth

The bandwidth is used for some routing protocols such as OSPF to calculate the route metric and for RSVP to calculate the reserved bandwidth. Modifying the interface bandwidth will not affect the data transmission rate of the physical interface.

Use the following commands to configure the bandwidth of an interface in interface configuration mode.

Command	Function
Ruijie(config-if)# **bandwidth** *kilobits*	Configures the bandwidth
Ruijie(config-if)# **no bandwidth**	Removes the settings of the bandwidth.

Configuring the Queue Size on an Interface

The Hold-Queue allows you to modify the size of the incoming and outgoing queues of each interface. This parameter can adjust the ability of the interface to process burst data.

Use the following commands to configure the size of the incoming and outgoing queues of an interface in interface configuration mode.

Command	Function
Ruijie(config-if)# **Hold-Queue l***ength* {**in** | **out**}	Configures the size of the incoming and outgoing queues of an interface.
Ruijie(config-if)# **no Hold-Queue**	Removes the settings.

However, adjusting the size of the incoming and outgoing queues of the interface will increase network delay, which may affect real-time interactive applications. Unless necessary, it is not recommended that you modify the sizes of queues on an interface.

Fixing the Interface Index

Use the **snmp-server if-index persist** command to fix the interface index when there is no need to change the index after creating or deleting the interface. Use the **no** form ofthis command to disable the setting.

Command	Function
Ruijie(config-if)# **snmp-server if-index persist**	Enables the function of fixing interface index.
Ruijie(config-if)# **no snmp-server if-index persist**	Disables the function of fixing interface index.

Configuration example

The following example fixes the interface index.

```
Ruijie(config)# snmp-server if-index persist

Ruijie(config)#
```

Monitoring and Maintaining Interfaces

Monitoring the Status of the Interface and Controller

Command	Function
Ruijie# **show interface** [**Serial** | **Async** | **FastEthernet** | …]	Shows the transmission feature and protocol feature of the interface.

The states of the interfaces encapsulated with different link layer protocols may have some different contents when shown. See the *WAN Protocol Configuration Guide* for the monitoring and maintaining commands of various WAN protocols. For example, when the interface is encapsulated with frame relay, the **show interface serial** *2/0* command will show interface information about frame relay.

Clearing and Resetting Interface Counters

The statistics on the interface vary with the change of communication. Sometimes, to avoid the interference of communication statistics, you need to clear the statistics of the interface, so that the current statistics can faithfully reflect the current communication state of the interface.

Command	Function
Ruijie# Clear counters [**serial**] | [**async**] | [**FastEthernet**] | …	Clears the communication statistics counter of the interface shown by using the show interface command to 0.
Ruijie# **Clear interface** [**serial**] | [**async**] | [**FastEthernet**] | …	Clears all state values of an interface.

For example, before you use the **clear counter** command, use the **show interface serial *1/0*** command to show information about the interface:

```
Ruijie# show interface serial 1/0
serial 1/0 is DOWN  , line protocol is DOWN
Hardware is Infineon DSCC4 PEB20534 H-10 serial
Interface address is: 192.168.10.10/24
MTU 1500 bytes, BW 2000 Kbit
Encapsulation protocol is PPP, loopback not set
Keepalive interval is 10 sec , set
Carrier delay is 2 sec
RXload is 1 ,Txload is 1
LCP Closed
Closed: ipcp
Queueing strategy: WFQ
5 minutes input rate 0 bits/sec, 0 packets/sec
5 minutes output rate 0 bits/sec, 0 packets/sec
1425 packets input, 22800 bytes, 0 no buffer
Received 0 broadcasts, 0 runts, 0 giants
0 input errors, 0 CRC, 0 frame, 0 overrun, 0 abort
1425 packets output, 22800 bytes, 0 underruns
0 output errors, 0 collisions, 2 interface resets
6 carrier transitions
V35 DTE cable
DCD=down  DSR=down  DTR=up  RTS=up  CTS=down
Ruijie# clear counter serial 1/0
```

Then, use the **show interface** command to show information about the interface:

```
Ruijie# show interface serial 1/0
serial 1/0 is DOWN  , line protocol is DOWN
Hardware is Infineon DSCC4 PEB20534 H-10 serial
Interface address is: 192.168.10.10/24
MTU 1500 bytes, BW 2000 Kbit
Encapsulation protocol is PPP, loopback not set
Keepalive interval is 10 sec , set
Carrier delay is 2 sec
RXload is 1 ,Txload is 1
LCP Closed
Closed: ipcp
Queueing strategy: WFQ
5 minutes input rate 0 bits/sec, 0 packets/sec
5 minutes output rate 0 bits/sec, 0 packets/sec
0 packets input, 0 bytes, 0 no buffer
Received 0 broadcasts, 0 runts, 0 giants
0 input errors, 0 CRC, 0 frame, 0 overrun, 0 abort
```

```
0 packets output, 0 bytes, 0 underruns
0 output errors, 0 collisions, 0 interface resets
0 carrier transitions
V35 DTE cable
DCD=down  DSR=down  DTR=up  RTS=up  CTS=down
```

Shutting Down and Restarting the Interface

When necessary, the interface must be shut down, for example, when you replace the cables on the interface and then restart the interface. The **shutdown** command allows you to shut down an interface, while the **no shutdown** command allows you to restart the interface.

Interface Configuration Example

Enabling an Interface

The following example configures a serial port to run PPP.

```
Ruijie(config)# interface serial 1/0
Ruijie(config-if)# encapsulation ppp
```

Configuring an Interface Description

The following example configures the function description of an Ethernet interface.

```
Ruijie(config)# interface FastEthernet 0/0
Ruijie(config-if)# description Gateway_of_trans1ation
Ruijie(config-if)# ip address 192.168.12.1 255.255.255.0
```

Shuting Down an Interface

If an interface is idle, you can shut down it, as shown in the following example.

```
Ruijie(config)# Interface serial 1/0
Ruijie(config-if)# shutdown
```

Configuring CPOS Interfaces

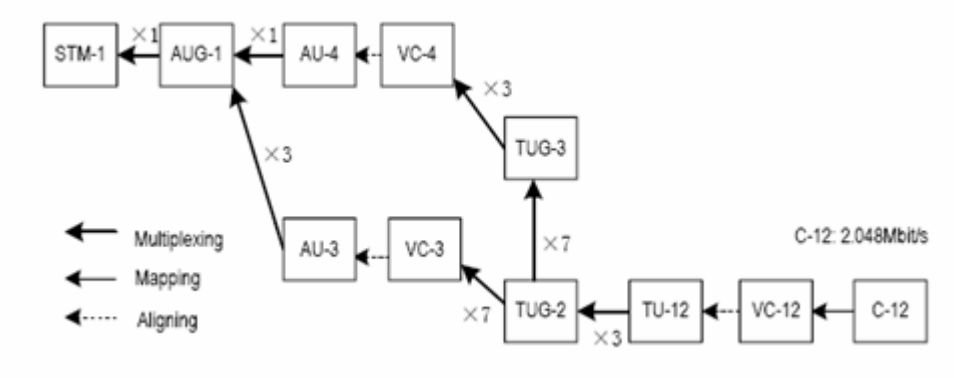
Understanding CPOS Interfaces

Overview

One CPOS module can be understood as a multiple-channel E1 module. One CPOS module can be configured to support up to 63 E1 lines, each of which can be configured with a 2 Mbit/s bandwidth as needed or divided into N×64K channel groups.

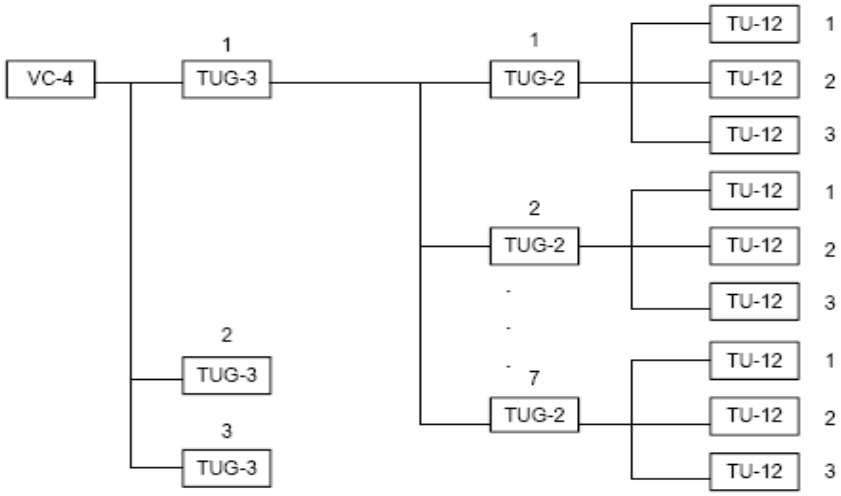
According to the definition given in ITU-T G.703, there are two popular STM multiplexing technologies globally. Currently, China Telecom uses the second multiplexing path: STM-1-AU-4-TUG-3-TUG-2-E1, more commonly known as 373 multiplexing.

Figure 1 Multiplexing from E1 to STM-1



To put it in a simple way, an E1 frame is first put into a container C-12 and then into a VC-12 container, forming a TU-12. Then, three TU-12s are multiplexed into an auxiliary unit group TUG-2, and 7 TUG-2s are multiplexed into a greater unit group TUG-3. Next, one VC-4 container is used to hold three TUG-3s, and is converted into an AU-4. Finally, the AU-4 is converted into the STM frame format.

Figure 2 Sequence of TUG-3, TUG-2 and TU-12 in VC-4s



Configuring CPOS Interfaces

Entering the Configuration Mode of the STM Module

To configure the CPOS controller, first enter CPOS controller configuration mode. Use the following command to enter CPOS controller configuration mode.

Command	Function
Ruijie(config)# **controller sonet** *slot/port*	Enters STM module configuration mode.

Configuring the CPOS Multiplexing Path

In SDH, there are two kinds of multiplexing paths for the payload: AU-4 and AU-3. The AU-4 multiplexing path is used in China. Currently, Ruijie products only support AU-4 multiplexing.

Command	Function
Ruijie(config-controller)# **aug mapping au-4**	Defines the multiplexing path used.
Ruijie(config-controller)# **no aug mapping**	Restores the default value (*au-4*).

The default value is *au-4*. Currently, Ruijie products only support AU-4 multiplexing.

Defining the STM Frame Format

The frame format determines whether the CPOS interface works in SONET mode or SDH mode. Currently, Ruijie products only support the SDH mode.

Command	Function
Ruijie(config-controller)# **framing** {**sdh**}	Defines the STM frame format.
Ruijie(config-controller)# **no framing sdh**	Restores the default value (SDH).

The frame format is SDH by default. Currently, Ruijie products only support the SDH mode.

Configuring the Clock Source of the Controller

The CPOS interface supports two clock modes:

1. Internal clock mode: using internal clock signals

2. Network clock mode: using line clock signals

When the device is connected with SDH equipment, you should set CPOS interfaces to use the network clock mode, since the clock precision of the SDH network is higher than that of the internal clock sources of CPOS interfaces. If CPOS interfaces are directly connected via optical fibers, one end should be set to use the internal clock, and the other end to use the network clock.

Command	Function
Ruijie(config-controller)# **clock source {internal | line}**	Configures the clock source of the controller.
Ruijie(config-controller)# **no clock source**	Restores the default value.

The default clock source of the controller is *line*.

Configuring the Loopback Function of the Controller

Loopback is used to test some special functions.

When the mode is set to the local mode, all packets from the CPOS card of the local device will be looped back to the receiving direction of the CPOS card and sent to the host.

When the mode is set to the network mode, all packets received by the CPOS card of the local device will be looped back to the transmitting direction of the CPOS card and sent to the remote end.

Command	Function
Ruijie(config-controller)# **loopback** [**local** | **network**]	Configures the loopback function of the controller.
Ruijie(config-controller)# **no loopback**	Restores the default value.

The loopback function is disabled by default.

Configuring the Section Overhead Byte and Higher-Order Path Overhead Bytes

On the controller of CPOS, you can configure the signal label byte C2, regeneration section trace byte J0 and path trace byte J1. J0 is a section overhead byte, used to detect the connectivity between two interfaces. C2 and J1 are higher-order path overhead bytes. C2 is used to indicate the information payload type of VC frames. J1 is used to detect the connectivity between two interfaces in the path layer, and to identify equipment information. B1 is used to monitor bit errors in the regenerator section.

The principle of B2 is similar to that of B1. The difference is that B2 monitores bit errors of the the multiplexing section. B3 monitores bit errors of VC-4s transmitted in STM-N frames.

G1 is the channel status byte used to feedback the channel terminal status and performance to the source device of VC-4 channels so as to monitor the status and performance of the overal bidirectional channel at any side or any point of the channel.

K2 is the remote defect indication signal of the multiplexing section that the receiving side returns to the sending side, indicating that it has detected an incoming call failure or is receiving a multiplexing section alarm signal.

M1 is the remote error block indication signal of the multiplexing section that the receiving side returns to the sending side, indicating error blocks detected by B2 so that the sending side can learn the receive bit errors at the receiving end.

S1 is a synchronization status byte. Different byte patterns indicate different clock quality levels as defined in ITU-T for deivces to determine the quality of received clock signals and then whether to switch the clock source.

Use the following commands to configure C2.

Command	Function
Ruijie(config-controller)# **overhead c2** *number*	Sets the Path Signal Label (C2) value of SDH.
Ruijie(config-controller)# **no overhead c2**	Restores the default value of C2, namely 2.

Use the following commands to configure J0.

Command	Function
Ruijie(config-controller)# **overhead j0** *number*	Sets the Section (RS) Trace identifier.
Ruijie(config-controller)# **no overhead j0**	Restores the default value of J0, namely 1.

Use the following commands to configure J1.

Command	Function
Ruijie(config-controller)# **overhead j1** {**length** {**16** | **64**}} | {**message** *text*}	Sets the information length and contents of J1.
Ruijie(config-controller)# **no overhead j1**	Restores the default value.

The default length is 16 and the default message is “Ruijie”.

Note

If the length is set to 16, the message can contain up to 15 characters, and insufficient ones are supplemented with NULL. The last byte is the CRC7 value calculated according to the message. If the length is set to 64, the maximum length of the message is 62 bytes, and insufficient ones are supplemented with NULL. The last two bytes are CR/LF (0x0D/0x0A).

Use the following commands to configure B1.

Command	Function
Ruijie(config-controller)# **overhead b1** *number*	Sets the monitoring value of bit errors in the regenerator section of SDH.
Ruijie(config-controller)# **no overhead b1**	Restores the default value, namely 255.

Use the following commands to configure B2.

Command	Function
Ruijie(config-controller)# **overhead b2** *number*	Sets the monitoring value of bit errors in the multiplexing section of SDH.
Ruijie(config-controller)# **no overhead b2**	Restores the default value, namely 255.

Use the following commands to configure B3.:

Command	Function
Ruijie(config-controller)# **overhead b3** *number*	Sets the monitoring value of VC4 bit errors of SDH.
Ruijie(config-controller)# **no overhead b3**	Restores the default value, namely 255.

Use the following commands to configure G1.

Command	Function
Ruijie(config-controller)# **overhead g1** *number*	Sets the status byte of SDH.
Ruijie(config-controller)# **no overhead g1**	Restores the default value, namely 255.

Use the following commands to configure K2.

Command	Function
Ruijie(config-controller)# **overhead k2** *number*	Sets the remote defect indication value of the multiplexing section of SDH.
Ruijie(config-controller)# **no overhead k2**	Restores the default value, namely 255.

Use the following commands to configure M1.

Command	Function
Ruijie(config-controller)# **overhead m1** *number*	Sets the remote code block indication in the multiplexing section of SDH.
Ruijie(config-controller)# **no overhead m1**	Restores the default value, namely 255.

Use the following commands to configure S1.

Command	Function
Ruijie(config-controller)# **overhead s1** *number*	Sets the synchronization status byte of SDH.
Ruijie(config-controller)# **no overhead s1**	Restores the default value, namely 255.

Entering the Tug-3 Configuration Mode

If the CPOS has been set to the SDH mode and the AU-4 multiplexing mode is used, you can use the following commands to specify a TUG-3 and enter TUG-3 configuration mode.

Command	Function
Ruijie(config-controller)# **au-4** *au-4-number* **tug-3** *tug-3-number*	Configures the specified TUG-3 command layer.
Ruijie(config-controller)# **no au-4** *au-4-number* **tug-3** *tug-3-number*	Deletes the configuration.

Currently, Ruijie products only support the SDH mode and AU-4 multiplexing, so you can use this command to enter TUG-3 configuration mode after you have entered controller mode.

Configuring the Working Mode of the Logical E1 Channel

In the current implementation, the CPOS-derived E1 supports framing (CE1) and non-framing (E1) modes:

1. In framing mode, the rest 31 timeslots of the E1 channel except timeslot 0 can be randomly bound as serial interfaces for use.

2. In non-framing mode, the E1 channel is not divided into timeslots but forms a serial port of 2.048 Mbit/s.

By default, the logical E1 channel does not work in any mode.

You can use the following commands to set the timeslot allocation mode on the logical E1 channel (provided that the logical E1 line is not set to the E1 mode). After that, the working mode of the logical E1 channel is set to the CE1 mode:

Command	Function
Ruijie(config-ctrlr-tug3)# **tug-2** *tug-2-number* **e1** *e1-line-number* **channel-group** *channel-group-number* **timeslots** *lists-of-timeslots*	Creates a framed logical CE1 channel on a TUG-3.
Ruijie(config-ctrlr-tug3)# **no tug-2** *tug-2-number* **e1** *e1-line-number* **channel-group** *channel-group-number*	Deletes the defined channel.

After you use the above command to allocate timeslots to a channel group, the system generates a logical interface, for example:

```
Ruijie (config) # controller sonet 1/0
Ruijie (config-controller)# au-4 1 tug-3 1
Ruijie(config-ctrlr-tug3)# tug-2 4 e1 3 channel-group 1 timeslots 1-31
```

The logical interface serial 1/0.1/1/4/3:1 is generated, and its logical feature is the same as a sync serial port.

To allow the logical E1 line to work in E1 mode, you can use the following commands (if the logical E1 line is already set to the CE1 mode, you need to delete all the channel groups under the E1 channel).

Command	Function
Ruijie(config-ctrlr-tug3)# **tug-2** *tug-2-number* **e1** *e1-line-number* **using-e1**	Configures a non-framed logical E1 channel on a TUG-3.
Ruijie(config-ctrlr-tug3)# **no tug-2** *tug-2-number* **e1** *e1-line-number* **using-e1**	Deletes the configuration.

After you use the above commands, the system generates a logical interface, for example:

```
Ruijie(config)# controller sonet 1/0
Ruijie(config-controller)# au-4 1 tug-3 1
Ruijie(config-ctrlr-tug3)# tug-2 4 e1 2 using-e1
```

The logical interface serial 1/0.1/1/4/2:0 is generated, and its logical feature is the same as a sync serial port.

Note: The CE1 mode is not supproted at present.

Configuring the Loopback Mode of an E1 Channel on a TUG-3

Usually, the loopback function is used for fault diagnosis.

When the mode is set to the local mode, all packets from the CPOS E1 channel will be looped back to the receiving direction of the E1 channel and sent to the host.

When the mode is set to the network mode, all packets received by the CPOS E1 channel will be directly looped back to the transmiting direction of the channel and sent to the remote end.

Command	Function
Ruijie(config-ctrlr-tug3)# **tug-2** *tug-2-number* **e1** *e1-line-number* **loopback** {**local** | **network**}	Configures the loopback mode of an E1 channel on a TUG-3.
Ruijie(config-ctrlr-tug3)# **no tug-2** *tug-2-number* **e1** *e1-line-number* **loopback**	Disables the loopback function.

By default, the loopback is disabled.

Setting the National Bit

Command	Function
Ruijie(config-ctrlr-tug3)# **tug-2** *tug-2-number* **e1** *e1-line-number* **national bits** *pattern*	Sets the national bit.
Ruijie(config-ctrlr-tug3)# **no tug-2** *tug-2-number* **e1** *e1-line-number* **national bits**	Restores the default value.

The national bit is set to 0x3 by default.

Setting the CRC Length of the Interface Layer

Use the following commands to configure the CRC checksum length of the logical interface generated by CPOS in interface configuration mode.

Command	Function
Ruijie(config-if)# **crc {16/32}**	Sets the CRC length of the interface layer.
Ruijie(config-if)# **no crc**	Restores the default value.

The default CRC checksum length is 16 bytes.

Setting the Channel Signal Label

Use the following commands to configure the channel signal label.

Command	Function
Ruijie(config-ctrlr-tug3)# **tug-2** *tug-2-number* **e1** *e1-line-number* **set psl** *number*	Sets the channel signal label.
Ruijie(config-if)# **no tug-2** *tug-2-number* **e1** *e1-line-number* **set psl**	Restores the default value.

The channel signal label is set to 2 by default.

Setting the Alarm Level

Use the following commands to configure the alarm level.

Command	Function
Ruijie(config- controller)#**alarm level {high|normal|trivial}**	Sets the alarm level.
Ruijie(config- controller)# **no alarm level**	Restores the default value, namely *high*.

Setting the Clock Synchronization Source

Use the following commands to configure the clock synchronization source.

Command	Function
Ruijie(config- controller)#**clock source {internal | line}**	Sets the clock synchronization source.
Ruijie(config- controller)# **no clock source**	Restores the default value, namely *line*.

Monitoring and Maintaining CPOS Interfaces

Use the following commands to monitor and maintain CPOS lines.

Command	Function
Ruijie# **show controller sonet** [*slot*/*port*]	Shows the details of the controller sonet.
Ruijie# **clear controller sonet** *slot*/*port*	Resets the CPOS controller.
Ruijie(config-controller)# **report** {**all** | *event*} Ruijie(config-controller)# **no report** {**all** | *event*}	Enables reporting of alarms and signal events of the CPOS.
Ruijie(config-controller)# **threshold** *type value* Ruijie(config-controller)# **no threshold** *type*	Sets the threshold of alarms.

Example:

```
Ruijie#show controller sonet 1/0
```

```
sonet 1/0 is up.
 Clock source : line
 Framing sdh.        Mapping : au-4 .
AU-4 1, TUG3 1 , TUG2 1 , E1 1 (c-12 1/1/1/1 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 1 , E1 2 (c-12 1/1/1/2 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 1 , E1 3 (c-12 1/1/1/3 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 2 , E1 1 (c-12 1/1/2/1 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 2 , E1 2 (c-12 1/1/2/2 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 2 , E1 3 (c-12 1/1/2/3 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 3 , E1 1 (c-12 1/1/3/1 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 3 , E1 2 (c-12 1/1/3/2 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 3 , E1 3 (c-12 1/1/3/3 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 4 , E1 1 (c-12 1/1/4/1 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 4 , E1 2 (c-12 1/1/4/2 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 4 , E1 3 (c-12 1/1/4/3 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 5 , E1 1 (c-12 1/1/5/1 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 5 , E1 2 (c-12 1/1/5/2 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 5 , E1 3 (c-12 1/1/5/3 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 6 , E1 1 (c-12 1/1/6/1 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 6 , E1 2 (c-12 1/1/6/2 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 6 , E1 3 (c-12 1/1/6/3 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 7 , E1 1 (c-12 1/1/7/1 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 7 , E1 2 (c-12 1/1/7/2 ) is inuse
Mode :E1
AU-4 1, TUG3 1 , TUG2 7 , E1 3 (c-12 1/1/7/3 ) is inuse
```

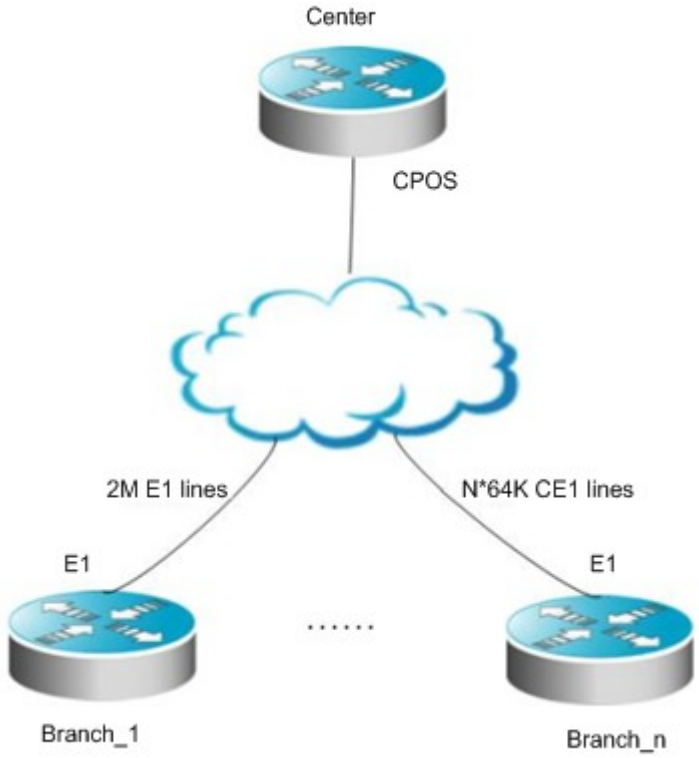
```
Mode :E1
AU-4 1, TUG3 2 , TUG2 1 , E1 1 (c-12 1/2/1/1 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 1 , E1 2 (c-12 1/2/1/2 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 1 , E1 3 (c-12 1/2/1/3 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 2 , E1 1 (c-12 1/2/2/1 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 2 , E1 2 (c-12 1/2/2/2 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 2 , E1 3 (c-12 1/2/2/3 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 3 , E1 1 (c-12 1/2/3/1 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 3 , E1 2 (c-12 1/2/3/2 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 3 , E1 3 (c-12 1/2/3/3 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 4 , E1 1 (c-12 1/2/4/1 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 4 , E1 2 (c-12 1/2/4/2 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 4 , E1 3 (c-12 1/2/4/3 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 5 , E1 1 (c-12 1/2/5/1 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 5 , E1 2 (c-12 1/2/5/2 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 5 , E1 3 (c-12 1/2/5/3 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 6 , E1 1 (c-12 1/2/6/1 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 6 , E1 2 (c-12 1/2/6/2 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 6 , E1 3 (c-12 1/2/6/3 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 7 , E1 1 (c-12 1/2/7/1 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 7 , E1 2 (c-12 1/2/7/2 ) is inuse
Mode :E1
AU-4 1, TUG3 2 , TUG2 7 , E1 3 (c-12 1/2/7/3 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 1 , E1 1 (c-12 1/3/1/1 ) is inuse
Mode :E1
```

```
AU-4 1, TUG3 3 , TUG2 1 , E1 2 (c-12 1/3/1/2 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 1 , E1 3 (c-12 1/3/1/3 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 2 , E1 1 (c-12 1/3/2/1 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 2 , E1 2 (c-12 1/3/2/2 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 2 , E1 3 (c-12 1/3/2/3 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 3 , E1 1 (c-12 1/3/3/1 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 3 , E1 2 (c-12 1/3/3/2 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 3 , E1 3 (c-12 1/3/3/3 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 4 , E1 1 (c-12 1/3/4/1 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 4 , E1 2 (c-12 1/3/4/2 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 4 , E1 3 (c-12 1/3/4/3 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 5 , E1 1 (c-12 1/3/5/1 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 5 , E1 2 (c-12 1/3/5/2 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 5 , E1 3 (c-12 1/3/5/3 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 6 , E1 1 (c-12 1/3/6/1 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 6 , E1 2 (c-12 1/3/6/2 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 6 , E1 3 (c-12 1/3/6/3 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 7 , E1 1 (c-12 1/3/7/1 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 7 , E1 2 (c-12 1/3/7/2 ) is inuse
Mode :E1
AU-4 1, TUG3 3 , TUG2 7 , E1 3 (c-12 1/3/7/3 ) is inuse
Mode :E1

Pci clock is 33M.
```

Configuration Examples

Networking Topology

The following figure shows the topology of a network. For details, see the **Typical Configuration** section.



Typical Configuration

The Ruijie 1CPOS-STM1 card can implement the simple convergence of multiple 2M E1 lines, which are then connected to an upstream data center via GE ports. This is suitable for enterprises and financial branches connected by private networks at the core layer. Below is typical configuration:

```
!
Controller sonnet 1/0
framing sdh
clock source internal
au-4 1 tug-3 1                          //Totally 12 E1 lines
tug-2 1 e1 1 using-e1          //interface Serial1/0.1/1/1/1:0 pure E1
tug-2 1 e1 2 using-e1              //interface Serial1/0.1/1/1/2:0
tug-2 1 e1 3 using-e1
tug-2 2 e1 1 using-e1
tug-2 2 e1 2 using-e1
tug-2 2 e1 3 using-e1
tug-2 3 e1 1 using-e1
tug-2 3 e1 2 using-e1
```

```
tug-2 3 e1 3 using-e1
tug-2 4 e1 1 using-e1
tug-2 4 e1 2 using-e1
!
interface FastEthernet1/0/0
ip address 10.1.1.254 255.255.255.0
speed 100
full-duplex
!
```

//Below are 12 virtual serial interfaces, corresponding to each E1 group above. Each serial port corresponds to a branch and a 2M timeslot.

```
interface Serial1/0.1/1/1/1:0
ip address 16.202.99.185 255.255.255.252
encapsulation ppp
!
interface Serial1/0.1/1/1/2:0
no ip address
encapsulation ppp
!
interface Serial1/0.1/1/1/3:0
ip address 16.202.99.181 255.255.255.252
encapsulation ppp
!
interface Serial1/0.1/1/2/1:0
ip address 16.202.99.229 255.255.255.252
encapsulation ppp
!
interface Serial1/0.1/1/2/2:0
encapsulation ppp
!
interface Serial1/0.1/1/2/3:0
ip address 16.202.99.165 255.255.255.252
encapsulation ppp
!
interface Serial1/0.1/1/3/1:0
ip address 16.202.99.193 255.255.255.252
encapsulation ppp
!
interface Serial1/0.1/1/3/2:0
no ip address
encapsulation ppp
!
interface Serial1/0.1/1/3/3:0
no ip address
```

```
encapsulation ppp
!
interface Serial1/0.1/1/4/1:0
ip address 16.202.99.105 255.255.255.252
encapsulation ppp
!
interface Serial1/0.1/1/4/2:0
ip address 16.202.99.109 255.255.255.252
encapsulation ppp
!
interface Serial1/0.1/1/4/3:0
ip address 16.202.99.113 255.255.255.252
encapsulation ppp
            !
```

Troubleshooting CPOS Interfaces

The logical interface generated by a CPOS interface is usually encapsulated with some link layer protocols. After you verify that the physical interface and the line connection are in good connection, if the CE1 logical interface link is still interrupted, you need to debug the configuration of the logical interface and the running of the link layer protocol. For the specific procedure, see the related link layer protocol configuration section. When the E1/CE1 logical interface is interrupted, you must first check the following aspects.

1) Make sure that the CE1 interfaces connected have the same working mode, such as the E1 mode or CE1 mode.
2) If both ends work in CE1 mode, ensure that the channel groups at both ends are configured the same.
3) Make sure that the two CE1 interfaces connected have the same CE1 frame check mode configured.
4) Make sure that the logical interfaces at both ends use the same link encapsulation protocol.
5) Make sure that the HDLCs at both ends have the same CRC configured, either CRC16 or CRC32.
6) Check if the physical status of the E1/CE1 interface is UP. If not, it means that the device at the other end is shut down, or the cable connection is abnormal. Use appropriate substitutes to locate the problem.

Note The CE1 mode is not supported at present

Configuring ATM

Understanding ATM

ATM refers to Asynchronous Transfer Mode. "Transfer" indicates the transmission and switching of information over the network, while "Asynchronous" indicates the method of bandwidth allocation among successive users, as the information of a certain user may not periodically appear on the channel. ATM integrates the features of circuit switching and packet switching, and divides various data (including user data) into groups. Such groups are call cells, each of which has a fixed length. The information of each user is distinguished via a cell header, so that the time point occupied by user data is no longer limited and the user information may appear irregularly as with multiplexing. However, since the cell length is fixed, the channel will be filled with idle cells when no data is being transmitted. This will divide the channel into time segements with an equal length, making it quite similar to circuit switching. ATM well integrates the simplicity of circuit switching and the flexibility of packet switching.

The basic protocol framework of ATM is divided into three planes: user plan, control plane and management plane, while the user plane and the control plane are also divided into 4 layers: physical layer, ATM layer, ATM adaptation layer and top layer, each of which may have further layer divisions. The management plane is also divided into layer management and plane management. The former one is responsible for the management of all layers of respective planes, and has the hierarchical structure corresponding to other planes; the latter is responsible for system management and communication between planes. The control plane uses signaling protocols to establish and remove links.

ATM features connection-oriented switching. During data transmission, multiple Virtual Paths (VPs) connected at the ATM layer will be multiplexed on the same physical line, and are distinguished via Virtual Path Identifiers (VPIs). Different Virtual Channels (VCs) are distinguished via Virtual Channel Identifiers (VCIs). Each connection will be identified by a VPI and a VCI. ATM establishes connections in two ways: PVC and SVC. However, during data transmission, since the data of different users does not need to appear periodically and no bandwidth will be occupied when there is no data of a specific user, ATM connections are virtual circuits.

This section introduces how to configure a router connected to an ATM network and how to bear IP traffic over an ATM network.

Configuring ATM

Entering ATM Configuration Mode

To configure ATM, you need to enter ATM interface configuration mode first. Use the following command to enter ATM interface configuration mode.

Command	Function
Ruijie(config)#interface atm [*interface-number* | *interface-number.subnum*]	Enters ATM interface configuration mode.

Configuring the ATM Interface

Command	Function
Ruijie(config-if) **ip address** *ip-address ip-mask*	Configures the network address of the interface.
Ruijie(config-if) **no shutdwon**	Starts the interface.

Configuring ATM Interface Parameters (Optional)

In order to adapt to different network environments and system requirements, the default ATM interface parameters can be modified. However, it shall be noted that although these parameters apply to both the master interface and slave interface of ATM, you must modify these parameters on the master interface (except for the **mtu** command, which can be executed on either the master interface or the slave interface).

Command	Function
Ruijie(config-if)# **mtu** *byte*	Configures the MTU size, which is 1500 by default.
Ruijie(config-if)#**atm sonet sts-3c**	Configures the STS-3C mode.
Ruijie(config-if)#**atm oam flush**	Configures the interface to drop the OAM cells received.
Ruijie(config-if)#**atm clock internal**	Configures the clock source.
Ruijie(config-if)#**atm maxvc** *number*	Modifies the maximum number of VCs supported.
Ruijie(config-if)#**loopback** [line| diagnostic]	Sets the ATM interface to the loopback mode.

Configuring the Overhead Bytes of the Interface

On the ATM interface, you can configure signal label byte C2, regeneration section trace byte J0 and path trace byte J1. J0 is a section overhead byte used to test the continuity of the connection between two interfaces at the section level. C2 and J1 are both higher-order path overhead bytes. C2 is used to indicate the payload type of virtual container (VC) frames, while J1 is used to test the continuity of the connection between two interfaces at the path level and to identify devices.

Use the following commands to configure overhead byte C2, which is 2 by default.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface atm** *interface-number*	Enters the configuration mode of the specific ATM interface.
Ruijie(config-if-atm *interface-number*)# **overhead c2** *number*	Sets the overhead byte C2 of the interface to *number*.

Use the following commands to configure overhead byte J0. The default length is 16, and the default message is "Ruijie".

Command	Function

Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface atm** *interface-number*	Enters the configuration mode of the specific ATM interface.
Ruijie(config-if-atm *interface-number*)# overhead j0 { length { 16 | 64 } } | { message *text* }	Sets the overhead byte J0 of the interface to *text*.

Use the following commands to configure overhead byte J1. The default length is 16, and the default message is "Ruijie".

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface atm** *interface-number*	Enters ATM interface configuration mode.
Ruijie(config-if-atm *interface-number*)# overhead j1 { length { 16 | 64 } } | { **message** *text* }	Sets overhead byte J1 of the interface.

Note If the length is set to 16, the maximum length of a message can only be 15 characters, and deficient ones are replaced with NULL. The last byte is the CRC7 value calculated according to this message. If the length is set to 64, the maximum length of message can be 62 bytes, and deficient ones are replaced with NULL. The last two bytes are CR/LF (0x0D/0x0A).

Note The J1 length configured for the interface must be identical with that configured for the peer interface, or else the J1 of the peer interface cannot be identified correctly.

Configuring a PVC

Command	Function
Ruijie(config)#interface atm [*interface-number|interface-number.subnumber*]	Enters ATM interface or sub-interface mode.
Ruijie(config-if)#pvc [*name*] *vpi* / *vci*	Creates a PVC and enters PVC mode.
Ruijie(config-if-atm-vc)#**encapsulation** [aal5snap | aal5nlpid | aal5mux]	Specifies the type of AAL5 encapsulation protocol of the PVC, which is *aal5snap* by default.
Ruijie(config-if-atm-vc)#protocol ip *ip_address* [[no] broadcast]	Bears IP over PVC and specifies an IP address.
Ruijie(config-if-atm-vc)#protocol ip Inarp [[no] broadcast]	Allows PVC to support reverse address resolution.
Ruijie(config-if-atm-vc)#broadcast	Enables broadcast on the PVC.
Ruijie(config-if-atm-vc)#**class-vc** *vc-class-name*	Applies a VC class to the PVC.
Ruijie(config-if-atm-vc)#**inarp** *minutes*	Modifies the ageing time of INARP.

Ruijie(config-if-atm-vc)#**oam-pvc manage** *frequency*	Enables OAM F5 lookback cell transmission and retransmission detection on the PVC.
Ruijie(config-if-atm-vc)#**oam retry** *up-count* *down-count retry-frequency*	Configures OAM management parameters to disconnect and reestablish connections.
Ruijie(config-if-atm-vc)#oam ais-rdi [*down-cout* [*up_count*]]	Modifies relevant parameters of AIS/RDI cells.
Ruijie (config-if-atm-vc)#oam-ver93	Sets the OAM version to *ver93*.

Configuring the Service Type of the PVC (Optional)

In order to adapt to different service needs, the service type supported by a PVC can be configured and is UBR by default.

Command	Function
Ruijie(config-if-atm-vc)#cbr [*input-scr*]	Specifies the service type of the PVC as Constant Bit Rate.
Ruijie(config-if-atm-vc)#ubr {*input-pcrt*}	Specifies the service type of the PVC as Unspecified Bit Rate.
Ruijie(config-if-atm-vc)#vbr-nrt {input-pcr| *input-scr* |*input-cdvt*}	Specifies the service type of the PVC as Non-Real-Time Variable Bit Rate
Ruijie(config-if-atm-vc)#vbr-rt {*output-pcr*| *input-pcr*|*input cdv*}	Specifies the service type of the PVC as Real-Time Variable Bit Rate.

Configuring a VC Class (Optional)

To configure a VC class, you must create a VC class first and then configure relevant parameters. Use the following commands to create a VC class.

Command	**Function**
Ruijie(config)#**vc-class atm** *name*	Creates a VC class.
Ruijie(config-if-atm-vc)#**class-vc** *vc-class-name*	Assigns a VC class to a PVC.

After creating a VC class, use the following commands to configure the parameters of the VC class.

broadcast

cbr

encapsulation

inarp

oam

oam-pvc

protocol

ubr

vbr-nrt

vbr-rt

See the section about PVC configuration for the formats of respective commands.

Configuring IPoA

IP over ATM (IPoA) allows the transmission of IP packets over an ATM LAN, so as to realize IP-based applications over an ATM network. RFC 2225 has defined a method for conversion between IP addresses and ATM addresses. IP applications within the same LIS can carry out direct communications, while the communications between IP applications from different LISs require a router to forward packets.

Use the following commands to configure IPoA.

Command	Function
Ruijie(config)#**interface atm** [*interface-number*|*interface-number.subnum*]	Enters ATM interface or sub-interface configuration mode.
Ruijie(config-if)#**pvc** [*name*] *vpi* / *vci*	Creates a PVC and enters PVC mode.
Ruijie(config-if-atm-vc)#**protocol ip** *ip-address*	Configures IPoA to enable the PVC to carry IP traffic.

ATM Configuration Examples

IPoA Configuration Examples

Networking Requirements

As shown in the following figure, Router A, Router B and Router C are all connected to an ATM network, with IP addresses being 10.1.1.1, 10.1.1.2 and 10.1.1.3 respectively. In the ATM network, the VPI and VCI of Router A are 0/40 and 0/50 repectively, allowing. Route A to connect to Router B and Router C respectively; the VP and VCI of Router B are 0/40 and 0/60 respectively, allowing Router B to connect to Router A and Router C respectively; the VPI and VCI of Router C are 0/50 and 0/60 respectively, allowing Router C to connect to Router A and Router B respectively.

Networking Topology

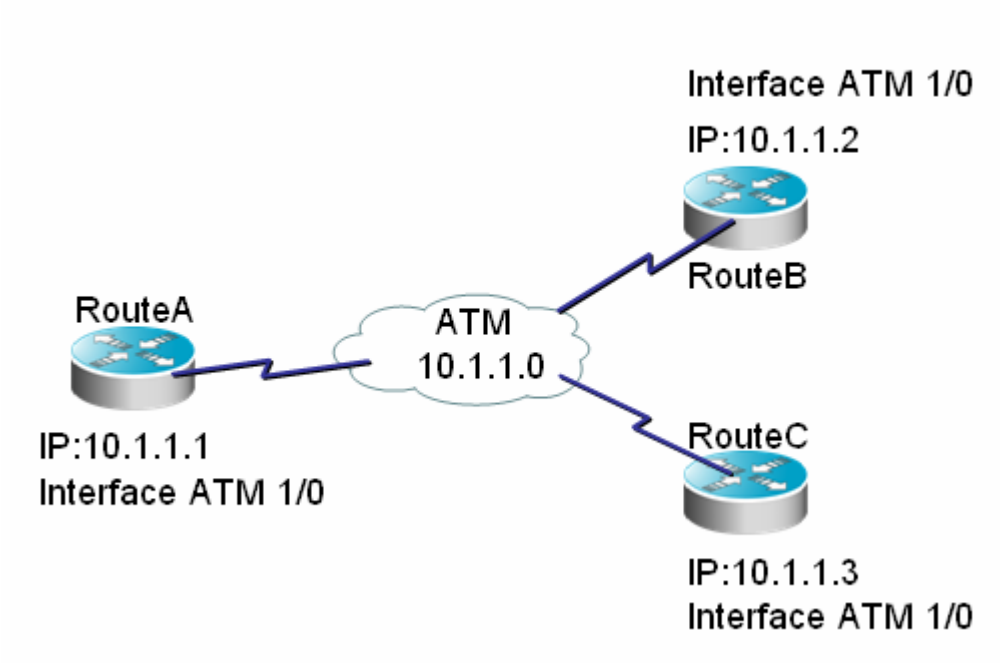


Figure 1

Configuration Steps

Route A

Enter the ATM interface and configure its IP address.

```
interface ATM 1/0
ip address 10.1.1.1 255.255.255.0
```

Create a PVC to bear the IP protocol.

```
        pvc to_b  0  /  40
```

In this version, the first PVC will be assigned a full bandwidth by default.

If more PVCs are to be created, the bandwidth of this PVC shall be reallocated.

```
cbr 256
protocol ip 10.1.1.2
exit
pvc to_c 0  /  50
protocol ip 10.1.1.3
exit
```

Route B

Enter the ATM interface and configure its IP address.

```
interface ATM 1/0
ip address 10.1.1.2 255.255.255.0
```

Create a PVC to bear the IP protocol.

```
pvc to_a  0  /  40
```

In this version, the first PVC will be assigned a full bandwidth by default.

If more PVCs are to be created, the bandwidth of this PVC shall be reallocated.

```
cbr 256
protocol ip 10.1.1.1
exit
pvc to_c  0  /  60
protocol ip 10.1.1.3
exit
```

Route C

Enter the ATM interface and configure its IP address.

```
interface ATM 1/0
ip address 10.1.1.3 255.255.255.0
# Create a PVC to bear the IP protocol.
pvc to_a  0  /  50
```

In this version, the first PVC will be assigned a full bandwidth by default.

If more PVCs are to be created, the bandwidth of this PVC shall be reallocated.

```
cbr 256
protocol ip 10.1.1.1
exit
pvc to_b  0  /  60
protocol ip 10.1.1.2
exit
```

Troubleshooting ATM

The ATM Link Layer Is Not Up

When a "line protocol is down" message is displayed after you enter the show interface atm command, check the physical line. If you see a message "ATM1/0 is administratively down", it indicates that the ATM interface is not started and you should use the no shutdown command to start the ATM interface first in the interface mode.

The Link Protocol is UP but IP Communication is Abnormal

The message "Line protocol is up" only indicates that the ATM layer has been activated. To successfully ping the IP address of the peer device, you need to set the local IP address and then check whether the VPI and VCI of the PVC are correctly set.

Use the **show int atm** command to check the status of a specific ATM interface.

Use the **show atm vc** command to display all PVCs activated on the router. For example:

```
Interface  Name  VPI  VCI  Type   Encaps   SC   Kbps   Kbps   Cells  Sts
ATM 1/0    1   0   40    PVC   SNAP    ubr  256      0    0    INA
ATM 1/0    3   1   60    PVC   SNAP    na   0        0    0    INA
```

Enter the **show atm vc** command and then the PVC descriptor to display detailed PVC information. For example:

```
Router#sh atm vc 0
Description: N/A
ATM1/0: VCD: 1, VPI: 0, VCI: 40, Connection Name: to_b
UBR, PeakRate: 155000 (365567 cps)
AAL5-LLC/SNAP, etype:0x0, Flags: 0xC20, VCmode: 0x0, Encapsize: 12
OAM frequency: 0 second(s)
InARP frequency: 15 minutes(s)
InPkts: 20, OutPkts: 30, InBytes: 2160, OutBytes: 3240
InPRoc: 20, OutPRoc: 30, Broadcasts: 0
InFast: 0, OutFast: 0, InAS: 0, OutAS: 0
Giants: 0
OAM cells received: 0
OAM cells sent: 0
Status: INACTIVE
```

Use the **show atm map** command to display all ATM mappings configured on the router. For example:

```
Router#sh atm map
Map list to_b_ATM1/0 : PERMANENT
ip 10.1.1.2 maps to VC 1, VPI 0, VCI 40, ATM1/0
```

Configuring POS Interfaces

Understanding POS

Overview

Packet Over SONET/SDH (POS) is also called IP Over SONET/SDH. As the name implies, POS allows the direct transmission of IP packets over high-speed transmission channels provided by SDH.

In 1985, Bellcore put forward a standard called the Synchronous Optical Network (SONET), while ANSI also approved a series of SONET standards.

In 1989, CCITT recognized the concept of SONET and released the Synchronous Digital Hierarchy (SDH) standard, making it a general technology applicable to optical fiber, microwave, and satellite transmission. Slightly different from SONET, SDH/SONET defines the rates and formats of a group of optical signals transmitted over optical fibers, and is universally called the optical synchronous digital transmission network which underlies the B-ISDN. Adopting the TDM technology, SDH/SONET is a synchronous system controlled by a master clock with the precision of 10^{-9}. Both of them are used for backbone network transmission, as well as a revolution to Plesiochronous Digital Hierarchy (PDH). SONET is mainly used in North America and Japan, while SDH is mainly used in China and Europe.

In SDH digital hierarchy, fundamental signals are STM-1 signals, which can form higher-rate STM-N signals through synchronous multiplexing and byte interleaving. Currently, SDH only supports limited N values, such as 1, 4, 16 and 64. The standard rates are given below:

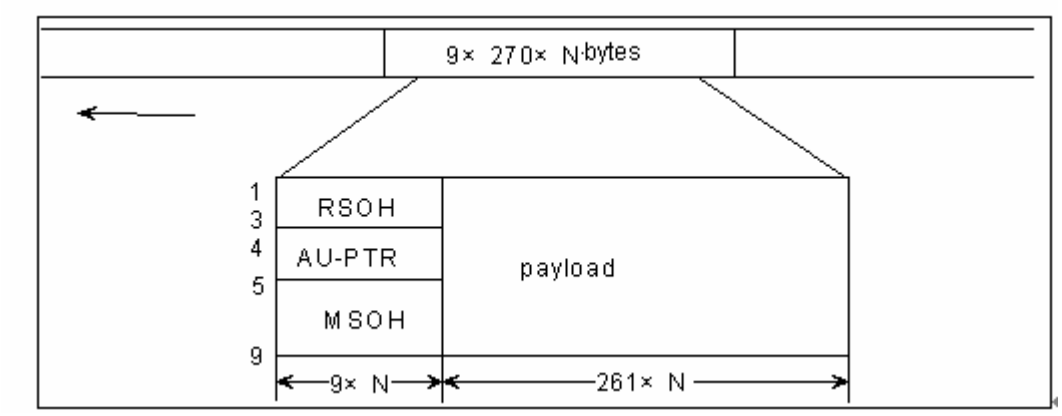
STM-1(OC-3): 155.520 Mbit/s;

STM-4(OC-12): 622.080 Mbit/s;

STM-16(OC-48): 2488.320 Mbit/s;

STM-64(OC-192): 9953.280 Mbit/s.

SDH signal is a byte structure based rectangular frame structure consisting of 9 rows and 270×N columns of 8-bit bytes. The entire frame structure can be divided into three parts: section overhead, administrative unit pointer, and information payload. Varied dates (such as PPP frames and ATM cells) or the combination thereof can be encapsulated in the information payload, no matter what the specific information structure is. Therefore, the information payload is transparent, and IP over SDH can be directly accomplished on an SDH transmission network.



STM-N frame structure

Working Principle

SONET/SDH is a physical-layer protocol responsible for transparent transmission of bit streams over channels. IP is a network-layer protocol responsible for addressing and routing of data packets from source to destination. According to the OSI 7-layer bmodel, a link-layer protocol is needed between the two protocols to perform frame alignment and error correction.

Currently, PPP is widely applied to encapsulate IP data packets in HDLC frame format (IP/PPP/HDLC/SDH). PPP provides such features as multi-protocol encapsulation, error control and link initialization control, while the HDLC frame format can delimit PPP-encapsulated IP data frames over synchronous transmission links.

POS allows the direct transmission of IP packets over high-speed transmission channels provided by SDH. Currently, PPP is widely applied to encapsulate IP data packets in HDLC frame format (IP/PPP/HDLC/SDH). PPP provides such features as multi-protocol encapsulation, error control and link initialization control, while the HDLC frame format can delimit PPP-encapsulated IP data frames over synchronous transmission links. The service adapter at the SDH channel layer will then map the encapsulated IP data packets to SDH Synchronous Payload Envelope and embed the payload into an SDH frame after passing the SDH transmission layer and the section layer (adding the corresponding path overhead and section overhead) before the SDH frame eventually reaches the optical network. POS reserves the connectionless feature of IP.

Currently, the lowest transmission rate of POS interfaces of Ruijie routers is STM-1/OC-3 (155.52Mbit/s). The PPP and HDLC protocol can be used at the data link layer, while IP can be used at the network layer. The transmission rates of interfaces will differ from device to device.

Protocol Specification

Ruijie is compatible with the following protocol specifications:

Protocol	Description
ISO 13239	International standard of HDLC protocol
RFC1619/2615	PPP over SONET/SDH
RFC1662	PPP in HDLC-like Framing

RFC1661	The Point-to-Point Protocol (PPP)
ITU-T Recommendation G.703	Physical/electrical characteristics of hierarchical digital interfaces
ITU-T Recommendation G.707	Network node interface for the synchronous digital hierarchy (SDH)
ITU-T Recommendation G.783	Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks
ITU-T Recommendation G.813	Timing characteristics for SDH equipment slave clocks (SEC)
ITU-T Recommendation G.825	The control of jitter and wander with digital networks which are based on the synchronous digital hierarchy (SDH)
ITU-T Recommendation G.957	Optical interfaces for equipment and systems relating to the synchronous digital hierarchy

Default Configuration

The following table describes the default configuration of POS interfaces.

	Feature	Default Setting
1	Enabling/disabling a POS interface	Enabled
2	Setting the frame format of an interface	sdh
3	Setting the clock mode of an interface	Line clock
4	Setting alarm reporting	b1-tca, b2-tca, b3-tca, sd-ber, sf-ber
5	Setting the alarm threshold of an interface	SD: 6; SF: 3
6	Setting the CRC length of an interface	32
7	Setting the loopback mode of an interface	Disabled
8	Setting the overhead bytes of an interface	C2: 2; J0:1; J1:”Ruijie”
9	Setting the maximum transmission unit of an interface	1500
10	Setting the link protocol of an interface	PPP

Entering Interface Configuration Mode

To configure POS interface, enter the designated POS interface mode first.

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)# interface pos *interface-number*	Enters the designated POS interface configuration mode.

For example, enter a POS interface with the slot number being 1 and the port number being 0.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface pos 1/0
```

Setting the Network Address of an Interface

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)# interface pos *interface-number*	Enters the designated POS interface configuration mode.
Ruijie(config-if-pos *interface-number*)# ip address *ip-address ip-mask*	Configures the network address of the interface.

For example, set the IP address of the interface POS 1/0 to 10.1.1.5.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface POS 1/0
Ruijie(config-if-pos 1/0)# ip address 10.1.1.5 255.255.255.0
```

Enabling/Disabling a POS Interface

A POS interface is enabled by default. Use the **shutdown** command to disable the interface.

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)# interface pos *interface-number*	Enters the designated POS interface configuration mode.
Ruijie(config-if-pos *interface-number*)# [no] shutdown	Enables or disables the interface.

For example, disable the POS interface with the slot number being 1 and the port number being 0

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface pos 1/0
Ruijie(config-if-pos 1/0)# shutdown
```

Setting the Frame Format of an Interface

The frame format of an interface is SDH by default.

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)# interface pos *interface-number*	Enters the designated POS interface configuration mode.
Ruijie(config-if-pos *interface-number*)# framing { sdh | sonet }	Sets the frame format of the interface to SDH or SONET.

For example, set the frame format of the interface POS 1/0 to SONET.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface pos 1/0
Ruijie(config-if-pos 1/0)# framing sonet
```

Setting the Clock Mode of an Interface

POS interface supports to clock modes:

- Internal clock mode: use the internal clock signal.
- External clock mode: use the clock signal provided by line.

Similar to the DTE or DCE model of synchronous serial interfaces, POS interfaces need to have a clock mode. When a POS interface on a router is directly connected to the POS interface of another router, one side shall use the internal clock mode and the other side shall use the external clock mode. In connection to a switching device, if the switch is DCE and uses internal clock signals, then the POS interface of the router shall be DTE and must adopt the external clock mode.

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)# interface pos *interface-number*	Enters the designated POS interface configuration mode.
Ruijie(config-if-pos *interface-number*)# clock { internal | line }	Sets the Tx clock of the interface to the internal clock or line clock. The Tx clock is the line clock by default.

For example, set the clock of the interface POS 1/0 to the internal clock.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface pos 1/0
Ruijie(config-if-pos 1/0)# clock internal
```

Setting the Scrambling of an Interface

A POS interface supports payload scrambling to prevent the presence of excessive consecutive 1s or 0s to facilitate line clock signal extraction at the receiving end. This function is enabled by default.

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)# interface pos *interface-number*	Enters the designated POS interface configuration mode.
Ruijie(config-if-pos *interface-number*)# scrambling-payload	Enables payload scrambling on the interface.

For example, enable payload scrambling on the interface POS 1/0.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface pos 1/0
Ruijie(config-if-pos 1/0)# scrambling-payload
```

Setting Alarm Reporting

Use the following commands to set whether to report various alarm signals on the line to the console (b1-tca, b2-tca, b3-tca, sd-ber and sf-ber are enabled by default).

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)# interface pos *interface-number*	Enters the designated POS interface configuration mode.
Ruijie(config-if-pos *interface-number*)# report { all | b1-tca | b2-tca | b3-tca | lais | lrdi | pais | plm | prdi | puneq | sd-ber | sf-ber }	Enables the corresponding alarms of the interface.

For example, enable LAIS alarms on the interface POS 1/0.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface pos 1/0
Ruijie(config-if-pos 1/0)# report lais
```

Setting Alarm Threshold of an Interface

SD and SF alarms are used to indicate current line performance, while the SF alarm is more serious than the SD alarm. They are generated when the receiving end detects a certain number of B2 errors. The bit error rate threshold of SF is higher than that of SD. When a small number of bit errors occur, an SD alarm is generated; When the bit error rate increases to a certain level, an SF alarm is generated, indicating the line performance has been degrading seriously.

Use the following commands to configure the threshold of SD and SF alarms.

By default, SD is 6, and SF is 3.

The threshold is represented in 10e-X, where X is an integer in the range from 3 to 9. The SD threshold must be lower than the SF threshold.

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)# interface pos *interface-number*	Enters the designated POS interface configuration mode.
Ruijie(config-if-pos *interface-number*)# threshold { sd-ber | sf-ber } *value*	Sets the SD or SF threshold to *value*.

For example, set the SD threshold of the interface POS 1/0 to 4.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface pos 1/0
Ruijie(config-if-pos 1/0)# threshold sd 4
```

Setting CRC Length of an Interface

A POS interface supports two types of CRC length: 16 bits and 32 bits. The CRC length is 32 bits by default.

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)# interface pos interface-number	Enters the designated POS interface configuration mode.
Ruijie(config-if-pos interface-number)# crc { 16 | 32 }	Sets the CRC length of the interface.

For example, set the CRC length of the interface POS 1/0 to 16 bits.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface pos 1/0
Ruijie(config-if-pos 1/0)# crc 16
```

Setting the Loopback Mode of an Interface

Loopback is intended for the testing of some special functions.

When the loopback mode is set to the local mode, all messages sent by the device through the corresponding POS card will all loop back to the receiving direction of this POS card and return to the sending device.

When the loopback mode is set to the remote mode, the messages received by POS card will directly look back to the transmitting direction of this POS card and be sent to the peer end.

By default, loopback is disabled

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)# interface pos *interface-number*	Enters the designated POS interface configuration mode.
Ruijie(config-if-pos *interface-number*)# loopback { local | remote }	Sets the loopback mode of the interface.

For example, set the loopback mode of the interface POS 1/0 to remote loopback.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface pos 1/0
Ruijie(config-if-pos 1/0)# loopback remote
```

Setting the Overhead Bytes of an Interface

On a POS interface, you can configure signal label byte C2, regeneration section trace byte J0 and path trace byte J1. J0 is a section overhead byte used to test the continuity of the connection between two interfaces at the section level. C2 and J1 are both higher-order path overhead bytes; C2 is used to indicate the payload type of virtual container (VC) frames , while J1 is used to test the continuity of the connection between two interfaces at the path level and to identify devices.

Use the following commands to set the overhead byte C2. The default value of C2 is 2.

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)# interface pos *interface-number*	Enters the designated POS interface configuration mode.
Ruijie(config-if-pos *interface-number*)# overhead c2 *number*	Sets the overhead byte C2 of the interface to *number*.

Use the following commands to set the overhead byte J0. The default value is 1.

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)# interface pos *interface-number*	Enters the designated POS interface configuration mode.
Ruijie(config-if-pos *interface-number*)# overhead j0 *number*	Sets the overhead byte J0 to *number*.

Use the following commands to set the overhead byte J1. The default length is 16, and the default message is "Ruijie".

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)# interface pos *interface-number*	Enters the designated POS interface configuration mode.

Ruijie(config-if-pos *interface-number*)# overhead j1 length { 16 | 64 } *message*	Sets the overhead byte J1.

Note

If the length is set to 16, then the maximum length of a message can only be 15 characters, and deficient ones are replaced with NULL. The last byte is the CRC7 value calculated according to this message. If the length is set to 64, then the maximum length of a message can be 62 bytes, and deficient ones are replaced with NULL. The last two bytes are CR/LF (0x0D/0x0A).

The length of J1 configured on an interface must be consistent with that configured on the peer interface; otherwise, the content of J1 on the peer interface cannot be identified.

Setting the Maximum Transmission Unit of an Interface

In order to adapt to different network environments and system requirements, the MTU value of an interface can be modified.

Use the following commands to modify the MTU of an interface.

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)# interface pos *interface-number*	Enters the designated POS interface configuration mode.
Ruijie(config-if-pos *interface-number*)# mtu *bytes*	Sets the MTU value of the interface to *bytes*. The value ranges from 64 to 1592. The default value is 1500 bytes.

For example, set the MTU value of the POS interface 1/0 to 1500 bytes.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface pos 1/0
Ruijie(config-if-pos 1/0)# mtu 1500
```

Setting the Link Protocol of an Interface

The encapsulation protocol is PPP by default.

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)# interface pos *interface-number*	Enters the designated POS interface configuration mode.
Ruijie(config-if-pos *interface-number*)# encapsulation { hdlc | ppp }	Sets the link-layer encapsulation protocol.

For example, set the encapsulation protocol of the POS interface 1/0 to HDLC.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface pos 1/0
Ruijie(config-if-pos 1/0)# encapsulation hdlc
```

Monitoring and Maintaining Interfaces

Use the following commands to monitor the configuration and working status of a POS interface.

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)# show interface pos *interface-number*	Views the configuration and working status of a POS interface.

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)# show pos interface pos *interface-number* alarm { *brief* | *detail* }	Views SONET/SDH alarms of a POS interface.

For example, view the configuration and alarms of the interface POS 1/0.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface pos 1/0
Ruijie(config-if-pos 1/0)# show interface pos 1/0
Ruijie(config-if-pos 1/0)# show pos interface pos 1/0 alarm detail
```

Debugging Interfaces

Use the following commands to debug a POS interface in priviledged user mode.

Command	Function
Ruijie# debug { hdlc | ppp } packet	Enables the debugging of HDLC or PPP packets received and sent on the device.

Command	Function
Ruijie(config)# debug hdlc events	Enables the debugging of all HDLC events on the interface

Command	Function
Ruijie# debug ppp { event | error }	Enables the debugging of all PPP events or errors on the interface.

For example, enables the debugging of PPP packets on the device.

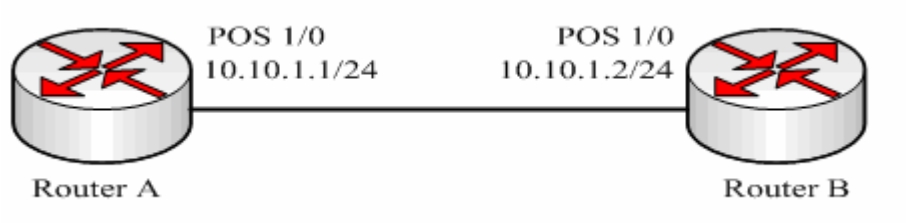
```
Ruijie# debug ppp packet
```

POS Interface Configuration Example

Networking Requirements

Use a pair of single-mode optical fibers (receive and transmit) to directly link the POS interfaces of Router A and Router B, with both sides adopting the SDH frame format, encapsulating HDLC and allowing payload scrambling. Router A uses the internal clock mode and Router B uses the external clock mode.

Networking Topology



Configuration Tips

PPP is used for link encapsulation by default. The HDLC encapsulation configuration needs to be displayed.
In order to guarantee clock synchronization, Router A shall use the internal clock and Router B shall use the line clock.
Two directly-connected POS interfaces shall be in the same IP network segment.

Configuration Steps

Router A:

1) Enter POS interface configuration mode.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface pos 1/0
```

2) Configure the IP address of the interface.

```
Ruijie(config-if-pos 1/0)#ip address 10.10.1.1 255.255.255.0
```

3) Configure the link-layer encapsulation protocol.

```
Ruijie(config-if-pos 1/0)# encapsulation hdlc
```

4) Configure the interface clock

```
Ruijie(config-if-pos 1/0)# clock internal
```

Router B:

1) Enter POS interface configuration mode

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface pos 1/0
```

2) Configure the IP address of the interface

```
Ruijie(config-if-pos 1/0)#ip address 10.10.1.2 255.255.255.0
```

3) Configure the link-layer encapsulation protocol.

```
Ruijie(config-if-pos 1/0)# encapsulation hdlc
```

4) Configure the interface clock.

```
Ruijie(config-if-pos 1/0)# clock line
```

Verification

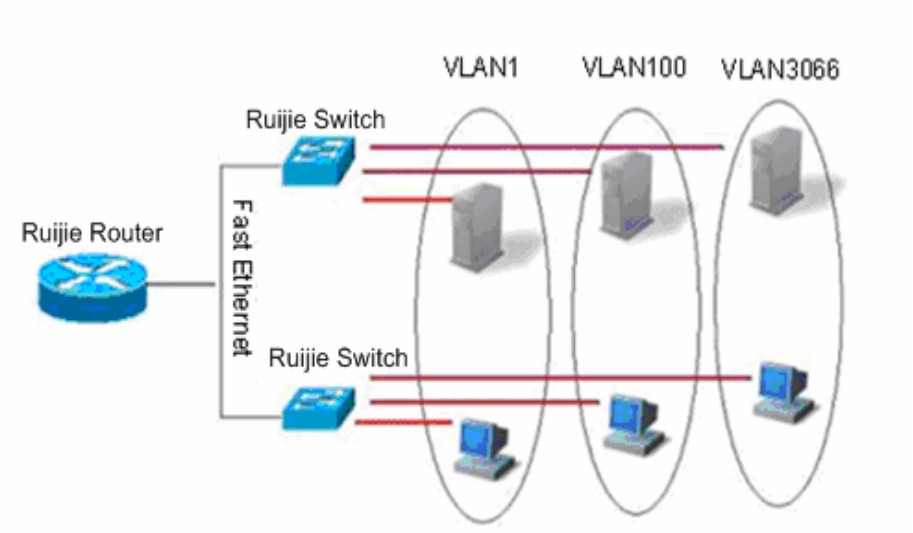
N/A

Configuring VLAN

This chapter describes how to configure IEEE802.1q VLAN.

Overview

Virtual Local Area Network (VLAN) is a logical network divided on a physical network. VLAN corresponds to the L2 network in the ISO model. The division of VLAN is not restricted by the physical locations of network ports. A VLAN has the same attributes as a common physical network. Except for no restriction on physical location, unicast, broadcast and multicast frames on layer 2 are forwarded and distributed within a VLAN, not being allowed to directly go to other VLANs.Therefore, when a host in a VLAN wants to communicate with another host in another VLAN, a layer 3 device must be used, as shown in the following diagram.
You can define a port as the member of a VLAN. All the terminals connected to the specified port are part of the VLAN. A network can support multiple VLANs. In this case, when you add, delete, and modify users in the VLANs, you do not need to modify the network configuration physically.



Like a physical network, a VLAN is usually connected to an IP subnet. A typical example is that all the hosts in the same IP subnet belong to the same VLAN. A layer 3 device must be used for communication between VLANs. Ruijie L3 devices can perform IP routing between VLANs through SVI (Switch Virtual Interfaces). For the configuration about SVI, refer to *Interface Management Configuration* and *IP Unicast Routing Configuration*.

Supported VLAN

Complying with IEEE802.1Q Standard, our products support up to 4094 VLANs(VLAN ID 1-4094), in which VLAN 1 is the default VLAN that cannot be deleted.

VLAN Member Type

You can determine the frames that can pass a port and the number of VLANs that the port can belong to by configuring the VLAN member type of the port. For the detailed description about VLAN member type , see the following table:

Member Type	Port Feature
Access	One access port can belong to only one VLAN, which must be specified manually.
Trunk (802.1Q)	By default, one Trunk port belongs to all the VLANs of the device itself, and it can forward the frames of all the VLANs. However, you can impose restriction by setting a list of allowed VLANs.

Configuring a VLAN

A VLAN is identified by its VLAN ID. You can add, remove, and modify the VLANs in the range of 2 to 4094 on a device. VLAN 1 is created by a device automatically and cannot be removed.
You can configure the member type of a port in a VLAN, add a port to a VLAN, and remove a port from a VLAN in the interface configuration mode.

Saving the VLAN Configuration

To save the VLAN configuration in the configuration file, execute the **copy running-config startup-config** command in the privileged EXEC mode. To view VLAN configuration, execute the **show vlan** command.

Default VLAN Configuration

The following table shows the default configuration of a VLAN.

Parameter	Default Value	Range
VLAN ID	1	1 to 4094
VLAN Name	VLAN xxxx, where xxxx is the VLAN ID	None
VLAN State	Active	Two status: active or inactive

Creating/Modifying a VLAN

In the privileged EXEC mode, you can create or modify a VLAN by executing the following commands.

Command	Function
Ruijie(config)# **vlan** *vlan-id*	Enter a VLAN ID. If you enter a new VLAN ID, the device will create it. If you enter an existing VLAN ID, the device modifies the corresponding VLAN.

Command	Function
Ruijie(config)# **name** *vlan-name*	(Optional) Name the VLAN. If you skip this step, the device automatically assigns the VLAN a name of VLAN xxxx, where xxxx is a 4-digit VLAN ID starting with 0. For example, VLAN 0004 is the default name of VLAN 4.

To restore the name of a VLAN to its default, simply enter the **no name** command.

The following example creates VLAN 888, names it test888, and saves its configuration into the configuration file:

```
Ruijie# configure terminal
Ruijie(config)# vlan 888
Ruijie(config-vlan)# name test888
Ruijie(config-vlan)# end
```

Deleting a VLAN

You cannot delete the default VLAN (VLAN 1).

In the privileged EXEC mode, you can delete a VLAN by executing the following command.

Command	Function
Ruijie(config)# **no vlan** *vlan-id*	Enter the VLAN ID that you want to delete.

Adding Existing Access Ports to Specified VLAN

If you assign a port to an inexistent VLAN, the switch will automatically create that VLAN.

In the privileged EXEC mode, you can assign a port to a VLAN by executing the following command.

Command	Function
Ruijie(config-if)# **switchport mode access**	Define the member type of the port in a VLAN (L2 ACCESS port).
Ruijie(config-if)# **switchport access vlan** *vlan-id*	Assign the port to the VLAN.

The following example adds Ethernet 1/10 to VLAN20 as an access port:

```
Ruijie# configure terminal
Ruijie(config)# interface fastethernet 1/10
Ruijie(config-if)# switchport mode access
Ruijie(config-if)# switchport access vlan 20
Ruijie(config-if)# end
```

The following example shows how to verify the configuration:

```
Ruijie(config)#show interfaces gigabitEthernet 3/1
 switchport
Switchport is enabled
Mode is access port
```

```
Acsess vlan is 1,Native vlan is 1
Protected is disabled
Vlan lists is ALL
```

Caution

In the R2700 switching card, although the access vlan can also be configured on the trunk port, the access port configuration does not take effect and the port remains in the trunk port. Only the configuration of native vlan and allowed vlan list takes effect.

Adding Access Ports to the Existing VLAN

In VLAN configuration mode, add the specified Access port to this VLAN. The effect of this command is the same as the command to specify the VLAN to which the interface belongs in interface configuration mode (namely **switchport access vlan** *vlan-id*).

Command	Function
Ruijie(config)# **vlan** *vlan-id*	Type in a VLAN ID. If a new VLAN ID is typed in, the device will create a VLAN. If an existing VLAN ID is typed in, the corresponding VLAN will be modified.
Ruijie(config-vlan)# **add interface** { *interface-id* | **range** *interface-range* }	Add one or a group of Access ports to the existing VLAN. By default, all layer-2 Ethernet ports belong to VLAN1.
Ruijie(config-vlan)# **[no]add interface** { *interface-id* | **range** *interface-range* }	Delete one or a group of Access ports form the existing VLAN.
Ruijie(config-vlan)#**show interface** *interface-id* **switchport**	Display the information about layer-2 interface.

Caution

This command only applies to Access port.

In terms of these two commands to add interface to the VLAN, the later configured command will override the previously configured command.

The following example adds Access port (GigabitEthernet 0/10) to VLAN20:

```
Ruijie# configure terminal
        SwitchA(config)#vlan 20
        SwitchA(config-vlan)#add interface GigabitEthernet 0/10
```

The following example how to verify the configurations:

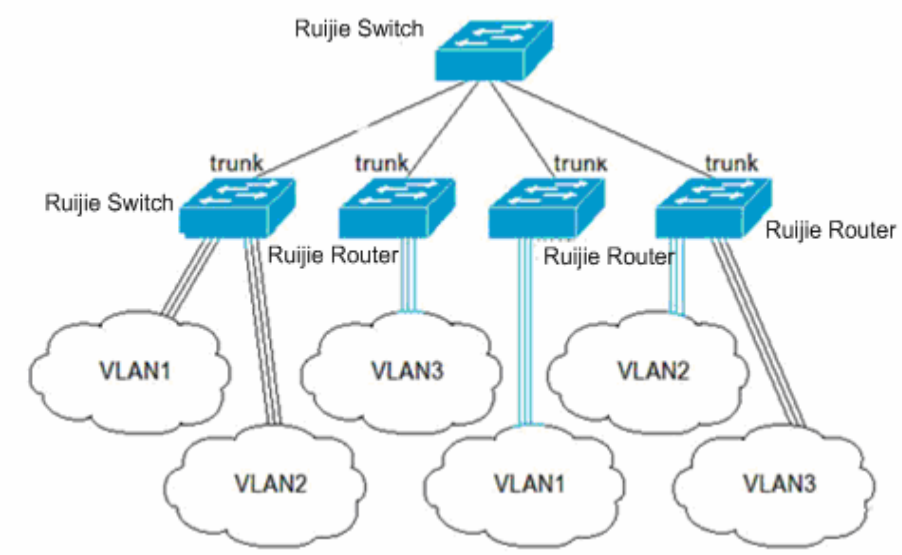
```
Ruijie# show interface GigabitEthernet 0/10 switchport
Interface        Switchport   Mode  Access Native Protected  VLAN lists
----------       --------     -----  ----- ------ ---------- -------
GigabitEthernet 0/10 enabled  ACCESS  20     1    Disabled   ALL
```

Configuring VLAN Trunks

Overview

A trunk is a point-to-point link that connects one or multiple Ethernet switching interfaces to other network devices (for instance, router or switch). A trunk can transmit the traffics of multiple VLANs.

The Trunk encapsulation of Ruijie device is 802.1Q-complied. The following diagram shows a network connected with trunks.



You can set a common Ethernet port or aggregate port to be a trunk port. For the details of aggregate port, refer to *Configuring Aggregate Port*.

In order to switch an interface between the access mode and the trunk mode, use the **switchport mode** command:

Command	Function
Ruijie(config-if)# **switchport mode access**	Set an interface to the access mode
Ruijie(config-if)# **switchport mode trunk**	Set an interface to the Trunk mode

A native VLAN must be defined for a trunk port. The untagged packets received and sent through the port are deemed as the packets of the native VLAN. Obviously, the default VLAN ID of the port (that is, the PVID in the IEEE 802.1Q) is the VLAN ID of the native VLAN. Moreover, you must untag them before sending the packets of the native VLAN through the trunk port. The default native VLAN of a trunk port is VLAN 1.

When you configure a trunk link, be sure that the ports on both ends of the trunk belong to the same native VLAN.

Configuring a Trunk Port

Basic Trunk Port Configuration

In the privileged EXEC mode, you can configure a trunk port by executing the following command.

Command	Function
Ruijie(config-if)# **switchport mode trunk**	Configure the port as a L2 trunk port.
Ruijie(config-if)# **switchport trunk native vlan** *vlan-id*	Specify a native VLAN for the port.

To restore all the trunk-related settings of a trunk port to their defaults, use the **no switchport mode** command in the interface configuration mode.

Defining the Allowed VLAN List of a Trunk Port

By default, the traffic of all VLANs in the range of 1 to 4094 can be transmitted over a trunk port. However, you can restrict the traffic of some VLANs from passing the trunk port by setting its allowed VLAN list.

In the priviledged mode, you can modify the allowed VLAN list of a trunk port by executing the following command.

Command	Function
Ruijie(config-if)# **switchport trunk allowed vlan {all | [add | remove | except] }** *vlan-list*	(Optional) Configure the allowed VLAN list of the trunk port. The vlan-list parameter may be a VLAN or a series of VLANs. It starts with a small VLAN ID and ends with a large VLAN ID. Both IDs are connected with "-", such as 10–20. All: Add all the allowed VLANs to the allowed VLAN list; add: Add the specified VLAN list to the allowed VLAN list; remove: Remove the specified VLAN list from the allowed VLAN list; except: Add all the VLANs other than the specified VLAN list to the allowed VLAN list.

To restore the allowed VLAN list of the trunk port to its default, execute the **no switchport trunk allowed vlan** command in the interface configuration mode.

The following example removes VLAN 2 from the allowed VLAN list of port 1/15:

```
Ruijie(config)# interface fastethernet 1/15
Ruijie(config-if)# switchport trunk allowed vlan remove 2
Ruijie(config-if)# end
Ruijie# show interfaces fastethernet 1/15 switchport
Interface Switchport Mode  Access Native Protected VLAN lists
--------- ---------- ----  ------ ------ -------- ----------
```

```
Gi0/15    enabled    TRUNK  1     1      Disabled   1,3—4094
```

Configuring a Native VLAN.

Tagged or untagged 802.1Q frames can be received or sent on a trunk port. Untagged frames are used to transmit the traffic of the native VLAN. By default, the native VLAN is VLAN 1.

In the privileged EXEC mode, you can configure a native VLAN for a trunk port by executing the following command.

Command	Function
Ruijie(config-if)# **switchport trunk native vlan** *vlan-id*	Configure a native VLAN.

To restore the native VLAN of a trunk port to its default, execute the **no switchport trunk native vlan** command in the interface configuration command.

If a frame carries the VLAN ID of the native VLAN, it will be automatically untagged when being forwarded through the trunk port.

When you set the native VLAN of a trunk port to an inexistent VLAN, the switch will not automatically create the VLAN. In addition, the native VLAN of a trunk port may be out the allowed VLAN list. In this case, the traffic of the native VLAN cannot pass the trunk port.

Showing VLAN Information

Only in the privileged EXEC mode can you view the VLAN information, including VLAN VID, VLAN status, member ports of the VLAN, and VLAN configuration. The related commands are listed as below:

Command	Function
show vlan [**id** *vlan-id*]	Show the information about all or the specified VLAN.

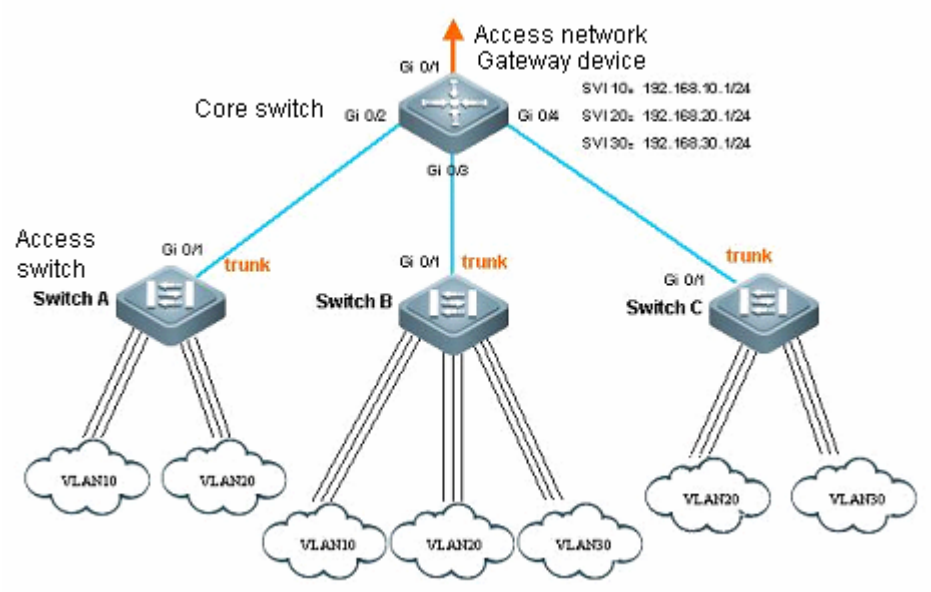
The following example shows the information about a VLAN:

```
Ruijie# show vlan
VLAN  Name      Status             Ports
---- --------  --------   -------------------------------
   1 VLAN0001   STATIC    Gi0/1, Gi0/5, Gi0/6, Gi0/7
                          Gi0/8, Gi0/9, Gi0/10, Gi0/11
                          Gi0/12, Gi0/13, Gi0/14, Gi0/15
                          Gi0/16, Gi0/17, Gi0/18, Gi0/19
                          Gi0/20, Gi0/21, Gi0/22, Gi0/23
                          Gi0/24
  10 VLAN0010  STATIC    Gi0/2, Gi0/3
  20 VLAN0020  STATIC    Gi0/2, Gi0/3, Gi0/4
30 VLAN0030  STATIC    Gi0/3, Gi0/4

Ruijie#show vlan id 20
VLAN  Name             Status    Ports
----  --------         ------    -----------------------
```

```
20  VLAN0020          STATIC    Gi0/2, Gi0/3, Gi0/4
```

Configuration Examp les

Network Topology



Networking Requirements

As shown above, an Intranet is divided into VLAN 10, VLAN 20 and VLAN 30 in order to realize laye-2 isolation. The IP subnets corresponding to three VLANs are 192.168.10.0/24, 192.168.20.0/24 and 192.168.30.0/24. The three VLANs are interconnected through the IP forwarding capacity of layer-3 core switch.

Configuration Tips

This example shows to how to configure the core switch and one of the access switches:

- Configure three VLANs on the core switch; configure the port connecting access switch to trunk port and specify the allowed vlan list to realize layer-2 isolation;
- Configure three SVI interfaces on the core switch to serve as the gateway interfaces for IP subnets corresponding to the three VLANs; configure the corresponding IP addresses;
- Create VLANs on three access switches and assign Access port for each VLAN; specify the trunk port for connecting core switch. This example shows the configuration steps on the access switch of Switch A.

Configuration Steps

Configurations on Core Switch

- Create VLAN

Enter the global configuration mode

```
Ruijie#configure terminal
```

Create VLAN 10

```
Ruijie(config)#vlan 10
```

Create VLAN 20

```
Ruijie(config-vlan)#vlan 20
```

Create VLAN 30

```
Ruijie(config-vlan)#vlan 30
```

Return to the global configuration mode

```
Ruijie(config-vlan)#exit
```

- Configure respective trunk ports and specify the allowed vlan list

Enter the interface range of Gi 0/2-4

```
Ruijie(config)#interface range GigabitEthernet 0/2-4
```

Configure Gi 0/2-4 as trunk ports

```
Ruijie(config-if-range)#switchport mode trunk
```

Return to the global configuration mode

```
Ruijie(config-if-range)#exit
```

Enter port Gi 0/2

```
Ruijie(config)#interface GigabitEthernet 0/2
```

Delete all vlans from the allowed vlan list of this port

```
Ruijie(config-if)#switchport trunk allowed vlan remove 1-4094
```

Add vlan 10 and vlan 20 into the allowed vlan list of this port

```
Ruijie(config-if)#switchport trunk allowed vlan add 10,20
```

Enter port Gi 0/3

```
Ruijie(config-if)#interface GigabitEthernet 0/3
```

Delete all vlans from the allowed vlan list of this port

```
Ruijie(config-if)#switchport trunk allowed vlan remove 1-4094
```

Add vlan 10, vlan 20 and vlan 30 into the allowed vlan list of this port

```
Ruijie(config-if)#switchport trunk allowed vlan add 10,20,30
```

Enter port Gi 0/4

```
Ruijie(config-if)#interface GigabitEthernet 0/4
```

Delete all vlans from the allowed vlan list of this port

```
Ruijie(config-if)#switchport trunk allowed vlan remove 1-4094
```

Add vlan 20 and vlan 30 into the allowed vlan list of this port

```
Ruijie(config-if)#switchport trunk allowed vlan add 20,30
```

Return to the global configuration mode

```
Ruijie(config-if)#exit
```

- Display vlan configurations on core switch

Display vlan information, including vlan id, name, state and member ports

```
Ruijie#show vlan
VLAN  Name      Status              Ports
---- --------  --------   --------------------------------
  1 VLAN0001   STATIC    Gi0/1, Gi0/5, Gi0/6, Gi0/7
                          Gi0/8, Gi0/9, Gi0/10, Gi0/11
                          Gi0/12, Gi0/13, Gi0/14, Gi0/15
                          Gi0/16, Gi0/17, Gi0/18, Gi0/19
                          Gi0/20, Gi0/21, Gi0/22, Gi0/23
                          Gi0/24
```

```
  10 VLAN0010  STATIC     Gi0/2, Gi0/3
  20 VLAN0020  STATIC     Gi0/2, Gi0/3, Gi0/4
  30 VLAN0030  STATIC     Gi0/3, Gi0/4
```

Display the vlan state of port Gi 0/2

```
Ruijie#show interface GigabitEthernet 0/2 switchport
Interface Switchport Mode  Access Native Protected VLAN lists
-------- ---------- -----  ------ ------ --------- ---------
Gi0/2     enabled   TRUNK    1      1     Disabled  10,20
```

Display the vlan state of port Gi 0/3

```
Ruijie#show interface GigabitEthernet 0/3 switchport
Interface Switchport Mode  Access Native Protected VLAN lists
-------- ---------- -----  ------ ------ --------- ----------
Gi0/3     enabled   TRUNK    1      1     Disabled  10,20,30
```

Display the vlan state of port Gi 0/4

```
Ruijie#show interface GigabitEthernet 0/4 switchport
Interface Switchport Mode  Access Native Protected VLAN lists
-------- ---------- -----  ------ ------ --------- ----------
Gi0/4     enabled   TRUNK    1      1     Disabled  20,30
```

- Create SVI port and specify the IP address

Enter the global configuration mode

```
Ruijie#configure terminal
```

Create SVI 10

```
Ruijie(config)#interface vlan 10
```

Configure the IP address of SVI 10

```
Ruijie(config-if)#ip address 192.168.10.1 255.255.255.0
```

Create SVI 20

```
Ruijie(config-if)#interface vlan 20
```

Configure the IP address of SVI 20

```
Ruijie(config-if)#ip address 192.168.20.1 255.255.255.0
```

Create SVI 30

```
Ruijie(config-if)#interface vlan 30
```

Configure the IP address of SVI 30

```
Ruijie(config-if)#ip address 192.168.30.1 255.255.255.0
```

Return to the global configuration mode

```
Ruijie(config-if)#exit
```

Configurations on the Access Switch of Switch A

- Create VLAN

Enter the global configuration mode

- Ruijie#configure terminal

Create VLAN 10

```
Ruijie(config)#vlan 10
```

Create VLAN 20

```
Ruijie(config-vlan)#vlan 20
```

Return to the global configuration mode

```
Ruijie(config-vlan)#exit
```

- Assign Access port for each VLAN

Enter the interface range of Gi 0/2-12

```
Ruijie(config)#interface range GigabitEthernet 0/2-12
```

Configure Gi 0/2-12 as Access ports

```
Ruijie(config-if)#switchport mode access
```

Add Gi 0/2-12 to VLAN 10

```
Ruijie(config-if)#switchport access vlan 10
```

Enter the interface range of Gi 0/13-24

```
Ruijie(config-if)#interface range GigabitEthernet 0/13-24
```

Configure Gi 0/13-24 as Access ports

```
Ruijie(config-if)#switchport mode access
```

Add Gi 0/13-24 to VLAN 20

```
Ruijie(config-if)#switchport access vlan 20
```

Return to the global configuration mode

```
Ruijie(config-if)#exit
```

- Specify the trunk port for connecting core switch

Enter port Gi 0/1

```
Ruijie(config)#interface GigabitEthernet 0/1
```

Configure Gi 0/1 as trunk port

```
Ruijie(config-if)#switchport mode trunk
```

Return to global configuration mode

```
Ruijie(config-if)#exit
```

Configuring RMON

Overview

RMON (Remote Monitoring) is a standard monitoring specification of IETF (Internet Engineering Task Force). It can be used to exchange the network monitoring data among various network monitors and console systems. In the RMON, detectors can be placed on the network nodes, and the NMS determines which information is reported by these detectors, for example, the monitored statistics and the time buckets for collecting history. The network device such as the switch or router acts as a node on the network. The information of current node can be monitored by means of the RMON.

There are three stages in the development of RMON. The first stage is the remote monitoring of Ethernet. The second stage introduces the token ring which is referred to as the token ring remote monitoring module. The third stage is known as RMON2, which develops the RMON to a high level of protocol monitor.

The first stage of RMON (known as RMON1) contains nine groups. All of them are optional (not mandatory), but some groups should be supported by the other groups.

The switch implements the contents of Group 1, 2 , 3 and 9: the statistics, history, alarm and event.

Statistics

Statistics is the first group in RMON. It measures the basic statistics information of each monitored subnet. At present, only the Ethernet interfaces of network devices can be monitored and measured. This group contains a statistics of Ethernet, including the discarded packets, broadcast packets, CRC errors, size block, conflicts and etc.

History

History is the second group in RMON. It collects the network statistics information regularly and keeps them for processing later. This group contains two subgroups:

1. The subgroup History Control is used to set such control information as sampling interval and sampling data source.
2. The subgroup Ethernet History provides history data about the network section traffic, error messages, broadcast packets, utilization, number of collision and other statistics for the administrator.

Alarm

Alarm is the third group in RMON. It monitors a specific management information base (MIB) object at the specified interval. When the value of this MIB object is higher than the predefined upper limit or lower than the predefined lower limit, an alarm will be triggered. The alarm is handled as an event by means of recording the log or sending the SNMP Trap message.

Event

Event is the ninth group in RMON. It determines to generate a log entry or a SNMP Trap message when an event

is generated due to alarms.

RMON Configuration Task List

Configuring Statistics

One of these commands can be used to add a statistic entry.

Command	Function
Ruijie(config-if)# **rmon collection stats** *index* [**owner** *ownername*]	Add a statistic entry.
Ruijie(config-if)# **no rmon collection stats** *index*	Remove a statistic entry.

Caution

The current version of Ruijie product supports only the statistics of Ethernet interface. The index value should be an integer between 1 to 65535. At present, at most 100 statistic entries can be configured at the same time.

Configuring History

One of these commands can be used to add a history entry.

Command	Function
Ruijie(config-if)# **rmon collection history** *index* [**owner** *ownername*] [**buckets** *bucket-number*] [**interval** *seconds*]	Add a history entry.
Ruijie(config-if)# **no rmon collection history** *index*	Remove a history entry.

Caution

The current version of Ruijie product supports only the records of Ethernet. The index value should be within 1 to 65535. At most 10 history entries can be configured.

Bucket-number: Specifies the used data source and time interval. Each sampling interval should be sampled once. The sampling results are saved. The Bucket-number specifies the maximum number of sampling. When the maximum is reached for the sampling records, the new one will overwrite the earliest one. The value range of Bucket-number is 1 to 65535. Its default value is 10.

Interval: Sampling interva in the range of 1 to 3600 seconds, 1800 seconds by default.

Configuring Alarm and Event

One of these command can be used to configure the alarm:

Command	Function

Command	Function
Ruijie(config)# **rmon alarm** *number variable interval* {**absolute	delta**} **rising-threshold** *value* [*event-number*] **falling-threshold** *value* [*event-number*] [**owner** *ownername*]	Add an alarm entry.
Ruijie(config)# **rmon event** *number* [**log**] [**trap** *community*] [**description** *description-string*] [**owner** *ownername*]	Add an event entry.
Ruijie(config)# **no rmon alarm** *number*	Remove an alarm.
Ruijie(config)# **no rmon event** *number*	Remove an event.

number: Alarm index in the range of 1 to 65535.
variable: Variable to be monitored by the alarm(in integer).
interval: Sampling interval in the range of 1 to 4294967295.
Absolute: each sampling value compared with the upper and lower limits.
Delta: the difference with previous sampling value compared with the upper and lower limits.
value: Upper and lower limits.
Event-number: when the value exceeds the upper or lower limit, the event with the index of Event-number will be triggered.
Log: Record the event.
Trap: Send the Trap message to the NMS when the event is triggered.
Community: Community string used for sending the SNMP Trap message.
Description-string: Description of the event.
Ownername: Owner of the alarm or the event.

Showing RMON status

Command	Function
Ruijie(config)# **show rmon alarms**	Show alarms.
Ruijie(config)# **show rmon events**	Show events.
Ruijie(config)# **show rmon history**	Show history.
Ruijie(config)# **show rmon statistics**	Show statistics.

RMON Configuration Examples

Example of Configuring Statistics

If you want to get the statistics of Ethernet Port 3 , use the following commands:

```
Ruijie(config)# interface gigabitEthernet 0/3
Ruijie(config-if)# rmon collection stats 1 owner aaa1
```

Example of Configuring History

Use the following commands if you want to get the statistics of Ethernet Port 3 every 10 minutes:

```
Ruijie(config)# interface gigabitEthernet 0/3
Ruijie(config-if)# rmon collection history 1 owner aaa1 interval 600
```

Example of Configuring Alarm and Event

If you want to configure the alarm function for a statistical MIB variable, the following example shows you how to set the alarm function to the instance ifInNUcastPkts.6 (number of non-unicast frames received on port 6; the ID of the instance is 1.3.6.1.2.1.2.2.1.12.6) in ***IfEntry*** table of MIB-II. The specific function is as follows: the switch checks the changes to the number of non-unicast frames received on port 6 every 30 seconds. If 20 or more than 20 non-unicast frames are added after last check (30 seconds earlier), or only 10 or less than 10 are added, the alarm will be triggered, and event 1 is triggered to do corresponding operations (record it into the log and send the Trap with "community" name as "rmon"). The "description" of the event is "ifInNUcastPkts is too much"). The "owner" of the alarm and the event entry is "aaa1".

```
Ruijie(config)#rmon alarm 10 1.3.6.1.2.1.2.2.1.12.6 30 delta rising-threshold 20 1
falling-threshold 10 1 owner aaa1
Ruijie(config)#rmon event 1 log trap rmon description "ifInNUcastPkts is too much " owner aaa1
```

Example of Showing RMON Status

show rmon alarm

```
Ruijie# show rmon alarms
rmon alarm table:
                index: 10,
                interval: 30,
                oid = 1.3.6.1.2.1.2.2.1.12.6
                sampleType: 2,
                alarmValue: 0,
                startupAlarm: 3,
                risingThreshold: 20,
                fallingThreshold: 10,
                risingEventIndex: 1,
                fallingEventIndex: 1,
                owner: zhangesan,
                stats: 1,
```

show rmon event

```
Ruijie# show rmon events
rmon event table:
                index = 1
                description = ifInNUcastPkts
                type = 4
```

```
                community = rmon
                lastTimeSent = 0 d:0 h:0 m:0 s
                owner = zhangsan
                status = 1
```

show rmon history

```
Ruijie# show rmon history
rmon history control table:
                index = 1
                interface = FastEthernet 0/1
                bucketsRequested = 10
                bucketsGranted = 10
                interval = 1800
                owner = zhangsan
                stats = 1

rmon history table:
                index = 1
                sampleIndex = 198
                intervalStart = 0d:14h:0m:47s
                dropEvents = 0
                octets = 67988
                pkts = 726
                broadcastPkts = 502
                multiPkts = 189
                crcAllignErrors = 0
                underSizePkts = 0
                overSizePkts = 0
                fragments = 0
                jabbers = 0
                collisions = 0
                utilization = 0
```

show rmon statistics

```
Ruijie#  show rmon statistics
ether statistic table:
                index = 1
                interface = FastEthernet 0/1
                owner = zhangsan
                status = 0
                dropEvents = 0
                octets = 1884085
                pkts = 3096
                broadcastPkts = 161
```

```
                multiPkts = 97
                crcAllignErrors = 0
                underSizePkts = 0
                overSizePkts = 1200
                fragments = 0
                jabbers = 0
                collisions = 0
                packets64Octets = 128
                packets65To127Octets = 336
                packets128To255Octets = 229
                packets256To511Octets = 3
                packets512To1023Octets = 0
                packets1024To1518Octets = 1200
```

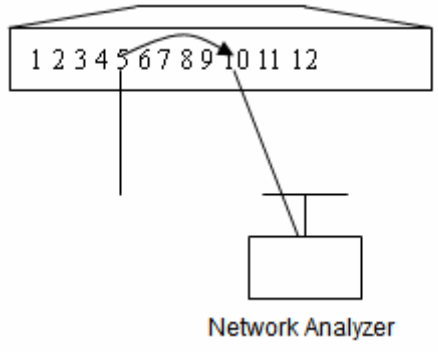
Configuring SPAN

Overview

With SPAN, you can analyze the communications between ports by copying a frame from one port to another port connected with a network analysis device or RMON analyzer. The SPAN mirrors all the packets sent/received at a port to a physical port for analysis.

For example, all the frames on the GigabitEhternet port 5 are mirrored to the GigabitEhternet port 10, as shown in Figure 18-1. Although the network analyzer connected to port 10 is not directly connected to port 5, it can receive all the frames from port 5.

Figure 1-1 SPAN Configuration Example



The SPAN allows you to monitor all the frames incoming/outgoing the source port, including the route input frames.

The SPAN does not affect the normal packet switching of the switch. Instead, it copies the frames incoming/outgoing the source port to the destination port. However, the frames may be discarded on an overflowed destination port, for example, when an 100Mbps port monitors an 1000Mbps port.

SPAN Concepts and Terms

This section describes the concepts and terms related to SPAN configuration.

SPAN Session

One SPAN session is the combination of one destination port and source port. You can monitor the received, transmitted, and bi-directional frames of one or multiple interfaces.

You can set up one or multiple SPAN sessions. Switched port and routed port can be configured with only one SPAN session. However, switched port, routed port, and AP can be configured as source port and destination port. The SPAN session does not affect the normal operation of the switch.

You can configure the SPAN session on one disabled port, but the SPAN does not take effect until you enable the destination and source ports. The **show monitor session** *session number* command allows you to show the operation status of the SPAN session. One SPAN session does not take effect immediately after the swtich is powered on until the destination port is active.

Frame Type

Frame Direction

The SPAN session includes the following frame types:

- Received frames

Received frames include all known unicast frames and routing frames, and each received frame is copied to the destination port. In one SPAN session, you can monitor the the frames inputted from one or multiple source ports. Although a frame inputted from the source port is dropped due to some reasons, for example, port security, it is still sent to the destination port. This does not affect the function of the SPAN.

- Transmitted frames

All the frames sent from the source port are copied to the destination port. In one SPAN session, you can monitor the frames input from one or multiple source ports. If a frame from a port to the source port is dropped due to some reasons, the frame will not be sent to the destination port as well. Moreover, the format of the frames destined to the source port may change, for example, routed frames, source MAC address, destination MAC address, VLAN ID and TTL. Similarly, the format of the frames copied to the destination port will change.

- Bi-directional frames

Bi-directional frames include the above mentioned two frames. In one SPAN session, you can monitor the frames received and transmitted from/to one or multiple source ports.

SPAN Traffic

You can use the SPAN to monitor all network communications, including multicast frames and BPDU frames.

Source Port

A source port (also known as monitored interface) is a switched port or routed port monitored for network analysis. In one SPAN session, you can monitor received, transmitted and bi-directional frames. There is no limit on the maximum number of the source ports.

A source port has the following features:

- It can be a switched port, routed port or AP.
- It cannot be a destination port at the same time.
- It can specify the inbounding or outbounding direction of the monitored frames.
- The source port and the destination port can reside in the same VLAN or different VLANs.

Destination Port

The SPAN session has a destination port (also known as the monitoring port) used to receive the frames copied from the source port.

The destination port has the following features:

- It can be a Switched Port , Routed Port or AP.
- The destination port can not be the source port at the same time.

Interaction between the SPAN and Other Functions

The SPAN interacts with the following functions.

- Spanning Tree Protocol (STP) — the destination port of SPAN participates in the STP.

Configuring SPAN

This section describes how to configure the SPAN on your switch.

Default SPAN Configuration

Function	Default Configuration
SPAN status	Disabled

Creating a SPAN Session and Specifying the Monitoring Port and Monitored Port

To set up a SPAN session and sepcify the destination port and the source port, execute the following commands.

Command	Function
Ruijie(config)# **monitor session** *session_number* **source interface** *interface-id* [,| -] {**both** | **rx** | **tx**}	Specify the source port. *interface-id*: Specify corresponding interface id.
Ruijie(config)# **monitor session** *session_number* **destination interface** *interface-id* [**switch**]	Specify the destination port. *interface-id*: Specify corresponding interface id. The **switch** parameter supports exchange on the mirrored destination port.

To delete a SPAN session, use the **no monitor session** *session_number* command in the global configuration mode. To delete all the SPAN sessions, use the **no monitor session all** command in the global configuration mode. You can use the **no monitor session** *session_number* **source interface** *interface-id* command or the **no monitor session** *session_number* **destination interface** *interface-id* command to delete the source port or destination port in the global configuration mode.

The following example shows how to create session 1. First, clear the configuration of session 1, and then mirror the frames from port 1 to port 8. The **Show monitor session** command allows you to verify your configuration.

```
Ruijie(config)# no monitor session 1
Ruijie(config)# monitor session 1 source interface gigabitEthernet 3/1 both
Ruijie(config)# monitor session 1 destination interface gigabitEthernet 3/8
Ruijie(config)# end
Ruijie# show monitor session 1
sess-num: 1
src-intf:
GigabitEthernet 3/1 frame-type Both
dest-intf:
GigabitEthernet 3/8
```

Caution

Session 1 is used to support ther global cross-linecard port mirror.

Deleting a Port from the SPAN Session

To delete a port from a SPAN session, execute the following commands:

Command	Function
Ruijie(config)# **no monitor session** *session_number* **source interface** *interface-id* [,| -] [**both**	**rx**	**tx**]	Specify the source port to delete. *interface-id*: Specify corresponding interface id.

You can use the **no monitor session** *session_number* **source interface** *interface-id* command to delete the source port from a SPAN session in the global configuration mode. The following example shows how to delete port 1 from session 1 and verify your configuration.

```
Ruijie(config)# no monitor session 1 source interface gigabitethernet 1/1 both
Ruijie(config)# end
Ruijie# show monitor session 1
sess-num: 1
dest-intf:
GigabitEthernet 3/8
```

Specifying the Source/Destination MAC for the Mirrored Frame

To specify the source and destination MAC addresses for the mirrored frames, execute the following commands:

Command	Function
Ruijie(config)# [**no**] **monitor session** *session_number* [**source interface** *interface-id* [**both**	**rx**	**tx**]	**destination interface** *interface-id*]	**mac** {**source** *mac-addr*| **destination** *mac-addr* } [**both**	**rx**	**tx**] {**source**	**destination**} *mac-address* [**both**	**rx**	**tx**]	Specify the source and destination MAC addresses for the mirrored frames.

You can use the **no monitor session** *session_number* **mac** {**source** | **destionation**} [**both** | **rx** | **tx**] command to delete the source and destination MAC addresses for the mirrored frames.

Configuring the Flow-based Mirror

To configure the flow-based mirror, execute the following commands:

Command	Function

Command	Function
Ruijie(config)# [**no**] **monitor session** *session_number* **source interface** *interface-id* **rx acl** *name*	Specify the matched acl name for the mirrored flow and the mirrored source and destination ports.

😐	Only the incoming port mirror is supported.
Product Support	For the ACL configuration commands, see the related configuration guide.

Other Precautions

- Connect the network analyzer to the monitoring port.
- When the SPAN is enabled, the configuration change has the following result.

1) If you change the VLAN configuration of the source port, the configuration takes effect immediately.
2) If you change the VLAN configuration of the destination port, the configuration takes effect immediately.
3) If you have disabled the source port or destination port, the SPAN does not take effect.
4) If you add the source or destination port to an AP, this will remove the source port or destination port from the SPAN.

Showing the SPAN Status

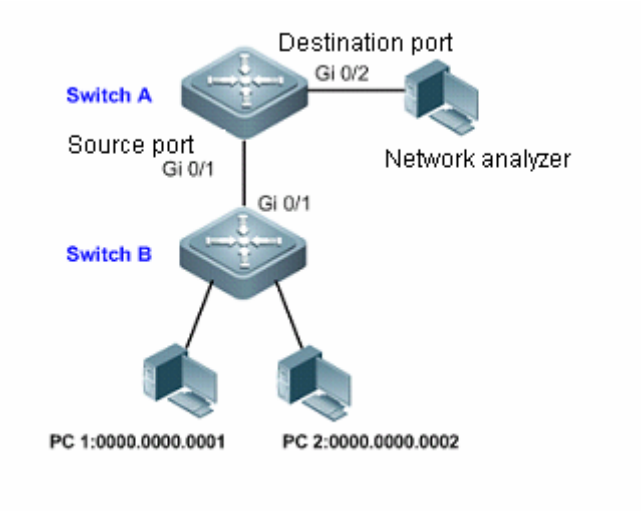
The **show monitor** command shows the current SPAN status. The following example illustrates how to show the current status of SPAN session 1.

```
Ruijie# show monitor session 1
sess-num: 1
src-intf:
GigabitEthernet 3/1 frame-type Both
dest-intf:
GigabitEthernet 3/8
```

Typical SPAN Configuration Examples

Example of Flow-based Mirror Configuration

Topology Diagram



Topology for simple SPAN application

Application Requirements

The network analyzer shall be able to monitor all dataflow forwarded by Switch A to Switch B and monitor specific dataflow from Switch B (such as the traffic from PC1 and PC2).

Configuration tips

1. Configure SPAN on the device (Switch A) connecting with network analyzer; configure the port (Gi 0/1) connected with Switch B as SPAN source port, and configure the port (Gi 0/2) connected with network analyzer as SPAN destination port.
2. Configure flow-based mirror (traffic from PC1 and PC2) on SPAN source port (Gi 0/1).

Configuration Steps

Step 1: Configure interconnection ports.

! Configure port Gi 0/1 of Switch A as Trunk Port.

```
SwitchA#configure terminal
            Enter configuration commands, one per line.  End with CNTL/Z.
            SwitchA(config)#interface gigabitEthernet 0/1
            SwitchA(config-if-GigabitEthernet 0/1)#switchport mode trunk
            SwitchA(config-if-GigabitEthernet 0/1)#exit
```

Step 2: Configure ACL.

! Create MAC extended ACL of "ruijie" on Switch A to permit source MACs of 0000.0000.0001 and 0000.0000.0002.

```
SwitchA(config)#mac access-list extended ruijie
```

```
SwitchA(config-mac-nacl)#permit host 0000.0000.0001 any
SwitchA(config-mac-nacl)#permit host 0000.0000.0002 any
SwitchA(config-mac-nacl)#exit
```

Step 3: Create SPAN session and specify the source port and destination port.

! On Switch A, create Session 1 and configure Gi 0/1 as the source port for mirroring bidirectional dataflow, and configure flow-based ingress mirror.

```
SwitchA(config)#monitor session 1 source interface gigabitEthernet 0/1 tx
SwitchA(config)#monitor session 1 source interface gigabitEthernet 0/1 rx acl ruijie
```

! On Switch A, configure Gi 0/2 as the destination port of Session 1

```
SwitchA(config)#monitor session 1 destination interface gigabitEthernet 0/2
```

Verification

Step 1: Display configurations of respective devices.

```
SwitchA#show running-config
!
mac access-list extended ruijie
 10 permit host 0000.0000.0001 any etype-any
 20 permit host 0000.0000.0002 any etype-any
!
interface GigabitEthernet 0/1
 switchport mode trunk
!
monitor session 1 destination interface GigabitEthernet 0/2
monitor session 1 source interface GigabitEthernet 0/1 tx
monitor session 1 source interface GigabitEthernet 0/1 rx acl ruijie
!
```

Step 2: Display SPAN state of the device.

```
SwitchA#show monitor session 1
sess-num: 1                          //SPAN Session
span-type: LOCAL_SPAN                 //Local SPAN
src-intf:                             //information about SPAN source port
GigabitEthernet 0/1        frame-type Both
rx acl id 2900                        //Traffic-based SPAN
acl name ruijie
dest-intf:                            //Information about SPAN destination port
GigabitEthernet 0/2
```

RGOS Configuration Guide

v10.4(3b13)

IP Address and Service Configuration

Configuring IP Addresses and Services

Understanding IP Address Configuration

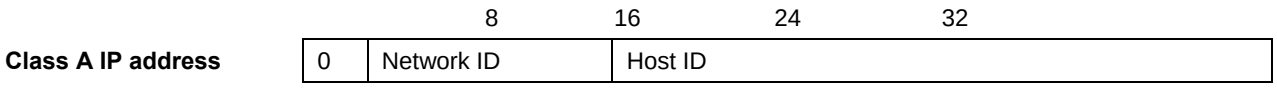
Overview

An IP address is made up of 32 binary bits and expressed in dotted decimal format for the convenience of writing and description. In dotted decimal format, the 32 binary bits form four octets (1 octet equals to 8 bits). Each octet is separated by a period (dot) in the range from 0 to 255. For example, 192.168.1.1 is an IP address in dotted decimal format.

An IP address is an address that IP uses for interconnection. A 32-bit IP address consists of two parts: network address and local address. According to the first several bits of the network address of an IP address, IP addresses are divided into four categories.

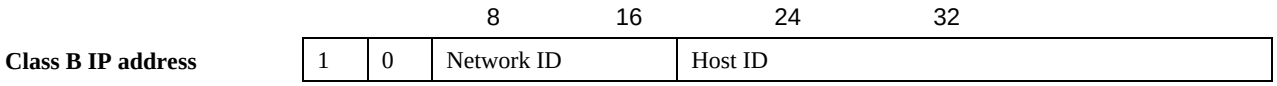
Class A: There are totally 128 Class A IP addresses. The most significant bit is 0, followed by seven bits representing a network ID and 24 bits representing a host ID.

Figure 1-1



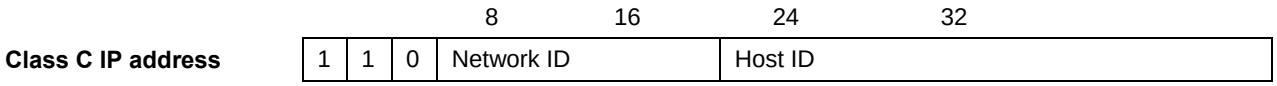
Class B: There are totally 16,384 Class B IP addresses. The two most significant bits are 10, followed by 14 bits representing a network ID and 16 bits representing a host ID.

Figure 1-2



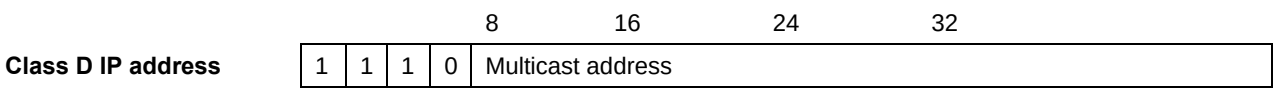
Class C: There are totally 2,097,152 Class C IP addresses. The three most significant bits are 110, followed by 21 bits representing a network ID and 8 bits representing a host ID.

Figure 1-3



Class D: The four most significant bits are 1110 and the other bits are a multicast IP address.

Figure 1-4



Note An IP address whose four most significant bits are 1111 is prohibited. This type of IP addresses, also called Class E IP addresses, is reserved.

When you build up a network, plan IP addresses according to the real network environment. To make the network connect to the Internet, you need to apply for IP addresses from a central authority, for example, China Internet Network Information Center (CNNIC) in China. Internet Corporation for Assigned Names and Numbers (ICANN) is the ultimate authority responsible for IP address allocation. However, for a private network, you do not need to apply for IP addresses. It is recommended that you assign private IP addresses for hosts in a private network.

The following table lists reserved and available addresses.

Class	Address Space	Status
Class A	0.0.0.0	Reserved
	1.0.0.0 to 126.0.0.0	Available
	127.0.0.0	Reserved
Class B	128.0.0.0 to 191.254.0.0	Available
	191.255.0.0	Reserved
Class C	192.0.0.0	Reserved
	192.0.1.0 to 223.255.254.0	Available
	223.255.255.0	Reserved
Class D	224.0.0.0 to 239.255.255.255	Multicast
Class E	240.0.0.0 to 255.255.255.254	Reserved
	255.255.255.255	Broadcast

Three blocks of IP addresses are reserved for private networks and are not used on the Internet. Address translation is required for a private network using one of these IP addresses to access the Internet. The following table lists these addresses, which are defined in RFC 1918.

Class	Address Space	Status
Class A	10.0.0.0 to 10.255.255.255	1
Class B	172.16.0.0 to 172.31.255.255	16
Class C	192.168.0.0 to 192.168.255.255	256

For information on the assignment of IP addresses, TCP/UDP ports and other codes, refer to RFC 1166.

IP Address Configuration Task List

The IP address configuration task list includes the following tasks. Only the first one is required, and the others are optional depending on your network requirements.

Assigning IP Addresses to Interfaces

Only hosts configured with IP addresses can receive and send IP packets. If an interface is configured with an IP address, this means that the interface supports the IP protocol.

Use the following commands to assign an IP address to an interface in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip address** *ip-address mask*	Assigns an IP address to an interface.
Ruijie(config-if)# **no ip address**	Removes the IP address configured for the interface.

A 32-bit mask identifies the network part of an IP address. In a mask, the IP address bit corresponding to 1 represents the network ID and the IP address bit corresponding to 0 represents the host ID. For example, the mask corresponding to a Class A IP address is 255.0.0.0. You can subdivide a network into multiple segments by using the mask. The goal of subnet definition is to use some bits of the host address of an IP address as the network address to reduce the number of hosts and increase the number of networks. At this point, the mask is called a subnet mask.


Note Theoretically, any bit of the host address of an IP address can be used as a subnet mask.

☑ Ruijie products only support continuous subnet masks from left to right starting from the network ID.

You can configure the following features related to IP addresses in a task list. These tasks are optional depending on your actual needs.

Assigning Multiple IP Addresses to an Interface

Ruijie products support assigning multiple IP addresses to an interface. Of the assigned IP addresses, one is the primary IP address and the others are secondary IP addresses. Theoretically, you can configure secondary addresses as many as you wish. A secondary IP address, however, must reside in different networks from the primary IP address or the other secondary IP addresses. The secondary IP address will be used frequently during the building of a network, for example, in the following cases:

- There are not enough host addresses for a network. For example, a LAN requires a Class C IP address to support up to 254 hosts. However, when there are more than 254 hosts in the LAN, another Class C IP address is necessary. Therefore, a host needs to connect two networks and thus needs configuring multiple IP addresses.
- Many older networks were built based on Layer 2 bridges without subnet definition. The use of secondary IP addresses makes it easy to upgrade such a network to an IP-based routing network. An IP address is assigned for every device in a subnet.
- Two subnets of a network might be separated by another network. By creating a subnet in each separated subnets, you can connect the two separated subnets together by assigning secondary IP addresses. One subnet cannot appear on two or more interfaces in a device.


Caution Before configuring a secondary IP address, you need to confirm that the primary IP address has been configured. If a secondary IP address is configured on one device of the network, the secondary IP addresses configured for other devices of the network must be located in the same network. If an IP address is not assigned to other devices, you can configure the IP address as the primary IP address for a

device.

Use the following command to assign a secondary IP address to an interface in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip address** *ip-address mask* **secondary**	Assigns a secondary IP address to the interface.
Ruijie(config-if)# **no ip address** *ip-address mask* **secondary**	Removes the secondary IP address configured for the interface.

Configuring the Management IP Address and the Gateway Together

Ruijie Layer-2 switches allow you to configure the management IP address and the gateway by using the same command. Generally, Layer-2 switches provide the **ip default-gateway** command to configure a default gateway. Sometimes, the Layer-2 switch supports remote management via Telnet, and the management IP address and default gateway of the Layer-2 switch must be modified. In such a case, configuring either the **IP address** command or the **IP default-gateway** command will prevent you from configuring the other command (because the configuration has changed and this device can no longer be accessed via the network). Therefore, use the **gateway** keyword of the **IP address** command to modify the management IP address and default gateway.


Caution This command is only supported on Layer-2 devices.

Use the following commands to configure the management IP address and the gateway at the same time in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip address** *ip-address mask* **gateway** *ip-address*	Configures the management IP address and gateway.
Ruijie(config-if)# **no ip address** *ip-address mask* **gateway**	Removes the configured management IP address and gateway.

Configuring the Address Resolution Protocol (ARP)

Every device in a LAN has two addresses: a local address and a network address. The local address is contained in the header of a frame at the data link layer. More exactly, it is a data link layer address. Since this local address is handled in the MAC sub-layer of the data link layer, it is normally called an MAC address representing an IP network device on a network. The network address represents a device on the Internet and indicates the network to which the device belongs.

For mutual communication, a device in a LAN must know the 48-bit MAC address of the other device. It can obtain the MAC address according to an IP address. This process is called ARP. The reversed ARP (RARP) can resolve the IP address based on a MAC address. You can resolve an address in two ways: ARP and proxy ARP. For more information on ARP, proxy ARP and RARP, refer to RFC 826, RFC 1027, and RFC 903.

ARP binds an IP to an MAC address. It can resolve the MAC address according to an IP address. Then, the relationship between the IP address and the MAC address is stored in the ARP cache. With the MAC address, a device can encapsulate the frames of the data link layer and send them to the LAN in the Ethernet II-type by default. However, the frames can also be encapsulated into other types of Ethernet frames, such as SNAP.

The principle of RARP is similar to ARP. RARP resolves the IP address according to an MAC address. RARP is applied on diskless workstations in general.

Normally, a device can work without any special address resolution configuration. Ruijie products can manage address resolution by the following configuration:

Configuring ARP Statically

ARP offers dynamic IP-to-MAC address mapping. It is not necessary to configure ARP statically in most cases. By configuring ARP Statically, Ruijie products can respond to ARP requests from other IP addresses.

Use the following commands to configure static ARP in global configuration mode.

Command	Function
Ruijie(config)# **arp** *ip-address mac-address arp-type*	Defines static ARP. Currently, Only *arp-type* can be set to **arpa** only.
Ruijie(config)# **no arp** *ip-address*	Removes static ARP.

Setting ARP Encapsulation

Currently Ruijie products only support Ethernet II ARP encapsulation, which also known as the **ARPA** keyword.

Setting ARP Timeout

ARP timeout takes effect for only the dynamically-learned IP-to-MAC address mapping. The shorter the timeout, the truer the mapping table saved in the ARP cache, but the more network bandwidth the ARP occupies. Hence the advantages and disadvantages should be weighted. Generally it is not necessary to configure the ARP timeout period unless otherwise stated.

Use the following commands to configure the ARP timeout period in interface configuration mode.

Command	Function
Ruijie(config-if)# **arp timeout** *seconds*	Configures the ARP timeout period in the range from 0 to 2147483, where 0 indicates no aging.
Ruijie(config-if)# **no arp timeout**	Removes the configuration.

By default, the timeout period is 3600 seconds.

Disabling IP Routing

IP routing is enabled by default. Do not execute this command unless you are sure that IP routing is not needed. Disabling IP routing will make the device lose all routes and the route forwarding function.

Run the following commands to disable IP routing in global configuration mode.

Command	Function
Ruijie(config)# **no ip routing**	Disables IP routing.

Command	Function
Ruijie(config)# **ip routing**	Enables IP routing

Configuring Broadcast Packet Processing

A broadcast packet is destined to all hosts in a physical network. Ruijie products support two kinds of broadcast packets: directed broadcast and flooding. A directed broadcast packet is sent to all the hosts in a specific network, with the host ID of the destination IP addresses set to all-1s. While a flooding broadcast packet is sent to all the hosts in all networks, with all 32 bits of the destination IP address set to 1s. Broadcast packets are currently misused by some protocols, including the Internet protocol. Therefore, it is a basic responsibility for a network administrator to manage and control broadcast packets.

Forwarding flooding broadcast packets may make the network overburden and thus affect network operation. This is known as broadcast storm. There are some ways to suppress and restrict broadcast storm in the local network. However, Layer 2 network devices like bridges and switches will forward and spread broadcast packets.

The best solution to solve broadcast storm is to specify a broadcast address for each network, that is, to implement directed broadcast. This requires the IP protocol to use directed broadcast instead of flooding broadcast as much as possible.

For details about broadcast, refer to RFC 919 and RFC 922.

You can configure the following features in a task list to process broadcast packets. These tasks are optional depending on actual network needs.

Enabling Directed Broadcast-to-Physical Broadcast Conversion

A directed broadcast IP packet is one destined to the broadcast address of an IP subnet. For instance, the packet destined to 172.16.16.255 is a directed broadcast packet. However, the node that generates this packet is not a member of the destination subnet.

Upon receipt of a directed broadcast IP packet, the device indirectly connecting the destination subnet will forward the packet in the same way as forwarding a unicast packet. After the directed broadcast IP packet arrives at a device directly connecting the subnet, the device transforms the packet into a flooding broadcast IP packet (whose destination address is all-1s in general), and then send it to all the hosts within the destination subnet by means of broadcast at the link layer.

Enabling the conversion from directed broadcast to physical broadcast on an interface allows the interface to forward directed broadcast IP packets to the directly connected network. This command only affects the transmission of the directed broadcast IP packets to the final destination subnet, but not other directed broadcast packets.

You can control the forwarding of directed broadcast IP packets as required on an interface by defining ACLs. Only those IP packets matching the ACLs will experience the conversion from directed broadcast to physical broadcast.

Use the following commands to configure directed broadcast-to-physical broadcast conversion in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip directed-broadcast** [*access-list-number*]	Enables directed broadcast to physical broadcast conversion on the interface.

Command	Function
Ruijie(config-if)# **no ip directed-broadcast**	Disables the conversion.

Establishing an IP Broadcast Address

Currently, the most popular way is the destination address consisting of all 1s (255.255.255.255). Ruijie products can be configured to generate other IP broadcast addresses and receive all types of IP broadcast packets.

Use the following commands to set a broadcast IP address other than 255.255.255.255 in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip broadcast-address** *ip-address*	Creates a broadcast address.
Ruijie(config-if)# **no ip broadcast-address**	Removes the configuration.

Monitoring and Maintaining IP Addresses

You can monitor and maintain networks according to the following task list. These tasks are optional depending on your actual needs.

Clearing Caches and Table Contents

You can remove all contents of a particular cache, table, or database, including

- Clearing the ARP cache
- Clearing the table of mapping between host names and IP addresses
- Clearing the routing table

Command	Function
Ruijie# **clear arp-cache**	Clears the ARP cache.
Ruijie# **clear ip route** {*network* [*mask*] | *}	Clears the IP routing table.

Displaying System and Network Status

You can show the contents of the IP routing table, cache, and database. Such information is very helpful in network troubleshooting. You also can display information about network reachability of a local device and determine the routing path that the packets of your device are taking after leaving the device.

Use the following commands to display system and network status information in privileged user mode.

Command	Function
Ruijie# **show arp** [[*ip* [*mask*] | *mac-address*] | **static** | **complete** | **incomplete**]	Shows the ARP cache table. The **complete** keyword is used to show resolved entries of dynamic ARP, and the **incomplete** keyword is used to show unresolved entries of dynamic ARP.
Ruijie# **show ip arp**	Shows the IP ARP cache table.
Ruijie# **show ip interface** [*interface-type interface-number*]	Shows interface IP address information.
Ruijie# **show ip route** [*network* [*mask*]]	Shows the routing table.
Ruijie#**show ip route**	Shows brief information about the routing table.

Command	Function
Ruijie# **ping** *ip-address* [**length** *bytes*] [**ntimes** *times*] [**timeout** *seconds*]	Tests network reachability.

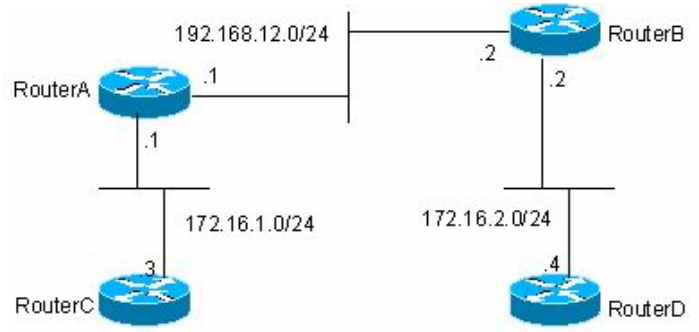
IP Address Configuration Examples

Example of Configuring Secondary IP Addresses

Configuration Requirements

The following figure shows IP address assignment and network device connections.

Figure 1-5 Examples of configuring secondary IP addresses.



Configure RIP. You can set the version to RIPv1 only. You can see the routes of 172.16.2.0/24 on router C and the routes of 172.16.1.0/24 on router D.

Configuration of the Routers

RIPv1 does not support classless routes. This means masks are not carried in route advertisements. 172.16.1.0/24 and 172.16.2.0/24 that belong to the same network are separated by the Class C network 192.168.12.0/24. Generally, router C and router D cannot learn detailed routes from each other. According to a feature of RIP, the mask of the route to be received should be set to the same value as that of the interface network if the route and the interface network belong to the same network. By configuring routers A and B, you can build a secondary network 172.16.3.0/24 on the network 192.168.12.0/24 to link the two separated subnets. The following presents a configuration description of routers A and B only.

Router A:

```
interface FastEthernet 0/0
ip address 172.16.3.1 255.255.255.0 secondary
ip address 192.168.12.1 255.255.255.0
!
interface FastEthernet 0/1
ip address 172.16.1.1 255.255.255.0
!
router rip
network 172.16.0.0
network 192.168.12.0
```

Router B:

```
interface FastEthernet 0/0
ip address 172.16.3.2 255.255.255.0 secondary
ip address 192.168.12.2 255.255.255.0
!
interface FastEthernet 0/1
ip address 172.16.2.1 255.255.255.0
!
router rip
network 172.16.0.0
network 192.168.12.0
```

Configuring the IP Service

IP Configuration Task List

IP service configuration covers the following configuration tasks. These tasks are optional depending on your actual needs.

Configuring the Default Gateway

☑ Run the command only on L2 devices.

If no destination IP address to which a packet will be sent is specified, the packet will be sent to the default gateway by default. Use the **show ip redirects** command to view the settings.

Use the following command to set the default gateway in global configuration mode. Use the **no** form of this command to remove the default gateway.

Command	Function
ip default-gateway *ip-address*	Sets the default gateway.

Use the following command to view the configured default gateway.

Command	Function
show ip redirects	Displays the default gateway.

Managing IP Connections

The IP protocol stack offers a number of services to control and manage IP connections. The Internet Control Message Protocol (ICMP) provides many of these services. Once a network problem occurs, a device or access server will send an ICMP message to the host or other devices. For detailed information on ICMP, see RFC 792.

Enabling the ICMP Destination Unreachable Message

When a router receives a non-broadcast packet destined to it and this packet uses an IP protocol that it cannot handle, it will return an ICMP destination unreachable message to the source address. Similarly, if the router is unable to forward the packet because it knows of no route to the destination address, it sends an ICMP host unreachable

message. This feature is enabled by default.

Use the following command to enable or disable ICMP host unreachable messages in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip unreachables**	Enables ICMP protocol unreachable and host unreachable messages.
Ruijie(config-if)# **no ip unreachables**	Disables ICMP protocol unreachable and host unreachable messages.

Enabling the ICMP Redirect Message

Routes are sometimes less than optimal. For example, it is possible for the device to be forced to resend a packet through the same interface on which the packet was received. If the device resends a packet through the receiving interface, it sends an ICMP redirect message to the originator of the packet, telling the originator that the gateway to this destination address is another device in the same subnet. Therefore, the originator will transmit subsequent packets based on the optimized path. This feature is enabled by default.

Use the following commands to enable or disable the ICMP redirect message in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip redirects**	Enables the ICMP redirect message. It is enabled by default.
Ruijie(config-if)# **no ip redirects**	Disables the ICMP redirect message.

Enabling the ICMP Mask Reply Message

Occasionally, a network device needs to know the mask of a subnet on the Internet. To obtain this information, the device can send an ICMP mask request message. The device receiving the request will return an ICMP mask reply message. Ruijie products can respond to the ICMP mask request message. This function is enabled by default.

Use the following commands to enable or disable the ICMP mask reply message in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip mask-reply**	Enables the ICMP mask reply message.
Ruijie(config-if)# **no ip mask-reply**	Disables the ICMP mask reply message.

Setting the IP MTU

All interfaces have a default MTU value. All packets which are larger than the MTU have to be fragmented before they are sent on an interface. Otherwise the packets cannot be forwarded on the interface.

Ruijie products allow you to adjust the MTU on an interface. Changing the MTU value can affect the IP MTU value, and the IP MTU value will be modified automatically to match the new MTU. However, changing the IP MTU value has no influence on the MTU value of the interface.

The interfaces of a device in a physical network should have the same MTU for the same protocol.

Use the following commands to set the IP MTU in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip mtu** *bytes*	Sets the MTU in the range from 68 to 1500 bytes.
Ruijie(config-if)# **no ip mtu**	Restores the default MTU settings.

Configuring IP Source Routing

Ruijie products support IP source routing. Upon receiving an IP packet, the device will check its IP header like strict source route, loose source route and recorded route, which are defined in RFC 791. If one of these options is enabled, the device performs an appropriate action. Otherwise, it sends an ICMP error message to the source and then discards the packet. Ruijie products support IP source routing by default.

Use the following commands to enable or disable IP source routing in interface configuration mode.

Command	Function
Ruijie(config)# **ip source-route**	Enables IP source routing.
Ruijie(config)# **no ip source-route**	Disables IP source routing.

Configuring VRF

VRF Overview

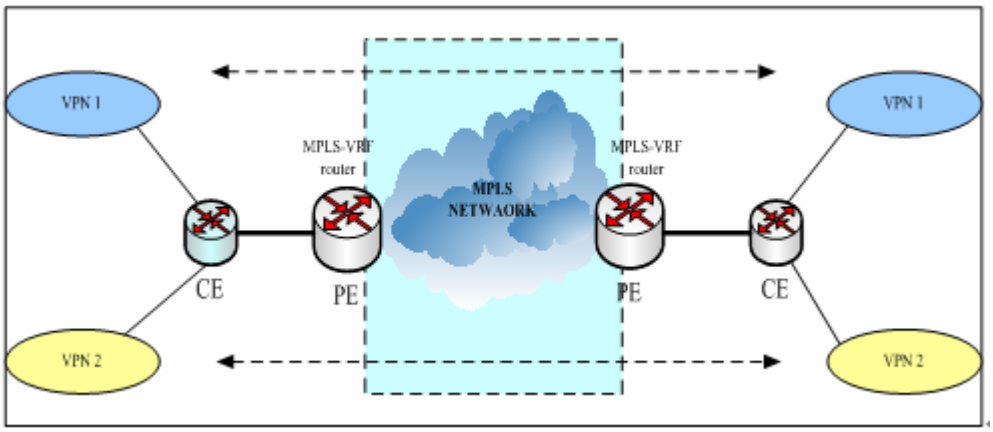
Virtual Private Networks (VPNs) provide a secure way to share bandwidths in the backbone networks of ISPs. One VPN is the collection of the sites sharing routes. The sites connect to the service provider's network through one or multiple interface links, with one VPN routing table associated with one interface. The VPN routing table is also referred to as a VPN routing or forwarding (VRF) table.

Caution Ruijie RSRs support the VRF-lite feature, which is also known as the multi-VRF CE or multi-VRF Customer Edge Device, and can implement multiple VPN route forwarding instances when serving as CEs.

Working Principles of VRF-Lite

The working principles of VRF-lite are as follows:

- CEs provide multiple access channels to PEs to support user access. CEs advertise local routes to PEs, and learns VPN remote routes from PEs.
- PEs exchange routing information with CEs via static routing and dynamic routing protocols, such as BGP, RIP, and OSPF.
- PEs may have multiple interfaces that belong to one VPN. PEs exchange VPN routing information with each other via BGP.
- PEs do not rely on the functions of CEs.
- P devices do not process VPN information. That is, VPN information is transparent to P devices.



Typical Application Model of VRF-Lite

The packet processing flow is as follows when VRF-lite is enabled on a network:

- When a CE receives a packet from a VPN, it checks interface information to query the related VRF table. If a route is successfully found in the VRF table, the CE sends the packet to a PE.
- When the ingress PE receives a packet from a CE, it queries the VRF table. If a route is successfully found in the VRF table, the ingress PE adds an MPLS label to the route and sends the packet to the MPLS network.
- When the egress PE receives an MPLS packet from the MPLS network, it removes the MPLS label and finds the related VPN routing table. The egress PE searches for a common route. If a route is successfully found, the egress PE sends the packet to the related adjacency.
- When a CE receives a packet from the egress PE, it checks the inbound interface of the packet to obtain the related VPN routing table and then searches for a route. If a route is successfully found, the packet is sent to the VPN.

Multi-Protocol VRF

You can create only single-protocol VRF supporting IPv4 in version earlier than 10.4(3). Use the **ip vrf** command to create a single-protocol IPv4 VRF. To enable single-protocol IPv4 VRF on a network interface, use the **ip vrf forwarding** command in interface configuration mode.

To support IPv6 VPNs, the 10.4(3) version has introduced multi-address-family VRFs. A multi-address-family VRF enables you to define multiple address families under the same VRF. You can apply a multi-address-family VRF to both IPv4 VPNs and IPv6 VPNs. A multi-address-family VRF is also called a multi-protocol VRF. You can use the **vrf definition** command to create a multi-protocol VRF. To enable a multi-protocol VRF on a network interface, use the **vrf forwarding** command in interface configuration mode.

It is not allowed to use the commands for configuring a single-protocol IPv4 VRF to configure a multi-protocol VRF, and vice versa.

For example, you can use the configuration command of a multi-protocol VRF to create a multi-protocol VRF named "vrf1".

```
Ruijie(config)#vrf definition vrf1
```

If you try to use a configuration command of a single-protocol VRF to edit vrf1, the following prompting message will be displayed:

```
Ruijie(config)#ip vrf vrf1
% Use ‘vrf definition vrf1’ command.
```

If you try to use a multi-protocol VRF command to edit the single-protocol VRF named "vrf2" which only supports IPv4, the following prompting message will be displayed:

```
Ruijie(config)# vrf definition vrf2
% Use ‘ip vrf vrf2’ command.
```

The configuration commands (ip vrf and ip vrf forwarding) of single-protocol IPv4 VRFs will be reserved for a period of time until they are abandoned.

Configuring VRF-Lite

You can configure VRF-Lite as follows:

- A CE supports multiple users via VRF-Lite. Each user has its own routing table on the CE.
- Since each user has its own routing table, they may use the same IP address. This function is temporarily not supported.
- Multiple users share the physical line between a CE and a PE, and there are multiple logical interfaces on the physical line. The physical line can be implemented by multiple means.
- VRF-lite does not support functions related to MPLS-VRF. It mostly acts on CEs.
- For a PE, connecting it to multiple CEs does not differ from using VRF-lite on it.
- EBGP is recommended for route exchange between a PE and a CE. Of course, OSPF, RIP, and static routing protocols may also be used for route exchange, but that would be more complex. If the OSPF protocol is used for route exchange, you need to exercise caution during configuration. It is recommended that you enable the capability VRF-lite function when using the OSPF protocol for route exchange.

Creating VRF

Use the following commands to create a single-protocol IPv4 VRF.

Command	Function
Ruijie(config)# **ip vrf** *vrf-name*	Creates a VRF. vrf-name shall not exceed 31 characters.
Ruijie(config)# **no ip vrf** *vrf-name*	Deletes the VRF.

Use the following commands to create a multiprotocol VRF.

Command	Function
Ruijie(config)# **vrf definition** *vrf-name*	Creates a multi-protocol VRF. *vrf-name* shall not exceed 31 characters.
Ruijie(config-vrf)# **address-family ipv4**	Configures an IPv4 address family, namely to enable the IPv4 protocol of VRFs. No IPv4 address family is configured by default.
Ruijie(config-vrf-af)# **exit-address-family**	Exits VRF address-family configuration sub-mode.
Ruijie(config-vrf)# **address-family ipv6**	Configures an IPv6 address family, namely to enable the IPv6 protocol of VRFs. No IPv6 address family is configured by default.
Ruijie(config-vrf-af)# **exit-address-family**	Exits VRF address-family configuration sub-mode.

Configuring a VRF Descriptor

Command	Function
Ruijie(config-vrf)# **description** *string*	Configures a VRF descriptor, which contains at most 244 characters.

The following example configures a VRF descriptor named “vpn-a” for a single-protocol IPv4 VRF named “vrf1”.

```
Ruijie(config)#ip vrf vrf1
```

```
Ruijie(config-vrf)#description vpn-a
```

The following example configures a VRF descriptor named “vpn-b” for a multiprotocol VRF named “vrf2”.

```
Ruijie(config)#vrf definition vrf2
Ruijie(config-vrf)#description vpn-b
```

Enabling VRF on Interfaces

Command	Function
Ruijie(config-if)# **ip vrf forwarding** *vrf-name*	Binds an interface to a single-protocol IPv4 VRF. Note that *vrf-name* cannot be a multiprotocol VRF. If the IPv6 function does not need to be enabled on an interface, you can bind the interface to a single-protocol IPv4 VRF. If the IPv6 function needs to be enabled on an interface, it is not recommended that you use this command to bind the interface to a single-protocol IPv4 VRF.
Ruijie(config-if)# **no ip vrf forwarding** *vrf-name*	Cancels the binding between an interface and a single-protocol IPv4 VRF.
Ruijie(config-if)# **vrf forwarding** *vrf-name*	Binds an interface to a multiprotocol VRF. Note that *vrf-name* cannot be a single-protocol IPv4 VRF. If the IPv6 function needs to be enabled on an interface, it is recommended that you bind the interface to a multiprotocol VRF instead of a single-protocol IPv4 VRF.
Ruijie(config-if)# **no vrf forwarding** *vrf-name*	Cancels the binding between an interface and a multiprotocol VRF.

An interface does not belong to any VRF by default. That is, global routing applies.


Caution After you bind an interface to a single-protocol IPv4 VRF, the IPv4 address originally configured for the interface will be invalid. The binding does not affect the IPv6 address configured for the interface. In general, enable VRF first on the interface and then configure an IPv4 address.


Caution If you bind an interface to a single-protocol IPv4 VRF and enables the IPv6 protocol on the interface, the switch cannot forward IPv6 packets received on the interface. Therefore, it is recommended that you use the multiprotocol VRF if you want to bind the interface to a VRF and enable the IPv6 protocol on the interface at the same time.


Caution You cannot bind an interface to a multiprotocol VRF not configured with any address family.

Caution If you bind an interface to a multiprotocol VRF, all existing IPv4, IPv6, VRRP IPv4, and VRRP IP6 addresses configured for the interface will be deleted. In addition, the IPv6 protocol will be disabled on the interface.

Caution If you bind an interface to a multiprotocol VRF not configured with any IPv4 address family, you cannot configure any IPv4 or VRRP IPv4 address for the interface. Before configuring an IPv4 or VRRP IPv4 address for the interface, you needs to configure an IPv4 address family for the multiprotocol VRF.

Caution If you bind an interface to a multiprotocol VRF not configured with any IPv6 address family, you cannot configure any IPv6 or VRRP IPv6 address for the interface. Before configuring an IPv6 or VRRP IPv6 address for the interface, you needs to configure an IPv6 address family for the multiprotocol VRF.

Caution If you delete the IPv4 address family configured for a multiprotocol VRF, all IPv4 and VRRP IPv4 addresses of all network interfaces bound to this VRF will be deleted, so will the static IPv4 routes whose routing VRF or next-hop VRF is this VRF. If you delete the IPv6 address family configured for a multiprotocol VRF, all IPv6 and VRRP IPv6 addresses of all network interfaces bound to this VRF will be deleted, the IPv6 protocol will be disabled on the interfaces, and all the static IPv6 routes whose routing VRF or next-hop VRF is this VRF will be deleted.

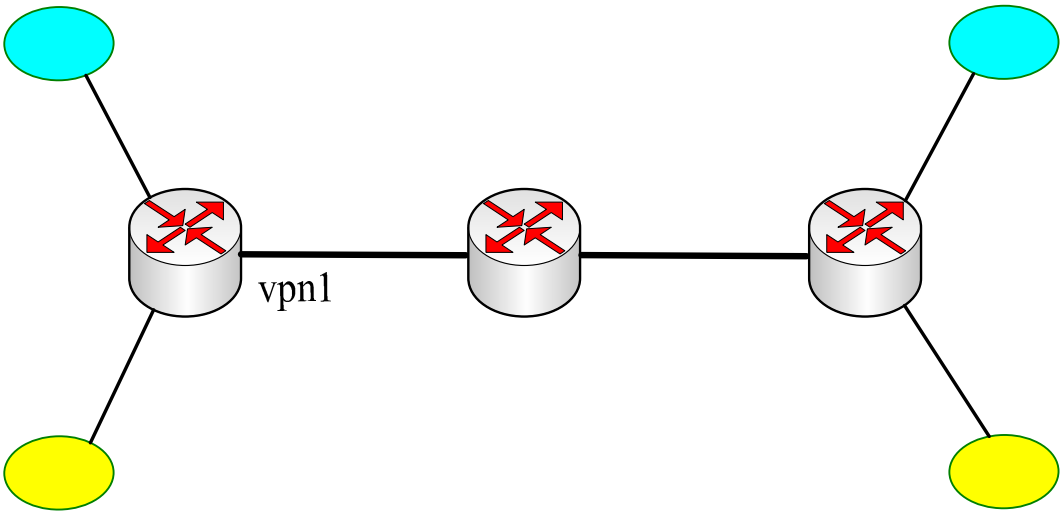
Configuring VRF Routes

Command	Function
Ruijie(config)# **ip route vrf** *vrf-name network mask interface nexthop*	Adds a route.
Ruijie(config)# **no ip route vrf** *vrf-name network mask*	Deletes a route.

You can also use routing protocols to configure routes.

VRF-Lite Configuration Examples

Example 1: As shown in the following figure, Ruijie devices serve as CEs and PEs. The CEs access two VPNs named “vpn1” and “vpn2”.




```
Ruijie# hostname CE-A
# Name the router.
CE-A# configure terminal
# Enter global configuration mode.
CE-A(config)# ip vrf vpn1
# Create a VRF named “vpn1”.
CE-A(config)# ip vrf vpn2
# Create a VRF named “vpn2”.
CE-A(config)# interface f0/0
# Enter interface configuration mode.
CE-A(config-if)#description  connecting-to-vpn1
# Link to vpn1.
CE-A(config-if)# ip vrf forwarding vpn1
# Enable VRF on the interface.
CE-A(config-if)# ip address 192.168.4.1 255.255.255.0
# Configure an IP address.
CE-A(config)# interface f0/1
# Enter interface configuration mode.
CE-A(config-if)# ip vrf forwarding vpn2
# Enable VRF on the interface.
CE-A(config-if)# ip address 192.168.5.1 255.255.255.0
# Configure an IP address.
CE-A(config-if)#description  connecting-to-vpn2
# Link to vpn2.
CE-A(config)# interface f1/0
# Enter interface configuration mode.
CE-A(config-if)#  no ip address
CE-A(config)# interface f1/0.10
# Enter a subinterface.
CE-A(config-if)# encapsulation dot1Q 10
# Encapsulate 802.1Q in VLAN 10.
```

```
CE-A(config-if)# ip vrf forwarding vpn1
# Enable VRF on the interface.
CE-A(config-if)# ip address 10.10.1.1 255.255.255.0
# Configure the IP address of the subinterface.
CE-A(config)# interface f1/0.20
# Enter a subinterface.
CE-A(config-if)# encapsulation dot1Q 20
# Encapsulate 802.1Q in VLAN 20.
CE-A(config-if)# ip vrf forwarding vpn2
# Enable VRF on the interface.
CE-A(config-if)# ip address 10.10.2.1 255.255.255.0
# Configure the IP address of the subinterface.
CE-A(config)# ip route vrf vpn1 192.168.44.0 255.255.255.0 10.10.1.2
# Configure a static route of vpn1.
CE-A(config)# ip route vrf vpn1 192.168.55.0 255.255.255.0 10.10.2.2
# Configure a static route of vpn2.
Ruijie# hostname CE-B
# Name the router.
CE-B# configure terminal
# Enter global configuration mode.
CE-B(config)# ip vrf vpn1
# Create a VRF named “vpn1”.
CE-B(config)# ip vrf vpn2
# Create a VRF named “vpn2”.
CE-B(config)# interface f0/0
# Enter interface configuration mode.
CE-Bconfig-if)# ip vrf forwarding vpn1
# Enable VRF on the interface.
CE-B(config-if)# ip address 192.168.44.1 255.255.255.0
# Configure an IP address.
CE-B(config-if)# description  connecting-to-vpn1
# Link to vpn1.
CE-B(config)# interface f0/1
# Enter interface configuration mode.
CE-B(config-if)# ip vrf forwarding vpn2
# Enable VRF on the interface.
CE-B(config-if)# ip address 192.168.55.1 255.255.255.0
# Configure an IP address.
CE-Bconfig-if)# description  connecting-to-vpn2
# Link to vpn2.
CE-B(config)# interface f1/0
# Enter interface configuration mode.
CE-B(config-if)#  no ip address
CE-B(config)# interface f1/0.10
# Enter a subinterface.
```

```
CE-B(config-if)# encapsulation dot1Q 100
# Encapsulate 802.1Q in VLAN 100.
CE-B(config-if)# ip vrf forwarding vpn1
# Enable VRF on the interface.
CE-B(config-if)# ip address 172.10.1.1 255.255.255.0
# Configure the IP address of the subinterface.
CE-B(config)# interface f1/0.20
# Enter a subinterface.
CE-B(config-if)# encapsulation dot1Q 200
# Encapsulate 802.1Q in VLAN 200.
CE-B(config-if)# ip vrf forwarding vpn2
# Enable VRF on the interface.
CE-B(config-if)# ip address 172.10.2.1 255.255.255.0
# Configure the IP address of the subinterface.
CE-B(config)# ip route vrf vpn1 192.168.4.0 255.255.255.0 172.10.1.2
# Configure a static route of vpn1.
CE-B(config)# ip route vrf vpn1 192.168.5.0 255.255.255.0 172.10.2.2
# Configure a static route of vpn2.
# Next, configure PEs.
Router# configure terminal
Router(config)# ip vrf v1
Router(config-vrf)# rd 100:1
Router(config-vrf)# route-target export 100:1
Router(config-vrf)# route-target import 100:1
Router(config-vrf)# exit
Router(config)# ip vrf v2
Router(config-vrf)# rd 100:2
Router(config-vrf)# route-target export 100:2
Router(config-vrf)# route-target import 100:2
Router(config-vrf)# exit
Router(config)# ip cef
Router(config)# interface FastEthernet0/0.10
Router(config-if)# encapsulation dot1q 10
Router(config-if)# ip vrf forwarding v1
Router(config-if)# ip address 10.10.1.2 255.255.255.0
Router(config-if)# exit
Router(config)# interface FastEthernet0/1.100
Router(config-if)# encapsulation dot1q 100
Router(config-if)# ip vrf forwarding v1
Router(config-if)# ip address 172.10.1.2 255.255.255.0
Router(config-if)# exit
Router(config)# interface FastEthernet0/0.20
Router(config-if)# encapsulation dot1q 20
Router(config-if)# ip vrf forwarding v2
Router(config-if)# ip address 10.10.2.2 255.255.255.0
```

```
Router(config-if)# exit
Router(config)# interface FastEthernet0/1.200
Router(config-if)# encapsulation dot1q 200
Router(config-if)# ip vrf forwarding v2
Router(config-if)# ip address 172.10.2.2 255.255.255.0
Router(config-if)# exit
Router(config)# ip route vrf v1 192.168.4.0 255.255.255.0 10.10.1.1
Router(config)# ip route vrf v1 192.168.44.0 255.255.255.0 172.10.1.1
Router(config)# ip route vrf v2 192.168.5.0 255.255.255.0 10.10.2.1
Router(config)# ip route vrf v2 192.168.55.0 255.255.255.0 172.10.2.1
```

Example 2 : Configure a simple multiprotocol VRF.

```
# Create a multiprotocol VRF.
Ruijie(config)#vrf definition multi-af-vrf-example
# Configure a VRF descriptor.
Ruijie(config-vrf)#description This-is-an-example
# Configure an IPv4 address family.
Ruijie(config-vrf)#address-family ipv4
Ruijie(config-vrf-af)#exit-address-family
# Configure an IPv6 address family.
Ruijie(config-vrf)#address-family ipv6
Ruijie(config-vrf-af)#exit-address-family
Ruijie(config-vrf)#interface VLAN 1
# Bind VLAN 1 to a multiprotocol VRF.
Ruijie(config-if-VLAN 1)#vrf forwarding multi-af-vrf-example
Ruijie(config-if-VLAN 1)#ip address 1.1.1.1 255.255.255.0
Ruijie(config-if-VLAN 1)#ipv6 address 1000::1/64
Ruijie(config-if-VLAN 1)#exit
# Configure a static IPv4 or IPv6 route of the multiprotocol VRF.
Ruijie(config)#ip route vrf multi-af-vrf-example 0.0.0.0 0.0.0.0 1.1.1.2
Ruijie(config)#ipv6 route vrf multi-af-vrf-example ::/0 1000::2
```

VRF-Lite Debugging

Use the following command to check the routing table of a VRF.

Command	Function
show ip route vrf *vrf-name*	Displays the routes of the specified VRF.

For details about the command syntax, see the *VRF Command Reference*.

Use the following command to clear the routing table of a VRF.

Command	Function

clear ip route vrf *vrf-name* *	Clears the routes of the specified VRF.

For details about the command syntax, see the *VRF Command Reference*.

Use the following commands to check information about a VRF in the system.

Command	Function
show ip vrf [*vrf-name*]	Displays information about an IPv4 VRF.
show vrf [brief] [vrf-name]	Displays brief information about a VRF.
show vrf ipv4 [*vrf-name*]	Displays brief information about an IPv4 VRF.
show vrf ipv6 [*vrf-name*]	Displays brief information about an IPv6 VRF.
show vrf detail [*vrf-name*]	Displays details about a VRF.

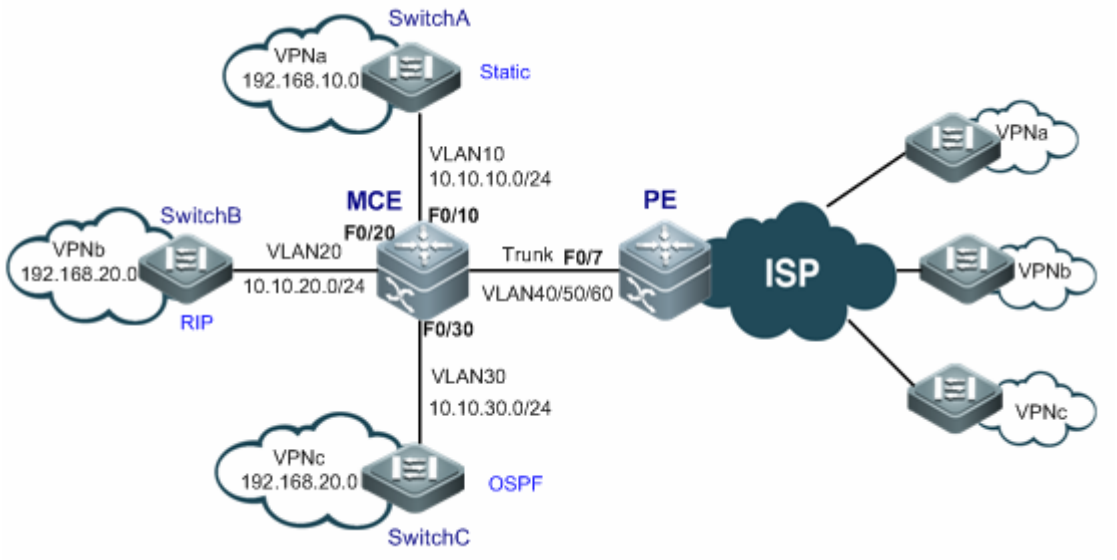
For details about the command syntax, see the *VRF Command Reference*.

MCE Configuration Example

Networking Topology

As shown in the following figure, VPNa, VPNb, and VPNc are located at different sites and exchange information across the backbone network.

- VPN sites access a PE via a MCE.
- Static routes are configured between the MCE and VPNa. RIP is configured between the MCE and VPNb to exchange routing information. The OSPF protocol is configured between the MCE and VPNc to exchange routing information.



Typical Topology of MCE Application

Networking Requirements

The MCE needs to isolate the routes of one VPN from the routes of the other VPNs. It advertises the routes of various VPNs to the PE via the static routing protocol, RIP, and the OSPF protocol respectively.

Duplicate addresses in a VPN must be supported.

Configuration Tips

Create multiple VRF instances on the MCE and the PE, so that the routes of different VPN services are isolated from one another. Perform the following two steps:

Configure VRF instances and bind them to various interfaces.

Interface	Bound VRF	Interface IP Address
Interface of the MCE that connects to VPNa (SVI 10)	VPNa	10.10.10.3
Logical interface of the MCE that connects to the PE (SVI 40)	VPNa	10.10.40.1
Logical interface of the PE that connects to the MCE (SVI 40)	VPNa	10.10.40.2
Interface of the MCE that connects to VPNb (SVI 20)	VPNb	10.10.20.3
Logical interface of the MCE that connects to the PE (SVI 50)	VPNb	10.10.50.1
Logical interface of the PE that connects to the MCE (SVI 50)	VPNb	10.10.50.2
Interface of the MCE that connects to VPNc (SVI 30)	VPNc	10.10.30.3
Logical interface of the MCE that connects to the PE (SVI 60)	VPNc	10.10.60.1
Logical interface of the PE that connects to the MCE (SVI 60)	VPNc	10.10.60.2

Configure route exchange between the MCE, VPN sites, and the PE.

VRF instances on the MCE cooperate with VRF instances on the PE to advertise VPN routes to the PE via the routing protocol between the MCE and the PE. Then the PE advertises the routes to other PEs on the network, so that each VPN site interworks with remote VPN sites on the network.

Note In this example, VRF instances on the MCE exchange routes with VPN sites and the PE via the same routing protocol.

Note If VRF instances on the MCE exchange routes with VPN sites and the PE via different routing protocols, to guarantee complete exchange of VPN routes, the routing protocols of VRF instances on the MCE must be redistributed, so that the MCE can advertise VPN routes to VRF instances on the PE and that the routes advertised by the PE to VRF instances on the MCE can be further advertised to VPN sites.

Configuration Steps

Configure VRF instances on the MCE and the PE, and bind VRF instances to interfaces.

Create VRF instances on the MCE.

Step 1: Create VRF instances named “VPNa”, “VPNb”, and “VPNc” on the MCE.

```
MCE(config)#ip vrf vpna
```

```
MCE(config-vrf)#exit
MCE(config)#ip vrf vpnb
MCE(config-vrf)#exit
MCE(config)#ip vrf vpnc
MCE(config-vrf)#exit
```

Step 2: Create VLAN 10, and add the FE interface 0/10 of the MCE that connects to Switch A to VLAN 10.

```
MCE(config)#interface fastEthernet 0/10
MCE(config-if-FastEthernet 0/10)#switchport access vlan 10
MCE(config-if-FastEthernet 0/10)#exit
```

Step 3: Bind the interface SVI 10 of VLAN 10 to VPNa, and set the IP address of the interface SVI 10 to 10.10.10.3/24.

```
MCE(config)#interface vlan 10
MCE(config-if-VLAN 10)#ip vrf forwarding vpna
MCE(config-if-VLAN 10)#ip address 10.10.10.3 255.255.255.0
MCE(config-if-VLAN 10)#exit
```

Step 4: Similarly, create VLAN 20 and VLAN 30 (see the previous two steps), bind the interface SVI 20 of the MCE that connects to Switch B to VPNb, and bind the interface SVI 30 of the MCE that connects to Switch C to VPNc. Set the IP address of the interface SVI 20 to 10.10.20.3, and the IP address of the interface SVI 30 to 10.10.30.3.

Step 5: Create VLAN 40, VLAN 50, and VLAN 60, and add the FE interface 0/7 of the MCE that connects to the PE to the three VLANs. Bind SVI 40 to VPNa, SVI 50 to VPNb, and SVI 60 to VPNc. Set the IP address of the interface SVI 40 to 10.10.40.1, the IP address of the interface SVI 50 to 10.10.50.1, and the IP address of the interface SVI 60 to 10.10.60.1.

```
MCE(config)#vlan 40
MCE(config-vlan)#exit
MCE(config)#vlan 50
MCE(config-vlan)#exit
MCE(config)#vlan 60
MCE(config-vlan)#exit
MCE(config)#interface fastEthernet 0/7
MCE(config-if-FastEthernet 0/7)#switchport mode trunk
MCE(config-if-FastEthernet 0/7)#exit
MCE(config)#interface vlan 40
MCE(config-if-VLAN 40)#ip vrf forwarding vpna
MCE(config-if-VLAN 40)#ip address 10.10.40.1 255.255.255.0
MCE(config-if-VLAN 40)#exit
MCE(config)#interface vlan 50
MCE(config-if-VLAN 50)#ip vrf forwarding vpnb
MCE(config-if-VLAN 50)#ip address 10.10.50.1 255.255.255.0
MCE(config-if-VLAN 50)#exit
MCE(config)#interface vlan 60
MCE(config-if-VLAN 60)#ip vrf forwarding vpnc
MCE(config-if-VLAN 60)#ip address 10.10.60.1 255.255.255.0
```

After the above steps are performed, VRF instances are created on the MCE.

Create VRF instances on the PE.

Step 1: Create VRF instances named “VPNa”, “VPNb”, and “VPNc” on the PE.

```
PE(config)#ip vrf vpna
PE(config-vrf)#exit
PE(config)#ip vrf vpnb
PE(config-vrf)#exit
PE(config)#ip vrf vpnc
PE(config-vrf)# exit
```

Step 2: Create VLAN 40, VLAN 50, and VLAN 60, and add the FE interface 0/7 of the PE that connects to the MCE to the three VLANs. Bind SVI 40 to VPNa, SVI 50 to VPNb, and SVI 60 to VPNc. Here, the operations for creating VLANs and adding interfaces to VLANs are omitted.

```
PE (config)#interface vlan 40
PE(config-if-VLAN 40)#ip vrf forwarding vpna
PE(config-if-VLAN 40)#ip address 10.10.40.2 255.255.255.0
PE(config-if-VLAN 40)#exit
PE(config)#interface vlan 50
PE(config-if-VLAN 50)#ip vrf forwarding vpnb
PE(config-if-VLAN 50)#ip address 10.10.50.2 255.255.255.0
PE(config-if-VLAN 50)#exit
PE(config)#interface vlan 60
PE(config-if-VLAN 60)#ip vrf forwarding vpnc
PE(config-if-VLAN 60)#ip address 10.10.60.2 255.255.255.0
```

After the above steps are performed, VRF instances are created on the PE.

Configure static routes between the MCE and VPNa, and between the MCE and the PE.

Configure a static route on Switch A (access switch for the site VPNa).

Set the IP address of the interface of Switch A that connects to the MCE to 10.10.10.2/24, and that of the interface of Switch A that connects to the site VPNa to 192.168.10.1/24. Here, the operations for adding ports to VLANs and setting interface IP addresses are omitted.

Configure a default route on Switch A, with the next hop of the outbound packet pointing to 10.10.10.3.

```
SwitchA(config)#ip route 0.0.0.0 0.0.0.0 10.10.10.3
```

Configure a static route on the MCE.

Configure a static route on the MCE for packets destined to the network segment 192.168.10.0, with the next hop pointing to 10.10.10.2, and binds the route to the instance VPNa.

```
MCE(config)#ip route vrf vpna 192.168.10.0 255.255.255.0 10.10.10.2
```

Configure static routes on the PE.

Configure two static routes on the PE, and bind them to the instance VPNa. One is for packets destined to the network segment 192.168.10.0, with the next hop pointing to 10.10.40.1. The other is for packets destined to the network segment 10.10.10.0, with the next hop also pointing to 10.10.40.1.

```
PE (config)#ip route vrf vpna 192.168.10.0 255.255.255.0 10.10.40.1
PE (config)#ip route vrf vpna 10.10.10.0 255.255.255.0 10.10.40.1
```

Configure RIP route exchange between the MCE and VPNb, and between the MCE and the PE.

Configure RIP on Switch B (access switch for the site VPNb).

Set the IP address of the interface of Switch B that connects to the MCE to 10.10.20.2/24, and that of the interface of Switch B that connects to the site VPNb to 192.168.20.1/24. Here, the operations for adding ports to VLANs and setting interface IP addresses are omitted.

```
SwitchB(config)#router rip
SwitchB(config-router)#version 2
SwitchB(config-router)#no auto-summary
SwitchB(config-router)#network 10.10.20.0 0.0.0.255
SwitchB(config-router)#network 192.168.20.0 0.0.0.255
```

Configure RIP on the MCE.

```
MCE(config)#router rip
MCE(config-router)#address-family ipv4 vrf vpnb
MCE(config-router-af)# version 2
MCE(config-router-af)# no auto-summary
MCE(config-router-af)#network 10.10.20.0 0.0.0.255
MCE(config-router-af)#network 10.10.50.0 0.0.0.255
```

Configure RIP on the PE.

```
PE(config)#router rip
PE(config-router)#address-family ipv4 vrf vpnb
PE(config-router-af)# version 2
PE(config-router-af)# no auto-summary
```

PE(config-router-af)#network 10.10.50.0 0.0.0.255 Configure OSPF route exchange between the MCE and VPNc, and between the MCE and the PE.

Configure the OSPF protocol on Switch C (access switch for the site VPNc).

Set the IP address of the interface of Switch C that connects to the MCE to 10.10.30.2/24, and that of the interface of Switch C that connects to the site VPNc to 192.168.20.1/24. Here, the operations for adding ports to VLANs and setting interface IP addresses are omitted.

```
SwitchC(config)#router ospf 1
SwitchC(config-router)#network 10.10.30.0 0.0.0.255 area 0
SwitchC(config-router)#network 192.168.20.0 0.0.0.255 area 0
```

Configure the OSPF protocol on the MCE.

```
MCE(config)#router ospf 1 vrf vpnc
MCE(config-router)#network 10.10.30.0 0.0.0.255 area 0
MCE(config-router)#network 10.10.60.0 0.0.0.255 area 0
```

Configure the OSPF protocol on the PE.

```
PE(config)#router ospf 1 vrf vpnc
PE(config-router)#network 10.10.60.0 0.0.0.255 area 0
```

Verification

Check routing information about the instance VPNa.

Check routing information on Switch A (access switch for the site VPNa).

```
SwitchA (config)#show ip route
Gateway of last resort is 10.10.10.3 to network 0.0.0.0
S*   0.0.0.0/0 [1/0] via 10.10.10.3
C    10.10.10.0/24 is directly connected, VLAN 10
C    10.10.10.2/32 is local host.
C    192.168.10.0/24 is directly connected, FastEthernet 0/23
C    192.168.10.1/32 is local host.
```

Check routing information about the instance VPNa on the MCE.

```
MCE#show ip route vrf vpna
Routing Table: vpna
C    10.10.10.0/24 is directly connected, VLAN 10
C    10.10.10.3/32 is local host.
C    10.10.40.0/24 is directly connected, VLAN 40
C    10.10.40.1/32 is local host.
S    192.168.10.0/24 [1/0] via 10.10.10.2
```

Check routing information about the instance VPNa on the PE.

PE#show ip route vrf vpna

```
Routing Table: vpna
S    10.10.10.0/24 [1/0] via 10.10.40.1
C    10.10.40.0/24 is directly connected, VLAN 40
C    10.10.40.2/32 is local host.
S    192.168.10.0/24 [1/0] via 10.10.40.1
```

Check routing information about the instance VPNb.

Check routing information on Switch B (access switch for the site VPNb).

SwitchB#show ip route vrf vpnb

```
Routing Table: vpnb
C    10.10.20.0/24 is directly connected, VLAN 20
C    10.10.20.2/32 is local host.
R    10.10.50.0/24 [120/1] via 10.10.20.3, 00:01:20, VLAN 20
C    192.168.20.0/24 is directly connected, FastEthernet 0/23
C    192.168.20.1/32 is local host.
```

Check routing information about the instance VPNb on the MCE.

```
MCE#show ip route vrf vpnb
Routing Table: vpnb
C    10.10.20.0/24 is directly connected, VLAN 20
```

```
C    10.10.20.3/32 is local host.
C    10.10.50.0/24 is directly connected, VLAN 50
C    10.10.50.1/32 is local host.
R    192.168.20.0/24 [120/1] via 10.10.20.2, 00:22:01, VLAN 20
```

According to the above information, the MCE has learned the private network routes of VPNb via RIP. These routes and the routes of VPNa and VPNc are separately maintained in three routing tables, thus effectively isolating the VPNs from each other and supporting address duplication inside each VPN.

Check routing information about the instance VPNb on the PE.

```
PE#show ip route vrf vpnb
Routing Table: vpnb
R    10.10.20.0/24 [120/1] via 10.10.50.1, 00:04:48, VLAN 50
C    10.10.50.0/24 is directly connected, VLAN 50
C    10.10.50.2/32 is local host.
R    192.168.20.0/24 [120/2] via 10.10.50.1, 00:02:15, VLAN 50
```

The above information shows that all the routes of the instance VPNb have been advertised to the PE.

Check routing information about the instance VPNc.

Check routing information on Switch C (access switch for the site VPNc).

```
SwitchC (config-router)#show ip route

C    10.10.30.0/24 is directly connected, VLAN 30
C    10.10.30.2/32 is local host.
O    10.10.60.0/24 [110/2] via 10.10.30.3, 00:02:42, VLAN 30
C    192.168.20.0/24 is directly connected, FastEthernet 0/23
C    192.168.20.1/32 is local host.
```

Check routing information about the instance VPNc on the MCE.

```
MCE#show ip route vrf vpnc

Routing Table: vpnc
C    10.10.30.0/24 is directly connected, VLAN 30
C    10.10.30.3/32 is local host.
C    10.10.60.0/24 is directly connected, VLAN 60
C    10.10.60.1/32 is local host.
O    192.168.20.0/24 [110/2] via 10.10.30.2, 00:01:36, VLAN 30
```

According to the above information, the MCE has learned the private network routes of VPNc via OSPF. These routes and the routes of VPNa and VPNb are separately maintained in three routing tables, thus effectively isolating the VPNs from each other and supporting address duplication inside each VPN.

Check routing information about the instance VPNc on the PE.

```
PE#show ip route vrf vpnc
```

```
Routing Table: vpnc
O    10.10.30.0/24 [110/2] via 10.10.60.1, 00:00:00, VLAN 60
C    10.10.60.0/24 is directly connected, VLAN 60
C    10.10.60.2/32 is local host.
O    192.168.20.0/24 [110/3] via 10.10.60.1, 00:00:00, VLAN 60
```

The above information shows that all the routes of the instance VPNc have been advertised to the PE.

Abbreviations

Abbreviation	Full Spelling
CE	Customer Edge Device
PE	Provider Edge Device
MCE	Multi-CE
VPN	Virtual Private Network
VRF	VPN Routing and Forwarding Table

Configuring IPv4 Express Forwarding

Understanding IPv4 Express Forwarding

Overview

To meet the needs of higher-end devices, we use a Prefix Tree+Adjacency Ruijie Express Forwarding (REF) model to enable express forwarding. REF constitutes the mirroring of the whole core routing table instead of buffering some information in the core routing table. Therefore, the cache does no longer need to be added to the CPU in the case of a cache failure, thus reducing the impact on the CPU and guaranteeing routing stability.

REF constructs the routing table mirroring by using the following two parts:

- Prefix Tree

The Prefix Tree is an IP prefix tree organized according to the maximum matching rule for retrieving adjacent nodes. In general, the data structure for constructing the Prefix Tree is different from the Radix Tree of the core routing table. Instead, a data structure called the M-Tries Tree is used to enable more rapid multi-step search. Using the M-Tries Tree to construct the Prefix Tree will take up more memory than using the Radix Tree. Although updating prefix and node information relatively consumes time, high retrieval performance can be obtained.

- Adjacency

Adjacency refers to an adjacent node, which contains the interface information output by routed packets, such as next-hop list, next processing part, and link-layer output encapsulation. When packets match with such an adjacent node, packets are directly encapsulated, and then the send function of this node is called to enable forwarding. To facilitate retrieval and update, the tables made up of adjacent nodes are generally organized into a hash table. To support load balancing of routes, the next list information on adjacent nodes is organized in load-balancing table form.

REF routing consists of three steps:

- REF de-encapsulates packets.
- Use the Prefix Tree to retrieve the adjacent nodes according to the routes of packets.
- After the adjacent nodes are matched, the final output interface of packets is determined according to adjacent nodes, and then packets are encapsulated according to the output interface type.

Configuring Load Balancing Policy for Express Forwarding

Express forwarding supports load balancing of packets. At present, four load balancing policies are supported. In the REF model, when the route prefix IP/MASK is associated with multiple next hops, namely, a multi-path route, the route will be associated with one load-balancing table and load is balanced according to route weights. When IP packets match with the load balancing table according to the longest prefix, express forwarding hashes the IP addresses of packets, and then one path is selected for packet forwarding. There are four routing policies:

- Load is balanced according to destination IP addresses. The destination IP addresses of packets are hashed. The route with a greater weight is more likely to be selected. By default, this policy is selected.
- Load is balanced according to destination and source IP addresses of IP packets. Destination and source IP addresses of packets are hashed and the route with a greater weight is more likely to be selected. It applies to the packet flow with changing source and destination IP addresses.
- Load is balanced according to the source IP addresses. The source IP addresses of packets are hashed. The route with a greater weight is more likely to be selected. It applies to the packet flow with changing source IP addresses.
- Load is balanced according to packets polling. Each packet takes turn to select the path and all paths can be selected.

Use the following commands to configure the load balancing policy in global configuration mode:

Command	Function
Ruijie(config)# **ip ref load-sharing algorithm original**	Sets the load balancing algorithm based on source and destination IP addresses.
Ruijie(config)# **ip ref load-sharing source**	Performs the load balancing according to the source IP addresses.
Ruijie(config)# **ip ref load-sharing packet**	Performs the load balancing according to packet polling
Ruijie(config)# **no ip ref load-sharing algorithm**	Load is balanced according to the destination IP addresses.

Note These commands are unique to routers.

Maintaining and Monitoring the Express Forwarding Table

The express forwarding module passively receives and maintains external routing information instead of actively adding or deleting any route information. As a result, the express forwarding table provides current statistical information on routes.

Statistical information on Express Forwarding Packets

Statistical information on express forwarding packets refers to the statistical information on the packets processed by the express forwarding REF, including the number of forwarded packets and the number of packets dropped due to various reasons.

Command	Function
Ruijie# show ip ref packet-statistic [clear]	Displays or clears the current statistical information on packets in REF.

Adjacency Table Information

In the express forwarding table, one type of important data table is the adjacency table. Use the following command to check current adjacency information.

Command	Function
Ruijie# show ip ref adjacency [glean | local | *ip* | (interface *interface_type interface_number*) | statistic]	Displays the specified gleaned adjacency, local adjacency, adjacency corresponding to the specified IP address, adjacency associated with the specified interface, and information on all adjacency nodes.

Information on Packet Forwarding Path

Packets are forwarded according to IP addresses of packets. Therefore, if source IP addresses and destination IP addresses of packets are specified, the path for forwarding packets will be determined. Use the following command and specify source IP addresses and destination IP addresses of packets. The actual path for forwarding packets will be displayed. For example, you can learn whether packets are dropped, submitted to the CPU, or forwarded. Furthermore, you can know about the interface through which packets are forwarded.

Command	Function
Ruijie# show ip ref exact-route [vrf *vrf_name*] *source-ipaddress dest_ipaddress*	Displays the actual forwarding path of a specified packet.

Note This command is unique to routers.

Routing information in the Express Forwarding Table

Express forwarding receives external route advertisements and maintains an express forwarding table, which is a mirroring of the core routing table. Use the following commands to display routing information in the express forwarding table.

Command	Function
Ruijie# show ip ref route [vrf vrf_name] [default | (ip mask) | statistic]	Displays current default routing information in the express forwarding table. If the default route is not specified, all routing information in the express forwarding table is displayed, including the 0 route, default route, and common gateway route.

Configuring Flow Platform

Introduction to flow platform

System flow table information

To display the current system flow table information, run the **show ip fpm flows** command.

Command	Function
Ruijie# **show ip fpm flows** [**filter** *ip_protocol_number source_ip source_ip_mask_len dest_ip dest_ip_mask_len*]	Current system flow table information

Note To display information about the specific flow, you must use the **filter** command of the flow platform itself to search rather than using the [**begin | exclude | include]** method

Statistics of messages dropped by flow platform

To display the statistics of messages dropped by the current system flow platform, run the **show ip fpm counters** command.

Command	Function
Ruijie# **show ip fpm counters**	Statistics of messages dropped by the current system flow platform

Global information of flow platform

To display the global information of current system flow platform, run the **show ip fpm statistics** command.

Command	Function
Ruijie# **show ip fpm statistics**	Global information of current system flow platform

User information of flow platform

To display the user information of current system flow platform, run the **show ip fpm users** command.

Command	Function
Ruijie# **show ip fpm users**	User information of current system flow platform

Configuring TCP

Overview

The TCP module provides a reliable and connection-oriented IP-based transmission layer protocol for the application layer.

The application layer sends data streams represented in 8-bit bytes for Internet transmission to the TCP layer, which separates the data streams into packet segments with proper sizes. The maximum segment size (MSS) is generally limited by the maximum transmission unit (MTU) of the data link layer of the network to which the computer is connected. After that, TCP transmits the result packets to the IP layer, which will then transmit the said packets through the network to the TCP layer of receiving terminal.

To ensure no packet loss, TCP assigns a sequence number to each byte, and the sequence number also ensures that packets transmitted to the receiving terminal are received in sequence. The receiving terminal will then reply with an ACK to confirm the receipt of each byte. If no ACK is received within the reasonable Round Trip Time (RTT), then the corresponding byte (assumed lost) will be retransmitted by the sender.

- With regard to data accuracy and validity, TCP uses a checksum function to verify the data. The checksum must be calculated while the date is sent or received. In the meantime, MD5 authentication can also be utilized to encrypt the data.
- To ensure reliability, TCP applies the mechanisms of timeout retransmission and piggybacking.
- The sliding window protocol is applied to implement flow control. According to the protocol, all unconfirmed packets within the window will be retransmitted.
- The widely recognized TCP congestion control algorithm (also called the AIMD algorithm) is applied to implement congestion control. This algorithm mainly involves: 1) additive increase and multiplicative decrease; 2) slow start; 3) response to timeouts.

Configuring TCP

Changing the Timeout for Establishing a TCP Connection

Establishing a TCP connection requires a three-way handshake: The local end sends a SYN packet, the remote end responds with a SYN+ACK packet, and then the local end responds with an ACK.

- After the local end sends SYN, if the remote end does not respond with SYN+ACK, the local end will continuously retransmit SYN packets until the specified number of retransmissions is reached or until the timeout timer expires.
- After the local end sends SYN and the remote end responds with SYN+ACK, if the local end no longer responds with ACK, the remote end will keep retransmission until the specified number of retransmissions is reached or until the timeout timer expires (Such as SYN attacks).

Use the following command to configure the timeout value for SYN packets (the maximum time from SYN transmission to successful three-way handshake), namely the timeout for establishing a TCP connection.

Command	Function
Ruijie(config)# ip tcp syntime-out *seconds*	Changes the timeout value for establishing a TCP connection. Range: 5 to 300 seconds; default: 20

Use the **no ip tcp syntime-out** command to restore the default value.


Note This command only applies to IPv4 TCP.

Changing the Buffer Size

The TCP receiving buffer is utilized to buffer the data received from the peer end. These data will be subsequently read by application programs. Generally, the window size of TCP packets implies the size of the free space in the receiving buffer. For connections involving a greater bandwidth and mass data, increasing the size of the receiving buffer will remarkably improve TCP transmission performance. The sending buffer is utilized to buffer the data of application programs. Each byte in the buffer has a sequence number, and bytes with sequence numbers acknowledged will be removed from the sending buffer. Increasing the sending buffer will improve the interaction between TCP and application programs, thus enhancing the performance. However, increasing the receiving buffer and sending buffer will result in more memory consumption of TCP.

Command	Function
Ruijie(config)# ip tcp window-size *size*	Changes the size of receiving buffer and sending buffer for TCP connections. Range: 0 to 65535 bytes; default: 4096.

Use the **no ip tcp window-size** command to restore the default value.


Note This command only applies to IPv4 TCP.


Note This command does not apply to existing TCP connections. It only applies to subsequent TCP connections.


Note This command will apply to both the receiving buffer and sending buffer.

Prohibiting the Reset Packet When the Port is Unreachable

When the TCP module distributes TCP packets, if the TCP connection to which such packets belong cannot be found, a reset packet will be replied to the peer end to terminate the TCP connection. The attacker may initiate attacks by sending excessive port-unreachable TCP packets.

Run the following commands to prohibit or restore the reset packet sent when the port-unreachable TCP packet is received.

Command	Function
Ruijie(config)# ip tcp not-send-rst	Prohibits sending a reset packet when the port-unreachable TCP packet is received.

Use the **no ip tcp not-send-rst** command to restore the default settings.

Note This command only applies to IPv4 TCP.

Limiting the MSS of TCP Connections

The MSS refers to the maximum size of the payload of a TCP packet, excluding TCP options.

During the three-way handshake for establishing a TCP connection, one important job is to carry out MSS negotiation. Both sides will insert an MSS option into the SYN packet to indicate the maximum size of the segment that can be received by the local end, namely the maximum size of the segment that can be sent by the remote end. Both sides will take the smaller of the MSS value sent locally and that received from the remote end as the maximum segment size of this connection.

The methods for calculating the value of the MSS option while sending SYN packets are shown below:

Non-directly connected network: MSS = Default value 536

Directly connected network: mss = egress interface MTU corresponding to the peer IP address – 20-byte IP header – 20-byte TCP header
Generally speaking, if the MTU is affected by certain applications configured on the egress interface, such applications will configure the MTU accordingly, such as the MTUs of the tunnel port and VPN port.

Note In release 10.4(3), in the SYN+ACK packet replied by the remote end of a directly connected network, the MSS option is not calculated through MTU. Instead, the default value 536 is used.

Note The MSS calculated cannot exceed the size of the receiving buffer or the IP TCP MSS configured by the user. Otherwise, the smaller of them will be used.

Note If certain options are supported by this connection, then the size obtained after 4-byte alignment of the option must be subtracted from the MSS. For example, if the size of the MD5 option is 18 bytes, 20 bytes will be obtained after alignment.

The RMSS value obtained here is the value of the MSS option in the SYN packet sent. For example, BGP adjacency is generally established in the directly connected network, and the MSS of such a connection is 1500 – 20 – 20 – 20 = 1440.

The function of IP TCP MSS is to limit the MSS of the pending TCP connection. The negotiated MSS cannot exceed the value configured.

Command	Function
Ruijie(config)# **ip tcp mss** *max-segment-size*	Limits the maximum segment size of TCP connections. Range: 68 to 10000 bytes.

Use the **no ip tcp mss** command to disable such limit.

Note This command only applies to IPv4 TCP.

Enabling PMTU Discovery

The TCP Path MTU (PMTU) is implemented as per RFC1191. This feature can improve the network bandwidth utilization ratio. When the user uses TCP to transmit mass data, this feature can substantially enhance the transmission performance.

Command	Function
Ruijie(config)# **ip tcp path-mtu-discovery** [**age-timer** *minutes* | **age-timer infinite**]	Enables PMTU discovery. **age-timer** *minutes*: The time interval for further discovery after discovering PMTU in the range from 10 to 30 minutes. The default value is 10. **age-timer infinite**: No further discovery after discovering PMTU.

According to RFC1191, after discovering PMTU, TCP can use a greater MSS to discover a new PMTU, and the time interval thereof is specified by the parameter **age-timer**. When the PMTU discovered by the device is smaller than the MSS negotiated, the device will try to discover a greater PMTU as per the aforementioned time interval. Such a discovery process will not end until PMTU reaches the value of MSS or until the user stops this timer. To turn off the timer, use the parameter **age-timer infinite**.

Use the **no ip tcp path-mtu-discovery** command to disable PMTU discovery.

Note This command applies to both IPv4 TCP and IPv6 TCP.

Note This command does not apply to existing TCP connections. It only applies to subsequent TCP connections.

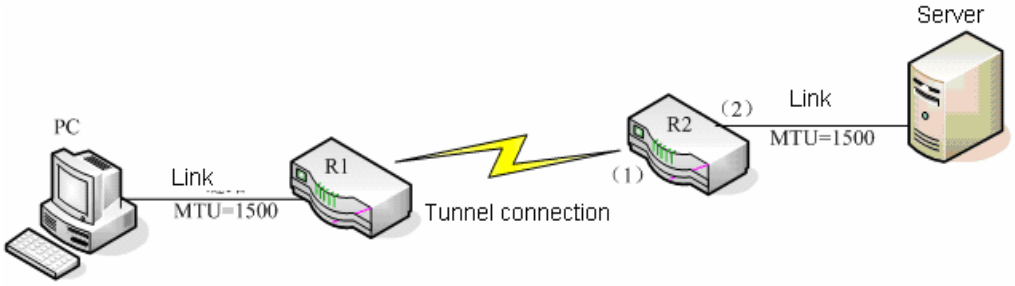
Configuring the MSS Option of SYN Packets Sent and Received on the Interface

The TCP Path MTU (PMTU) is implemented as per RFC1191. This feature can improve the network bandwidth utilization ratio. When the user uses TCP to transmit mass data, this feature can substantially enhance the transmission performance.

When the client initiates a TCP connection, it negotiates the maximum payload of TCP packets through the MSS Option field of the TCP SYN packet. The MSS value of client's SYN packet implies the maximum payload of TCP packets sent by the server, and vice versa.

As shown in the following figure, a PC may fail to access the server through HTTP, because the MSS of 1460 will be negotiated between the PC and the server, but such MSS cannot pass R1 and R2 (R1 and R2 are connected through a tunnel, with an MTU smaller than 1500).

Figure 1-1



In such a case, we can configure the following command on port (1) and port (2) of R2 to change the MSS Option value of the SYN packet, so as to change the MSS value negotiated for the TCP connection going through port (1) and port (2).

Command	Function
Ruijie(config-if)# **ip tcp adjust-mss** *max-segment-size*	Configures the MSS Option value of SYN packets sent and received on the interface. Range: 500 to 1460 bytes.

Use the **no ip tcp adjust-mss** command to remove the configuration. In such a case, the MSS Option value of packets will not be changed when the interface sends and receives SYN packets.

Configuring this command on the interface will change the MSS option of SYN packets received or sent on the interface to the MSS value configured on the interface. It is suggested that you configure the same value on the ingress interface and egress interface, or else the MSS option of SYN packets going through the device will be changed to the smaller of the two values configured.

Note This command only applies to IPv4 TCP and is only supported by routers.

Note In release 10.4(3), the MSS value of SYN+ACK packets will not be changed.

Monitoring and Maintenance

Command	Function
Ruijie# show tcp connect	Displays basic information about the current TCP connection.
Ruijie# show tcp pmtu	Displays information about TCP PMTU.
Ruijie# show tcp port	Displays information about the current TCP port.

RGOS Configuration Guide

v10.4(3b13)

Application Protocol Configuration

Configuring DNS

Overview

Due to the Domain Name System (DNS), each IP address can present a host name consisting of one or more strings separated by the decimal. Then, you only need to remember the host name rather than IP address.

There are two methods of mapping the host name to the IP address: 1) Static mapping: A device maintains its host name to IP address mapping table and uses it only by itself. 2) Dynamic mapping: The host name to IP address mapping table is maintained on the DNS server. In order for a device to communicate with others by its host name, the corresponding IP address needs to be searched on the DNS server.

The domain name resolution (or host name resolution) is the process that the device obtains an IP address corresponding to the host name by the host name. Ruijie switches support the host name resolution locally or by the DNS. During domain name resolution, you can firstly adopt the static method. If it fails, use the dynamic method. Some frequently used domain names can be put into the resolution list of static domain names. In this way, the efficiency of domain name resolution can be increased considerably.

Configuring Domain Name Resolution

Default DNS Configuration

The following table describes default configurations of DNS.

Attribute	Default value
Enable/disable the DNS resolution service	Enable
IP address of DNS server	None
Status Host List	None
Maximum number of DNS servers	Six

Enabling DNS Resolution Service

The following table describes how to enable the DNS resolution service.

Command	Function
Ruijie(config)# **ip domain**-lookup	Enables DNS.

To disable DNS, use the **no ip domain-lookup** command.

```
Ruijie(config)# ip domain-lookup
```

Configuring the DNS Server

This section describes how to configure the DNS server. The dynamic domain name resolution can be carried out only when the DNS Server is configured.

Use the **no ip name-server** [*ip-address*] command to remove the DNS server. In the command, the *ip-address* parameter indicates the specified DNS server to be removed. If this parameter is omitted, all the DNS servers will be removed.

Command	Function
Ruijie(config)**# ip name-server** *ip-address*	Adds the IP address of the DNS Server. The switch will add a DNS Server every time this command is executed. If the domain name can't be obtained from the first DNS Server, the switch will send the DNS request to the subsequent several servers until the correct response is received. The system can support six DNS servers at most.

Configuring the Host Name to IP/IPv6 Address Mapping Statically

This section describes how to configure the host name to IP/IPv6 address mapping. The switch maintains a host name to IP/IPv6 address corresponding table, which is also referred to as the host name to IP/IPv6 address mapping table. You can obtain the mapping table in two ways: manual configuration and dynamic learning. Manual configuration is required when dynamic learning is impossible.

Command	Function
Ruijie(config)# **ip host** *host-name ip-address*	Configures the host name to IP address mapping manually.
Ruijie(config)# **ipv6 host** *host-name ip-address*	Configures the host name to IPv6 address mapping manually.

To remove the mapping between the host name and IP/IPv6 address, use the **no** form of this command.

Clearing the Dynamic Buffer Table of Host Names

This section describes how to clear the dynamic buffer table of host names. If the **clear host** or **clear host** * command is entered, the dynamic buffer table will be cleared. Otherwise, only the entries of specified domain names will be cleared.

The following table describes related command.

Command	Function
Ruijie# **clear host** [*word*]	Clears the dynamic buffer table of host names. The host names configured statically will not be removed.

Showing Domain Name Resolution Information

This section describes how to display the DNS configuration.

Command	Function

Command	Function
Ruijie# **show hosts** [*host-name*]	Show parameters related to DNS.

```
Ruijie# show hosts
Name servers are:
192.168.5.134  static
Host               type      Address         TTL(sec)
www.163.com        static    192.168.5.243   ---
```

Typical DNS Configuration Examples

Example of Static DNS Configuration

Topological Diagram

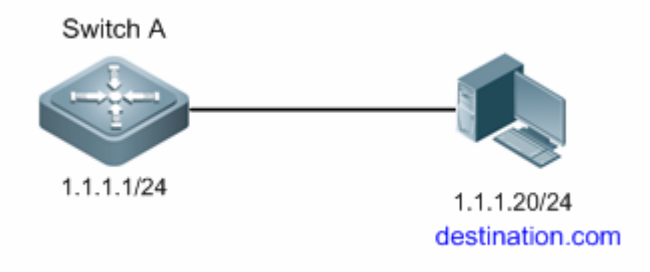


Figure1 Networking topology for static DNS configuration

Application Requirements

Since Switch A will frequently access the host of destination.com, you can use static DNS to access the host of IP 1.1.1.20 through the domain name of destination.com for domain resolution efficiency.

Configuration Tips

- Ensure that the route between device and host is reachable.
- The mapping between host name and IP address is correct.

Configuration Steps

Manually configure the mapping between host name and IP address. In this example, configure the host name to "destination.com" and the corresponding IP address to 1.1.1.20.

```
SwitchA(config)#ip host destination.com 1.1.1.20
```

Verification

Step 1: Show DNS information. Key points: the mapping between host and IP address shall be correct.

```
Ruijie-A# show host
```

```
Name servers are:
Host              type    Address                TTL(sec)
destination.com    static  1.1.1.20               ---
```

Step 2: Use the **ping destination.com** command to verify the result.

```
Ruijie-A# ping destination.com
Translating "destination.com"...[OK]
Sending 5, 100-byte ICMP Echoes to 1.1.1.20, timeout is 2 seconds:
  < press Ctrl+C to break >
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

The output shows that Ruijie-A has successfully accessed the host with IP address being 1.1.1.20 through the host name of destination.com by means of static DNS.

Example of Dynamic DNS Configuration

Topological Diagram

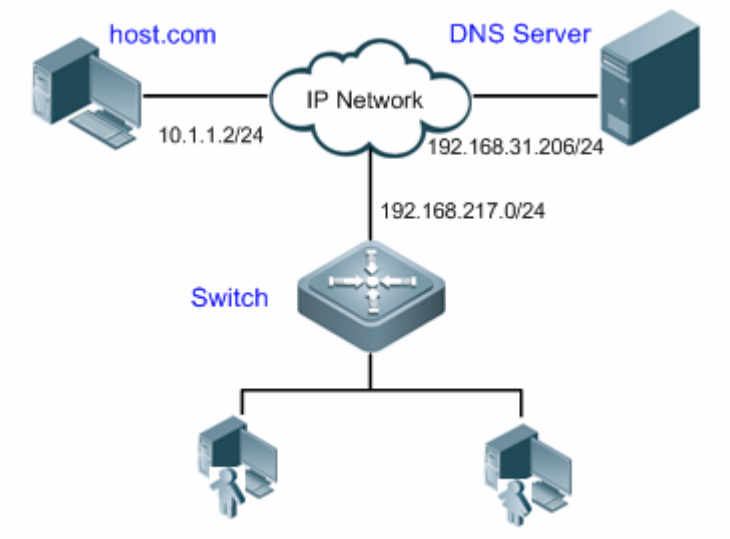


Figure2 Networking topology for dynamic DNS configuration

Application Requirements

- The IP address of DNS server is 192.168.31.206/24.
- The switch is the DNS client that can access the host of 10.1.1.2 through the host name of host.com by means of dynamic DNS.

Configuration Tips

- The route between DNS client, DNS server, and access PC shall be reachable.
- DNS shall be enabled. DNS is enabled by default.
- The IP address of the DNS server has been correctly configured.

Configuration Steps

Step 1: Configure the DNS server

Configure different DNS servers according to the actual conditions.

Configure the mapping between host and IP address on DNS server. This example configures the host name as "host.com" and the IP address as 10.1.1.2/24.

Step 2: Configure the DNS client

The route between DNS client, DNS server, and access PC shall be reachable. The interface IP configurations are shown in the topological diagram.

! DNS shall be enabled. The DNS feature is enabled by default.

```
Ruijie(config)#ip domain-lookup
```

! Configure the IP address of DNS server as 192.168.31.206

```
Ruijie(config)#ip name-server 192.168.31.206
```

Verification

Step 1: Use the **ping host.com** command to verify the result.

```
Ruijie#ping host.com

Translating " host.com "...[OK]
Sending 5, 100-byte ICMP Echoes to 10.1.1.2, timeout is 2 seconds:
  < press Ctrl+C to break >
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

The preceding information shows that the client can ping the host, and the destination IP is 10.1.1.2. Through dynamic DNS, the host with the IP address 10.1.1.2 can be accessed through the host name of host.com.

Step 2: Show DNS information. Key points: the host name and IP address.

```
Ruijie#show host
Name servers are:
192.168.31.206 static

Host               type      Address         TTL(sec)
host.com          dynamic    10.1.1.2          3503
```

The output shows that the mapping between host name and host IP is correct.

Configuring DHCP

Understanding DHCP

The Dynamic Host Configuration Protocol (DHCP), as specified in RFC 2131, provides configuration parameters for hosts over the Internet. DHCP works in client/server mode. The DHCP server assigns IP addresses for the hosts dynamically and provides configuration parameters.

DHCP assigns IP address in three ways:

- Assigning IP addresses automatically. The DHCP server assigns permanent IP addresses to the clients;
- Assigning IP addresses dynamically. The DHCP server assigns temporary IP addresses to the clients (or the clients can release the addresses by themselves);
- Configuring IP addresses manually. Network administrators specify IP addresses and send the specified IP addresses to the clients through DHCP.

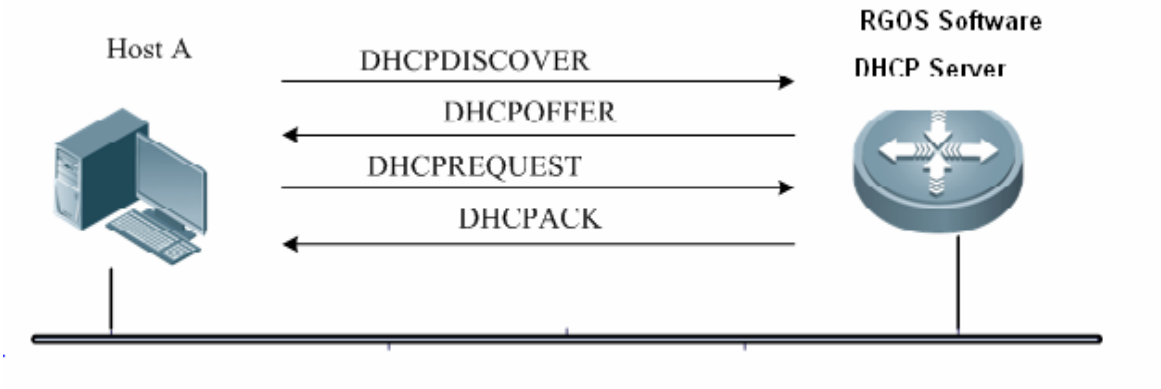
Among the mentioned three methods, only dynamic assignment allows reuse of the IP address that the client does not need any more.

The format of a DHCP message is based on that of a Bootstrap Protocol (BOOTP) message. Hence, the device must act as the BOOTP relay agent and interact with the BOOTP client and the DHCP server. The BOOTP relay agent eliminates the need of deploying a DHCP server in every physical network. DHCP is detailed in RFC 2131 and RFC 2132.

Understanding the DHCP Server

As specified in RFC2131, the DHCP server of Ruijie Networks is implemented to assign and manage IP addresses for the DHCP clients. The DHCP operation process is shown in the following figure.

Fig 1-1 DHCP process



Process of requesting an IP address:

The host broadcasts a DHCPDISCOVER packet in the network to locate the DHCP server;
The DHCP server sends a DHCPOFFER packet in unicast form to the host, including IP address, MAC address, domain name and address lease period;
The host sends a DHCPREQUEST packet in broadcast form to formally request the server to assign the provided IP address;

The DHCP server sends a DHCPACK packet in unicast form to the host to confirm the request.

Note

The DHCP client may receive the DHCPOFFER packets from multiple DHCP servers, and accept all received DHCPOFFER packet. However, the DHCP client usually accepts the first received DHCPOFFER packet only.

Note

The address specified in the DHCPOFFER packet from the DHCP server is unnecessarily the finally assigned address. Generally, the DHCP server reserves this address until the client sends a formal request.

The DHCPREQUEST that requests the DHCP server to assign an address is a broadcast packet with the server address to enable all other DHCP servers that send DHCPOFFER response packets to receive the packet. Other DHCP servers are unable to find that the client has received the DHCPOFFER packet from just the DHCPREQUEST packet, so they will not release the IP addresses provided (pre-assigned) to the clients and will enable the IP addresses corresponding to the unaccepted OFFER lease to be reused through the timing mechanism.

If the DHCPOFFER packet sent to the DHCP client contains invalid parameters, the DHCP client sends the DHCPDECLINE packet to refuse the assigned configuration.

The following are advantages of using the DHCP server of Ruijie Networks for network construction:

- Decreases network access cost. Generally, dynamic address assignment costs less than static address assignment.
- Simplifies configuration tasks and reduce network construction cost. Dynamic address assignment significantly simplifies equipment configuration, and even reduces deployment cost if devices are deployed in the places where there are no professionals.
- Centralizes management. During configuration management on several subnets, each configuration parameter can be changed simply by modifying and updating configurations in the DHCP server.

Understanding the DHCP Client

The DHCP client can obtain IP addresses and other configuration parameters from the DHCP server automatically. The DHCP client brings the following advantages:

- Saves device configuration and deployment time.
- Reduces the possibility of configuration errors.
- Centrally manages IP address assignment.

☑ The DHCP client is supported on the Ethernet interface, FR, PPP, and HDLC interfaces.

Understanding the DHCP Relay Agent

The DHCP relay agent forwards DHCP packets between the DHCP server and the DHCP clients. When the DHCP clients and the server are not located in the same subnet, the DHCP relay agent must be available for forwarding the DHCP request and response messages. Data forwarded by the DHCP relay agent is different from general forwarding. In general forwarding, IP packets are unaltered and the transmission is transparent. However, upon receiving a DHCP message, the DHCP relay agent regenerates a DHCP message before forwarding it.

For the DHCP client, the DHCP relay agent works like a DHCP server. For the DHCP server, the DHCP relay agent works like a DHCP client.

Configuring DHCP

To configure DHCP, perform the following tasks, of which the first three tasks are mandatory.

Enabling the DHCP Server and Relay Agent

Use the following commands to enable the DHCP server and relay agent in global configuration mode.

Command	Function
Ruijie(config)# **service dhcp**	Enables the DHCP server and the DHCP relay agent.
Ruijie(config)# **no service dhcp**	Disables the DHCP server and the DHCP relay agent.

- By default, in v10.1 and later, the **service dhcp** command can be used for both the DHCP server and DHCP relay, which are two mutually-exclusive functions. The switchover of those two functions depends on whether the DHCP address pool is configured.
- However, for the product in the version earlier than v10.1 (excluding v10.1), the **service dhcp** command is not supported by both DHCP server and DHCP relay. You can use the **service dhcp** command to enable the DHCP service or the DHCP server.
- For some products in v10.1 and later, DHCP may conflict with some functions. For more information, see the prompting message of a specific product.

Configuring DHCP Excluded Addresses

Unless configured particularly, the DHCP server tries to assign all the subnet addresses defined in the address pool to the DHCP clients. To reserve some addresses, such as those addresses that have been assigned, you must define those addresses as excluded.

Use the following commands to configure the excluded addresses in global configuration mode.

Command	Function
Ruijie(config)# **ip dhcp excluded-address** *low-ip-address [high-ip-address]*	Defines excluded addresses.
Ruijie(config)# **no ip dhcp excluded-address** *low-ip-address [high-ip-address]*	Removes the configuration.

Note

A good practice in configuring the DHCP server is to prohibit the DHCP server from assigning any address that has been assigned specifically. This provides two advantages: 1) No address conflict will occur; 2) When DHCP assigns addresses, the time for detection is shortened and DHCP will perform assignment more efficiently.

Configuring DHCP Address Pool

DHCP Address assignment and DHCP parameters sent to the client should be defined in the DHCP address pool. If no DHCP address pool is configured, addresses cannot be assigned to the DHCP clients even though the DHCP server has been enabled. However, if the DHCP server has been enabled, the DHCP relay agent is always working regardless of the DHCP address pool.

You can give a meaningful name that can be memorized easily to the DHCP address pool. The name of address pool contains characters and digits. Ruijie product allows you to define multiple address pools. The IP address of the DHCP relay agent in the DHCP request packet is used to determine which address pool is used for address assignment.

- If a DHCP request packet contains no IP address of the relay agent, the address will be assigned according to the segment range of the interface receiving request packets. The logic of assignment is that, if an address pool of a large segment scope is configured, addresses can be assigned for the request packets received by the small segment interfaces within the large address pool segment scope. For example, if the large address pool configured is 192.168.0.0/16, it can be used to assign addresses to the DHCP requests arriving at the small segment interfaces 192.168.1.0/24, 192.168.2.0/24 and 192.168.4.0/24. If multiple address pools of small segments are configured, these pools can assign addresses to the request packets arriving at the large segment interface covering the small segments. For example, the two small address pools 192.168.1.0/24 and 192.168.3.0/24 can assign addresses to the DHCP requests arriving at the interface of 192.168.0.0/16. If the minimum match between the segment range of the interface receiving request packets and the segment range of the address pool is unsuccessful, the address assignment fails.
- If the DHCP request packet contains the IP address of the DHCP relay agent, the address that is in the same subnet or network as this address is assigned to the DHCP client. If no address pool is defined for this network segment, address assignment fails.

To configure a DHCP address pool, perform the following tasks as appropriate, of which the first three tasks are mandatory:

-

Configuring an Address Pool Name and Enter Configuration Mode

Use the following command to configure an address pool name and enter address pool configuration mode in global configuration mode.

Command	Function
Ruijie(config)# **ip dhcp pool** *dhcp-pool*	Configures an address pool name and enter address pool configuration mode.

To display address pool configuration mode, use the **Ruijie(dhcp-config)** command.

Configuring the Address Pool Network Number and Mask

To configure dynamic address binding, the subnet and its mask of the new address pool must be configured to provide the DHCP server with an address space that can be assigned to clients. Unless there is address exclusion configuration, the addresses in all the address pools can be assigned to clients. DHCP assigns addresses in the address pool in order. If an address exists in the DHCP binding table or is detected to have existed in the segment, the next address will be checked until a valid address is assigned.

Use the following command to configure the subnet and mask of an address pool in address pool configuration mode.

Command	Function
Ruijie(dhcp-config)# **network** *network-number mask*	Configures the network number and mask of a DHCP address pool

Configuring the Client Boot File

The client boot file is the boot mapping file required when the client boots up. The boot mapping file is usually the operating system to be downloaded to the DHCP client.

Use the following commands to configure the client boot file in address pool configuration mode.

Command	Function
Ruijie (dhcp-config)# **bootfile** *filename*	Configures the client boot file.

Configures the Default Gateway of the Client

The default gateway of the client is configured to function as the default gateway parameter that the server assigns to the client. The IP address of the default gateway must be in the same network as the IP address of the DHCP client.

Use the following commands to configure the default gateway of the client in address pool configuration mode.

Command	Function
Ruijie(dhcp-config)# **default-router** *address* [*address2…address8*]	Configures the default gateway.

Configuring the Default Gateway for the DHCP Client

When Ruijie devices assign DHCP addresses, default gateways to be assigned to clients can be either specified manually or assigned dynamically.

- If the default gateway of the address pool is specified manually, the gateway address manually specified is the default gateway of the client when a lease is obtained from the corresponding address pool.
- If no default gateway is configured, the default address type dynamically assigned is determined based on whether the VRRP address is configured to the interface that receives packets. If the VRRP address has been configured, the gateway is selected based on whether the request packets carry the field “relay”. If the request packet is forwarded by the relay, the segment of the field “relay” is used as the default gateway to issue; otherwise, the interface address selected by the longest match principle is the gateway to be issued.

Use the following command to configure the default gateway for the DHCP client in address pool configuration mode.

Command	Function
Ruijie(dhcp-config)# **default-router** *address* [*address2…address8*]	Configures the default gateway.

Configuring the Address Lease Period

The lease period of the addresses assigned to clients by the DHCP server is infinite for static address pools, and 1 day for other address pools, by default. The client should request to update when the lease period is going to expire. Otherwise, it cannot use this address when the lease period expires.

Use the following command to configure the address lease period in address pool configuration mode.

Command	Function
Ruijie(dhcp-config)# **lease** {*days* [*hours*] [*minutes*] | **infinite**}	Configures the address lease period.

Configure the startup server and boot file of the client. The client startup file is the boot image file that is used for client startup. Usually, after obtaining an IP address from the DHCP server, the DHCP client will download the boot image file from the startup server (usually the TFTP server) and initialize the device using the obtained configuration file. If no configuration file information is obtained, the device will be started up with the empty configuration.

Use the following commands to configure the download server and boot file of a client in address pool configuration mode.

Command	Function
Ruijie (dhcp-config)# **next-server** *address* [*address2…address8*]	Configures the download server address for client startup
Ruijie (dhcp-config)# **bootfile** *filename*	Configures the client boot file name

Configuring the Domain Name of the DHCP Client

The domain name of the DHCP client can be specified. In this way, the domain name suffix will be automatically added to the incomplete host name to form a complete host name when the DHCP client accesses the network resources using the host name.

Use the following command to configure the domain name of the DHCP client in address pool configuration mode.

Command	Function
Ruijie(dhcp-config)# **domain-name** *domain*	Configures the domain name.

Configuring the Domain Name Server

A domain name server (DNS) should be specified for domain name resolution when the DHCP client accesses the network resources using a host name.

Use the following command to configure a domain name server for the DHCP client in address pool configuration mode.

Command	Function
Ruijie(dhcp-config)# **dns-server** *address* [*address2…address8*]	Configures a DNS server.

Configuring the NetBIOS WINS Server

Windows Internet Naming Server (WINS) is a domain name resolution service from Microsoft used by the TCP/IP network to resolve a NetNBIOS name to an IP address. The WINS server runs in Windows NT. After started, the WINS server will receive a registration request from the WINS client. When the WINS client is being shut down, it will send a

name release message to the WINS server to guarantee the consistency of available computers between the WINS database and the network.

Use the following command to configure a NetBIOS WINS server for the DHCP client in address pool configuration mode.

Command	Function
Ruijie(dhcp-config)# **netbios-name-server** *address* [*address2…address8*]	Configures a DNS server.

Configuring the NetBIOS Node Type for the DHCP Client

There are four types of NetBIOS nodes for Microsoft DHCP client: 1) Broadcast. The NetBIOS name is resolved in broadcast mode; 2) Peer-to-peer. The WINS server is asked directly to resolve the NetBIOS name; 3) Mixed. First, the name is resolved in broadcast mode, and then the WINS server is connected to resolve the name; 4) Hybrid. First the WINS server is asked directly to resolve the NetBIOS name. If there is no response, the NetBIOS name is resolved in broadcast mode.

By default, the Windows operation systems support the broadcast or hybrid type NetBIOS nodes. If no WINS server is configured, the node is of the broadcast type. If a WINS server is configured, the node is of the hybrid type.

Use the following command to configure the NetBIOS node type for the DHCP client in address pool configuration mode.

Command	Function
Ruijie(dhcp-config)# **netbios-node-type** *type*	Configures the NetBIOS node type.

Configuring the Network ID and Mask of the DHCP Address Pool

You must configure the subnet and its mask to provide the DHCP server with a client address assignment range when binding dynamic addresses. All address in this range can be allocated to clients if no excluded address is configured. DHCP assigns addresses in the range one by one. If an address exists in the DHCP binding table or is detected in the network segment, the DHCP proceeds to the next address until finding an effective allocable address.

Use the following commands to configure the subnet and its mask of the address pool in address configuration mode.

Command	Function
Ruijie(dhcp-config)# **network** *network-number mask*	Configures the network ID and mask of the DHCP address pool.

Caution Address assignment is indexed by the physical address and ID of the client in the DHCP dynamic address pool of Ruijie products. In this case, the DHCP address pool cannot have two leases of the same client. Then, address assignment of the server becomes faulty and may result in failure to assign addresses if path redundancy occurs in the network topology between the server and the client (the client can connect to the server through both the direct path and the relay path).

Caution To avoid the preceding problem, the network administrator can avoid path redundancy between the server and the client using methods such as adjusting the physical link or network link.

Configuring DHCP Address Pool to Allocate Address as per Option82

Generally, the DHCP relay agent will insert Option 82 to carry relevant information about the client during the process of packet forwarding (such as the VLAN to which the client belongs, slot number, port number or user's 1X class). Upon receipt of such packets, the DHCP server will allocate addresses according to the specific information about clients by analyzing Option 82 information. For example, Option 82 can be used to allocate an IP address range to clients belonging to a VLAN or user class. This feature can be used when required to allocate a specific range of IP addresses according to user's network allocation information (such as VLAN, slot number or port number) or user's priority.

Each DHCP address pool can allocate addresses using Option 82 information. Option 82 information will be matched and classified, and we can specify the allocable address range for the corresponding class. One DHCP address pool can be associated with multiple classes, and different network segment ranges can be specified for each class.

During the process of address allocation, we can first determine the allocable address pool according to the network segment to which the client belongs, and then further determine its CLASS according to Option 82 information, so as to allocate IP address from the network segment range corresponding to the CLASS. When a request packet matches multiple classes in the address pool, address will be assigned from the address ranges corresponding to these classes so that the classes are configured in the address pool. If the class has no allocable address, the network segment range for the next matching class will be used, and the like. Each class corresponds to one address range, and the addresses must be assigned from low to high. Multiple classes can be configured with the same address range. If the CLASS associated with the address pool is specified, but the segment range of the CLASS is not configured, the DHCP clients of this CLASS cannot be assigned addresses.

Use the following commands to configure the CLASS associated with address pool and the address range corresponding to the class in address pool configuration mode.

Command	Function
Ruijie(dhcp-config)# **class** *class-name*	Configures the name of associated class, and enter class configuration mode of address pool.
Ruijie(config-dhcp-pool-class)# **address range** *low-ip-address high-ip-address*	Configures the corresponding network segment range.

Note 1. When the global class cannot be found, it will be created automatically.
2. The associated class configured in the address pool may conflict with the static manual binding, and therefore they cannot be configured at the same time.
3. Up to five classes can be configured for each address pool

Configuring Class

Configuring Option82 Matching Information for the CLASS

The specific Option82 matching information corresponding to each CLASS can be configured after entering CLASS configuration mode in global mode. One CLASS can match multiple pieces of Option 82 information, and it is considered matched if the packet matches any information. If no matching information is configured for CLASS, then this CLASS can match any request packets carrying Option 82 information. The address can only be assigned from the corresponding address pool after the request packet matches a specific CLASS.

Use the following commands to configure global CLASS and the Option 82 information corresponding to the CLASS in global configuration mode.

Command	Function
Ruijie(config)# **ip dhcp class** *class-name*	Configures CLASS name and enters global CLASS configuration mode.
Ruijie(config-dhcp-class)# **relay agent information**	Enters Option 82 matching information configuration mode.
Ruijie(config-dhcp-class-relayinfo)# **relay-information hex** *aabb.ccdd.eeff…* [*****]	Configures specific Option 82 matching information: 1. The parameter *aabb.ccdd.eeff..* is a hexadecimal number. The asterisk (*) indicates imperfect matching mode. It is considered matched if the information before * is matched.

Note The Global CLASS can have up to 20 matches.

Configuring Remark Information for the CLASS

Use the following commands to configure remark information to describe the meaning of CLASS in global configuration mode.

Command	Function
Ruijie(config)# **ip dhcp class** *class-name*	Configures CLASS name and enters CLASS configuration mode.
Ruijie(config-dhcp-class)#**remark** *used in #1 building*	Configures remark information.

Configuring whether to Use CLASS Allocation

Use the following command to configure address allocation using CLASS in global configuration mode.

Command	Function
Ruijie(config)# **ip dhcp use class**	Configures address allocation using CLASS.

Caution This command is enabled by default. Execute NO command to disable address allocation using CLASS.

Configuring Binding Database Storage

Configuring to Periodically Save Binding Database into FLASH

To avoid the loss of binding database (lease information) on DHCP server due to power failure or reboot of the device, you can configure the delay time to write the database into FLASH. The time is **0** by default, namely the database will be written into FLASH at variable intervals.

Use the following command to periodically write the binding database into the FLASH in global configuration mode.

Command	Function
Ruijie(config)# [**no**] **ip dhcp database write-delay** [*time*]	Configures DHCP delay time to write into FLASH. *The range of the time* parameter is from 600—to 86400 in seconds. The default is 0.

Caution Since frequent FLASH reading and writing will shorten the service life of FLASH, we shall pay attention to the delay time configured. Short delay will enable efficient storage of device information, while long delay can reduce the frequency of FLASH reading and writing, thus prolonging the service life.

Configuring to Manually Save the Binding Database into FLASH

To avoid the loss of DHCP binding database (lease information) due to power failure or reboot of the device, you can also manually write the existing binding database information into the FLASH as needed besides configuring the delay time for FLASH writing.

Use the following command to manually write the binding database into the FLASH in global configuration mode.

Command	Function
Ruijie(config)# **ip dhcp database write-to-flash**	Writes DHCP binding database information into the FLASH

Manual Address Binding

Address binding refers to mapping the IP address to the MAC address for the DHCP clients. You can bind addresses in two ways. 1) Manual binding: Configure the static IP address to MAC address mapping for the DHCP client on the DHCP server manually. Manual binding actually offers a special address pool; 2) Dynamic binding: Upon receiving a DHCP request from the DHCP client, the DHCP server dynamically assigns an IP address from the DHCP address pool to the DHCP client, and thus mapping the IP address to the MAC address for the DHCP client.

To define manual address binding, you first need to define a host address pool for each manual binding, and then define the IP address and hardware address (MAC address) or ID for the DHCP client. Generally, a client ID, instead of a MAC address, is defined for the Microsoft clients. The client ID contains media type and MAC address. For the codes of media types, see the section "Address Resolution Protocol Parameters" in RFC 1700. The code of Ethernet type is “01”.

Use the following commands to configure the manual address binding in address pool configuration mode.

Command	Function
Ruijie(config)# **ip dhcp pool** *name*	Defines the name of the DHCP address pool and enters DHCP configuration mode.
Ruijie(dhcp-config)# **host** *address* [*netmask*]	Defines an IP address for the DHCP client.

Command	Function
Ruijie(dhcp-config)# **hardware-address** *hardware-address type* *or:* Ruijie(dhcp-config)# **client-identifier** unique-identifier	Defines a hardware address for the DHCP client, such as aabb.bbbb.bb88. Defines an ID for the DHCP client, such as 01aa.bbbb.bbbb.88.
Ruijie(dhcp-config)# **client-name** *name*	(Optional) Defines the client name using standard characters of American Standard Code for Information Interchange (ASCII). Exclude the domain name in the client name. For example, if you define the host name as *mary*, do not define the client name as *mary.rg.com*.

Configuring Ping Times

By default, when trying to assign an IP address from the DHCP address pool to a DHCP client, the DHCP server will ping the IP address twice (one packet for each time). If there is no response, the DHCP server considers this address an idle address and assigns it to the DHCP client. If there is a response, the DHCP server considers that this address is in use and tries to assign another address to the DHCP client until an address is assigned successfully.

Use the following command to configure the number of Ping packets in global configuration mode.

Command	Function
Ruijie(config)# **ip dhcp ping** *packets number*	Configures the number of Ping packets before the DHCP server assigns an address. If it is set to **0**, the Ping operation is not performed. The default value is **2**.

Configuring Ping Packet Timeout

By default, the DHCP server considers an IP address nonexistent if no response is received within 500 milliseconds after pinging the IP address. You can adjust the Ping packet timeout.

Use the following command to configure the Ping packet timeout in global configuration mode.

Command	Function
Ruijie(config)# **ip dhcp ping timeout** *milliseconds*	Configures the Ping packet timeout for the DHCP server. The default value is 500ms.

Configuring the DHCP Client on the Ethernet Interface

☑ Ruijie products support the function of dynamically obtaining the IP address that is assigned by the DHCP server on an Ethernet interface.

Use the following command to configure the DHCP client on the Ethernet port, execute the following command in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip address dhcp**	Obtains an IP address through DHCP.

Configuring the DHCP Client in the PPP Encapsulation Link

Ruijie products support the function of dynamically obtaining the IP addresses that is assigned by the DHCP server on a PPP encapsulation interface.

Use the following command to configure the DHCP client, execute the following command in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip address dhcp**	Obtains an IP address through DHCP.

Configuring the DHCP Client in the FR Encapsulation Link

☑ Ruijie products support obtaining the IP addresses dynamically assigned by the DHCP server on an FR encapsulation interface.

Use the following command to configure the DHCP client, execute the following command in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip address dhcp**	Obtains an IP address through DHCP.

Configuring the DHCP Client in the HDLC Encapsulation Link

☑ Ruijie products support obtaining the IP address dynamically assigned by the DHCP server on an HDLC encapsulation interface.

Use the following command to configure the DHCP client, execute the following command in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip address dhcp**	Obtains an IP address through DHCP.

☑ For some product of v10.1 and later versions, DHCP client supports obtaining the IP address assigned by the DHCP server in the point-to-point link of PPP, HDLC, and FR encapsulation.

Monitoring and Maintaining Information

Monitoring and Maintaining the DHCP Server

Three types of commands are available for monitoring and maintaining the DHCP server:

Clear commands, used to clear such information as DHCP address binding, address conflict and server statistics;

Debug commands, used to output necessary debugging information. Such commands are mainly used to diagnose and fix faults;

Show commands, used to show information about DHCP.

Ruijie products provide three clear commands. Use the following commands to clear information in command execution mode.

Command	Function
Ruijie# **clear ip dhcp binding** { *address* | ***** }	Clears the DHCP address binding information.
Ruijie# **clear ip dhcp conflict** { *address* | *}	Clears the DHCP address conflict information.
Ruijie# **clear ip dhcp server statistics**	Clears the DHCP server statistics.

Use the following command to debug the DHCP server in command execution mode.

Command	Function
Ruijie# **debug ip dhcp server** [**events | packet**]	Debugs the DHCP server.

Use the following commands to show the working status of the DHCP server in command execution mode.

Command	Function
Ruijie# **show ip dhcp binding** [*address*]	Shows the DHCP address binding information.
Ruijie# **show ip dhcp conflict**	Shows the DHCP address conflict information.
Ruijie# **show ip dhcp server statistics**	Shows the DHCP server statistics.

Monitoring and Maintaining the DHCP Client

There are two types of commands for monitoring and maintaining the DHCP client. The following operations can be performed on the DHCP client:

Debug commands, used to output necessary debugging information. Such commands are mainly used to diagnose and clear faults.
Show commands, used to show information about DHCP.

Use the following command to debug the DHCP client, execute the following command in command execution mode.

Command	Function
Ruijie# **debug ip dhcp client**	Debugs the DHCP client.

Use the following command to show information about the lease of the DHCP client in command execution mode.

Command	Function
show dhcp lease	Shows the information about DHCP lease.

Example of Configuring the Address Pool to Support Option82

In the following example, an address pool of "net82" is defined; the address pool is in the network segment of 172.16.1.0/24, and the associated classes include class1, class2, class3 and class4. Class1 will allocate addresses from the range of 172.16.1.1-172.16.1.8; class2 will allocate addresses from the range of 172.16.1.9-172.16.1.18; class3 will allocate addresses from the range of 172.16.1.19-172.16.1.28; class4 has no defined address range, and will allocate addresses from the range of entire network segment. Configure class1 to match Option 82 information of 0100002120, class2 to match 0106020145, class3 to match 06020506*, and class4 to match any information.

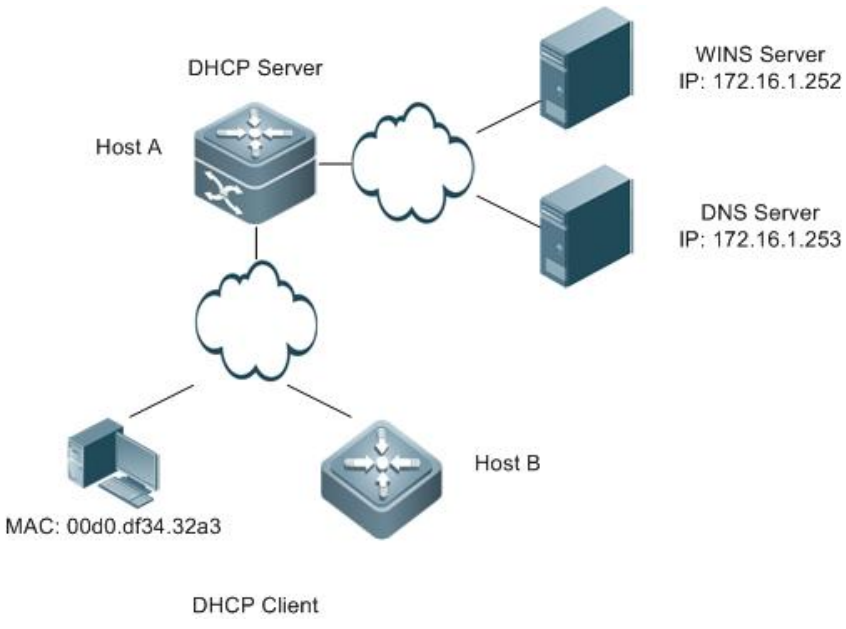
```
!
```

```
ip dhcp class class1
 relay agent information
    relay-information hex 0100002120
!
ip dhcp class class2
 relay agent information
    relay-information hex 0106020145
!
ip dhcp class class3
 relay agent information
    relay-information hex 06020506*
!
ip dhcp class class4
!
ip dhcp pool net82
network 172.16.1.0 255.255.255.0
class class1
address range 172.16.1.1 172.16.1.8
class class2
address range 172.16.1.9 172.16.1.18
class class3
address range 172.16.1.19 172.16.1.28
class class4
```

Typical DHCP Configuration Examples

Topological Diagram

Fig 1-6 Diagram of DHCP example



Application Requirements

- Host A can serve as the DHCP server to assign dynamic IP addresses to some client users. The network segment for IP address assignment is 172.16.1.0/24; the default gateway is 172.16.1.254; the domain name is ruijie.com; the domain name server is 172.16.1.253; the WINS server is 172.16.1.252; the NetBIOS node type is compound; and the address lease period is 1 day. Except the addresses from 172.16.1.2 to 172.16.1.100 in the address segment, all the other addresses can be assigned.
- Host A assigns fixed IP addresses to some client users. The IP address assigned to the fit AP (DHCP client) with the MAC address 00d0.df34.32a3 is 172.16.1.101; the mask is 255.255.255.0; the domain name is admin; the default gateway is 172.16.1.254; the domain name server is 172.16.1.253; the WINS server is 172.16.1.252; and the NetBIOS node type is compound.
- Host B configures the DHCO automatically assigned address to the device interface FastEthernet 0/0.

Configuration Tips

- Enable the function of DHCP server on Host A and create an address pool to dynamically assign IP addresses. And create another address pool to manually bind IP addresses. Specify the address of the domain name server in the corresponding address pool (in this example, the addresses of the DNS server and WINS server) and the domain name of the client.
- Enable the function of the DHCP client on Host B to obtain the IP address automatically.

Configuration Steps

Step 1: Create a new DHCP address pool and configure dynamic IP address allocation on the Host A.

! Configure the name of address pool as "dynamic" and enter DHCP configuration mode.

```
HostA# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
HostA(config)# ip dhcp pool dynamic
```

! In DHCP configuration mode, configure an IP address network allocable to clients, configure the default gateway of this network segment, and set the lease period to 1 day.

```
HostA(dhcp-config)# network 172.16.1.0 255.255.255.0
HostA(dhcp-config)# default-router 172.16.1.254
HostA(dhcp-config)# lease 1
```

Step 2: Specify the DNS Server of "dynamic" address pool and configure the domain name of client.

! Assuming that the IP address of DNS Server is 172.16.1.253, configure Domain Name Server in the address pool and configure the domain name of client as ruijie.com.

```
HostA(dhcp-config)# dns-server 172.16.1.253
HostA(dhcp-config)# domain-name ruijie.com
```

Step 3: Specify the WINS Server of "dynamic" address pool and configure the NetBIOS node type of client.

! Assuming that the IP address of WIN Server is 172.16.1.252, configure NetBIOS WINS server in the address pool and configure the NetBIOS node type as Hybrid.

```
HostA(dhcp-config)# netbios-name-server 172.16.1.252
```

```
HostA(dhcp-config)# netbios-node-type h-node
```

Step 4: Configure excluded addresses in global mode.

! As shown in the preceding information, IP addresses of 172.16.1.254, 172.16.1.253 and 172.16.1.252 have been assigned to the gateway, the DNS server and the WINS server, and the addresses from 172.16.1.2 to 172.16.1.100 are excluded addresses. The excluded addresses won't be assigned to clients.

```
HostA(dhcp-config)# exit
HostA(config)# ip dhcp excluded-address 172.16.1.252 172.16.1.254
HostA(config)# ip dhcp excluded-address 172.16.1.2 172.16.1.100
```

Step 5: Create another address pool and manually bind the IP address.

! Configure the name of address pool as "static" and enter DHCP configuration mode.

```
HostA(config)# ip dhcp pool static
```

! Manually bind the IP address of 172.16.1.101/24 to the MAC address of 00d0.df34.32a3, with client name being "admin". Note: The identifier for identifying the client shall indicate the network media type ("01" for Ethernet), namely the identifier of the client corresponding to the manually bound MAC address shall be 00d0.df34.32a3.14.

```
HostA(dhcp-config)# host 172.16.1.101 255.255.255.0
HostA(dhcp-config)# client-identifier 00d0.df34.32a3.14
HostA(dhcp-config)# client-name admin
```

Step 6: Specify the gateway address corresponding to the "static" address pool.

! Configure gateway address as 172.16.1.254.

```
HostA(dhcp-config)# default-router 172.16.1.254
```

Step 7: Specify the DNS Server of "static" address pool and configure the domain name of client.

! Assuming that the IP address of the DNS server is 172.16.1.253,configure the DNS in the address pool and configure the domain name of client as ruijie.com.

```
HostA(dhcp-config)# dns-server 172.16.1.253
```

HostA(dhcp-config)# domain-name ruijie.com Step 8: Specify the WINS Server of "static" address pool and configure the NetBIOS node type of client.

! Assuming that the IP address of WIN Server is 172.16.1.252, configure NetBIOS WINS server in the address pool and configure the NetBIOS node type as Hybrid.

```
HostA(dhcp-config)# netbios-name-server 172.16.1.252
HostA(dhcp-config)# netbios-node-type h-node
```

HostA(dhcp-config)# exit Step 9: Enable the DHCP server on HOST A.

```
HostA(dhcp-config)# exit
```

HostA(config)# service dhcp Step 10: Enable the DHCP client on Host B.

!The following example shows how to enable the DHCP client, assuming that the client uses a layer 3 interface by default.

```
HostB(config)# interface fastEthernet 0/1
HostB(config-if-fastEthernet 0/1)# ip address dhcp
```

Verification

Step 1: View the configuration information on Host A.

```
HostA# show running-config
!
service dhcp
!
ip dhcp excluded-address 172.16.1.252 172.16.1.254
ip dhcp excluded-address 172.16.1.2 172.16.1.100
!
!
ip dhcp pool dynamic
 netbios-node-type n-node
 netbios-name-server 172.16.1.252
 domain-name ruijie.com
 lease 1 0 0
 network 172.16.1.0 255.255.255.0
 dns-server 172.16.1.253
 default-router 172.16.1.254
!
ip dhcp pool static
 client-name admin
 client-identifier 00d0.df34.32a3.14
 host 172.16.1.101 255.255.255.0
 netbios-node-type n-node
 netbios-name-server 172.16.1.252
 domain-name ruijie.com
 dns-server 172.16.1.253
 default-router 172.16.1.254
!
```

Step 2: View the configuration information on Host B.

```
HostB# show running-config
!
interface fastEthernet 0/1
 // Note: For switches, the no switchport command is also required, and the interface is configured as a layer 3 interface.
ip address dhcp
```

Step 3: Connect a PC with the MAC address 0013.2049.9014, and view the IP address information assigned by the DHCP server on the Host A.

```
Ruijie#show ip dhcp binding
IP address    Client-Identifier/    Lease expiration        Type
              Hardware address
172.16.1.101  00d0.df34.32a3.14     IDLE                    Manual 172.16.1.102
0100.e04c.70b7.e2 000 days 23 hours 48 mins Automatic
```

Configuring DHCP Relay

Overview

Understanding DHCP

The Dynamic Host Configuration Protocol (DHCP) is widely used to dynamically allocate reusable network resources such as IP addresses.

The DHCP client sends the DHCP DISCOVER broadcast packet to the DHCP server. After receiving the DHCP DISCOVER broadcast packet, the DHCP server allocates resources such as IP addresses to the DHCP client according to the appropriate policy, and sends the DHCP OFFER packet. After receiving the DHCP OFFER packet, the DHCP client checks if the resources are available. If yes, the DHCP client sends the DHCP REQUEST packet. If no, the DHCP client sends the DHCP DISCOVER packet. After receiving the DHCP REQUEST packet, the DHCP server checks if the IP addresses (or other limited resources) can be allocated. If yes, the DHCP server sends the DHCP ACK packet. If no, the DHCP server sends the DHCP NAK packet. After receiving the DHCP ACK packet, the DHCP client starts to use the resources allocated by the DHCP server. Upon receiving the DHCP NAK packet, the DHCP client may re-send the DHCP DISCOVER packet to request another IP address.

Understanding DHCP Relay

The destination IP address of DHCP REQUEST packet is 255.255.255.255. Such packets are only forwarded inside a subnet. To allocate IP addresses dynamically across network segments, the DHCP relay agent comes into being. It encapsulates the received DHCP REQUEST packet into unicast IP packets and forwards it to the DHCP server. Meanwhile, it forwards the received DHCP response packet to the DHCP client. In this way, the DHCP Relay Agent works as a transit station responsible for communicating with the DHCP clients and the DHCP server on different network segments. In this case, one DHCP server in a LAN can implement the dynamic IP management for all network segments, that is, a dynamic DHCP IP management in Client - Relay Agent - Server mode, as shown in Figure 1.

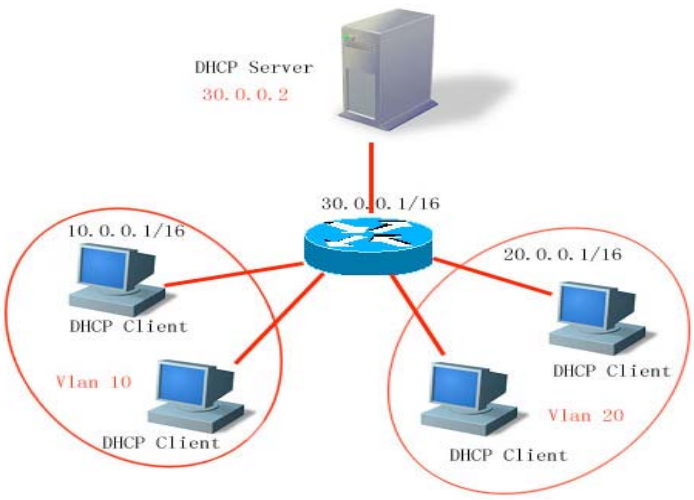


Figure 1

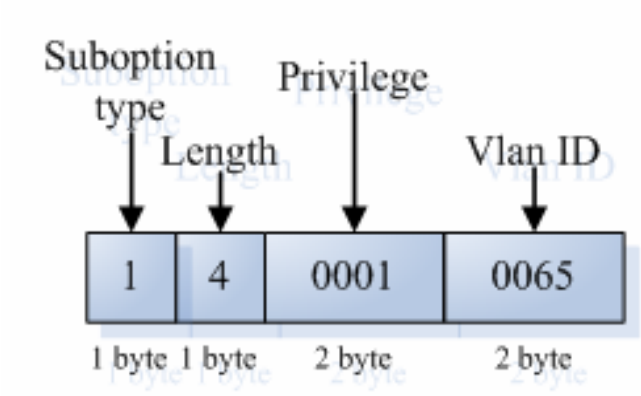
VLAN 10 and VLAN 20 correspond with the 10.0.0.1/16 and 20.0.0.1/16 networks respectively, while the DHCP server is located on the 30.0.0.1/16 network. To have a dynamic IP management on the 10.0.0.1/16 and 20.0.0.1/16 networks through the DHCP server at 30.0.0.2, just enable the DHCP Relay Agent on the device that functions as the gateway, and specify the IP address of the DHCP server to 30.0.0.2.

Understanding DHCP Relay Agent Information (option82)

As specified in RFC3046, when a relay device performs DHCP relay, an option can be added to identify the network information of the DHCP client, so that the DHCP server can assign users with IP addresses of different privileges. RFC3046 specifies that the option is numbered 82, so it is also called option82. This option can be divided into several sub-options. Currently, the sub-options frequently used are Circuit ID and Remote ID. Ruijie Networks provides threetwo schemes for relay agent information, which are described as follows.

relay agent information option dot1x: This requires the combination of 802.1x authentication and Ruijie RG-SAM.

DHCP relay forms the Circuit ID sub-option by combining the IP priority assigned to RG-SAM in 802.1x authentication with VID of the DHCP client. Figure 2 shows the option format.



relay agent information option82: This can be used without running other protocol modules. During DHCP relay, the device forms option82 information according to the port that receives the DHCP request message and the physical IP address of the device, and uploads the option82 information to the DHCP server.

Figure 3 and Figure 4 show the option formats.

Agent Circuit ID

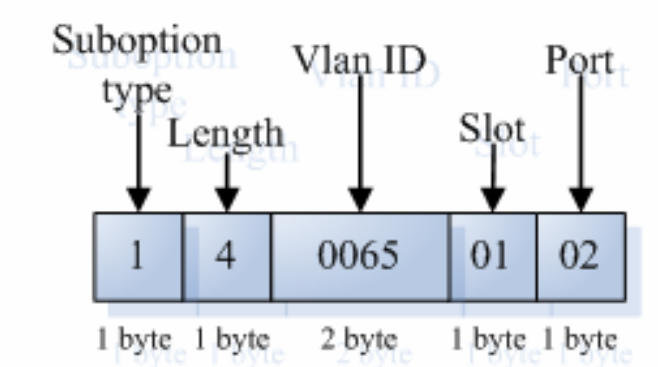


Figure 3

Agent Remote ID

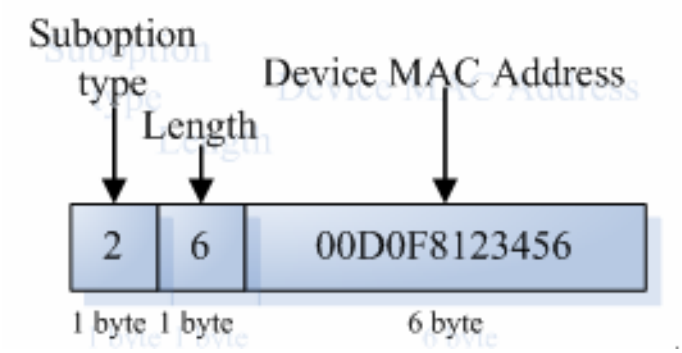


Figure 4

Understanding the DHCP Relay Check Server-id Function

This section describes the DHCP relay check server-id function. When DHCP is used, multiple DHCP servers are configured for a network for backup, so that the network will continue to work even if a server fails. During the four interaction processes of DHCP acquisition, a DHCP server has been selected when the DHCP client sends the DHCP request message. The DHCP request message includes the optional server-id. In particular application circumstances, you need to enable this option for relay to reduce loads on the network server. In this way, the DHCP request message is only sent to the specified DHCP server.

Configuring DHCP

Configuring the DHCP Relay Agent

Use the following commands to configure the DHCP relay agent in global configuration mode.

Command	Function
Ruijie (config)# **service dhcp**	Enables the DHCP agent.
Ruijie(config)# **no service dhcp**	Disables the DHCP agent.

Configuring the IP Address of the DHCP Server

After you have configured the IP address of the DHCP server, the DHCP request message received by the device will be forwarded to the DHCP server. Meanwhile, the DHCP response message from the DHCP server will be forwarded to the DHCP client.

The IP address of the DHCP server can either be configured globally or on the layer 3 interface. Up to 20 IP addresses can be configured for the DHCP server in each mode. When the DHCP request message is received from an interface, the DHCP server list on the interface is at first. If no DHCP server list is configured on the interface, the DHCP server list globally configured will be used.

DHCP supports vrf-based relay by adding the *vrf* parameter to the IP address of the DHCP server.

Use the following commands to configure the IP address of the DHCP server in global configuration mode.

Command	Function
Ruijie(config)# **ip helper-address** [**vrf** { *vrf-name*} **| global**] *A.B.C.D*	Adds the IP address of the DHCP server globally. The VPN or global space of the specified server can be displayed.
Ruijie(config-if)# **ip helper-address** [**vrf** {*vrf-name*} **| global**] *A.B.C.D*	Adds the IP address of the DHCP server on the interface. This command must be set on the layer 3 interface. The VPN or global space of the specified server can be displayed. The server is of the same VPN or global space as the current interface by default.
Ruijie(config)# **no IP helper-address** [**vrf** { *vrf-name*} **| global**] *A.B.C.D*	Deletes the globally configured IP address of the DHCP server.
Ruijie(config-if)# **no IP helper-address** [**vrf** { *vrf-name* } **| global**] *A.B.C.D*	Deletes the IP address of the DHCP server configured on the interface.

Configuring DHCP option dot1x

The section "Understanding the DHCP Relay Agent Information" shows that you can configure the **ip dhcp relay information option dot1x** command to enable the **option dot1x** function of DHCP relay when you need to assign the IP addresses with different privileges to the users of different privileges. When this function is enabled, the device will work with 802.1x to add corresponding option information to the DHCP server when it relays. This function should be used with the dot1x function.

Use the following commands to configure DHCP option dot1x in global configuration mode.

Command	Function
Ruijie(config)# **ip dhcp relay information option dot1x**	Enables the DHCP option dot1x function.
Ruijie(config)# **no ip dhcp relay information option dot1x**	Disables the DHCP option dot1x function.

Configuring DHCP option dot1x access-group

In the option dot1x application scheme, the device needs to restrict the unauthorized IP address or the IP address with low privilege to access certain IP addresses, and restrict the access between users with low privileges. To do so, configure the **ip dhcp relay information option dot1x access-group** *acl-name* command. The Access Control List (ACL) defined by *acl-name* must be configured in advance. It is used to filter some contents and prohibit unauthorized users from accessing each other. In addition, the ACL associated here is applied to all the ports on the device. This ACL has no default Access Control Entry (ACE) and does not conflict with ACLs associated with other interfaces. For example:

Assign a type of IP addresses for all the unauthorized users, namely 192.168.3.2-192.168.3.254, 192.168.4.2-192.168.4.254, and 192.168.5.2-192.168.5.254. Do not assign gateway addresses 192.168.3.1, 192.168.4.1, and 192.168.5.1 to users. In this way, an unauthorized user uses one of the 192.168.3.x-5.x addresses to access the web portal for downloading the client software. The device should be configured as follows:

```
Ruijie# configure terminal
Ruijie(config)# ip access-list extended DenyAccessEachOtherOfUnauthrize
Ruijie(config-ext-nacl)# permit ip any host 192.168.3.1
```

//Permit the packet to be transmitted to the gateway.

```
Ruijie(config-ext-nacl)# permit ip any host 192.168.4.1
Ruijie(config-ext-nacl)# permit ip any host 192.168.5.1
Ruijie(config-ext-nacl)# permit ip host 192.168.3.1 any
```

//Permit the packet communication with the source IP address being the gateway.

```
Ruijie(config-ext-nacl)# permit ip host 192.168.4.1 any
Ruijie(config-ext-nacl)# permit ip host 192.168.5.1 any
Ruijie(config-ext-nacl)# deny ip 192.168.3.0 0.0.0.255 192.168.3.0 0.0.0.255
```

//Prohibit mutual accesses of unauthorized users.

```
Ruijie(config-ext-nacl)# deny ip 192.168.3.0 0.0.0.255 192.168.4.0  0.0.0.255
Ruijie(config-ext-nacl)# deny ip 192.168.3.0 0.0.0.255 192.168.5.0  0.0.0.255
Ruijie(config-ext-nacl)# deny ip 192.168.4.0 0.0.0.255 192.168.4.0  0.0.0.255
Ruijie(config-ext-nacl)# deny ip 192.168.4.0 0.0.0.255 192.168.5.0  0.0.0.255
Ruijie(config-ext-nacl)# deny ip 192.168.5.0 0.0.0.255 192.168.5.0  0.0.0.255
Ruijie(config-ext-nacl)# deny ip 192.168.5.0 0.0.0.255 192.168.3.0  0.0.0.255
Ruijie(config-ext-nacl)# deny ip 192.168.5.0 0.0.0.255 192.168.4.0  0.0.0.255
Ruijie(config-ext-nacl)# exit
```

Then, apply the command to the global interfaces using the **ip dhcp relay information option dot1x access-group** *DenyAccessEachOtherOfUnauthrize* command.

Use the following commands to configure **DHCP option dot1x access-group** in global configuration mode.

Command	Function
Ruijie(config)# **ip dhcp relay information option dot1x access-group** *acl-name*	Enables DHCP option dot1x acl.
Ruijie(config)# **no ip dhcp relay information option dot1x access-group** *acl-name*	Disables DHCP option dot1x acl.

Configuring DHCP option82

When the **ip dhcp relay information option82** command is configured, the device, as DHCP relay, adds option information in the DHCP request packet to the DHCP server during forwarding the request packet.

Use the following commands to configure DHCP option82 in global configuration mode:

Command	Function
Ruijie(config)# ip dhcp relay information option82	Enables the DHCP option82 function.
Ruijie(config)# no ip dhcp relay information option82	Disables the DHCP option82 function.

Configuring DHCP relay check server-id

After the **ip dhcp relay check** *server-id* command is configured, the device resolves the *dhcp server-id* option upon receiving DHCP relay. If this option is set, the DHCP request message is sent to this server only.

Use the following commands to configure **DHCP relay check** *server-id* function in global configuration mode.

Command	Function
Ruijie(config)# **ip dhcp relay check** *server-id*	Enables the DHCP relay check server-di function.
Ruijie(config)# **no ip dhcp relay check** *server-id*	Disables the DHCP relay check server-id function.

Configuring DHCP Relay Suppression

After the **ip dhcp relay suppression** command is configured, the port will not relay the DHCP request broadcast packet by transforming it into the unicast form. However, it will not suppress the normal forwarding of broadcast packets received.

Use the following commands to configure DHCP relay suppression in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip dhcp relay Suppression**	Enables the DHCP relay suppression function.
Ruijie(config-if)# **no ip dhcp relay Suppression**	Disables the DHCP relay suppression function.

DHCP Relay Configuration Example

The following commands enable the DHCP relay function and add two groups of IP addresses of the DHCP server:

```
Ruijie# configure  terminal
Ruijie(config)# service dhcp       //Enable the dhcp relay function
Ruijie(config)# service dhcp            //Enable the DHCP option vpn function.
Ruijie(config)# ip helper-address 192.18.100.1
Ruijie(config)# ip helper-address 192.18.100.2
  //Add the IP address of the server at the interface.
Ruijie(config)# interface gigabitEthernet 0/3
Ruijie(config-if-gigabitEthernet 0/3)# ip helper-address 192.18.200.1
Ruijie(config-if-gigabitEthernet 0/3)# ip helper-address 192.18.200.2
Ruijie(config-if-gigabitEthernet 0/3)# end
```

Other Precausions on DHCP Relay Configuration

For layer 2 network devices, you must enable at least one of the option dot1x, dynamic address binding, and option82 functions when the cross network segment management vlan relay function is required. Otherwise, only the relay function of management VLAN can be enabled for the layer 2 device.

Precautions on DHCP option dot1x Configuration

This command works only when the configuration related to AAA/802.1x is correct.

When this scheme is adopted, the IP authorization of the DHCP mode of 802.1x should be enabled.

This command cannot be used together with the **dhcp option82** command because they are conflicted.

When the IP authorization of the DHCP mode of 802.1x is enabled, the MAC address and the IP address will also be bound. Therefore, IP authorization and DHCP dynamic binding function cannot be enabled at the same time.

Precautions on DHCP option82 Configuration

The DHCP option82 function and the **dhcp option dot1x** function cannot be used at the same time because they are conflicted.

Showing the DHCP Configuration

Use the **show running-config** command to show the DHCP configuration in privileged mode.

```
Ruijie# show running-config
Building configuration...
Current configuration : 1464 bytes
version RGOS 10.1.00(1), Release(11758)(Fri Mar 30 12:53:11 CST 2007 -nprd
hostname Ruijie
vlan 1
ip helper-address 192.18.100.1
ip helper-address 192.18.100.2
ip dhcp relay information option dot1x
interface GigabitEthernet 0/1
interface GigabitEthernet 0/2
interface GigabitEthernet 0/3
no switchport
ip helper-address 192.168.200.1
ip helper-address 192.168.200.2
interface VLAN 1
ip address 192.168.193.91 255.255.255.0
line con 0
exec-timeout 0 0
line vty 0
exec-timeout 0 0
login
password 7 0137
line vty 1 2
login
password 7 0137
line vty 3 4
```

```
login
end
```

Typical DHCP Relay Configuration Examples (for Switches)

Topological Diagram

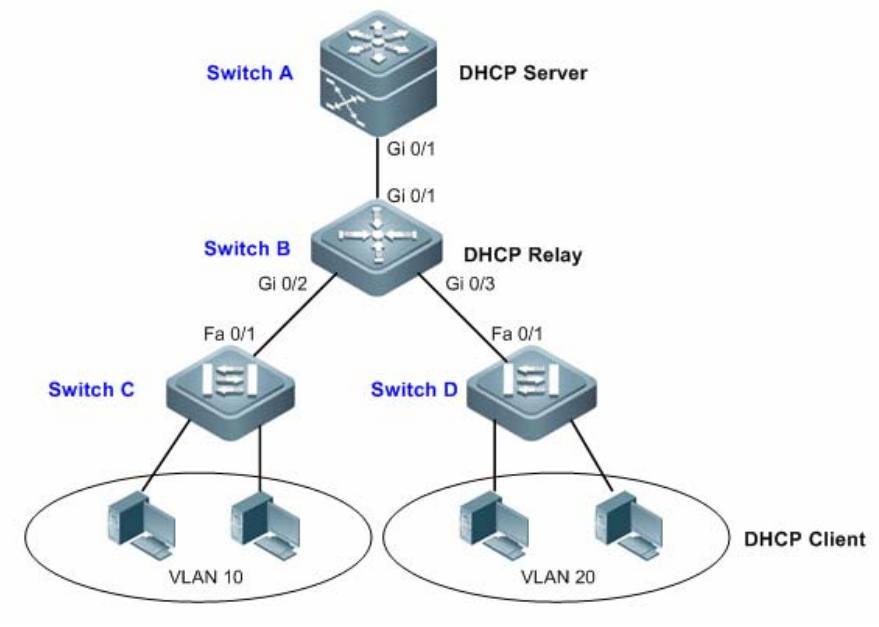


Diagram for DHCP relay configuration

Application Requirements

As shown in the preceding diagram, Switch C and Switch D are access devices connecting with PC users belonging to VLAN 10 and VLAN 20. Switch B is the gateway device, while Switch A is the core routing device. The following requirements must be met:

- Switch A can serve as DHCP server allocating dynamic IP addresses to VLAN users.
- The users connecting to Switch C and Switch D can acquire dynamic IP addresses across the network segment.

Configuration Tips

- **Configuring the DHCP server:** On Switch A, create DHCP address pools for users from VLAN 10 and VLAN 20 respectively, and enable the DHCP server (relevant configurations of the DHCP server can be found in the section "DHCP Configuration").
- **Configuring DHCP Relay:** On Switch B, configure the address of the DHCP server (configure the address of the DHCP server as 10.1.1.2/24) and enable the DHCP server.

Note

On Switch C and Switch D, configure the VLAN to which the corresponding ports belong, and the access PC can dynamically acquire IP address once connected.

Configuration Steps

Configure the DHCP server.

! In global mode, create a DHCP address pool named "vlan10" on Switch A, with corresponding IP network segment being 192.168.1.0/24 and the address of network gateway being 192.168.1.1.

```
SwitchA(config)#ip dhcp pool vlan10
SwitchA(dhcp-config)#network 192.168.1.0 255.255.255.0
SwitchA(dhcp-config)#default-router 192.168.1.1
SwitchA(dhcp-config)#exit
```

! Create an address pool named "vlan20", with IP network segment being 192.168.2.0/24 and gateway address being 192.168.2.1.

```
SwitchA(config)#ip dhcp pool vlan20
SwitchA(dhcp-config)#network 192.168.2.0 255.255.255.0
SwitchA(dhcp-config)#default-router 192.168.2.1
SwitchA(dhcp-config)#exit
```

! In global configuration mode, configure 192.168.1.1 and 192.168.2.1 as the excluded addresses, so as to avoid the conflict between allocated IP address and gateway address.

```
SwitchA(config)#ip dhcp excluded-address 192.168.1.1
SwitchA(config)#ip dhcp excluded-address 192.168.2.1
```

! Enable the DHCP server.

```
SwitchA(config)#service dhcp
```

Step 2: Configure layer-3 communication between Switch A and Switch B.

! On Switch A, configure port Gi 0/1 as the Route Port, with the corresponding IP address being 10.1.1.2/24.

```
SwitchA(config)#interface gigabitEthernet 0/1
SwitchA(config-if-GigabitEthernet 0/1)#no switchport
SwitchA(config-if-GigabitEthernet 0/1)#ip address 10.1.1.2 255.255.255.0
SwitchA(config-if-GigabitEthernet 0/1)#exit
```

! On Switch B, configure port Gi 0/1 as the Route Port, with the corresponding IP address being 10.1.1.3/24.

```
SwitchB(config)#interface gigabitEthernet 0/1
SwitchB(config-if)#no switchport
SwitchB(config-if)#ip address 10.1.1.3 255.255.255.0
SwitchB(config-if)#exit
```

! Configure default route on Switch A

```
SwitchA(config)#ip route 0.0.0.0 0.0.0.0 10.1.1.3
```

Step 3: Configure the gateway for access users.

! On Switch B, configure the Switch Virtual Interface (SVI) of VLAN 10 to 192.168.1.1/24.

```
SwitchB(config)#vlan 10
SwitchB(config-vlan)#exit
SwitchB(config)#interface vlan 10
SwitchB(config-if)#ip address 192.168.1.1 255.255.255.0
SwitchB(config-if)#exit
```

! Configure the SVI of VLAN 20 to 192.168.2.1/24.

```
SwitchB(config)#vlan 20
SwitchB(config-vlan)#exit
SwitchB(config)#interface vlan 20
SwitchB(config-if)#ip address 192.168.2.1 255.255.255.0
SwitchB(config-if)#exit
```

Step 4: Configure DHCP Relay.

! On Switch B, globally configure the address of DHCP server as 10.1.1.2 and enable the DHCP server.

```
SwitchB(config)#ip helper-address 10.1.1.2
SwitchB(config)#service dhcp
```

Step 5: Configure layer-2 communication between Switch B and Switch C/D.

! On Switch B, configure ports Gi 0/2 and Gi 0/3 as the Trunk Port.

```
SwitchB(config)#interface range gigabitEthernet 0/2-3
SwitchB(config-if-range)#switchport mode trunk
```

! Configure port Fa 0/1 of Switch C and Switch D as the Trunk Port.

Verification

Step 1: Show configurations of devices.

! Configurations of Switch A

```
SwitchA#show running-config
!
service dhcp
!
ip dhcp excluded-address 192.168.1.1
ip dhcp excluded-address 192.168.2.1
!
ip dhcp pool vlan10
 network 192.168.1.0 255.255.255.0
 default-router 192.168.1.1
!
ip dhcp pool vlan20
 network 192.168.2.0 255.255.255.0
 default-router 192.168.2.1
!
```

```
interface GigabitEthernet 0/1
 no switchport
 no ip proxy-arp
 ip address 10.1.1.2 255.255.255.0
!
ip route 0.0.0.0 0.0.0.0 10.1.1.3
!
! Configurations of Switch B
SwitchB#show running-config
!
vlan 10
!
vlan 20
!
service dhcp
ip helper-address 10.1.1.2
!
interface GigabitEthernet 0/1
 no switchport
 no ip proxy-arp
 ip address 10.1.1.3 255.255.255.0
!
interface GigabitEthernet 0/2
 switchport mode trunk
!
interface GigabitEthernet 0/3
 switchport mode trunk
!
interface VLAN 10
 no ip proxy-arp
 ip address 192.168.1.1 255.255.255.0
!
interface VLAN 20
 no ip proxy-arp
 ip address 192.168.2.1 255.255.255.0
!
```

Step 2: Connect two PCs with the ports belonging to VLAN 10 and VLAN 20 and verify dynamic IP address allocation.

```
SwitchA#show ip dhcp binding
IP address Client-Identifier/ Lease expiration  Type Hardware address
192.168.1.2 0100.1320.4990.14 000 days 23 hours 59 mins  Automatic
192.168.2.2 0100.e04c.70b7.e2 000 days 23 hours 59 mins  Automatic
```

Typical DHCP Relay Configuration Examples (for Routers)

Topological Diagram

Diagram for DHCP Relay configuration

Application Requirements

As shown in the preceding diagram, obtaining the IP address and surfing the Internet by the user in different network segment shall be implemented when the DHCP Relay function is enabled.

Configuration Tips

- Enable the function of acquiring IP addresses through DHCP.
- Enable the DHCP Relay function on the DHCP Relay Agent.
- Configure the DHCP server.

Configuration Steps

Enable DHCP to acquire IP addresses.

Configure DHCP Relay:

Enable the DHCP Relay Agent.

```
Ruijie(config)# server dhcp
```

Add an IP address of DHCP server globally.

```
Ruijie(config)# ip helper-address 172.2.2.1
```

Configure an IP address of the port connecting the user device.

```
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if)# ip address 192.1.1.1 255.255.255.0
```

Configure an IP address for the port connecting the user device.

```
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if)# ip address 192.1.1.1 255.255.255.0
```

Configure an IP address for the port connecting the Server device.

```
Ruijie(config)# interface gigabitEthernet 0/2
Ruijie(config-if-gigabitEthernet 0/2)# ip address 172.2.2.2 255.255.255.0
```

Configure the DHCP server.

Verification

Verify configurations of the DHCP Relay Agent device.

Log in to the DHCP Relay Agent device, and use the **show running-config** command in privileged mode to show the DHCP Relay configuration.

```
Ruijie# show running-config
service dhcp
ip helper-address 172.2.2.1
!
interface GigabitEthernet 0/1
ip address 192.1.1.1 255.255.255.0
!
interface GigabitEthernet 0/2
ip address 172.2.2.2 255.255.255.0
!
```

Typical Option dot1x Configuration Example (for Switches)

Topological Diagram

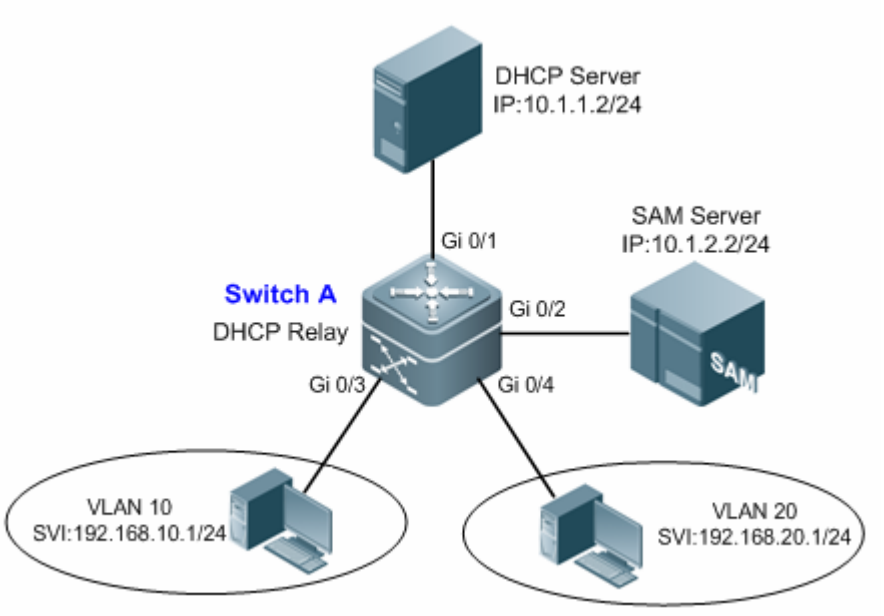


Diagram for DHCP Option Dot1x

Application Requirements

- Switch A is a layer 3 device allowing route communication cross different network segments.

- Access users belonging to different VLANs access Internet after Dot1x authentication, and SAM Server assigns different access privileges to different users.
- The DHCP server can allocate IP addresses to users according to the privilege of an authenticated user.

Configuration Tips

- **Configure basic DHCP Relay:** On Switch A, configure the address of the DHCP server (10.1.1.2/24) and enable the DHCP server. After configuration, the user can acquire dynamic IP address across the network segment.
- **Configure 802.1X authentication:** On Switch A, enable 802.1X authentication and set the user ports to controlled ports (Gi 0/3 and Gi 0/4). After configuration, the user will need to pass Dot1x authentication before accessing the Internet.
- **Configure the assignment of privilege-based IP address:** On Switch A, enable DHCP Option dot1x and configure IP authorization mode as DHCP server mode. After configuration, the DHCP server can allocate IP addresses according to user's privilege.

Note 1. Relevant configurations of 802.1X are detailed in the *802.1X Configuration*.

Note 2. The implementation of this example also needs the configuration of SAM Server and the DHCP server. For relevant details, see the relevant documents.

Configuration Steps

Configuring Switch A

Configure the address of the user gateway and the address of server interface.

! Configure the VLANs corresponding to Gi 0/3 and Gi 0/4 and configure the SVI corresponding to each VLAN.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface gigabitEthernet 0/3
Ruijie(config-if-GigabitEthernet 0/3)#switchport access vlan 10
Ruijie(config-if-GigabitEthernet 0/3)#exit
Ruijie(config)#interface gigabitEthernet 0/4
Ruijie(config-if-GigabitEthernet 0/4)#switchport access vlan 20
Ruijie(config-if-GigabitEthernet 0/4)#exit
Ruijie(config)#interface vlan 10
Ruijie(config-if-VLAN 10)#ip address 192.168.10.1 255.255.255.0
Ruijie(config-if-VLAN 10)#exit
Ruijie(config)#interface vlan 20
Ruijie(config-if-VLAN 20)#ip address 192.168.20.1 255.255.255.0
Ruijie(config-if-VLAN 20)#exit
```

! Configure the interface address of the DHCP server and SAM Server.

```
Ruijie(config)#interface gigabitEthernet 0/1
```

```
Ruijie(config-if-GigabitEthernet 0/1)#no switchport
Ruijie(config-if-GigabitEthernet 0/1)#ip address 10.1.1.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/1)#exit
Ruijie(config)#interface gigabitEthernet 0/2
Ruijie(config-if-GigabitEthernet 0/2)#no switchport
Ruijie(config-if-GigabitEthernet 0/2)#ip address 10.1.2.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/2)#exit
```

Configure relevant features of DHCP Relay.

! Configure the address of DHCP server as 10.1.1.2/24 and enable DHCP service.

```
Ruijie(config)#ip helper-address 10.1.1.2
Ruijie(config)#service dhcp
```

! Enable DHCP Option dot1x.

```
Ruijie(config)#ip dhcp relay information option dot1x
```

Configure 802.1X relevant features.

! Enable AAA and configure the address of Radius Server as 10.1.2.2/24; configure Radius Key as "ruijie".

```
Ruijie(config)#aaa new-model
Ruijie(config)#radius-server host 10.1.2.2
Ruijie(config)#radius-server key ruijie
```

! Create Dot1x authentication method list named "d1x" and configure Dot1x to apply such authentication method list.

```
Ruijie(config)#aaa authentication dot1x d1x group radius
Ruijie(config)#dot1x authentication d1x
```

! Configure ports Gi 0/3 and Gi 0/4 as controlled ports.

```
Ruijie(config)#interface range gigabitEthernet 0/3-4
Ruijie(config-if-range)#dot1x port-control auto
Ruijie(config-if-range)#exit
```

! Configure IP authorization mode as DHCP server mode.

```
Ruijie(config)#aaa authorization ip-auth-mode dhcp-server
```

Verification

Verify configurations of devices.

! Configurations of Switch A

```
Ruijie#show running-config
!
aaa new-model
!
aaa authorization ip-auth-mode dhcp-server
aaa authentication dot1x d1x group radius
```

```
!
vlan 10
!
vlan 20
!
service dhcp
ip helper-address 10.1.1.2
!
ip dhcp relay information option dot1x
!
radius-server host 10.1.2.2
radius-server key ruijie
!
dot1x authentication d1x
interface GigabitEthernet 0/1
 no switchport
 no ip proxy-arp
 ip address 10.1.1.1 255.255.255.0
!
interface GigabitEthernet 0/2
 no switchport
 no ip proxy-arp
 ip address 10.1.2.1 255.255.255.0
!
interface GigabitEthernet 0/3
 switchport access vlan 10
 dot1x port-control auto
!
interface GigabitEthernet 0/4
 switchport access vlan 20
 dot1x port-control auto
!
interface VLAN 10
 no ip proxy-arp
 ip address 192.168.10.1 255.255.255.0
!
interface VLAN 20
 no ip proxy-arp
 ip address 192.168.20.1 255.255.255.0
!
```

Configuring NTP

Understanding NTP

Network Time Protocol (NTP) is designed for time synchronization on network devices. With its clock source or the server. Moreover, NTP can provide time correction (the time difference is less than one millisecond on the LAN and dozens of milliseconds on the WAN, compared with the standard time) and prevent attacks using encryption and confirmation.

To provide accurate Coordinated Universal Time (UTC), NTP needs an accurate clock source from the atom clock, observatory, satellite or Internet.

To prevent the time server from malicious attacks, NTP uses an authentication mechanism is used to check whether the time synchronization request really comes from the declared server, and check the return path, thus providing the protection of anti-interference.

Ruijie switches support the NTP client and server. That is, the switch can synchronize the time from the time server and work as the time server (only in unicast server mode) to synchronize the time of other switches.

Configuring NTP

This chapter describes how to configure the NTP client and server.

Configuring the Global NTP Authentication Mechanism

Ruijie NTP client supports encrypted communication with the NTP server using key encryption.

Configure the encrypted communication between the NTP client and the NTP server as follows: Step 1, Authenticate the NTP client and configure the key globally; Step 2, Configure the trusted key for the NTP server. To initiate the encrypted communication with the NTP server, you need to set the authentication key for the NTP server in addition to performing Step 1.

By default, the NTP client does not use the global security authentication mechanism and the communication will not be encrypted. To enable encrypted communication, you need to enable the global security authentication, configure other global keys and set an encryption key for the server.

Use the following commands in global configuration mode to configure the global security authentication mechanism.

Command	Function
ntp authenticate	Configures the global NTP security authentication mechanism.
no ntp authenticate	Disables the global NTP security authentication mechanism.

To verify the packet, use the trusted key specified by the **ntp authentication-key** or **ntp trusted-key** command.

Configuring the Global NTP Authentication Key

The next step to configure the global security authentication for the NTP is to set the global authentication key.

Each key is identified by a globally unique key-id. You can use the **ntp trusted-key** command to set the key corresponding to the key-id as a global trusted key.

Use the following commands in global configuration mode to specify a global authentication key.

Command	Function
ntp authentication-key *key-id* **md5** *key-string* [*enc-type*]	Specifies a global authentication key. *key-id*: sets the parameter in the range 1 to 4294967295. *key-string*: sets the parameter to any values. *enc-type*: sets the parameter to **0** or **7**.
no ntp authentication-key *key-id* **md5** *key-string* [*enc-type*]	Removes a global authentication key.

The global authentication key takes effect after being configured as a global trusted key.


Caution Ruijie's current NTP version supports up to 1024 authentication keys, but only one key can be set for each server for encrypted communication.

Configuring the Global NTP Trusted key ID

The last step is to set a global authentication key as a global trusted key. Only by this trusted key you can send encrypted data and check the validity of the packet.

Use the following commands to specify a global trusted key in global configuration mode.

Command	Function
ntp trusted-key *key-id*	Specifies a global trusted key ID.
no ntp trusted-key *key-id*	Removes a global trusted key ID.

The three steps are the basis of implementing the security authentication mechanism. To initiate encrypted communication between the NTP client and the NTP server, a trusted key must be set for the corresponding server.


Caution When a global authentication key is removed, its trusted information is also removed.

Configuring the NTP Server

No NTP server is configured by default. Ruijie's client can simultaneously interact with up to 20 NTP servers, and one authentication key can be set for each server to initiate encrypted communication with the NTP server after relevant settings of global authentication and keys are completed.

NTP version 3 is used in communication with the NTP server by default. NTP version 3 enables you to specify the source interface for sending the NTP packet and configure that the NTP packet from the relevant server can only be received on the sending interface at the same time.

Use the following commands to configure the NTP server in global configuration mode.

Command	Function
ntp server ip-addr [**version** *version*] [**source** *if-name number*] [**key** *keyid*] [**prefer**]	Configures the NTP server. version (NTP version number): sets the parameter in the range 1 to 3 if-name (interface type): sets the parameter to **Aggregateport, Dialer GigabitEthernet**, **Loopback, Multilink, Null, Tunnel, Virtual-ppp, Virtual-template,** or **VLAN.** keyid: sets the parameter in the range 1 to 4294967295.
no ntp server *ip-addr*	Removes the NTP server.

The NTP client can initiate the encrypted communication with the NTP server only when the global security authentication and key setting mechanisms are completed and the trusted key for communicating with the server is set. To this end, the NTP server should have the same trusted key.

Disabling the Function of Receiving the NTP Packet on the Interface

Use this command to disable the function of receiving the NTP packet on the interface for time synchronization, which is available to the NTP client by default.


Caution This command takes effect only for the interface whose IP address can be configured to receive and send packets.

Use the following commands to disable the interface to receive the NTP packet in interface configuration mode.

Command	Function
interface interface-type number	Enters interface configuration mode.
ntp disable	Disables the function of receiving NTP packets on the interface.

To enable the function of receiving NTP packets on the interface, use the **no ntp disable** command in interface configuration mode.

Enabling or Disabling NTP

Use the **no ntp** command to disable the NTP synchronization service, stop the time synchronization, and clear relevant information of NTP configuration.

The NTP function is disabled by default, but may be enabled as long as the NTP server is configured.

Use the following commands to disable or enable the NTP in global configuration mode:

Command	Function
ntp authenticate or ntp server *ip-addr* [version *version*] [source *if-name number*] [*key keyid*] [*prefer*]	Enables NTP.
no ntp	Disables NTP.

Configuring the NTP Real-time Synchronization

To improve accuracy, eight consecutive packets are synchronized for the first synchronization between the client and the server. Follow-up NTP synchronization occurs automatically every one minute. To manually implement real-time synchronization during the auto-synchronization interval, you can use this command.

Use the following commands to configure the NTP real-time synchronization in global configuration mode.

Command	Function
ntp synchronization	Enables the NTP real-time synchronization.
no ntp synchronization	Disables the NTP real-time synchronization.

The synchronization is set to be implemented every 30 minutes on Ruijie's client system. New servers will trigger the real-time synchronization, which is also be implemented when this command is used during the synchronization interval. However, the command is invalid during the auto-synchronization.

The command of disabling the real-time synchronization and the one that disables NTP can be used to end the time synchronization (during the synchronization) or disable the synchronization function (between the synchronization interval). The difference lies in that the NTP-disabling command disables the NTP synchronization as well as clears related NTP configuration.

Note

The NTP real-time synchronization is supported only by some products. The **ntp synchronize** command cannot be executed on products that do not support this function.

Configuring the NTP Update-Calendar

Use this command to enable the NTP client to update the calendar using the clock time synchronized from an external clock source.

Use the following commands to configure the NTP update-calendar in global configuration mode.

Command	Function
ntp update-calendar	Configures the update-calendar.
no ntp update-calendar	Disables the update-calendar.

The update-calendar is not configured by default. After configuration, the NTP client updates the calendar when the time synchronization of external clock source is successful. It is recommended to enable this function for keeping the accurate calendar.

Setting the NTP Master

Use this command to set the local clock as the NTP master (the reference source of the local clock is reliable), providing the synchronized time for other devices.

Generally, the local system synchronizes the time from the external clock source directly or indirectly. However, if the time synchronization of the local system fails for the network connection trouble, use the command to set the reliable reference source of the local time, providing the synchronized time for other devices.

Once set, the system time can not be synchronized to the clock source with higher stratum.

Note NTP uses stratum to describe the hops between the device and the authorization clock. A time server with 1 stratum shall have a directly connected atomic clock or radio wave clock. A time server with the 2 stratums obtains time from the stratum 1 server and a time server with 3 stratums obtains time from the stratum 2 server and so on. Therefore, the clock source with the lowest stratum value is more precise than others.

Use the following commands to configure the NTP master in global configuration mode:

Command	Function
ntp master [*stratum*]	Sets the local time as the NTP master and specifies the corresponding stratum. The time stratum is in the range 1 to 15. The default value is 8.
no ntp master	Cancels the NTP master setting.

The following example shows how to set the reliable reference source of the local time and set the time stratum to 12:

```
Ruijie(config)# ntp master 12
```

Caution Be careful when using this command. Using this command to set the local time as the master (in particular, specify a lower stratum value), is likely to cover the effective clock source. If multiple devices in the same network use this command, time synchronization instability may occur due to time difference between the devices.

Caution In addition, before using this command, if the system has never been synchronized with an external clock source, it is necessary to manually calibrate the system clock to prevent too much bias. (For more information, see the section about system time configuration in the *Basic Host management Configuration Guide*.)

Configuring the Access Control Privilege of NTP Service

The NTP service access control function provides a minimal security measure (a more secure way is to use the NTP authentication mechanism). By default, no NTP access control rules are configured in the system.

Use the following commands to set the NTP services access control privilege in global configuration mode.

Command	Function
ntp access-group { **peer** | **serve** | **serve-only** | **query-only** } *access-list-number* | *access-list-name*	Sets the access control privilege of the local service.
no ntp access-group { **peer** | **serve** | **serve-only** | **query-only** } *access-list-number* | *access-list-name*	Cancels the settings of access control privilege of the local service.

peer: allows the time requests and control queries for the local NTP service as well as the time synchronization between the local device and the remote system (full access privilege).

serve: allows the time requests and control queries for the local NTP service, not the time synchronization between the local device and the remote system.

serve-only: allows the time requests for the local NTP service.

query-only: allows the control queries for the local NTP service.

access-list-number: indicates the IP access control list label in the range of 1 to 99 and 1300 to 1999. For how to create IP access control list, see the *Access Control List Configuration Guide*.

access-list-name: indicates the IP access control list name. For how to create IP access control list , see the *Access Control List Configuration Guide*.

When an access request arrives, the NTP service matches the rules from the smallest to the largest access restriction, and the first matched rule shall prevail. The matching order is *peer*, *serve*, *serve-only*, and *query-only*.


Caution

The control query function (used by the network management device to control the NTP server, such as setting the leap second mark or monitoring the working state) is not supported in the current system. Although it matches with the order in accordance with the preceding rules, requests related to the control query function are not supported.

If you do not configure any access control rules, all accesses are allowed. Once the access control rules are configured, only the rule that allows access can be carried out.

The following example shows how to allow the peer device in acl1 to control the query, request for and synchronize the time with the local device; and limit the peer device in acl2 to request the time for the local device.

```
Ruijie(config)# ntp access-group peer 1
Ruijie(config)# ntp access-group serve-only 2
```

Showing NTP Information

Debugging NTP

Use this command to debug NTP for diagnosis and troubleshooting,.

Use the following commands to enable or disable the function of debugging NTP in privilege mode.

Command	Function
debug ntp	Enables the debugging function.
no debug ntp	Disables the debugging function.

Showing NTP Information

Use the **show ntp status** command in privilege mode to show the current NTP information.

Use the following command to show the NTP status information in privilege mode.

Command	Function
show ntp status	Shows the current NTP information.

This command be used to print the shown information only when the relevant communication server is configured.

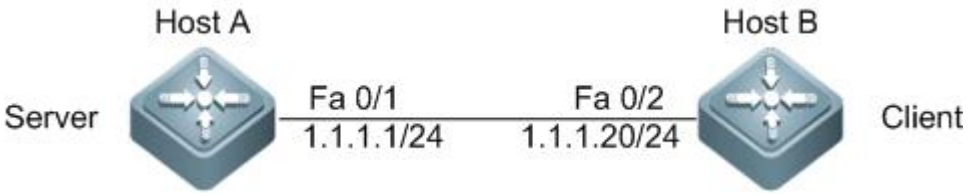
```
Ruijie# show ntp status
Clock is synchronized, stratum 9, reference is 192.168.217.100
nominal freq is 250.0000 Hz, actual freq is 250.0000 Hz, precision is 2**18
reference time is AF3CF6AE.3BF8CB56 (20:55:10.000 UTC Mon Mar 1 1993)
clock offset is 32.97540 sec, root delay is 0.00000 sec
root dispersion is 0.00003 msec, peer dispersion is 0.00003 msec
```

Note *stratum* indicates the level of current clock;
reference indicates the address of the server used for synchronization;
freq indicates the clock frequency of current system;
precision indicates the precision of current system clock;
reference time indicates the UTC time of reference clock on the synchronization server;
clock offset indicates the offset of current clock;
root delay indicates the delay of current clock,
root dispersion indicates the precision of top server;
peer dispersion indicates the precision of synchronization server.

Typical NTP Configuration Examples

Configuring NTP Client or Server Mode

Topological Diagram



NTP client or server model

Application Requirements

On Host A, the local clock is configured as the NTP master clock, with the clock stratum being 12;
Host B is configured as the NTP client and Host A is specified as the NTP server;
The hardware clock of Host B shall be synchronized as well.

Configuration Tips

NTP server

Generally, the local system will directly or indirectly synchronize with the external clock sources. However, the local system may not be able to synchronize with the external clock sources due to the network connection failure. In this case, you can use the **ntp master** command to configure the local clock as NPT master to synchronize time to other devices.

NTP client

Configure the NTP server

By configuring the NTP update-calendar, the NTP client can use the clock value synchronized from external clock sources to update its calendar for accuracy.

Configuration Steps

Configuration of the NTP server

! Configure the NTP master. Configure local clock as the trusted reference clock source, with the clock stratum being 12.

```
HostA(config)# ntp master 12
```

Configuration of the NTP client

! Configure Host A as the NTP server.

```
HostB(config)#ntp server 1.1.1.1
```

! Configure NTP hardware clock update

```
HostB(config)# ntp update-calendar
```

Verification

Verify the time before configuring NTP synchronization.

! Verify the time of reference clock source.

```
HostA#show clock
17:12:48 UTC Tue, Sep 8, 2009
```

! Verify the time of client before synchronization.

```
HostB#show clock
12:01:10 UTC Sat, Jan 1, 2000
```

! Verify the NTP status of client before synchronization.

```
HostB(config)#show ntp status
Clock is unsynchronized, stratum 16, no reference clock
nominal freq is 250.0000 Hz, actual freq is 250.0000 Hz, precision is 2**0
reference time is 0.0 (00:00:00.000 UTC Thu, Jan 1, 1970)
clock offset is 0.00000 sec, root delay is 0.00000 sec
root dispersion is 0.00000 msec, peer dispersion is 0.00000 msec
```

The output shows that the time hasn't been synchronized.

After configuring NTP synchronization, show NTP configurations. Key points: the NTP server address and stratum.

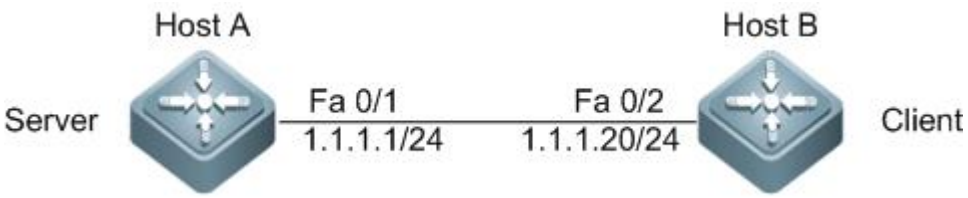
The following log information will be displayed on CLI interface:

```
*Sep  8 18:10:37: %SYS-6-CLOCKUPDATE: System clock has been updated to 18:10:37 UTC Tue Sep
8 2009.
HostB#show ntp status
Clock is synchronized, stratum 13, reference is 1.1.1.1
nominal freq is 250.0000 Hz, actual freq is 250.0000 Hz, precision is 2**24
reference time is CE511CC9.37EB5B2D (18:11:21.000 UTC Tue, Sep 8, 2009)
clock offset is -0.00107 sec, root delay is 0.00000 sec
root dispersion is 0.00002 msec, peer dispersion is 0.00002 msec
```

The output shows that the NTP client has connected to the server and the time of Host B has been synchronized with the time of Host A, with the stratum level being higher than that of Host A by 1 (i.e., 13).

Configuring NTP Client or Server Mode with Authentication

Topological Diagram



NTP client/server model

Application Requirements

On Host A, the local clock is confiugred as the NTP master clock, with the clock stratum being 12;
Host B is configured as the NTP client and Host A is specified as the NTP server;
The authentication mechanism is enabled to prevent illegal users from maliciously attacking the clock server.

Configuration Tips

Configuring NTP server/client authentication will involve the following steps:

Enable NTP global authentication.
Configure the key for NTP global authentication and the corresponding key ID.
Specify NTP global trusted key ID.

The authentication key used by NTP client to communicate with NTP server must be consistent with the corresponding Key ID.

Configuration Steps

Configuration of the NTP server

Step 1: Configure the NTP master. Configure the local clock as the trusted reference clock source, with the clock stratum being 12;

```
HostA(config)#ntp master 12
```

Step 2: Configure NTP authentication;

! Enable NTP global authentication.

```
HostA(config)# ntp authenticate
```

! Configure the NTP global authentication key as **helloworld** and the corresponding key ID as **6**.

```
HostA(config)# ntp authentication-key 6 md5 helloworld
```

! Specify **6** as the NTP global trusted key ID

```
HostA(config)# ntp trusted-key 6
```

Configuration of the NTP client

Step 1: Configure NTP authentication;

! Enable NTP global authentication.

```
HostB(config)# ntp authenticate
```

! Configure NTP global authentication key as **helloworld** and the corresponding key ID as **6**.

```
HostB(config)# ntp authentication-key 6 md5 helloworld
```

! Specify **6** as the NTP global trusted key ID.

```
HostB(config)# ntp trusted-key 6
```

! Configure Host A as the NTP server and set the key ID for communicating with this server as **6**.

```
HostB(config)# ntp server 1.1.1.1 key 6
```

Verification

Verify the configurations of NTP server. Key points: the NTP master clock configuration, NTP server's IP address, and authentication related configurations.

```
HostA#show run
!
interface fastEthernet 0/1
ip address 1.1.1.1 255.255.255.0
!
ntp authentication-key 6 md5 07360623191d300a004609 7
ntp authenticate
ntp trusted-key 6
ntp master 12
!
```

Verify the configurations of NTP client. Key points: the IP address and key ID of NTP server, and authentication related configurations.

```
HostB #show run
!
interface fastEthernet 0/2
 ip address 1.1.1.20 255.255.255.0
!
ntp authentication-key 6 md5 141a4f012d1d3c23174905 7
ntp authenticate
ntp trusted-key 6
ntp server 1.1.1.1 key 6
!
```

After proper configurations, the following log information will be displayed on the CLI:

```
*Sep  9 11:31:29: %SYS-6-CLOCKUPDATE: System clock has been updated to 11:31:29 UTC Wed Sep
9 2009.
```

The log information indicates that the clock of HostB (NTP client) has been updated.

Verify NTP server status.

```
HostA #show ntp status
Clock is synchronized, stratum 12, reference is 127.127.1.1
nominal freq is 250.0000 Hz, actual freq is 250.0000 Hz, precision is 2**24
reference time is CE521261.E52DECA2 (11:39:13.000 UTC Wed, Sep 9, 2009)
clock offset is 0.00000 sec, root delay is 0.00000 sec
root dispersion is 0.00002 msec, peer dispersion is 0.00002 msec
```

Verify NTP client status. Key points: the NTP server address and stratum.

```
HostB# show ntp status
Clock is synchronized, stratum 13, reference is 1.1.1.1
nominal freq is 250.0000 Hz, actual freq is 250.0000 Hz, precision is 2**24
reference time is CE5212A1.E5D712A0 (11:40:17.000 UTC Wed, Sep 9, 2009)
clock offset is -0.00005 sec, root delay is 0.00000 sec
root dispersion is 0.00002 msec, peer dispersion is 0.00002 msec
```

The output shows that the NTP client has successfully connected to the server and the time of Host B has been synchronized with that of Host A, with the stratum level being higher than that of Host A by 1 level (i.e., 13).

Configuring SNTP

Overview

Network Time Protocol (NTP) is designed for time synchronization on network devices. Another protocol, the Simple Network Time Protocol (SNTP) can also be used to synchronize the network time.

NTP can be used across various platforms and operating systems, provide precise time calculation (1-50 ms precision), and prevent from latency and jitter in the network. NTP also provides the authentication mechanism with a high security level. However, the NTP algorithm is complicated and demands delicate systems.

As a simplified version of NTP, SNTP simplifies the algorithm of time calculation while maintains great performance, with the precision about 1s.

The SNTP client is totally compatible with the NTP server due to the consistency between the SNTP and NTP packets.

Understanding SNTP

SNTP works in client/server mode. The standard server system time is set by receiving the GPS signal or the atomic clock. The client obtains its accurate time from the service time accessing the server regularly, and adjusts its system clock to synchronize the time.

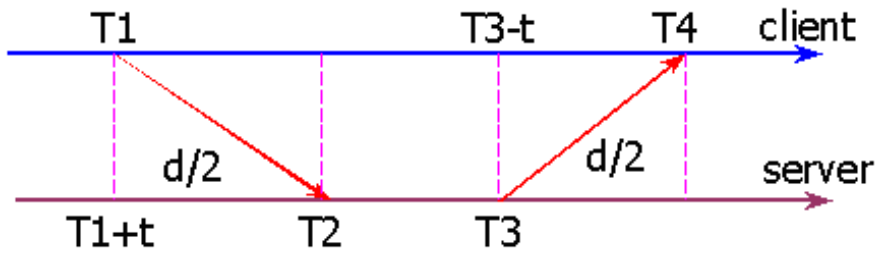


Figure-1

Originate Timestamp	T1	Time request sent by client
Receive Timestamp	T2	Time request received at server
Transmit Timestamp	T3	Time reply sent by server
Destination Timestamp	T4	Time reply received at client

T1: Time request sent by client (refer to the client time) with the mark “Originate Timestamp”;

T2: Time request received at server (refer to the server time) with the mark “Receive Timestamp”;

T3: Time reply by server (refer to the server time) with the mark “Transmit Timestamp”;

T4: Time reply received at client (refer to the client time) with the mark “Destination Timestamp”.

T: Time offset between the server and the client

d: Round-tour time between the server and the client

The following formula calculates the time:

```
∵ T2 = T1 + t + d / 2;
∴ T2 – T1 = t + d / 2;
∵ T4 = T3 – t + d / 2;
∴ T3 – T4 = t – d / 2;
∴ d = (T4 – T1) – (T3 – T2);
t = ((T2 – T1) + (T3 – T4)) / 2;
```

Then, according to the value of *t* and *d*, the SNTP client gets the current time: T4 + t.

Configuring SNTP

This chapter describes how to configure SNTP.

Default Configuration

The following table describes the default SNTP configurations.

Function	Default
SNTP state	Disabled
IP address for the NTP server	0
SNTP Sync Interval	1800 seconds
Local Time-zone	GMT + 8

Enabling SNTP

Enter privileged mode and perform the following steps to enable the SNTP:

Enter global configuration mode:

```
Ruijie# config
```

Enable the SNTP and synchronize the time once immediately. The time will be immediately synchronized if this command is entered and regular synchronization is unnecessary. (in order to prevent frequent time synchronization, the sync-interval must not be less than 5 seconds)

```
Ruijie(config)# sntp enable
Return to privileged mode:
Ruijie(config)# End
```

Show the current configuration:

```
Ruijie# show running-config
```

Save the configuration:

```
Ruijie# copy running-config startup-config
```

To disable the SNTP, use the **no sntp enable** command.

Configuring the IP address of the SNTP Server

The SNTPclient is totally compatible with the NTP server due to the consistency between SNTP and NTP packets. There are many NTP servers in the network, and you can choose one with less latency.

For the detailed NTP server ip addresses, please log on to http://www.time.edu.cn/ or http://www.ntp.org/. For example, 192.43.244.18 (time.nist.gov).

Enter privileged mode and perform the following steps to specify an IP address for the SNTP server:

Enter global configuration mode:

```
Ruijie# config
```

Specify the IP address for the SNTP server.

```
Ruijie(config)# sntp server <ip-addr>
```

Return to privileged mode:

```
Ruijie(config)# End
```

Show the current configuration:

```
Ruijie# show running-config
```

Save the configuration:

```
Ruijie# copy running-config startup-config
```

Configuring the SNTP Synchronization Interval

To adjust the time regularly, you need to set the synchronization interval for SNTP client to access the NTP server SNTP client regularly. Perform the following steps to set the sync interval for the device and the NTP server:

Enter global configuration mode:

```
Ruijie# config
```

Configure the SNTP sync interval, in second.

Interval range: 60-65535s; Default value: 1800s.

```
Ruijie(config)# sntp interval <seconds>
```

Return to privileged mode:

```
Ruijie(config)# End
```

Show the current configuration:

```
Ruijie# show running-config
```

Save the configuration:

```
Ruijie# copy running-config startup-config
```


Caution

The synchronization interval configuration cannot take effect immediately unless you execute the **sntp enable** command immediately after configuring the synchronization interval.

Configuring the Local Time Zone

Greenwich Mean Time (GMT) is obtained through the SNTP communication. To obtain the accurate local time, you need to set the local time to adjust the mean time.

Enter global configuration mode:

```
Ruijie# config
```

Configure the time-zone, ranging from GMT-23 to GMT+23, wherein “-” indicates western area, “+” indicates eastern area. For example "8" indicates the 8th eastern time zone, "-8" indicates the 8th western time zone and “0” indicates Greenwich mean time. Universal Time Coordinated (UTC) is the default time zone name and the default value is **0**.

```
Ruijie(config)# clock timezone <time-zone>
```

Return to privileged mode:

```
Ruijie(config)# end
```

Show the current configuration:

```
Ruijie# show running-config
```

Save the configuration:

```
Ruijie# copy running-config startup-config
```

To restore the local time-zone to the default, use the command **no clock time-zone**.

Showing SNTP Information

The procedure is as follows:

Show related SNTP parameters:

```
Ruijie# show sntp
```

Use the **show sntp** command to show configured SNTP parameters:

```
Ruijie# show sntp
SNTP state              : ENABLE          //to view whether SNTP is enabled or not
SNTP server             : 192.168.4.12   //NTP Server
SNTP sync interval      : 60            //SNTP sync interval
Time zone            : +8               //Local Time-zone
```

Configuring UDP-Helper

Understanding UDP-Helper

Overview

UDP-Helper relays and forwards User Datagram Protocol (UDP) broadcast packets. As a relay, UDP-Helper can convert the UDP broadcast packets into the unicast packets and then forward them to the specified destination server by configuring the destination server for the UDP broadcast packets to be forwarded.

Once enabled, UDP-Helper checks whether the destination UDP port number of the received packet matches the port number to be forwarded to. If yes, it modifies the destination IP address of packets as the IP address of the specified destination server, and sends the packet to the destination server in unicast form.

When UDP-Helper is enabled, the broadcast packets from Ports 69, 53, 37, 137, 138 and 49 are relayed and forwarded by default.


Note

The BOOTP/DHCP broadcast packet is relayed through the UDP Port 67 and 68 by the DHCP Relay module; therefore, the two ports cannot be configured as the relay port of UDP-Helper.

Configuring UDP-Helper

Default Configuration

The following table describes the default configuration.

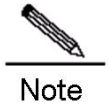
Attribute	Default value
Relay and forwarding	Disabled
UDP port for relay and forwarding	Indicates that the UDP broadcast packets from Ports 69, 53, 37, 137, 138 and 49 are relayed and forwarded by default when UDP-Helper is enabled.
Destination server for delay and forward	None

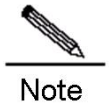
Enable the Relay and Forward Function of UDP-Helper

Command	Function
Ruijie(config)# **udp-helper Enable**	Enables the relay and forward function of UDP broadcast packets. This function is disabled by default.

To disable this function ,sue the **no udp-helper enable** command.


Note This function is disabled by default.

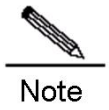

Note When UDP-Helper is enabled, the broadcast packets from UDP Ports 69, 53, 37, 137, 138 and 49 are relayed and forwarded by default.

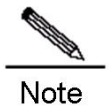

Note When UDP-Helper is disabled, all of the configured UDP ports including the default ports are cancelled.

Configuring the Destination Server for Relay and Forwarding

Command	Function
Ruijie(config-if)# **ip helper-address** *IP-address*	Configures the destination server to which the UDP broadcast packets are relayed and forwarded. By default, it is not configured.

To remove the destination server for relay and forwarding, use the **no ip helper-address** command.


Note At most 20 destination servers can be configured for an interface.


Note If the destination server for relay and forwarding is configured on a specified interface and UDP-Helper is enabled, the broadcast packets of the specified UDP port received from this interface will be sent to the destination server configured for this interface in unicast form.

Configuring the UDP Port for Relay and Forwarding

Command	Function
Ruijie(config)# **ip forward-protocol udp** [*port*]	Configures the UDP port for relay and forwarding. If only the UDP parameter is specified, the default port will be used for relay and forwarding; otherwise, the port can be configured if necessary. When UDP-Helper is enabled, the broadcast packets from Ports 69, 53, 37, 137, 138 and 49 are relayed and forwarded by default.

To disable the UDP port for relay and forwarding, use the **no ip forward-protocol udp** [*port*] command.

Note The UDP port can be configured for relay and forwarding. Otherwise, the error prompts will appear only when the function of delay and forwarding is enabled for UDP-Helper and the destination server is configured for the relay and forwarding.

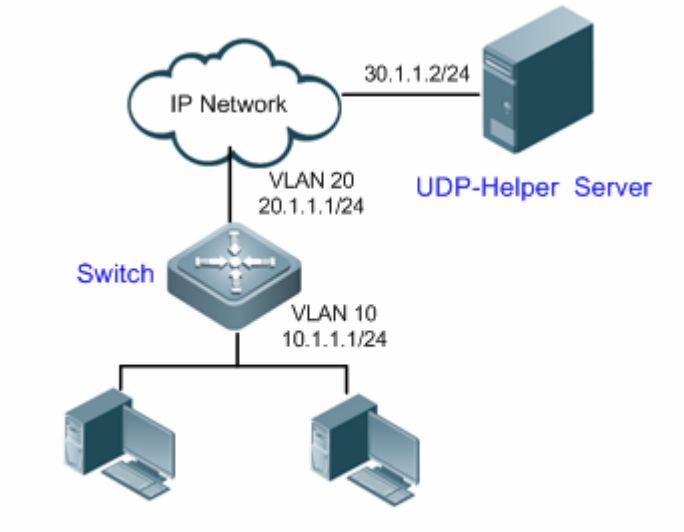
Note When the relay and forwarding function of UDP-Helper is enabled, the function of forwarding the broadcast UDP packets from the default ports 69, 53, 37, 137, 138 and 49 will be enabled immediately without any configuration.

At most 256 UDP ports are supported for relay and forwarding by the switch.

You can use both the **ip forward-protocol udp domain** and **ip forward-protocol udp** *53* commands to configure default ports.

Configuration Examples

Topology Diagram



Topology diagram for UDP-Helper configuration

Application Requirements

The network device can forward UDP broadcast packets with destination port being 1000 to the specified UDP-Helper server (with server IP being 30.1.1.2/24).

Configuration Tips

Configure UDP-Helper relay and forwarding as follows:

Enable UDP-Helper relay forwarding.

Configure the destination server of UDP-Helper relay forwarding.

Configure the destination port number of UDP broadcast packets for relay forwarding (in this example, UDP broadcast packets with destination port being 1000 are subject to relay forwarding; meanwhile, the device will by default forward UDP broadcast packets containing destination port numbers of 69, 53, 37, 137, 138 and 49).


Note

The UDP port for relay forwarding can only be configured after UDP-Helper relay forwarding is enabled and the destination server is configured; otherwise, error messages will be displayed.

After UDP relay forwarding is enabled, the device will immediately forward UDP broadcast packets containing the default port numbers of 69, 53, 37, 137, 138 and 49 without further configuration.

Configuration Steps

Before configuring relevant features of UDP-Helper, make sure that the route from the switch to the network segment of UDP-Helper server is reachable. The IP addresses configured on respective interfaces are shown in the topological diagram. Here we will introduce how to configure relevant features of UDP-Helper.

Step 1: Enable UDP-Helper relay forwarding on the network device

```
Ruijie(config)#udp-helper enable
```

Step 2: Configure the IP address for the destination server of UDP-Helper relay forwarding as 30.1.1.2 on fastEthernet 1/1.

```
Ruijie(config)# interface fastEthernet 1/1
Ruijie(config-if-VLAN 10)#ip address 10.1.1.1 255.255.255.0
Ruijie(config-if-VLAN 10)# ip helper-address 30.1.1.2
Ruijie(config-if-VLAN 10)#exit
```

Step 3: Configure the Switch to forward UDP broadcast packets carrying the destination port number 1000.

```
Ruijie(config)#ip forward-protocol udp 1000
```

Verification

Verify configurations of the switch. Key points: whether relay forwarding is enabled or not; IP address of relay server; destination port number carried in UPD broadcast packets requiring relay forwarding.

```
Ruijie#show run
!
udp-helper enable
!
ip forward-protocol udp 1000
!
interface fastEthernet 0/1
 ip address 10.1.1.1 255.255.255.0
!
interface fastEthernet 1/1
ip helper-address 30.1.1.2
```

```
 ip address 20.1.1.1 255.255.255.0
!
```

Verify whether relay forwarding has taken effect.

Step 1: Send UDP broadcast packets carrying the destination port number 999.

PC1 sends a UDP broadcast packet of the following format:

```
Src_mac:0000.0000.0001
Dst_mac:0xFFFFFFFFFFFF
Src_ip:1.0.0.3
Dst_ip:255.255.255.255
Dst_port:999
PC2 acts as UDP-Helper server. Such packet is not received on PC2.
Step 2: Send UDP broadcast packets carrying the destination port number of 1000.
PC1 sends a UDP broadcast packet of the following format:
Src_mac:0000.0000.0001
Dst_mac:0xFFFFFFFFFFFF
Src_ip:1.0.0.3
Dst_ip:255.255.255.255
Dst_port:1000
PC2 acts as UDP-Helper server. Such packet is received on PC2. The destination IP address of packet is 30.1.1.2, and the data contained are the same as the packets sent.
```

Step 3: Send UDP broadcast packets with destination port number 69, 53, 37, 137, 138 or 49.

PC1 sends a UDP broadcast packet of the following format (taking destination port number of 69 as the example):

```
Src_mac:0000.0000.0001
Dst_mac:0xFFFFFFFFFFFF
Src_ip:1.0.0.3
Dst_ip:255.255.255.255
Dst_port:69
```

PC2 acts as UDP-Helper. Such packet is received on PC2. The destination IP address of packet is 30.1.1.2, and the data contained are the same as the packets sent.

From the verification output, we can learn that the switch has successfully forwarded UDP broadcast packets with the user-defined destination port number (destination port number 1000 and default numbers of 69, 53, 37, 137, 138, and 49) to the specified UDP-Helper server.

Configuring URPF

Understanding URPF

Overview

Recently, frequent Denial of Service (DOS) attacks caused by forged source address are causing many troubles to Internet Service Providers (ISPs) and network maintenance.

Figure 1 shows a common scenario of using a forged source address to perform DOS attacks.

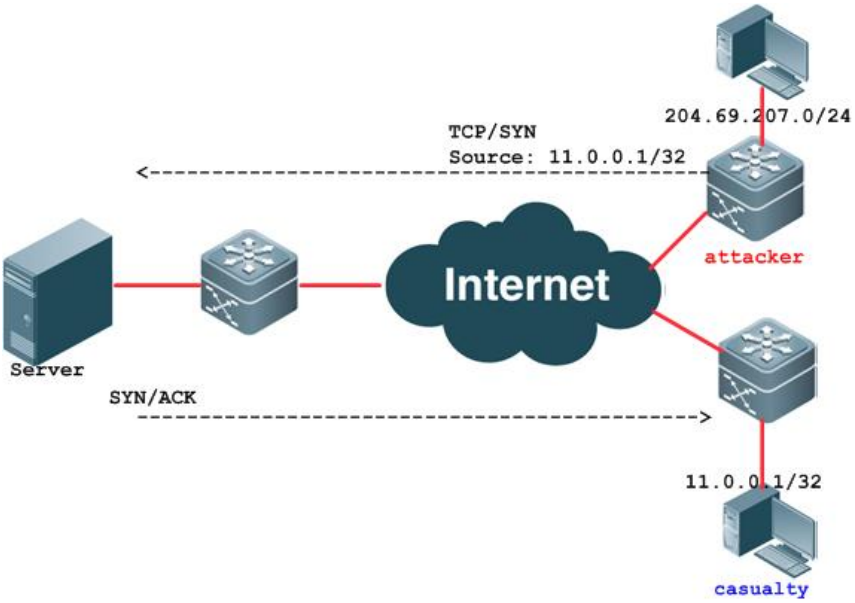


Figure 1 Scenario of source-address-based attacks

The attacker initiates attacks by sending packets with the forged source address 11.0.0.1, making the server send excessive SYN/ACK packets to the host unrelated to this attack, and the host with the real source address is also affected. What's worse, if the network administrator identifies that this address is related to the attack on the network and discards all data streams from this source address; therefore, the denial of service to the source address occurred.

Unicast Reverse Path Forwarding (URPF) well addresses the preceding problem.

It is known that during packet forwarding, the forwarding table is looked up according to the destination address contained in the IP packet received, and the packet is forwarded according to the entry found in the forwarding table. URPF will look up the forwarding table for the forwarding entry according to source address and ingress interface of the incoming packet. If the forwarding entry is not found in the forwarding table, the packet will be discarded; if the egress interface specified in the forwarding table doesn't match with the ingress interface of the packet, the packet will also be discarded. Otherwise, the packet will be forwarded.

URPF can protect the network by intercepting source address spoofing attacks.

Features of URPF

URPF strict mode

Conventional URPF technical requirements: URPF will look up the forwarding table for the forwarding entry according to the source address and ingress interface of the incoming packet. If the forwarding entry is not found in the forwarding table, the packet will be discarded; if the egress interface specified in the forwarding table doesn't match with the ingress interface of the packet, the packet will also be discarded. This requires that the "ingress interface of the packet received must be the egress interface of the route reaching this source address". We call such URPF check mode as URPF strict mode.

Note

URPF strict mode is generally deployed on the point-to-point interface, and the data streams from both directions need to pass this point-to-point interface.

URPF loose mode

URPF strict mode has its limitations, and is particularly not applicable to the asymmetrical routing environment and multi-homed network environment.

To implement the network flow control and routing policy, asymmetrical routing is a common seen network application. In asymmetrical routing, URPF strict mode will result in the loss of data streams. Figure 2 shows an example of asymmetrical routing. If G1/2 on R1 enables URPF strict mode and receives packets from the network segment of 192.168.20.0/24, URPF check will indicate the interface of G1/1 and the packet will not be able to pass URPF check.

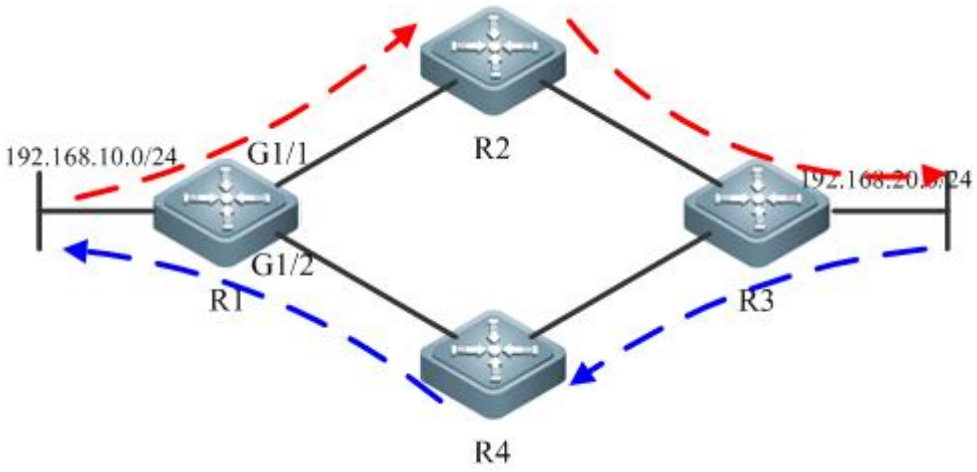


Figure 2 Asymmetrical routing

The multi-homed network is the common network application between a user and the ISP or between ISPs. As shown in Figure 3, user network A is simultaneously connected to multiple ISPs, and the incoming and outgoing streams are always asymmetrical. The figure shows that user network A is visiting user network B.

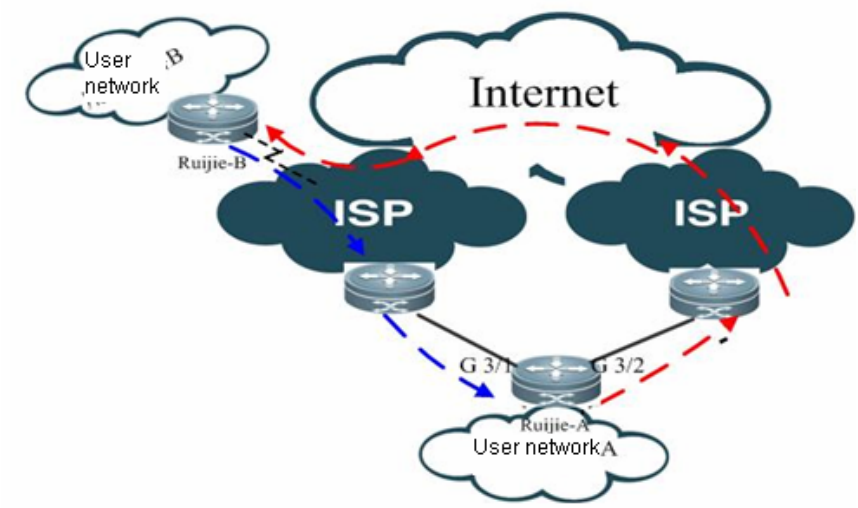


Figure 3 Multi-homed network

In the preceding two application scenarios, valid packets will be filtered if URPF strict mode is enabled. Therefore, URPF loose mode is introduced.

URPF loose mode: Reverse route check is conducted according to the source IP of incoming packet. As long as the route is found, the next-hop egress interface may unnecessarily be the interface that receives the packet. URPF loose mode well addresses the asymmetrical stream problem in the aforementioned asymmetrical routing application and multi-homed network.

URPF monitoring

To conveniently monitor the drop rate of packets after URPF is enabled, Ruijie devices initiatively inform the user of such drop rate via Syslog and Trap. The mechanism will be detailed in this section.

URPF monitoring has introduced the following concepts:

Drop rate: indicates the number of packets discarded due to URPF check within a specific period of time divided by this time. Unit: packets/second (pps).

Drop rate computation interval: indicates the time interval from the previous calculation to the recalculation of the drop rate.

Drop rate sampling interval: indicates the time interval for calculating the number of packets dropped. This value must not be smaller than the drop rate computation interval.

Drop rate notification threshold: indicates the maximum drop rate allowed. When the drop rate is higher than this threshold, the user will be notified via Syslog or Trap. The user may also adjust the drop rate notification threshold according to actual situations of the network.

Drop rate notify hold-down time: indicates the time interval between two successive notifications. The user may adjust the value according to actual situations of the network to avoid frequent Log printing or Trap sending.

The following figure shows two successive computations of the drop rate:

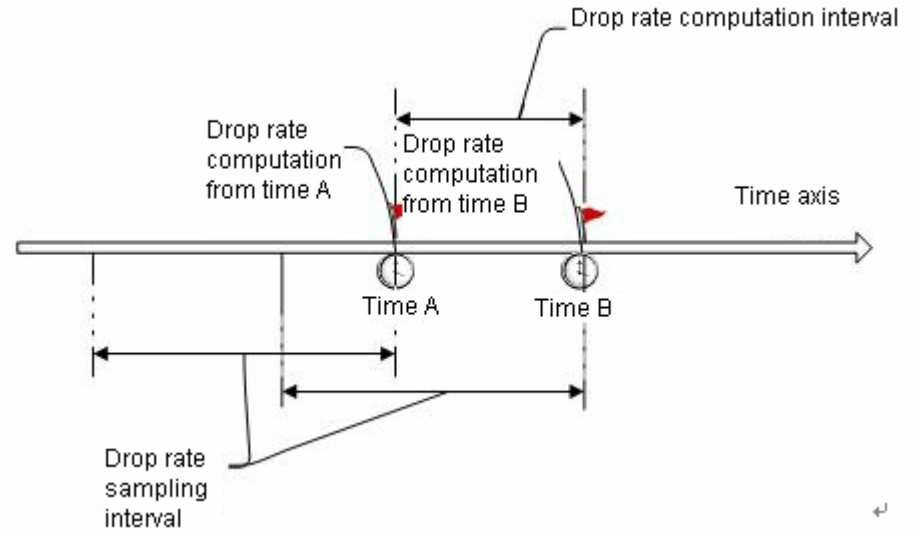


Figure 4 Two successive computations of drop rate

Main points of URPF monitoring:

Drop rate computation

After URPF function is enabled, within the time interval of "0-drop rate sampling interval (including the sampling time point reaching the drop rate)", the drop rate is computed by dividing the currently computed number of dropped packets by the time of URPF running. The subsequent method for drop rate computation: Computed the number of currently dropped packets at every drop rate computation interval, deduct the number of dropped packets before the drop rate sampling interval, and then divide the difference by drop rate sampling interval to obtain the current drop rate.

URPF allows interface-based and global-based drop rate computation and monitoring.

For configurations related to URPF monitoring, see the *Configuring URPF Drop Rate Notification*.

Working Principle

The working principle of URPF has been described in the section Features of URPF.

URPF functions can be applied to IPv4/IPv6 packets according to configurations. However, note that the following packets will not be subject to URPF check.

Destination addresses being multicast packets. URPF check is only applied to the source address with destination address being IPv4/IPv6 packet.
DHCP/BOOTP packets with source IP address being 0.0.0.0 and destination IP address being 255.255.255.255
IPv6 packets with source IP address being Link local addresses

Application Restrictions

Ruijie products that support URPF include:

1) Router products.
2) Switches that support URPF function:

S5750 V2.x product

Category B and C line cards and the M8600-MPLS line card of the S8600 series products

S12000EA line card

The URPF function supported by our router products has the following application restrictions:

Router products only support the URPF function during progress forwarding. If the fast forwarding is enabled on the interface (interface configuration mode: **ip ref**), the URPF function will be disabled.

Currently, the URPF function on routers cannot be applied to IPv6 packets.

The URPF function also has the following characteristics in switch and router products:

After the URPF function is enabled, a route whose source address is matched with a NULL interface will still be subject to URPF check.
After the URPF function is enabled, URPF enjoys precedence over the Access Control List (ACL, interface configuration mode: **ip access-group in**) during packet check.
If URPF strict mode is enabled, incoming packets with the source address being the address of the ingress interface will be discarded. If URPF loose mode is enabled, such packets will pass the interface.

Protocol Specification

Protocol specifications related to URPF include:

RFC 2827, Network Ingress Filtering: DDOS Attacks which employ IP Source Address Spoofing

RFC 3704, Ingress Filtering for Multi-homed Networks

Default Configurations

The following table describes the default configurations of URPF.

Function	Default setting
URPF global configuration mode	Disabled
URPF interface configuration mode	Disabled
URPF drop rate monitoring	Disabled
URPF drop rate computation interval	30 seconds
URPF drop rate sampling interval	URPF drop rate computation interval x 5
URPF drop rate notification threshold	1000 pps
URPF drop rate notify hold-down time	300 seconds
URPF Trap sent for drop rate notification	Disabled

Configuring URPF Functions

The following sections describe how to configure the basic functions of URPF:

Configuring URPF (Global Configuration Mode)

After the MPLS line card is inserted in the S8600 series switches, packets will be forwarded by the MPLS line card. In this case, you need to enable the URPF function according to the steps described in the following table.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **ip verify unicast source reachable-via rx**	Enables the URPF function rx: uses strict mode to perform URPF check
Ruijie(config)# **end**	Exits global configuration mode
Ruijie# **show ip urpf**	Shows URPF configurations and statistics

To disable global URPF function, use the **no ip verify** command in global configuration mode.


Caution The configuration of the URPF feature in global configuration mode takes effect on the S8600 series switches only after the MPLS line card is inserted. After the URPF function takes effect, it will enable URPF check on IPv4 packets.


Caution The URPF function configured in global configuration mode supports only URPF strict mode. When used with equal-cost routing, it will switch to URPF loose mode.


Caution URPF function configured in global configuration mode doesn't support URPF check with the default route.


Caution The URPF function cannot be configured in global configuration mode and in interface configuration mode at the same time.


Caution Note that it is not recommended to configure URPF globally if the S8600 series devices are directly connected to users' network segments. The URPF check fails and the packets are discarded if the S8600 series devices did not learn the Address Resolution Protocol (ARP) entry of a directly-connected user before packet forwarding.

Configuration example:

```
# Enable URPF in global configuration mode:
```

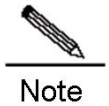
```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# ip verify unicast source reachable-via rx
```

Configuring URPF (Interface Configuration Mode)

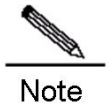
URPF is not enabled on the interface by default.

Use the following commands to enable the URPF function on the interface.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *interface-name*	Enters interface configuration mode.
Ruijie(config-if)# **ip verify unicast source reachable-via** { **any** | **rx** } [**allow-default** | *acl_name*]	Enables the URPF function. any: uses loose mode to perform URPF check. rx: uses strict mode to perform URPF check. allow-default: allows the use of default route to perform URPF check. *acl-name*: indicates the ACL number, supporting: 1 to 99 (IP standard access list) 100 to 199 (IP extended access list) 1300 to 1999 (IP standard access list, expanded range) 2000 to 2699 (IP extended access list, expanded range)
Ruijie(config-if)# **end**	Exits interface configuration mode and returns to privilege mode.
Ruijie# **show ip urpf interface** *interface-name*	Displays URPF configurations and statistics.



Note By default, the default route is not used for URPF check; if required, the user can use the keyword *allow-default* to enable this function.



Note By default, a packet failing in URPF check will be discarded. If the ACL (*acl-name*) is configured, such a packet will undergo ACL check after failing in URPF check. If ACL doesn't exist or the packet points to a deny ACE, such packet will be discarded. If the packet points to a permit ACE, the packet will be forwarded.

Caution After this command is enabled, the S5700 V2.x switch and the S8600 and S12000 series switches will enable the URPF check on IPv4 and IPv6 packets at the same time, and the routers will enable the URPF check on IPv4 packets.

Caution For switches, the URPF feature is supported only on the S5700 V2.x switch and the routed port and Layer 3 AP associated with category B line cards of S8600 series. The restrictions are as follows:

- The URPF function doesn't support the function of associating ACL options.
- The URPF function doesn't support the use of IPv6 routes with 65-to-127 bit prefix to perform URPF check.
- After URPF function is enabled, all packets received by the physical port of these interfaces will be subject to URPF check, thus expanding the range of URPF check. A typical application scenario is: If a packet received by Tunnel interface is received from the aforementioned physical port, this packet will also be subject to URPF check. If such an application scenario exists, be cautious when enabling URPF check.
- After URPF function is enabled, the route forwarding capacity of the device will be reduced by 50%.
- After URPF strict mode is enabled, if the packets received by the interface match with equal-cost routing during URPF check, it will switch into loose mode.
- The URPF function cannot take effect on interfaces of the S8600 series switches after the MPLS line card is inserted.

Caution The URPF function cannot be configured in global configuration mode and in interface configuration mode at the same time.

Configuration example:

```
# Perform strict URPF check for packets received by interface
```

GigabitEthernet 0/21, with no need to use default route for URPF check.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface gigabitEthernet0/21
Ruijie(config-if)# ip verify unicast source reachable-via rx
```

Configuring URPF Drop Rate Notification

To configure URPF drop rate notification, you must enable the URPF function first.

Use the following commands to configure URPF drop rate notification.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **ip verify urpf drop-rate compute interval** *seconds*	Configures URPF drop rate computation interval in seconds. The value range is 30 to 300. The default value is 30 seconds.

Ruijie(config)# ip verify urpf drop-rate notify **hold-down** *seconds*	Configures URPF drop rate notify hold-down time in seconds. The range is 30 to 300. The default value is 300 seconds.
Ruijie(config)# **interface** *interface-name*	Enters interface configuration mode.
Ruijie(config-if)# **ip verify urpf drop-rate notify**	Enables URPF drop rate monitoring.
Ruijie(config-if)# ip verify urpf notification threshold *rate-value*	Configures URPF drop rate notification threshold.in Packets Per Second (pps). The range is 0 to 4294967295. The default value is 1000 pps.
Ruijie(config-if)# **exit**	Exits interface configuration mode and returns to global configuration mode.
Ruijie(config)# **snmp-server enable traps urpf**	Sends Trap packets after the URPF drop rate has exceeded the notification threshold.
Ruijie(config)# **snmp-server host** {*host-addr*| *ipv6 ipv6-addr* } **traps** *word urpf*	Configures the host to receive URPF Trap.
Ruijie(config)# **end**	Exits global configuration mode.
Ruijie# **show ip urpf**	Shows URPF configurations and statistics.

Note By default, the drop rate notification threshold is 1000 pps. The user may adjust the drop rate notification threshold as required.

Caution Drop rate monitoring is only effective in interface configuration mode, and is not supported in global configuration mode.

Caution In interface configuration mode, the drop rate will be computed according to the packets dropped by the interface after URPF check is enabled.

Configuration example:

Perform strict URPF check for packets received by interface GigabitEthernet 0/21 with no need to use default route for URPF check. Monitor the URPF drop rate via SNMP Trap. Configure the drop rate notification threshold to 500 pps. Configure the SNMP host 192.168.12.219 to receive Trap packets.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# ip verify urpf notification threshold 500
Ruijie(config)# snmp-server enable traps urpf
Ruijie(config)# snmp-server host 192.168.12.219 public urpf
Ruijie(config)# interface gigabitEthernet0/21
Ruijie(config-if)# ip verify unicast source reachable-via rx
```

Viewing URPF Configurations

Use the following command provided by URPF to show various configurations and statistics.

Command	Function
show ip urpf [**interface** *interface-name*]	Shows URPF configurations and statistics.

Use the following command provided by URPF to clear URPF statistics.

Command	Function
clear ip urpf [**interface** *interface-name*]	Clears the statistics about packets dropped in URPF check.

Typical URPF Configuration Example

Example of Strict Mode Configuration

Networking Requirements

Figure 5 shows the typical hierarchical network architecture.

The packets with forged source addresses may be transmitted from user PCs to the core-layer network. To avoid this, the source address attack packets need to be isolated on the access layer or distribution layer to eliminate invalid data on the aggregation-layer and core-layer network.

The preceding requirement can be satisfied by enabling URPF strict mode on the interface linking aggregation-layer devices and access-layer devices.

Networking Topology

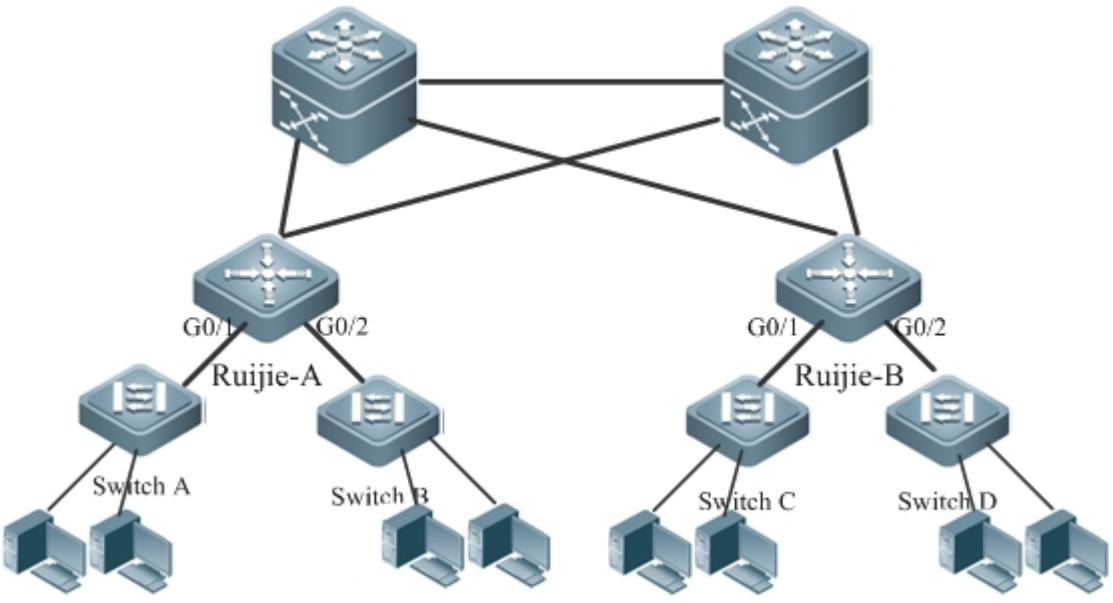


Figure 5 Application of URPF strict mode

Configuration Steps

As shown in Figure 5, enable URPF strict mode on the aggregation-layer device. That is, enable URPF strict mode on Ruijie-A and Ruijie-B.

Configurations of device Ruijie-A:

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface gigabitEthernet0/1
Ruijie(config-if)# ip address 195.52.1.1 255.255.255.0
Ruijie(config-if)# ip verify unicast source reachable-via rx
Ruijie(config-if)# ip verify urpf drop-rate notify
```

The configurations to enable URPF strict mode are the same on interface G0/2 of Ruijie-A and G0/1 and G0/2 of Ruijie-B.

Verification

Verify URPF configurations of Ruijie-A.

```
Ruijie #show ip urpf interface gigabitEthernet 0/1
IP verify source reachable-via RX
IP verify URPF drop-rate notify enabled
IP verify URPF notification threshold is 1000pps
Number of drop packets in this interface is 124
Number of drop-rate notification counts in this interface is 0
```

Example of Loose Mode Configuration

Networking Requirements

The section describes the common application scenario of URPF loose mode, including asymmetrical routing environment and multi-homed network environment.

This section describes the configurations of outlet device connecting the ISP in the multi-homed network as shown in Figure 3.

Networking Topology

Figure 3 shows the multi-homed network.

Configuration Steps

As shown in Figure 3, URPF loose mode is enabled on G3/1 and G3/2 connecting two ISPs to prevent invalid packets from attacking the interior user network and isolate invalid packets outside the user network on the outlet device Ruijie-A in the user network.

Configurations of Ruijie-A:

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface gigabitEthernet3/1
Ruijie(config-if)# ip address 195.52.1.2 255.255.255.252
Ruijie(config-if)# ip verify unicast source reachable-via any
Ruijie(config-if)# ip verify urpf drop-rate notify
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitEthernet3/2
Ruijie(config-if)# ip address 152.95.1.2 255.255.255.252
Ruijie(config-if)# ip verify unicast source reachable-via any
Ruijie(config-if)# ip verify urpf drop-rate notify
Ruijie(config-if)# end
```

Verification

Verify URPF configurations of Ruijie-A.

```
Ruijie #show ip urpf
IP verify URPF drop-rate compute interval is 300s
IP verify URPF drop-rate notify hold-down is 300s
Interface gigabitEthernet3/1
IP verify source reachable-via ANY
IP verify URPF drop-rate notify enabled
IP verify URPF notification threshold is 1000pps
Number of drop packets in this interface is 4121
Number of drop-rate notification counts in this interface is 2
Interface gigabitEthernet3/2
IP verify source reachable-via ANY
IP verify URPF drop-rate notify enabled
IP verify URPF notification threshold is 1000pps
Number of drop packets in this interface is 352
Number of drop-rate notification counts in this interface is 0
```

Configuring IPFIX

Overview

IP Flow Information eXport (IPFIX), is a standard protocol published by the Internet Engineering Task Force (IETF) for the netflow measurement. It standardizes the format of the network traffic statistics. IPFIX is applicable to network devices and management system platforms of any manufacturers, and is used to export the flow statistics by network device. On one hand, IPFIX allows an administrator to easily extract and view the important flow information stored in the network device. On the other hand, it is unnecessary for the administrator to upgrade the network device software or management tools if the flow monitoring requirement changes as the export format is extensible.

IP flow information is transmitted from an export device (router, switch, or network sniffer device) to the collector. Different data formats are defined to meet different requirements, because IPFIX is a highly-scalable template-based format for the data export.

To export the complete data, seven key fields are adopted to represent each network flow: source IP address, destination IP address, source port, destination port, Layer-3 protocol type, byte of Type-of-service, and input logical interface. If all those seven key fields of different IP packets are matched, then all the IP packets belong to the same flow. Network optimization, security detection and traffic accounting can be performed according to the current network application information about recorded features of the netflow, such as flow duration, and the average length of the packet in the flow.

Basic Concept

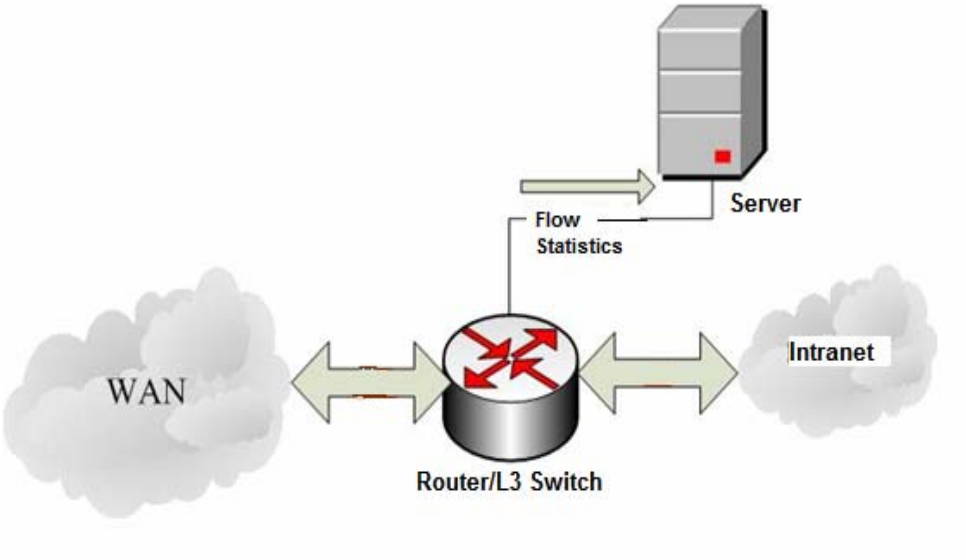
Template: Defines the recorded data format, including a series of data bit domain fields, each of which contains the data type of the data bit domain and the data length. You can parse the recorded data according to the template. If you want to add a data field you are interested in to the data record, you only need to add the corresponding data bit domain field to this template, without modifying the management software.

Collector: Receives the IP flow information generated from the network device. The collector analysis is based on the received data template and data records, and it clearly shows flow information in graphics or tables and saves the information to the database for further use.

IPFIX Application

The router/switch enabled with the IPFIX flow statistics function can collect the statistics on lots of information of packets, including the Layer-3 protocol type, the transport layer port, source/destination address, and service type. The information can be widely used in application scenarios such as user detection, network analysis and planning, security analysis, traffic accounting, and network traffic engineering. Figure-1 shows a typical application topology.

Figure-1



Network Application and User Detection

The IPFIX traffic statistics feature allows you to view detailed, real-time, application-based, and current network usage. It allows you to reasonably allocate and optimize the network resources, and provides the capability of real-time detection of the network capacity. With the IPFIX flow detection function, you can easily understand the network usage and plan to limit the usage combined with other functions such as the Access Control List (ACL). IPFIX can also help effectively and quickly solve some potential security problems.

Network Planning

The IPFIX flow statistics function can detect netflow information over a long period and track network trends. The data enables you to predict network changes and optimize upgrade plans of various networks effectively. It minimizes network costs, but maximizes network performance, capacity and stability. IPFIX can also detect unwanted traffic in Wide Area Network (WAN) and redundant bandwidth and quality of service (QoS) usage. The IPFIX flow statistics function offers valuable information for reducing the cost of operating the network. For example, when the traffic over a WAN link increases, generally you will increase the investment to upgrade the link. However, the traffic increase is possibly attributed to some illegal usage such as BT download. IPFIX enables you to find out the real reason, modify the network usage policy and solve the problem, and thus preventing unnecessary network upgrade.

Security Analysis and Attack Detection

You can use the export flow record of the IPFIX flow statistics to identify denial of service (DoS) attacks, viruses and worms in real-time. Anomalistic changes in network behaviors are clearly reflected in flow records. Take DoS attack for example, its feature is to send a bulk of IP packets (different from the ordinary ones) in the network from untrusted source addresses to the same destination address. Combined with other network control methods (ACL and QoS), the IPFIX flow statistics function can prevent malicious network attack effectively by collecting the source address, destination address, protocol number, port number and size of these packets and sending the information to the collector for network security experts or software analysis.

Flow Accounting

The IPFIX flow statistics function measures the flows in a network in a fine granularity way, including the source/destination IP address, number of packets, total bytes, timestamp, QoS and application ports. Internet Service Providers (ISPs) can utilize the information for accounting based on time, bandwidth, application or network service quality.

IPFIX Function


Note Ruijie IPFIX function is implemented based on the multi-service card only.

Understanding the IP Packet Flow

A packet flow is a series of consecutive packets of the same attributes and pass a same detection point in a period. The packets belong to a same flow have some same attributes, which can be some fields in the head of the IP packets, such as source IP address, Tos field and any combination of those fields. The key fields defining the packet flow are not fixed. For Ruijie switches, a netflow is defined as the unidirectional packet flow with the same source and destination. To be precise, a netflow is determined by the combination of the following key fields:

- Source IP address
- Destination IP address
- Source port number
- Destination port number
- Layer-3 protocol type
- Tos
- Input logical interface
- VRF

Those eight key fields determine a unique flow. If one key field of a packet is different from that of another packet, they belong to different flows. A flow record also includes other statistical fields, such as the packet number, the next-hop IP address, total flow byte number, etc. For each probe packet, ascertain the flow records first, and record the corresponding information stored in the main cache. The flow record cache is used to store the IP flow information, including the main cache and the flow aggregation cache.

Understanding the Main Cache

The main cache is used to store the raw IP flow information, using seven keywords to match the flow statistics. The IPFIX export mechanism records the flow information and sends it to the configured collector. For an IP packet, first search for the corresponding flow record from its keyword in the main cache: if no flow record exists, create a new one; and if the flow record exists, then update the flow statistical information, such as the packet number, flow bytes, etc. The cache capacity is limited; therefore, the aging mechanism of the flow record is set. The following conditions are used to determine whether a flow is aged out or not:

If no packets belong to the flow are detected in a certain period of time (the non-active time), this flow has been aged and shall be exported.

The flow information cannot be recored indefinitely for it persists for a too long time, which exceeds the set active time, then this flow shall be aged.

When it needs to export the aged flow record, the flow information shall be encapsulated as User Datagram Protocol (UDP) packets and sent to the set collector on the server for processing. The collector is the software tool for processing the flow record, and can display the visualized current network status and analyze the netflow according to the received flow record information.

Understanding the Format of the Flow Export Packet

The format of the flow record export packet is the IPFIX standard format. The IPFIX standard format is based on the template, and easy to extend. When encapsulating the data record, first create the format template of the data record, which defines the filed type and length of the data record. For each data record, use the template to identify and explain the analytical format. To add a new field to the date record, you only need to re-create the corresponding data template rather than to upgrade the software, which greatly improves the scalability.

On Ruijie routers, IPFIX supports the exporting of netflow packet formats of version 9 and version 10, and supports the netflow software versions ManageEngine_NetFlowAnalyzer_7001 and ManageEngine_NetFlowAnalyzer_8000. However, the netflow software version ManageEngine_NetFlowAnalyzer_9100 may be problematic on Ruijie routers, because the deployed template is different from Cisco's template.

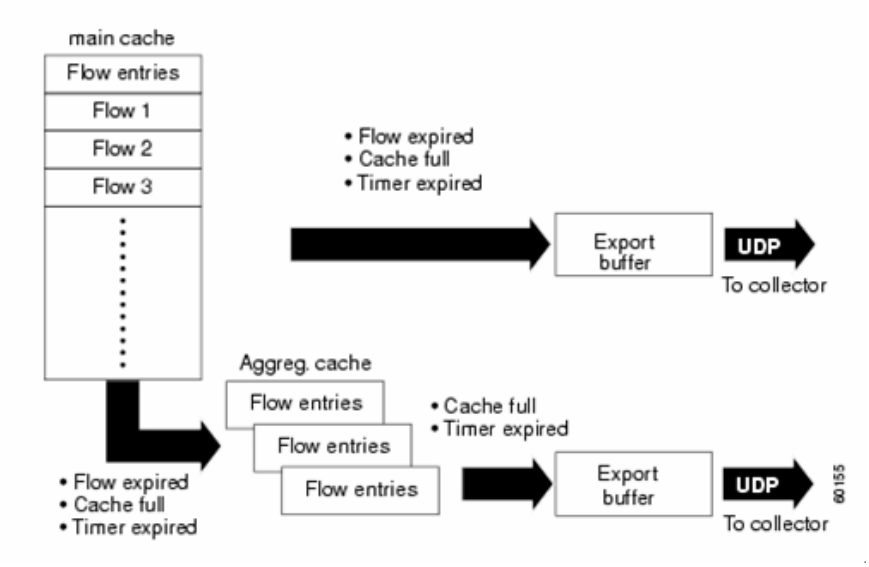
Understanding Flow Aggregation Mode

Similar to main mode, flow aggregation mode also deals with the netflow statistics. The only difference is that the main mode acquires the original packet to generate and export the flow record, while flow aggregation mode reprocesses the flow record to generate and export the new record of the flow aggregation.

Such processing meets requirements of using different key fields to reprocess flow records and generate the required flow records in different flow aggregation modes. As described in the preceding sections, a flow consists of packets of the same attributes, and the attributes can be the combination of any fields in packet headers. In the software, seven keywords differentiate flows, and you can select any seven fields in packet headers to reprocess flow records. For example, to know Layer-3 packet distribution, you can use Layer-3 protocol ID as the key field to aggregate flow records exported in main mode and obtain the required flow information.

Similar to the main mode, flow aggregation mode requires the cache to store the current statistical flow information. The flow aggregation function maps the export flow record in the main cache to the corresponding flow record in the flow aggregation cache, updates the flow aggregation record and regularly checks whether the flow aggregation record expires. Once expired, the flow aggregation record must be exported. Figure-2 shows the principle..

Figure-2:



Configuring the Flow Record Export in Main Mode

When a flow record in the main cache expires, the software uses the export mechanism to encapsulate the expired flow record to a UDP packet and sends the UDP packet to the configured server. Meanwhile, to prevent the loss of the template carrying the flow record because of unrelizable transmission over UDP, it requires for the regular template retransmission to ensure the successful receiving of the data template.

Configuring the Export Destination IP Address and Port

Up to two export servers can be set at the same time to improve the reliability of flow information transmission.

Use the following commands to configure the export server.

Command	Function
Ruijie> **enable**	Enters privileged command mode.
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **ip flow-export destination** *ip-address udp-port* [**vrf** [*vrf-name*]]	Configures the destination IP address and destination port of the flow export, and VRF.
Re-execute the third command	Configures the destination IP addresses and destination ports of multiple flow exports.
Ruijie(config)# **end**	Returns to privileged command mode.
Ruijie# copy running-config startup-config	Saves the configuration.

To remove the flow export, use the **no ip flow-export destination** *ip-address udp-port* [**vrf** [*vrf-name*]] command.

Configuration example

```
Ruijie# config terminal
Ruijie(config)#ip flow-export destination 192.168.217.76 1111
Ruijie(config)#ip flow-export destination 192.168.217.76 2222
%Warning: Second destination address is the same as previous address 192.168.217.76
Ruijie(config)#ip flow-export destination 192.168.217.76 3333
%Exceeded maximum export destinations
```

```
Ruijie(config)# end
Ruijie products display error information when the third export destination is configured.
```


Caution By default, no flow export is set in the system. The flow record will be saved in the device for checking instead of being exported.

Configuring the Export Source IP Address

A device can have multiple IP addresses, so the IP address on one port can be specified as the source IP address for the sent packet when exporting the flow record.

Use the following commands to configure the source IP address.

Command	Function
Ruijie> **enable**	Enters privileged command mode.
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **ip flow-export source** *interface-number*	Configures the export source IP address as the IP address for an interface.
Ruijie(config)# **end**	Returns to privileged command mode.
Ruijie# copy running-config startup-config	Saves the configuration.

Configuration example

```
Ruijie# config terminal
Ruijie(config)# ip flow-export source gigabitEthernet 6/2
Ruijie(config)# end
Ruijie#
```

The example uses the IP address of g 6/2 as the source address.


Caution By default, the default system IP address is used as the source IP address when sending the packets in the system.


Caution An IP address must have been configured for the port designated as the source address.

Configuring the Related Parameters of the Export Template

Before exporting the netflow data, the corresponding data template shall be sent to the server. UDP, an unreliable protocol, may result in the template loss and cause that the server fails to analyze the flow data correctly. Therefore, the retransmission mechanism is adopted to send the template. There are two RGOS retransmission mechanisms: 1. In the unit of packets, retransmit the template once each time sending *n* data packets; 2. In the unit of minutes, retransmit the template at every certain interval.

Use the following configuration commands.

Command	Function
Ruijie> **enable**	Enters privileged command mode.
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **ip flow-export template refresh-rate** *packets*	Configures the retransmission packet number. The range is from 1 to 600. The default value is 20.
Ruijie(config)# **ip flow-export template timeout-rate** *minutes*	Configures the retransmission interval, in minutes. The range is from 1 to 1000 minutes. The default value is 30 minutes.
Ruijie(config)# **end**	Returns to privileged command mode.
Ruijie(config)# **copy running-config startup-config**	Saves configurations.

Configuration example

```
Ruijie# config terminal
Ruijie(config)#ip flow-export template refresh-rate 30
Ruijie(config)#ip flow-export template timeout-rate 40
Ruijie(config)# end
Ruijie#
```

In the example, *refresh-rate 30* indicates that the template is retransmitted every 30 packets, and *timeout-rate 40* indicates that the template is retransmitted every 40 minutes.

Caution By default, the retransmission packet refresh rate is 20, the time interval is 10 minutes.

Showing the Export Configurations in Main Mode

Use the **show ip flow export** command to display the current export configurations, including the export enable, export destination, the format of the flow record export packet, etc.

Configuring the Main Cache

The main cache is used to save the raw flow record information, and each flow entry size is fixed. A flow entry is created for each active flow in the system, with the record of flow characteristic and statistical information. All flow entries will be regularly checked for determining whether they have expired based on the following conditions:

1. The cache is full and no available space for the flow entries, so some entries shall expire.

2. A flow is inactive. By default, if a flow is not updated within 15 seconds, it becomes inactive.

3. A flow keeps active for too long time. By default, a flow shall expire if it has been active for 30 minutes.

The following introduces those configurable parameters.

Configuring the Flow Cache Entry Number

With the IPFIX flow statistics function enabled on a port, certain storage space is reserved for saving the flow entry in the main cache, which meets the user network demands generally. By default, 64K flow entries (with each entry size 64 bytes) are reserved, so it needs 4M memory space for the main cache. You can increase or decrease the entry number according to your needs to improve the performance or reduce the memory usage, which depends on your device memory size. Use the **ip flow-cache entries** *number* command to set the entry number in the cache.The range of *number* is from 1024 to 524288. The detailed configuration is described as follows.

Use the following configuration commands.

Command	Function
Ruijie> **enable**	Enters privileged command mode.
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **ip flow-cache entries** *number*	Configures the entry number in the cache. The range is from 1024 to 524288.
Ruijie(config)# **end**	Returns to privileged command mode.
Ruijie# **copy running-config startup-config**	Saves the configuration.

To restore the entry number to the default value, use the **no ip flow-cache entries** command.

Configuration example

```
Ruijie# config terminal
Ruijie(config)#ip flow-cache entries 32768
Ruijie(config)# end
```

Caution By default, 65536 entries are in the main cache. With IPFIX enabled, the entry number configuration in the cache will take effect only after you re-enabling the IPFIX function. It is not recommended to change the entry number in the cache casually and inappropriately, which may result in abnormal system working.

Configuring the Flow Cache Timeout

Use the following command to set the flow cache timeout parameters.

Command	Function
Ruijie> **enable**	Enters privileged command mode.
Ruijie# **config terminal**	Enters global configuration mode.

Command	Function
Ruijie(config)# **ip flow-cache timeout active** *minutes*	Configures the active aging time in minutes. The range is from 1 to 60 minutes.
Ruijie(config)# **ip flow-cache timeout inactive** *seconds*	Configures the inactive aging time in seconds. The range is from 10 to 600 seconds.
Ruijie(config)# **end**	Returns to privileged command mode.
Ruijie# **copy running-config startup-config**	Saves the configuration.

By default, the active aging time is 30 minutes and the inactive aging time is 15 seconds. To restore the default value, use the **no ip flow-cache timeout active** command and the **no ip flow-cache timeout inactive** command.

Configuration example

```
Ruijie# config terminal
Ruijie(config)#ip flow-cache entries 32768
Ruijie(config)#ip flow-cache timeout active 20
Ruijie(config)#ip flow-cache timeout inactive 20
Ruijie(config)# end
```

Showing Information About the Main Cache

Use the **show ip flow cache** command to show the packet flow statistical information in the current main mode, including the packet size distribution, the cache entry usage, etc.

The output is as follows:

```
Ruijie# sh ip flow cache
Ipfix collect data from CM-CARD
ip flow switching cache, 250000 entries
   10 active, 249990 inactive
   active flows timeout in 1 minutes
   inactive flows timeout in 15 seconds
Protocol      Total Flows   Total packets  Total bytes   Active time
udp-other     3            13           834          151
ospf         12           72           5284         622
gre          2            76           1900         114
udp          3            13           834          151
Total:        17           161          8018         887
Display entries in main cache :
SrcIf            SrcIPAddress     DstIf            DstIPAddress     Pr   Tos  SrcPort
DstPort Pkts       ActiveTime  Vrf
Vi1              111.1.1.200      Null0            224.0.0.5        89   0    0      0
0         16         0
Ipfix collect data from device 3
ip flow switching cache, 250000 entries
   17 active, 249983 inactive
   active flows timeout in 1 minutes
```

```
   inactive flows timeout in 15 seconds
Protocol      Total Flows   Total packets  Total bytes   Active time
udp-other     8            144          10436        468
ospf         14           82           6144         791
gre          4            253          16182        246
udp          8            144          10436        468
Total:        26           479          32762        1505
Display entries in main cache :
SrcIf            SrcIPAddress     DstIf            DstIPAddress     Pr   Tos  SrcPort
DstPort Pkts       ActiveTime  Vrf
Lo1              22.2.2.2        Gi1/0/1          55.1.1.55        17   0    32768   99
2         12         0
Lo0              20.1.1.1        Gi1/0/1          20.1.1.2         17   0    10000   10000
1         12         0
```

Enabling Flow Statistics

The preceding configurations are performed when the IPFIX flow statistics function is disabled. This section describes how to enable the IPFIX flow statistics function which is to measure the ingress or egress packets. Therefore, to enable the IPFIX flow statics function, you need to set the observation point, flow types, and ports where flows are measured. To enable the IPFIX flow statistics function for ingress or egress flows, you need to enter interface configuration mode.

Use the following configuration commands.

Command	Function
Ruijie> **enable**	Enters privileged command mode.
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *interface-type interface-number*	Enters interface configuration mode.
Ruijie(config)# **ip flow { ingress | egress }**	Enables the IPFIX flow statistics function on the interface.
Ruijie(config)# **end**	Returns to privileged command mode.
Ruijie# **copy running-config startup-config**	Saves the configuration.

To disable the IPFIX flow statistics function, use the **no ip flow { ingress | egress }** command interface configuration modein interface configuration mode.

Configuration example

```
Ruijie# config terminal
Ruijie(config)# interface gigabitEthernet 6/2
Ruijie(config-if)# ip flow ingress          //Enable IPFIX on port 6/2 for statistics of ingress flows.
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitEthernet 6/3
```

```
Ruijie(config-if)# ip flow ingress          //Enable IPFIX on port 6/3 for statistics of ingress flows.
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitEthernet 6/4
Ruijie(config-if)# ip flow ingress          //Enable IPFIX on port 6/4 for statistics of ingress flows.
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitEthernet 6/5
Ruijie(config-if)# ip flow ingress          //Enable IPFIX on port 6/5 for statistics of ingress flows.
Ruijie(config-if)# exit
Ruijie(config)#
```

Use the **show ip flow interface** command to show the IPFIX state on the interface.

Configuration example

```
Ruijie# show ip flow interface
interface gigabitEthernet 6/2
Ip flow ingress
interface gigabitEthernet 6/3
Ip flow ingress
interface gigabitEthernet 6/4
Ip flow ingress
interface gigabitEthernet 6/5
Ip flow ingress
```

Caution

By default, IPFIX is disabled on all interfaces. Once the IPFIX flow statistics function is enabled on an interface, the global IPFIX function is enabled, and the corresponding cache and timer are created. The settings of the main cache will take effect when the IPFIX function is re-enabled. Use the **no** form to disable all interface with IPFIX enabled, and then the global IPFIX takes no effect.

The IPFIX captured data flow is sent to the data flow analysis software (Such as NewFlow,RILL) and then be converted into a visible report for the user. Because the IPFIX flow statistics function is enabled on an interface.When the system restarted, the interface index might change and the IPFIX is unable to capture the data flow on the original designated interface. To avoid this consequence, use the command snmp-server if-index persist to bind the function on a interface.

Configuring Flow Aggregation Mode

Flow Aggregation Mode Overview

Flow aggregation mode re-aggregates the main mode flow and generates a new flow through the defined specified key field. The system reserves certain cache, which is similar to the main cache and here called the flow aggregation cache,

for aggregation mode. When a flow entry comes out of the main cache, the flow information is used to refresh the flow aggregation record in each enabled flow aggregation cache. You could set the entry number in the aggregation cache, entry aging parameter, export destination IP address and export destination UDP port separately. Meanwhile, the entry aging mechanism in the flow aggregation mode, which supports the forcible aging according to the user requirements, is the same as the one in main mode. By default, the entry number in the flow aggregation cache is 4096.

The following flow aggregation modes are supported:

- Destination Prefix aggregation mode
- Prefix aggregation mode
- Protocol Port aggregation mode
- Source Prefix aggregation mode
- Destination Prefix-ToS aggregation mode
- Prefix-port aggregation mode
- Prefix-ToS aggregation mode
- Protocol-port-ToS aggregation mode
- Source Prefix-ToS aggregation mode

Aggregation Mode	Key Field
destination-prefix	Destination AS number, destination address mask length, destination prefix and egress interface index
prefix	Source AS number, destination AS number, source address mask length, destination address mask length, source prefix, destination prefix and egress interface index.
prefix-port	Source prefix, destination prefix, source port, egress interface index and ToS value.
protocol-port	Protocol number, source port and destination port.
source-prefix	Source AS number, source address mask length, source prefix.
destination-prefix-tos	Destination AS number, destination mask length, destination prefix and egress interface index.
prefix-tos	ToS, source AS number, source prefix, source mask length, destination AS number, destination mask length, destination prefix.
protocol-port-tos	ToS, protocol type, source port and destination port.
source-prefix-tos	ToS, source prefix, source mask length and source interface index.

The nine modes are independent and can be configured concurrently.

Configuring Flow Aggregation Mode

IPv4 Aggregation Mode

Configuration example

```
enable
configure terminal
```

```
ip flow-aggregation cache { destination-prefix | destination-prefix-tos | prefix | prefix-port
| prefix-tos | protocol-port | protocol-port-tos | source-prefix | source-prefix-tos}
cache entries number
cache timeout active minutes
cache timeout inactive seconds
export destination ip-address udp-port
Repeat the step7, set the second export destination.
enabled
exit
interface interface-type interface-number
ip flow {ingress | egress}
exit
Repeat the step11-13, set the IPFIX function on other interfaces.
end
```

The following table describes the configuration commands in detail.

Command	Function
Ruijie> **enable**	Enters user execution mode.
Ruijie# config terminal	Enters global configuration mode.
Ruijie(config)# ip flow-aggregation cache { destination-prefix | destination-prefix-tos | prefix | **prefix-port | prefix-tos** | **protocol-port** | **protocol-port-tos** | **source-prefix** | **source-prefix-tos** }	Enters corresponding flow aggregation mode. destination-prefix: enters destination-prefix aggregation configuration mode. destination-prefix-tos: enters destination-prefix-tos aggregation configuration mode. prefix: enters prefix aggregation configuration mode. prefix-port: enters prefix-port aggregation configuration mode. prefix-tos: enters prefix-tos aggregation configuration mode. protocol-port: enters protocol-port aggregation configuration mode. protocol-port-tos: enters protocol-port-tos aggregation configuration mode. source-prefix: enters source-prefix aggregation configuration mode. source-prefix-tos: enters source-prefix-tos aggregation configuration mode.
Ruijie(config-flow-cache)# **cache entries number**	Configures the cache entry number. number: indicates the allowed cache entry number in this aggregation mode. The range is from 1024 to 524288. The default value is 4096.

Command	Function
Ruijie(config-flow-cache)# **cache timeout active minutes**	(Optional) Configures the cache entry active timeout time. minutes: indicates the active timeout time. The range is from 1 to 60 minutes. The default value is 30 minutes.
Ruijie(config-flow-cache)# **cache timeout inactive seconds**	(Optional) Configures the cache entry inactive timeout time. seconds: indicates the inactive timeout time. The range is from 10 to 600 seconds. The default value is 15 seconds.
Ruijie(config-flow-cache)# **export destination ip-address udp-port**	(Optional) Configures the flow aggregation export destination. ip-address: indicates the export destination IP address. udp-port: indicates the destination UDP port number.
Repeat the previous step, set the second export destination.	(Optional) Configures up to two export destination for each aggregation mode.
Ruijie(config-flow-cache)# **enabled**	
Ruijie(config-flow-cache)# exit	Exits flow aggregation configuration mode and enters global configuration mode.
Ruijie(config)# **interface ethernet** 0/0	Enters interface configuration mode.
Ruijie(config-if)# ip flowegress	Enables the IPFIX function on the interface. Ingress: detects the ingress flow to the interface; Egress: detects the egress flow from the interface.
Ruijie(config-if)# **end**	Exits interface configuration mode.

Configuration example

```
Ruijie> enable
Ruijie# configure terminal
Ruijie(config)# ip flow-aggregation cache destination-prefix
Ruijie(config-flow-cache)# cache entries 2048
Ruijie(config-flow-cache)# cache timeout active 15
Ruijie(config-flow-cache)# cache timeout inactive 300
Ruijie(config-flow-cache)# export destination 172.30.0.1 991
Ruijie(config-flow-cache)# enabled
Ruijie(config-flow-cache)# exit
Ruijie(config)# interface ethernet 0/0
Ruijie(config-if)# ip flow egress
Ruijie(config-if)# end
```

Showing Flow Aggregation Information

IPv4 configuration commands

show ip flow cache aggregation { **as** | **as-tos** | **destination-prefix** | **destination-prefix-tos** | **prefix** | **prefix-port** | **prefix-tos** | **protocol-port** | **protocol-port-tos** | **source-prefix** | **source-prefix-tos** } [vrf *vrf-name*]

Use this command to show the cache information in each flow aggregation mode, including the cache size, effective flow entry number, idle flow entry number, etc.

Configuration example

```
Ruijie# sh ip flow cache aggregation protocol-port
IP Flow Switching Cache, 278544 bytes
2 active, 4094 inactive, 12523 added
239947 ager polls, 0 flow alloc failures
Active flows timeout in 30 minutes
Inactive flows timeout in 15 seconds
IP Sub Flow Cache, 17160 bytes
0 active, 1024 inactive, 0 added, 0 added to flow
0 alloc failures, 0 force free
1 chunk, 1 chunk added
Protocol  Source Port  Dest Port  Flows  Packets  Bytes/Packet  Active
0x11      0x007B     0x007B     1      1       76
0.0
0x01      0x0000     0x0303     1      5      132
5.0
Ruijie#
```

show ip flow export

Use this command to show the export information in main mode, and the export configuration information about enabled aggregation modes, such as the format of the ouput packet, export destination, etc.

Configuration example

```
Ruijie# sh ip flow export
Ipfix collect data from CM-CARD
cache for main metering process:
       flow export is enabled
       Exporting flows to 55.1.1.55 (99)
       Exporting using source interface Loopback 1
       Template export information:
          Template timeout = 10 minutes
          Template refresh rate = 20 packets
       total 400 packets metering
       total 0 packets dropped for no memory
       total 42 flows exported in 5 udp datagrams
       0 ipfix message export failed

Ipfix export information from device 3
cache for main metering process:
       flow export is enabled
       Exporting flows to 55.1.1.55 (99)
       Exporting using source interface Loopback 1
```

```
Template export information:
  Template timeout = 10 minutes
  Template refresh rate = 20 packets
total 1124 packets metering
total 0 packets dropped for no memory
total 62 flows exported in 9 udp datagrams
0 ipfix message export failed
```

Configuring the Flow Filtering and Sampling Mechanism

With the netflow growth, concurrent netflows set in, affecting the performance of the IPFIX flow measurement. Then the flow filtering and sampling mechanism comes into being. The flow filtering analyzes the flows which the users are interested in, decreasing the IPFIX flow and network device loads sharply. The sampling mechanism analyzes some netflows randomly according to a certain sampling rate, decreasing the IPFIX flow greatly.

Configuring Sampling for the Specified Flow

The sampling for the specified flow uses the ACL to match the packets, and only the matched packet flow is recorded.

Use the following configuration commands.

Command	Function
Ruijie> **enable**	Enters privileged command mode.
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *interface-name*	Enters interface configuration mode.
Ruijie(config-if)# **flow-sample** *packet-num* filter *acl-name*	Applies the ACL to the interface to filter the input flow. *acl-name* is the existed ACL ID or name, it can also be 0, which means all flows are permitted. The matched packets are sampled by the ratio of 1/*packet-num*, and then flow statistics are collected.
Ruijie(config)# **end**	Returns to privileged command mode.
Ruijie# **copy running-config startup-config**	Saves the configuration.

To restore the default configuration of an interface, use the **no** form of this command in interface configuration mode.

All packets of ports are sampled and measured by the ratio 1/255 by default.

Caution If the IPFIX flow measurement is disabled on the configured interface, this configuration will be saved. Once IPFIX is enabled on the port, this configuration takes effect. The corresponding ACL must exist when you configure this command. If the ACL is deleted, this configuration will be deleted automatically.

For example:

```
Ruijie# config terminal
Ruijie(config)# interface gi 2/2
Ruijie(config-if)# flow-sample 100 filter acl1
Ruijie(config-if)# end
```

Configuring RLOG

Overview

The device side is responsible for log collection and uploading, while RLOG will send all Internet access information and user connection information to the server. The server-side software will analyze the logs and then write the logs into the database, and the user can then find the corresponding connection records through log query system.

RLOG contains NAT logs and the number of bytes received/sent, as well as connection establishment/deletion and other relevant information.

To enable logging function, you need to complete the following configurations:

- Configure logging service on device side and enable flow log;
- Enable background service program on the service side;
- Configure web server.

Log configuration

Log Server Configuration

Configure log server to enable logging function. If no log server is configured, the device will not send any log to the log server.

When the log server is configured, the device will enable the logging module and send out log information in UDP packets.

To configure log server, execute the following commands in global configuration mode:

Command	Function
Ruijie(config)# **rlog server** *server-ip* [**vrf** *vrf-name*]	Specify the IP address and VRF name of log server and enable log service;
Ruijie(config)# **no rlog server**	Remove log server configuration, disable logging service and clear relevant statistics.

Note The command to configure log server will only enable log service, and the log output function is not enabled at the same time. Executing this command along will not output any log. The command to enable flow log is "**ip session log-on**", which must be executed separately.

Log Service Parameter Configuration

Log service related parameters include the maximum length of log packets, number of service port.

By executing these commands, the user can modify the configurations of log server and avoid the conflict between log service and other network services.

To configure log service parameters, execute the following commands in global configuration mode:

Command	Function
Ruijie(config)# **rlog mtu** *number* Ruijie(config)# **no rlog mtu**	Configure maximum length of log packets Remove the configuration of maximum length of log packets and restore to the default 1500
Ruijie(config)# **rlog port** *number* Ruijie(config)# **no rlog port**	Specify the log service port number Remove the configuration of log service port number and restore to the default 10000.
Ruijie(config)# **rlog export-rate** *number* Ruijie(config)# **no rlog export-rate**	Specify the log service export rate (maximum number of logs sent per second) Remove the configuration of log service export rate and restore to the default 1000

Note Any change to the log service parameters will not take effect immediately. You need to restart log service to apply the configurations. You can reconfigure log server to reboot the server.

Note The default value for log export rate is on the low side. You can configure to the maximum value if the performance of log server allows.

Log Service Testing

You can execute log service testing command to check whether the logging function is normal. This command is used to check free buffer and send test packets to the log server. If the log server receives the test packets and replies with the corresponding prompting messages, we can then determine that whether the log service is properly configured and whether the network is accessible.

To test the log server, execute the following command in global configuration mode:

Command	Function
Ruijie(config)# **rlog test**	Test log server and check free buffer; send test packets to the log server.

Note Checking free buffer may occupy full log buffer and result in the loss of logs. Please don't use this function unless it is necessary.

Log Service Statistics

Log service statistics also includes the current configuration information, the number of logs received, the number of logs sent, the number of errors sent, and the cause of the latest error.

To display log service statistics, execute the following command in global configuration mode:

Command	Function
Ruijie(config)# **show rlog**	Display log service statistics.

Log Database

The log server supports MySQL, SQLSever, Oracle and etc.

Log data are long-term and continuous records. The storage of long-term data will require sufficient storage space. Different on-site service conditions will have different requirements on database.

The following is a simple example for explaining the size of database required.

Approximate 4,000 users in one school access Internet through router. Assuming that there are averagely 8k new connections and each connection contains 50 bytes of data.

Data per second: 8k*50 = 400k

Daily data: 400k*60*60*24 = 34.5G

Monthly data: 34.5*30 = about 1T

If there are more users or if the storage time is longer, then the storage space shall be increased accordingly.


Caution The device will only send logs ceaselessly, while the log server will only analyze the logs and write into the database. The user shall be responsible for data maintenance.


Caution For example, logs to be kept for only 15 days can be deleted by adding a trigger configured to delete data exceeding 15 days at 12:00pm of everyday.


Caution The logs will keep all connection information, as well as some attack attempts or invalid connections. If these data are considered unnecessary, you can add a trigger configured to periodically records with 0 received byte in order to optimize the data.


Caution These actions cannot be achieved by programs on the device or log server.

Web pages are directly related to database. Any change to the database (address, username, password and other configuration items) will need to change the corresponding web page.

Log Server

Please refer to the enclosed CD for content and web configurations of the server.

Configuring HTTP Service

Understanding HTTP

Overview

The Hypertext Transfer Protocol (HTTP) is used to transmit web page information over the Internet. HTTP resides at the application layer of the TCP/IP protocol stack. The transmission layer uses connection-oriented TCP.

Hypertext Transfer Protocol Secure (HTTPS) is the HTTP supporting the Secure Sockets Layer (SSL). HTTPS sets up a secure channel on an insecure network to ensure that information can hardly be intercepted and to defend against man-in-the-middle attacks to some extent. Currently, HTTPS has been widely used among security-sensitive communication services, such as electronic payment.

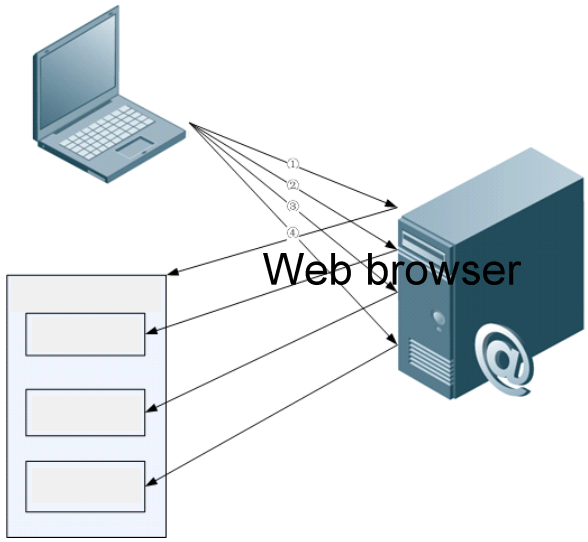
Basic Concept

HTTP Service

The HTTP service facilitates HTTP to transmit web page information over the Internet. HTTP/1.0 is the most popular HTTP version in the industry. HTTP/1.0 uses the short connection mode to simplify connection management, as a web server may be accessed for tens of thousands or even a million times each day. When receiving a connection request, the server sets up a TCP connection and releases it after the request is completed. The server does not record or trace previous requests. Although HTTP/1.0 simplifies connection management, it introduces certain performance defects.

For example, a web page may contain URLs of multiple images, so that the browser sends multiple requests in the access process. When receiving a request, the server sets up an independent connection which is completely isolated from other connections. The process of setting up and releasing a connection consumes plenty of resources, and therefore has serious severe impact on the performance of the client and the server, as shown in Figure 0-1.

Figure 0-1 HTTP/1.0 Protocol Packet Exchange



HTTP/1.1, however, has solved this defect. HTTP/1.1 supports a persistent connection, through which multiple requests and responses can be transmitted. The client can send the next request before the previous request is completed, thereby reducing network delay and enhancing performance, as shown in Figure 0-2.

Figure 0-2 HTTP/1.1 Protocol Packet Exchange

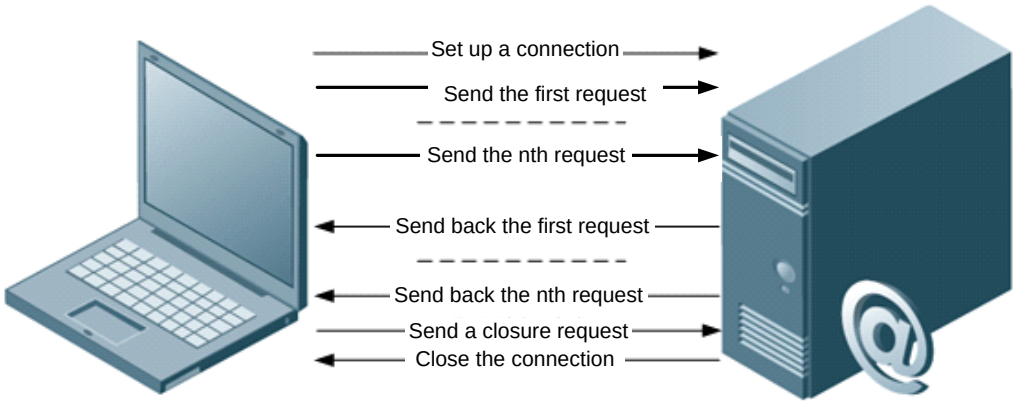


Figure 3

Currently, Ruijiedevices support HTTP/1.0 and HTTP/1.1.

Note The protocol version used by a device depends on the specific web browser.

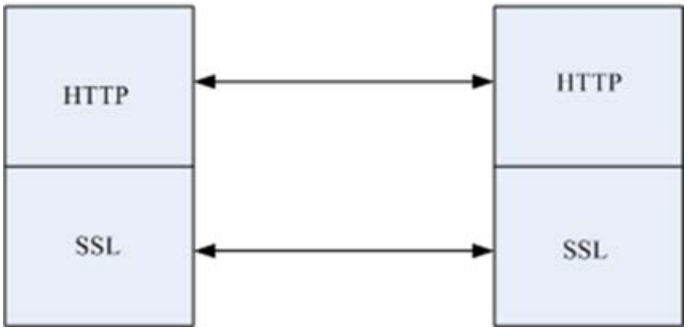
HTTPS Service

HTTPS adds the security base of SSL to HTTP. To enable HTTPS to run normally, the server must have a Public Key Infrastructure (PKI) certificate, which is not necessary for the client. SSL provides the following services:

- Authenticating users and servers to ensure that data is sent to correct clients and servers

- Encrypting data to prevent data interception during transmission
- Keeping data integrity to ensure that data is not changed during transmission

Figure 0-3 HTTPS Service



HTTP Upgrade Service

The HTTP upgrade service includes local and remote HTTP upgrade services.

- During local upgrade, the device works as an HTTP server. Users can log in to the device through the web browser and upload the upgrade files to the device so as to upgrade files on the device.
- During remote upgrade, the device works as a client connected to a remote HTTP server. It obtains the upgrade files from the server so as to upgrade local files.

Working Principle

HTTP Working Process

HTTP is used for web management. Users log in to the device through the web interface for configuration and management. Web management involves the web client and web server. The HTTP service adopts the client/server mode accordingly. The HTTP client is embedded in the web browser of the web management client and can send HTTP packets, receive HTTP response packets, and handle HTTP response packets. The web server (HTTP server) is embedded in the device. The client and the server exchanges information with each other according to the following process:

- The client sets up a TCP connection with the server. The default HTTP port number is 80, and the default HTTPS port number is 443.
- The client sends a request to the server.
- After processing the request, the server sends a response to the client.
- After processing a request, the HTTP service directly closes the TCP connection between the client and the server; while HTTPS can handle multiple requests until the client sends a TCP connection closure request or until the connection is closed due to server timeout.

The HTTP remote upgrade process is summarized as follows:

- The device connects to the server. In this process, the user-configured server address is preferentially used. If the connection fails, the server address in the local upgrade record file is used to establish the connection.

- The device sends the version numbers of local programs to the server.
- After resolution, the server returns a download file list.
- The device connects to file servers according to the list and downloads the upgrade files as necessary.
- The device can connect to different file servers according to the different files to be downloaded.
- The device upgrades its local files.

Protocol Specification

RFC1945 - Hypertext Transfer Protocol -- HTTP/1.0

RFC2616 - Hypertext Transfer Protocol -- HTTP/1.1

RFC2818 - Hypertext Transfer Protocol Over TLS -- HTTPS

Typical Application

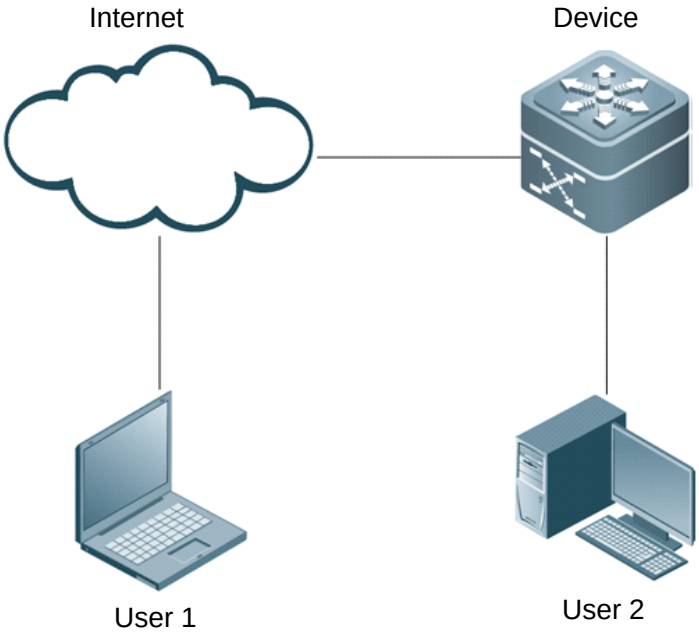
HTTP Application Service

Currently, the web NMS is still a major method for users to maintain and manage devices. Ruijie network devices also provide the web management function. When HTTP is enabled, users can log in to the web management interface after entering "http://+device IP address" on the PC browser and passing the authentication. Through the web interface, users can perform various operations, such as monitoring device states, configuring devices, uploading files, and downloading files.

The common HTTP-based service is actually insecure. For security-sensitive communications, Ruijie devices also provide the more secure HTTPS service, which encrypts the information transmitted between users and the device, so that third-party devices cannot intercept or modify the information. Users can perform web management simply after entering "https://+device IP address" on the web browser and passing the authentication.

Figure 0-4 illustrates a typical web management scenario. Users can remotely access and manage the device through the Internet or log in to the web server through a LAN to perform configuration management for the device. Users can enable either HTTPS or HTTP, or both as necessary on the device.Users can also specify HTTP/1.0 or HTTP/1.1 on the web browser for accessing the HTTP service of the device.

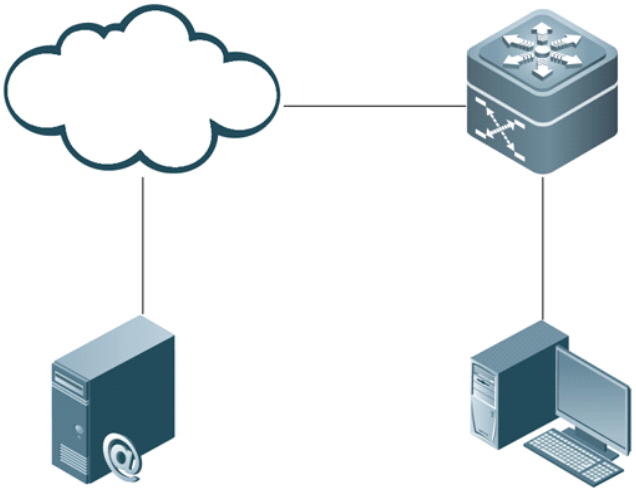
Figure 0-4 HTTP Application Scenario



HTTP Remote Upgrade Service

The HTTP Remote Upgrade Service means that a device serving as a client connects the remote HTTP server and obtains files from the server to upgrade local files. The default domain name of Ruijie web server is "rgos.ruijie.com.cn." Figure 0-5 shows a typical application scenario.

Figure 0-5 HTTP Remote Upgrade



Configuring HTTP

Default Configuration

The following table describes the default configuration of HTTP.

Feature	Default Setting
Enabling the HTTP service	The HTTP service is disabled by default.
HTTP authentication method	Usernames: **admin** and **guest**
HTTP service port	Common HTTP port number: 80 HTTPS port number: 443
HTTP upgrade server	Server address: 0.0.0.0 Port number: 80
HTTP upgrade mode	Manual
HTTP upgrade auto-detection time	Random

Prerequisites

Before configuring the domain name of the HTTP upgrade server, enable the DNS function on the device and configure the address of the DNS server.

Configuration Steps

Step	Configuration Task	Description
1	Enable the HTTP service.	Mandatory
2	Configure HTTP authentication information.	(Optional) This step is performed when authentication information needs to be modified.
3	Configure the HTTP port.	(Optional) This step is performed when the HTTP port needs to be changed.
4	Configure the HTTP upgrade server.	(Optional) This step is performed when the server address needs to be specified.
5	Configure the HTTP upgrade mode.	(Optional) This step is performed when the upgrade mode needs to be changed.
6	Configure HTTP upgrade auto-detection time.	(Optional) This step is performed when the HTTP upgrade auto-detection time needs to be changed.
7	Manually upgrade files with HTTP.	Mandatory

Enabling the HTTP Service

The HTTP service includes the commonly used HTTP service and the HTTPS service. HTTPS adds SSL on the basis of HTTP to enhance information security.

Use the following commands to enable the HTTP service in configuration mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)#**enable service web-server http**	(Mandatory) Enables the HTTP service.
Ruijie(config)#**enable service web-server https**	(Mandatory) Enables the HTTPS service.
Ruijie(config)#**enable service web-server [all]**	(Mandatory) Enables both HTTP and HTTPS services.

Configuration example:

The following example enables both HTTP and HTTPS services on a Ruijie device.

```
Ruijie# configure terminal
```

```
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)# enable service web-server
```

Configuring HTTP Authentication Information

When HTTP is enabled, users can log in to the web interface only after being authenticated. Use the **webmaster level** command to configure HTTP authentication information.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(confing)# **webmaster level** *privilege-level* **username** *name* **password** { *password* | [**0 | 7**] *encrypted-password* }	(Mandatory) Configures the login authentication mode, which is not configured by default.

Note Usernames and passwords come with three permission levels, each of which includes at most 20 usernames and passwords.

Configuration example:

The following example uses the username **admin** and plain-text password **ruijie** at level 0 to perform web authentication on a Ruijie device.

```
Ruijie# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)# webmaster level 0 username admin password ruijie
```

Configuring the HTTP Port

Configuring the HTTP port can reduce attacks from unauthorized users to HTTP. Ruijie devices support the HTTP and HTTPS service modes.

- Use the following commands to configure the HTTP port number.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **ip http port** *port-number*	(Optional) Configures the HTTP port number, which is 80 by default.

Configuration example:

The following example configures the HTTP port number as 8080 on a Ruijie device.

```
Ruijie# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)# ip http port 8080
```

- Use the following commands to configure the HTTPS port.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **ip http secure-port** *port-number*	(Optional) Configures the HTTPS port number, which is 443 by default.

Configuration example:

The following example configures the HTTPS port number as 4430 on a Ruijie device.

```
Ruijie# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)# ip http secure-port 4430
```

Configuring the HTTP Upgrade Server

The address of the HTTP remote upgrade server is 0.0.0.0 and the port number is 80 by default. Use the following commands to change the server address.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **http update server** { *host-name* | *ip-address* } [**port** *port-number*]	(Optional) Configures the address of the HTTP upgrade server.

Note The HTTP upgrade server address does not need to be configured because the local upgrade record file records available upgrade server addresses.

Caution If the server domain needs to be configured, enable the DNS function on the device and configure the DNS server address.

Caution The server address cannot be an IPv6 address.

Configuration example:

The following example configures the domain name of the HTTP upgrade server as **rgos.ruijie.com.cn** and the port number as 85 on a Ruijie device.

```
Ruijie# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)# http update server rgos.ruijie.com.cn port 85
```

Configuring an HTTP Upgrade Mode

The manual upgrade mode applies for HTTP by default. Use the following commands to enter global configuration mode and configure HTTP to automatically detect the files available for upgrade on the server.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **http update mode auto-detect**	(Optional) Configures the HTTP upgrade mode as auto-detection. If this step is not performed or the **no** form of this command is executed, the manual upgrade mode is used by default.

In auto-detection mode, the device detects the files on the server during upgrade. Users can find the web versions to be upgraded through the web interface.

Configuration example:

The following example configures the HTTP upgrade mode as auto-detection on a Ruijie device.

```
Ruijie# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)# http update mode auto-detect
```

Configuring HTTP Upgrade Auto-Detection Time

In auto-detection mode, the remote HTTP auto-detection time is random. Use the following commands to change the auto-detection time in global configuration mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **http update time daily** *hh*:*mm*	(Optional) Configures HTTP auto-detection time, which is random by default.


Note The HTTP auto-detection time is a specific time point with the accuracy of minutes each day.


Caution This configuration command takes effect only when the HTTP upgrade mode is auto-detection.

Configuration example:

The following example configures the HTTP auto-detection time as 3:00 am on a Ruijie device.

```
Ruijie# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)# http update time daily 03:00
```

Manually Upgrading Files with HTTP

- Remote Upgrade

HTTP provides only the remote auto-detection function by default, and the system does not automatically perform upgrade. Use the following commands to upgrade the system in privileged EXEC mode.

Command	Function
Ruijie# **http check-version**	(Optional) Checks the upgrade version.
Ruijie# **http update web** [**version** *string*]	Updates the web package.

Configuration example:

The following example performs remote file upgrade for a Ruijie device through HTTP.

```
Ruijie# http check-version
app name:web
sn           version               filename
-- ------------------ -------------------------
0       1.2.1(82381)     web1.2.1(145680).upd
1       1.2.1(82380)     web1.2.1(145680).upd
2       1.2.1(82379)     web1.2.1(145680).upd
3       1.2.1(82378)     web1.2.1(145680).upd
```

- Local Upgrade

You can use the **copy tftp** command to download latest web files to a Ruijie device and then use the following command to upgrade the web package.

Command	Function
Ruijie# **http web-file update**	Updates the web package.

Caution To enable the new web package to take effect, log in to the web interface again.

The following example locally upgrades the web package for a Ruijie device.

```
Ruijie#copy tftp://10.10.10.13/web_management_pack.upd flash:web_management_pack.upd
Ruijie#http web-file update
```

Monitoring and Maintaining HTTP

Displaying HTTP Configuration Information

Command	Function
show web-server status	Displays the configuration information and status of the web service.

Configuration example:

The following example displays the HTTP configuration information of a Ruijie device.

```
Ruijie# show web-server status
http server status : enabled
http server port : 80
```

```
https server status: enabled
https server port: 443
http(s) use memory block: 768, create task num: 0
```

Configuration Examples

HTTP Configuration Example

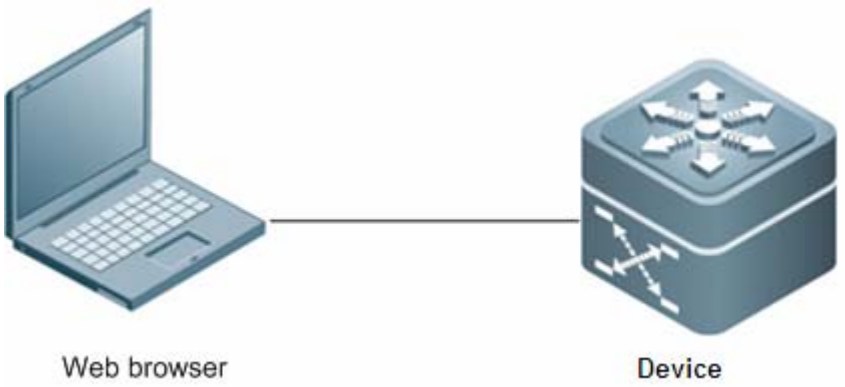
Networking Requirements

Network administrators hope to manage a device through web, and therefore log in to the device through the web browser to configure the switch.

- Log in with the user-configured authentication information.
- Ensure that the web browser can be accessed through HTTP or HTTPS so as to enhance security.
- Configure the HTTP port to reduce attacks from unauthorized users to HTTP.

Networking Topology

Figure 0-6 HTTP Application Topology



Configuration Tips

To meet the customer's requirements, focus on the following points:

- Use the **webmaster level** command to configure authentication information.
- Enable HTTP and HTTPS at the same time to meet the customer's security requirements.
- Configure the HTTP port number as 8080 and the HTTPS port number as 4430.

Configuration Steps

3) Configure the username as admin and the password as ruijie.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)# webmaster level 0 username admin password ruijie
```

4) Enable the HTTP and HTTPS services.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#enable service web-server
```

5) Configure the HTTP port number as 8080.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#ip http port 8080
```

6) Configure the HTTPS port number as 4430.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#ip http secure-port 4430
```

Verification

7) Check HTTP configuration information.

```
Ruijie#show web-server status
http server status : enabled
http server port : 8080
https server status: enabled
https server port: 4430
http(s) use memory block: 768, create task num: 0
```

Configuration Example of HTTP Remote Upgrade

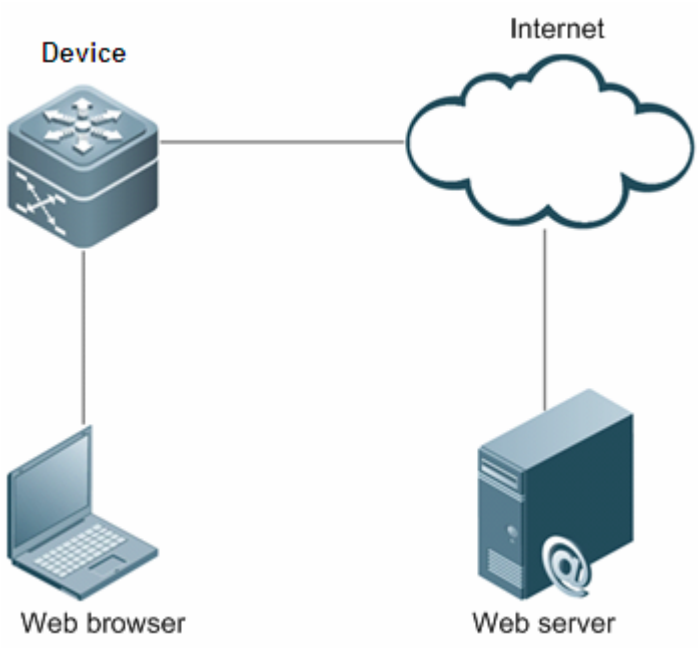
Networking Requirements

An enterprise purchasing a Ruijie device hopes to use the HTTP upgrade function to upgrade files.

- Ensure that the device can periodically and remotely obtain information about the files available for upgrade from a Ruijie server.
- Check the files currently available for upgrade.
- Download the latest files from the Ruijie server and update the device to be upgraded.

Networking Topology

Figure 0-7 Networking Topology of HTTP Remote Upgrade



Configuration Tips

To meet the customer's requirements, focus on the following point:

- Configure the device to remotely obtain information about the latest files at 2:00 am each day.

Configuration Steps

8) Configure DNS information.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#ip domain-lookup                          //Enable the DNS function on the
device.
Ruijie(config)#ip name-server 192.168.5.134               //Configure the IP address of
the DNS server.
```

9) Configure the address of the upgrade server.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)# http update server rgos.ruijie.com.cn
```

10) Enable the auto-detection mode and configure the remote detection time of the device as 2:00 am.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#http update mode auto-detect
Ruijie(config)#http update time daily 02:00
```

11) Obtain information about the files available for upgrade from the remote server.

```
Ruijie#http check-version
app name:web
sn           version               filename
-- ------------------ ------------------------
0       1.2.1(82381)     web1.2.1(145680).upd
1       1.2.1(82380)     web1.2.1(145680).upd
2       1.2.1(82379)     web1.2.1(145680).upd
3       1.2.1(82378)     web1.2.1(145680).upd
```

12) Download the files from the server and update the device.

```
Ruijie#http update web
```

Verification

Check server version information on the online upgrade interface of web.

Configuration Example of HTTP Local Upgrade

Networking Requirements

- Users hope to run the latest web package, which is obtained from an official website, on a device.

Networking Topology

Figure 0-8 Networking Topology of HTTP Local Upgrade

Configuration Tips

To meet the customer's requirements, focus on the following points:

- Connect the device to a local PC whose IP address is 10.10.10.13, and configure the device with an IP address 10.10.10.131 in the same network segment.
- Download the latest web package to the device.
- Update the web package on the device.

Configuration Steps

13) Create VLAN1 and configure an IP address for the device

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#vlan 1
Ruijie(config-vlan)#exit
Ruijie(config)#interface vlan 1
Ruijie(config-VLAN 1)#ip address 10.10.10.131 255.255.255.0
```

14) Enable the TFTP server function on the PC and run the copy tftp command on the device to download the web package.

```
Ruijie#copy tftp://10.10.10.13/web_management_pack.upd flash:web_management_pack.upd
```

15) Update the web package on the device.

```
Ruijie#http web-file update
```

Verification

On the PC, log in with web authentication once again to check whether the latest web interface is displayed.

Configuring RADIUS Dynamic Authorization Extension

Understanding RADIUS Dynamic Authorization Extension

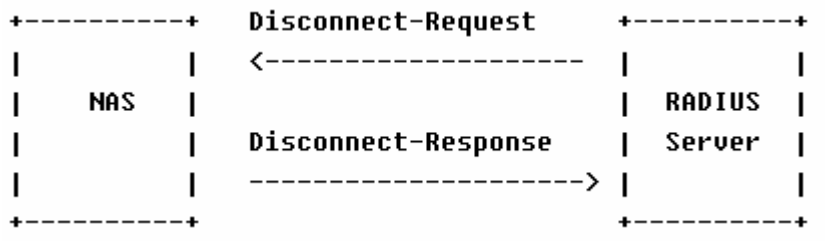
Overview

The Dynamic Authorization Extensions to Remote Authentication Dial In User Service (RADIUS) protocol is defined in RFC 3576 by IETF. This protocol defines a user offline management method, that is, the device communicates with a RADIUS server through Disconnect-Messages (DMs) to log out authenticated users. This protocol enables devices from different vendors to communicate with a RADIUS server and log out users of these devices.

The DM mechanism is as follows: A RADIUS sends user logout requests to the device. The device logs out the users that match the session IDs in the request packets, and sends response packets that contain processing results to the server. This mechanism allows the RADIUS server to manage user logout.

Working Principle

Figure 1-1 DM exchange for RADIUS dynamic authorization extension



The above figure shows the DM exchange between the RADIUS server and device. When the RADIUS server sends a Disconnect-Request packet to the UDP port numbered 3799, the device processes the packet and sends a Disconnect-Response packet containing the processing results to the server.

Protocol Specification

RADIUS is defined in RFC 3576.

Default Configuration

The default configuration about RADIUS dynamic authorization extension is shown in the table below.

Feature	Default Setting
RADIUS dynamic authorization extension	Disabled
The number of a UDP port for intercepting DMs	3799

Configuring RADIUS Dynamic Authorization Extension

Enabling RADIUS Dynamic Authorization Extension

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)#**radius dynamic-authorization-extension enable**	Enables RADIUS dynamic authorization extension.
Ruijie(config)# **show running-config**	Shows configuration.

Use the **no radius dynamic-authorization-extension enable** command to disable RADIUS dynamic authorization extension in global configuration mode.

The example below shows how to configure RADIUS dynamic authorization extension:

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# radius dynamic-authorization-extension enable
Ruijie(config)# show run
```

Note By default, RADIUS dynamic authorization extension is disabled.

Viewing the Configuration

Command	Function
Ruijie# **show radius dynamic-authorization-extension statistics**	Shows statistics about RADIUS dynamic authorization extension.
Ruijie# **clear radius dynamic-authorization-extension statistics**	Clears statistics about RADIUS dynamic authorization extension.

The example below shows how to show statistics about RADIUS dynamic authorization extension.

```
Ruijie# show radius dynamic-authorization-extension statistics
Disconnect-Request Received:                        50
Incorrect Disconnect-Request Received:               1
Disconnect-Request Dropped for Queue Full:           0
Disconnect-Request Process Timeout:                  0
Disconnect-Request Process Success:                 49
Disconnect-ACK Sent:                                25
Disconnect-ACK Sent Failed:                          0
Disconnect-NAK Sent:                                24
```

```
Disconnect-NAK Sent Failed:                              0
```

Configuring Optional Features of RADIUS Dynamic Authorization Extension

Configuring a UDP Port

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)#**radius dynamic-authorization-extension port** *num*	Sets a UDP port for intercepting the packets about RADIUS dynamic authorization extension. The value ranges from 1024 to 65535. The default value is 3799.
Ruijie(config)# **show running-config**	Shows configuration.

Use the **no radius dynamic-authorization-extension port** command to restore the default interception port in global configuration mode.

The example below shows how to configure a UDP port intercepting the packets about RADIUS dynamic authorization extension.

Set the port numbered 8080 to intercept RADIUS requests:

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# radius dynamic-authorization-extension port 8080
Ruijie(config)# show running-config
```

Reset the configuration:

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# no radius dynamic-authorization-extension port
Ruijie(config)# show running-config
```

Examples for Configuring RADIUS Dynamic Authorization Extension

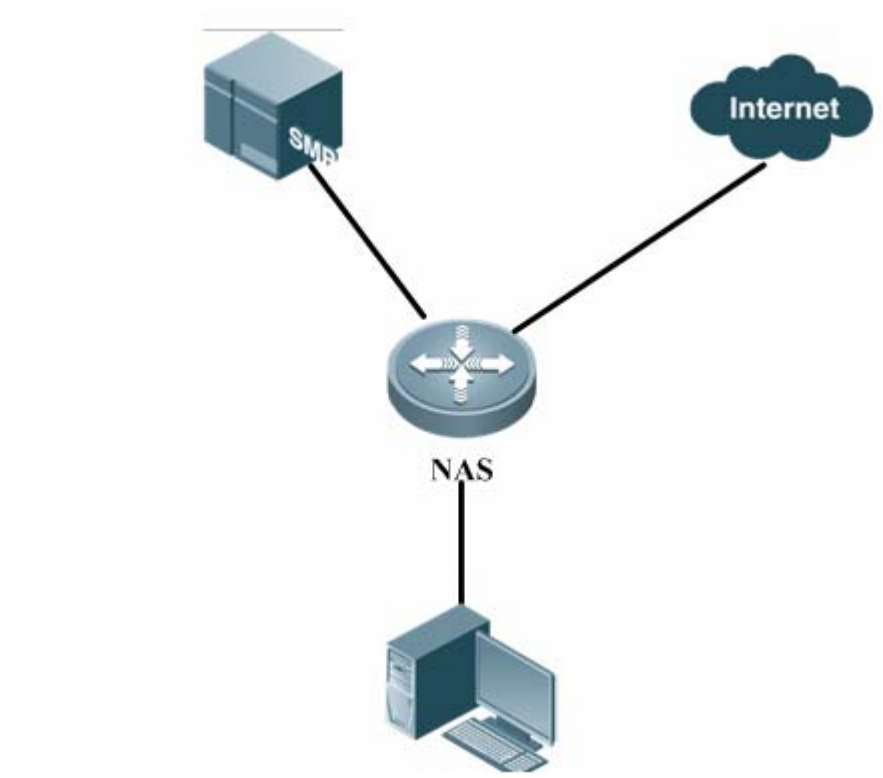
Networking Requirements

RADIUS dynamic authorization extension must work with the authentication mechanism. The network comprises SAM servers, Ruijie access devices, and PCs of users.

Ruijie access devices must support RADIUS dynamic authorization extension.

Networking Topology

Figure 4-1 Network topology of RADIUS dynamic authorization extension



Configuration Procedure

1. Configure AAA on the access authentication device.

```
aaa new-model
aaa accounting update periodic 1
aaa accounting update
aaa accounting network default start-stop group radius
aaa authentication ppp default local group radius
```

2. Configure the PPP authentication on the access device.

```
vpdn enable
vpdn-group 1
accept-dialin
protocol l2tp
  virtual-template 1

interface Virtual-Template 1
ppp authentication chap
 ip unnumbered Loopback 1
interface Loopback 1
 ip address 110.1.1.254 255.255.255.0
interface GigabitEthernet 8/1/1
```

```
ip address 100.1.1.2 255.255.255.0
duplex auto
     speed auto
```

3. Enable RADIUS dynamic authorization extension.

```
radius dynamic-authorization-extension enable
```

4. After the user logs in, the administrator uses RADIUS dynamic authorization extension on the SAM to log out the user.

5. The user is logged out and needs to be authenticated again to access the network.

RGOS Configuration Guide

V10.4(3b13)

Configuring Routing Protocol

Configuring Protocol-Independent

Configuring the IP Routing

Configuring Static Routes

Static routes are manually configured to send the packets to the specified target network. It is essential to configure the static routes when the routes of some target network cannot be learned by the dynamic routing protocols. Usually, a default static route is configured for the packets without the routes.

To configure static routes, execute the following commands in global configuration mode:

Command	Function
Ruijie(config)# **ip route** [**vrf** *vrf_name1*] *network mask* {*ip-address* | *interface-type interface-number* [*ip-address*]} [*distance*] [**tag** *tag*] [**permanent** | **track** *object-number*] [**weight** *weight*]	Configures the static routes. The vrf vrf-name1 parameter can be used to specify the VRF for the routes.
Ruijie(config)# **no ip route** [**vrf** *vrf_name1*] *network mask*	Deletes the static routes.
Ruijie(config)# **ip static route-limit** *number*	Specifies the upper limit of the static routes.
Ruijie(config)# **no ip static route-limit**	Restores the static routes to the default maximum values.

For examples of configuring the static routes, see the "Example of Replacing the Static Routes with the Dynamic Routes" section.

If the static routes are not deleted, they will be retained on Ruijie products permanently. However, you can replace the static routes with the better routes learned by the dynamic routing protocols. Better routes mean that they have smaller management distances. All routes, including the static ones, carry the parameters of the management distance. The following table shows the management distances for various route sources retained on Ruijie products:

Route source	Default management distance
Directly connected network	0
Static route	1
OSPF route	110
ISIS route	115
RIP route	120
Unreachable route	255

Note The static route redistribution shall be configured if the static routes require to be advertised by the dynamic routing protocols such as RIP and OSPF.

When an interface is "down", all routes to the interface disappear from the routing table. In addition, when Ruijie products fail to find the forwarding route to the next-hop address for a static route, the static route will also disappear from the routing table.

When the specified VRF static routes are added to the corresponding VRF, if the egress is specified at the same time, the addition fails when the VRF of the egress does not match the specified VRF. If no VRF is specified, it is added to the global routing table by default.

If the specified VRF is a multi-protocol VRF, the static route can be configured only for the multi-protocol VRF that is configured for the IPv4 address family. When the IPv4 address family of the VRF is deleted, the IPv4 static route of the VRF will also be deleted.

If the association of the static route with the track object is specified, and if the track object is advertised to be inactive, the static route also takes no effect.

By default, the weight of the static route is 1. To view the static route of non-default weights, execute the command **show ip route weight**. The weight parameter is used to enable the WCMP function. When there are load-balanced routes to a destination address, the switch assigns data flows by their weights. The higher the weight of a route is, the more data packets the route carries. The WCMP limit is generally 32 for routers. However, the WCMP limit varies depending on switch models because their chipsets support different weights. For the detailed information about the route weight value of specific models, see the product specifications. When the sum of the load-balanced route weights exceeds the WCMP limit, the excessive routes will not take effect. For example, if the WCMP limit on a device is 8, only one of the following static route configurations takes effect:

```
Ruijie(config)#ip route 10.0.0.0 255.0.0.0 172.0.1.2 weight 6
Ruijie(config)#ip route 10.0.0.0 255.0.0.0 172.0.1.4 weight 6
Ruijie(config)#show ip route 10.0.0.0

Routing entry for 10.0.0.0/8
  Distance 1, metric 0
  Routing Descriptor Blocks:
  *172.0.1.2, generated by "static"
Ruijie(config)#show ip route weight

------------[distance/metric/weight]-----------
S    10.0.0.0/8 [1/0/6] via 172.0.1.2
```

The maximum number of the static routes is 1024 by default. If the number of the configured static routes exceeds the specified upper limit, they are not be automatically deleted, but the addition fails.

To view the configurations of the IP routing, execute the **show ip route** command to view the IP routing table. For details, see Protocol-independent Command Configuration.

Configuring the Default Route

Not all devices have a complete network-wide routing table. To allow every device to route and forward all packets, it is a common practice that the powerful core device on the network is provided with a complete routing table, while the other devices have a default route to this core device. Default routes can be transmitted by the dynamic routing protocols, and can also be manually configured on every router.

Default routes can be generated in two ways: 1) manually configuring a default static route. For details, see the "Configuring Static Routes" section; 2) manually configuring a default network.

Most internal gateway routing protocols have a mechanism that transmits the default route to the entire routing domain. The device that transmits the default route must have a default route. The transmission of the default route described in this section applies only to the RIP routing protocol. The RIP always notifies the 0.0.0.0/0 network as the default route to the RIP routing domain. For details about how the OSPF routing protocols generate and transmit the default route, see related sections in Guide on Configuring the OSPF Routing Protocols.

For generating the default static route, execute the following commands in global configuration mode:

Command	Function
Ruijie(config)# **ip default-network** network	Configures the default network.
Ruijie(config)# **no ip default-network** network	Deletes the default network.

Note

Generating the default route by using the **default-network** command must meet the following requirement: The default network is not a directly-connected interface network, but is reachable in the routing table.

Note

Under the same condition, the RIP can also transmit the default route. Alternatively, the RIP can use another way to transmit the default route, that is, by configuring the default static route or learning the 0.0.0.0/0 route by other routing protocols.

If the router has a default route, whether it is learned by the dynamic routing protocol or manually configured, when you execute the show ip route command, the "gateway of last resort" area in the routing table will show information about the last gateway. A routing table may have multiple routes as alternative default routes, but only the best default route is presented in the "gateway of last resort" area.

Configuring the Number of Equivalent Routes

To enable the load-balancing function, configure the number of the equivalent routes for control. An equivalent route is an alternative path to the same destination address. When there is only one equivalent route, one destination address can be configured with only one route, then the load-balancing function is disabled.

To configure the number of the equivalent routes, execute the following command in global configuration mode. Use the no form of this command to restore the default number of the equivalent routes.

This command is valid for both the IPv4 and the IPv6. That is to say, after configuring this command, the maximum numbers of the equivalent paths to the IPv4 and IPv6 destinations are the same as the configured value.

Command	Function

Ruijie(config)# **maximum-paths** *number*	Configures the number of the equivalent routes. The maximum number of the equivalent routes configured on different products varies. The maximum number of the equivalent routes configured on routers is 32. However, this number varies depending on the chipsets for switches. Therefore, see the prompts during the configuration.

Configuring the Route-Map

The route-map is a collection of filter policies that are independent from the detailed routing protocols and used in the routing protocols and the policy-based routing. The route-map is used to filter and modify the routing information in the routing protocols, and control the packet forwarding in the policy-based routing.

To define the route-map, execute the following commands in global configuration mode:

Command	Function
Ruijie(config)# **route-map** *route-map-name* [[**permit** | **deny**] *sequence*]	Defines the route-map.
Ruijie(config)# **no route-map** *route-map-name* [{**permit** | **deny**} *sequence*]	Deletes the route-map.

When configuring the rules for a route-map, you can execute one or more **match** or **set** commands. If there is no **match** command, all routes are matched. If there is no **set** command, no operation is performed.

To define the matching conditions for the rules, execute the following commands in route-map configuration mode:

Command	Function
Ruijie(config-route-map)# **match community** {*standard-list-number* | *expanded-list-number* | *community-list-name*} [**exac-match**]…	Matches the community attribute of the BGP route.
Ruijie(config-route-map)# **match interface** [*interface-type interface-number*…]	Matches the next-hop interface of the route.
Ruijie(config-route-map)# **match ip address** *access-list-number* [*access-list-number*…]	Matches the IP address in the ACL.
Ruijie(config-route-map)# **match ip next-hop** *access-list-number* [*access-list-number*…]	Matches the next-hop IP address in the ACL.
Ruijie(config-route-map)# **match ip route-source** *access-list-number* [*access-list-number*…]	Matches the route source IP address in the ACL.
Ruijie(config-route-map)# **match ipv6 address** { *access-list-name* | **prefix-list** *prefix-list-name* }	Matches the IPv6 ACL or prefix list.
Ruijie(config-route-map)# **match ipv6 next-hop** { *access-list-name* | **prefix-list** *prefix-list-name* }	Matches the next-hop IP address in the ACL or prefix list.
Ruijie(config-route-map)# **match ipv6 route-source** { *access-list-name* | **prefix-list** *prefix-list-name* }	Matches the route source IP address in the ACL or prefix list.
Ruijie(config-route-map)# **match metric** *Metric*	Matches the route metric value. The metric value is in the range from 0 to 4294967295.

Ruijie(config-route-map)# **match origin** {**egp** | **igp** | **incomplete**}	Matches the route origin type.
Ruijie(config-route-map)# **match route-type** {**local** | **internal** | {{**external** | **nssa-external**} [**type-1**][**type-2**]} | [**level-1** | **level-2**]}	Matches the route type.
Ruijie(config-route-map)# **match tag tag**	Matches the route tag value. The tag value is in the range from 0 to 4294967295.

To define operations after matching, execute the following commands in route-map configuration mode:

Command	Function
Ruijie(config-route-map)# **set aggregator as** *as-num ip_addr*	Sets the AS attribute value for the route aggregator.
Ruijie(config-route-map)# **set as-path prepend** *as-number*	Sets the AS_PATH attribute value.
Ruijie(config-route-map)# **set comm-list** *community-list-number* | *community-list-name delete*	Deletes all COMMUNITY attribute values in the COMMUNITY_LIST.
Ruijie(config-route-map)# **set community** {*community-number*[*community-number*…] **additive** | **none**}	Sets the COMMUNITY attribute value.
Ruijie(config-route-map)# **set dampening** *half-life reuse suppress max-suppress-time*	Sets the route dampening parameters.
Ruijie(config-route-map)#**set extcommunity** {**rt** *extend-community-value* | **soo** *extend-community-value*}	Sets the extended community attribute value.
Ruijie(config-route-map)# **set interface** *interface-type interface-number*	Sets the interface for forwarding packets.
Ruijie(config-route-map)# **set ip default next-hop** *ip-address* [*weight*] [*ip-address* [*weight*] …]	Sets the default next-hop IP address.
Ruijie(config-route-map)# **set ipv6 default next-hop** *global-ipv6-address* [*weight*] [*global-ipv6-address* [*weight*]...]	Sets the default next-hop IPv6 address.
Ruijie(config-route-map)# **set ip next-hop** *ip-address* [*weight*] [*ip-address* [*weight*]…]	Sets the next-hop IP address.
Ruijie(config-route-map)# **set ipv6** [**vrf** *vrf-name* | **global**] **next-hop** *global-ipv6-address* [*weight*] [*global-ipv6-address* [*weight*]]	Sets the next-hop IPv6 address. If the **vrf** *vrf-name* parameter is specified, the VRF is crossed when packets are forwarded. If the **global** parameter is specified, packets are forwarded globally from the VRF. If the [**vrf** *vrf-name* | **global**] parameter is not specified, the IPv6 packets will inherit the VRF during transmission. That is, the next hop belongs to the VRF that receives the IPv6 packets.
Ruijie(config-route-map)# **set level** {**stub-area** | **backbone** | **level-1** | **level-1-2** | **level-2**}	Sets the routing area.
Ruijie(config-route-map)# **set local-preference** *number*	Sets the LOCAL_PREFERENCE value.
Ruijie(config-route-map)# **set metric** *metric*	Sets the metric value for the redistributed route.

Ruijie(config-route-map)# **set metric** [+ *metric-value* |- *metric-value* | *metric-value*]	Sets the metric type for the redistributed route.
Ruijie(config-route-map)# **set metric-type** {**type-1** | **type-2** | **external** | **internal**}	Sets the metric type for the redistributed route.
Ruijie(config-route-map)# **set next-hop** *next-hop*	Sets the next-hop IP address for the redistributed route. next-hop: indicates the next-hop IP address.
Ruijie(config-route-map)# **set origin** {**egp** | **igp** | **incomplete**}	Sets the route origin attribute.
Ruijie(config-route-map)#**set originator-id** *ip-addr*	Sets the route originator ID.
Ruijie(config-route-map)# **set tag** *tag*	Sets the tag value for the redistributed route.
Ruijie(config-route-map)# **set weight** *number*	Sets the BGP route weight.

Whether a route-map supports the **match** command and the **set** command depends on applications associated with the route-map. The general instructions are as follows:

- When you configure commands associated with a route-map, the system displays a prompt when the configured match command or the set command is inapplicable to the current applications associated with the route-map.
- When you configure a route-map, the match command, or the set command, the system displays a prompt when any match command or set command is inapplicable to any application associated with the route-map.

For examples of displaying the prompt when the command is not applicable, see the "*Example of Route-Map Configuration*" section.


Caution The two instructions are inapplicable to the association of the policy-based routing with the route-map.

Redistributing Routes

Configuring Route Redistribution

To enable the device to run multiple routing protocol processes, Ruijie products provide the function for redistributing the route information from one routing process to another routing process. For example, you can redistribute the routes in the OSPF routing area to the RIP routing area, and vice versa. All IP routing protocols support the mutual route redistribution.

For route redistribution, route-maps are usually used to control the mutual route redistribution between two routing areas

To redistribute routes from one routing area to another and control the route redistribution, execute the following commands in routing process configuration mode:

Command	Function
Ruijie(config-router)# **redistribute** *protocol* [*process-id*] [metric *metric*] [**metric-type** *metric-type*] [**match internal** | **external** *type*| **nssa-external** *type*] [[**tag** *tag*] [**route-map** *route-map-name*] [**subnets**]	Redistributes the routes. Protocol (protocol type): bgp, connected, isis, rip, static

Ruijie(config-router)# **default-metric** *metric*	Sets default metric values for all redistributed routes.

The route redistribution may easily cause loops, so be careful when performing the operation.

Note

When the route redistribution is configured in the OSPF routing process, the metric value of 20 is allocated to the redistributed routes with the type of Type-2 by default. This type of the routes is the least credible routes to the OSPF.

Configuring Default Route Distribution

To advertise the default route, it is necessary for the routing protocol to introduce the default route to the process, or enforce to generate a default route.

To configure the default route distribution, execute the following commands in routing process configuration mode:

Command	Function
Ruijie(config-router)# **default-information originate** [**always**] [**metric** *metric*] [**metric-type** *type*] [**route-map** *map-name*]	Introduces the default route to the routing protocol process and advertises the default route. **always** (optional): always introduces a default route to the process no matter whether the default route exists in the local routing table. **metric** (optional): sets the metric value for the introduced default route. **metric-type** (optional): sets the metric type for the introduced default route. **route-map** (optional): filters and sets the introduced default route.
Ruijie(config-router)# no default-information originate [always] [metric metric] [metric-type type] [route-map map-name]	Cancels the operation for introducing the default route to the routing protocol process and advertising the default route.

Configuring Route Filtering

The route filtering is the process to control the inbound/outbound routes so that the device only learns the necessary and predictable routes, and only advertises the necessary and predictable routes to external trusted devices. The divulgence and chaos of the routes may affect the running of the network. Therefore, it is essential to configure the route filtering, especially for telecom operators and on financial service networks.

Controlling Route Updating Advertising

To prevent other routers on a local network from learning unnecessary information, you can control the route updating advertisement to prevent the specified route from updating.

To prevent the route updating advertisement, execute the following commands in routing process configuration mode:

Command	Function
Ruijie(config-router)# **distribute-list** {[*access-list-number* | *access-list-name*] **prefix** *prefix-list-name*} **out** [*interface-type interface-number*| *protocol*]	According to the ACL rules, permits or denies some routes. **prefix**: This keyword specifies the prefix list for filtering the routes. The prefix list should be separately configured by using the ip prefix-list command.
Ruijie(config-router)# **no distribute-list** {[*access-list-number* | *access-list-name*] **prefix** *prefix-list-name*} **out** [*interface-type interface-number*| *protocol*]	Cancels the operation for preventing the route updating advertising.

When you configure the OSPF, you cannot specify the interface. This feature is only applicable to the external routes in the OSPF routing area.

Controlling the Process of Route Updating

To avoid processing some specified routes of the inbound route updating packets, you can configure this feature, which does not apply to the OSPF routing protocols.

To control the route updating processing, execute the following commands in routing process configuration mode:

Command	Function
Ruijie(config-router)# **distribute-list** {[*access-list-number* | *access-list-name*] | **prefix** *prefix-list-name* [**gateway** *prefix-list-name*]| **gateway** *prefix-list-name*} **in** [*interface-type interface-number*]	According to the ACL rules, permits or denies receiving the specified inbound routes. **prefix**: This keyword specifies the prefix list for filtering the routes. The prefix list should be separately configured by using the ip prefix-list command. **gateway**: Uses the prefix list to filter the inbound routes according to the route sources.
Ruijie(config-router)# **no distribute-list** {[*access-list-number* | *access-list-name*] | **prefix** *prefix-list-name* [**gateway** *prefix-list-name*]| **gateway** *prefix-list-name*} **in** [*interface-type interface-number*]	Cancels the operation for controlling the process of the route updating.

Configuring Fast Reroute

When a link or router fails, the packets that need to forwarded through this link or router will be lost or a loop will be generated to cause service suspension. This problem can be avoided by configuring the router with the static fast reroute function.

Please refer to *Configuring OSPF* for OSPF fast rerouting configuration details.

Run the following commands to enable a static fast reroute in global configuration mode.

Command	Function
Ruijie(config)# route-map fast-reroute	Enters the route map configuration mode.
Ruijie(config-route-map)# set fast-reroute backup-nexthop GigabitEthernet 0/1 192.168.1.2	Configures a backup interface and backup next hop of the fast reroute.
Ruijie(config-route-map)# exit	Returns to the global configuration mode.
Ruijie(config)# ip fast-reroute route-map fast-reroute	Configures a static fast reroute.

Configuring the Key Chain

The key chain is used to manage authentication keys, assign key IDs, and specify the authentication string and the lifetime in the sending and receiving directions. Each key is identified and stored using a unique ID.

To manage the authentication keys, run the following commands in global configuration mode.

Command	Function
Ruijie(config)# **key chain** *key-chain-name*	Configures the key chain.
Ruijie(config-keychain)# **key** *key-id*	Configures the key ID.
Ruijie(config-keychain-key)# **key-string** [**0**|**7**] *text*	Configures the authentication string.
Ruijie(config-keychain-key)# **accept-lifetime** *start-time* {**infinite** | *end-time* | **duration** *seconds*}	Configures the lifetime in the receiving direction.
Ruijie(config-keychain-key)# **send-lifetime** *start-time* {**infinite** | *end-time* | **duration** *seconds*}	Configures the lifetime in the sending direction.
Ruijie(config-keychain-key)# **end**	Exits key chain configuration mode.
Ruijie# **show key chain**	Shows configuration information about key chains.

Configuration Examples

Example of Route-Map Configuration

The route-map can be configured very flexibly and applies to the route redistribution and the policy-based routing configuration. No matter how the route-map is used, the configuration principle is the same, except that different command sets are used. Even if the route-map is used for the route redistribution, different routing protocols can use different commands.

The following examples show that the RIP routes are redistributed based on the OSPF routing protocols. It is required that only the RIP routes whose hops are 4 be redistributed. The type of these routes is the external route type-1, the default metric value is 40, and the route tag is set to 40 in the OSPF routing area.

Configure the OSPF.

```
Ruijie(config)# router ospf 1
Ruijie(config-router)# redistribute rip subnets route-map redrip
Ruijie(config-router)# network 192.168.12.0 0.0.0.255 area 0
```

Configure the access control list.

```
Ruijie(config)# access-list 10 permit 200.168.23.0 0.0.0.255
```

Configure the route-map.

```
Ruijie(config)# route-map redrip permit 10
Ruijie(config-route-map)# match metric 4
Ruijie(config-route-map)# set metric 40
Ruijie(config-route-map)# set metric-type type-1
Ruijie(config-route-map)# set tag 40
```

The following examples show that the OSPF routes are redistributed based on the RIP routing protocols. It is required that only the OSPF routes whose tag is 10 be redistributed. The default metric value of these routes is set to 10.

Configure the RIP.

```
Ruijie(config)# router rip
Ruijie(config-router)# version 2
Ruijie(config-router)# redistribute ospf 1 route-map redospf
Ruijie(config-router)# network 200.168.23.0
```

Configure the route-map.

```
Ruijie(config)# route-map redospf permit 10
Ruijie(config-route-map)# match tag 10
Ruijie(config-route-map)# set metric 10
```

The following examples show that the OSPF routes are redistributed based on the RIP routing protocols. Since rules that are not supported in the route-map application have been configured, when the route redistribution is associated with the route-map, a prompt displays indicating that the application does not support the rules.

Configure the route-map.

```
Ruijie(config)# route-map redrip permit 10
Ruijie(config-route-map)# match length 1 3
Ruijie(config-route-map)# match route-type external
Ruijie(config-route-map)# set level backbone
```

Configure the OSPF.

```
Ruijie(config)# router ospf 1
Ruijie(config-router)# redistribute rip subnets route-map redrip
% ospf redistribute rip not support match length
```

```
% ospf redistribute rip not support match route-type
% ospf redistribute rip not support set level backbone
```

Example of the Static Route Redistribution

- Configuration Requirements

A device exchanges route information with other devices through the RIP. In addition, there are three static routes that require the route redistribution based on the RIP. The RIP only allows to advertise two routes 172.16.1.0/24 and 192.168.1.0/24.

- Specific Configurations of the Routers

This is a common configuration example in practice for route filtering according to the distribution list. Note that the metric value is not specified for the routes to be redistributed. Since a static route is redistributed, the RIP automatically assigns the metric value. During the RIP configuration, the version must be specified and the route aggregation must be disabled because the access list allows the 172.16.1.0/24 route. To advertise the route externally, the RIP protocol must first support the classless route, and the route cannot be aggregated to the 172.16.0.0/16 network.

Configure the static route.

```
Ruijie(config)# ip route 172.16.1.0 255.255.255.0 172.200.1.2
Ruijie(config)# ip route 192.168.1.0 255.255.255.0 172.200.1.2
Ruijie(config)# ip route 192.168.2.0 255.255.255.0 172.200.1.4
```

Configure the RIP.

```
Ruijie(config)# router rip
Ruijie(config-router)# version 2
Ruijie(config-router)# redistribute static
Ruijie(config-router)# network 192.168.34.0
Ruijie(config-router)# distribute-list 10 out static
Ruijie(config-router)# no auto-summary
```

Configure the extended ACL.

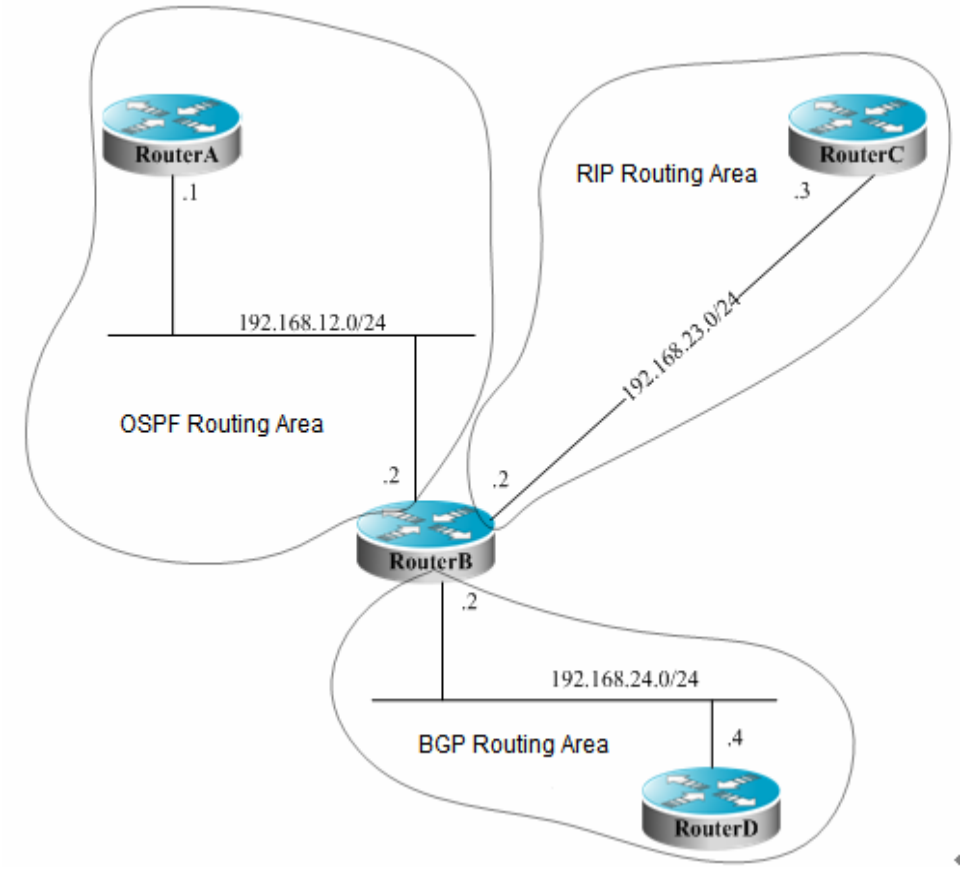
```
Ruijie(config)# ip access-list extended EXT_ACL
Ruijie(config-ext-nacl)#10 permit ip 192.168.1.0 0.0.0.255
any
Ruijie(config-ext-nacl)#10 permit ip 172.16.1.0 0.0.0.255 any
```

Example of Dynamic Routing Protocol Redistribution

- Configuration Requirements

The connection among four routers is shown in Figure 1. Router A belongs to the OSPF routing area. Router C belongs to the RIP routing area. Router D belongs to the BGP routing area. Router B is connected to the three routing areas. Router A advertises the two routes 192.168.10.0/24 and 192.168.100.1/32. Router C advertises the two routes 200.168.3.0/24 and 200.168.30.0/24. Router D advertises the two routes 192.168.4.0/24 and 192.168.40.0/24.

Figure 1 Dynamic routing protocol redistribution



On Router B, the OSPF redistributes the RIP routes with the route type of Type-1, redistributes the BGP routes whose community attribute is 11:11 in the BGP routing area. The RIP redistributes the 192.168.10.0/24 route whose metric value is set to 3 in the OSPF routing area, and advertises a default route to the RIP routing area.

■ Specific Configurations of the Routers

When the routing protocols redistribute the routes among each other, the simple route filtering can be controlled by using the distribution list. However, different attributes must be set for different routes, which cannot be implemented by using the distribution list. In this case, a route-map must be used for control. The route-map provides more control functions than the distribution list, but the router configuration is more complex. Therefore, do not use the route-map if possible. The following examples use the route-map to match the community attribute of the BGP routes.

Configurations of Router A:

Configure the network interface.

```
Ruijie(config)# interface gigabitEthernet 0/0
Ruijie(config-if)# ip address 192.168.10.1 255.255.255.0
Ruijie(config)# interface loopback 1
Ruijie(config-if)# ip address 192.168.100.1 255.255.255.255
Ruijie(config-if)# no ip directed-broadcast
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if)# ip address 192.168.12.1 255.255.255.0
```

Configure the OSPF.

```
Ruijie(config)# router ospf 12
Ruijie(config-router)# network 192.168.10.0 0.0.0.255 area 0
```

```
Ruijie(config-router)# network 192.168.12.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.168.100.0 0.0.0.255 area 0
```

Configurations of Router B:

Configure the network interface.

```
Ruijie(config)# interface gigabitEthernet 0/0
Ruijie(config-if)# ip address 192.168.12.2 255.255.255.0
Ruijie(config)# interface Serial 1/0
Ruijie(config-if)# ip address 192.168.23.2 255.255.255.0
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if)# ip address 192.168.24.2 255.255.255.0
```

#Configure the OSPF and specify the redistribution route type.

```
Ruijie(config)# router ospf 12
Ruijie(config-router)# redistribute rip metric 100 metric-type 1 subnets
Ruijie(config-router)# redistribute bgp route-map ospfrm subnets
Ruijie(config-router)# network 192.168.12.0 0.0.0.255 area 0
```

#Configure the RIP and use the distribution list to filter the redistributed routes.

```
Ruijie(config)# router rip
Ruijie(config-router)# redistribute ospf 12 metric 3
Ruijie(config-router)# network 192.168.23.0
Ruijie(config-router)# distribute-list 10 out ospf
Ruijie(config-router)# default-information originate always
Ruijie(config-router)# no auto-summary
```

Configure the BGP.

```
Ruijie(config)# router bgp 2
Ruijie(config-router)# neighbor 192.168.24.4 remote-as 4
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 192.168.24.4 activate
Ruijie(config-router-af)# neighbor 192.168.24.4 send-community
```

Configure the route-map.

```
Ruijie(config)# route-map ospfrm
Ruijie(config-route-map)# match community cl_110
```

Define the access list.

```
Ruijie(config)# access-list 10 permit 192.168.10.0
```

Define the community list.

```
Ruijie(config)# ip community-list standard cl_110 permit 11:11
```

Configurations of Router C:

Configure the network interface.

```
Ruijie(config)# interface gigabitEthernet 0/0
Ruijie(config-if)# ip address 192.168.30.1 255.255.255.0
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if)# ip address 192.168.3.1 255.255.255.0
Ruijie(config)# interface serial 1/0
Ruijie(config-if)# ip address 192.168.23.3 255.255.255.0
```

Configure the RIP.

```
Ruijie(config)# router rip
Ruijie(config-router)# network 192.168.23.0
Ruijie(config-router)# network 192.168.3.0
Ruijie(config-router)# network 192.168.30.0
```

Configurations of Router D:

Configure the network interface.

```
Ruijie(config)# interface gigabitEthernet 0/0
Ruijie(config-if)# ip address 192.168.40.1 255.255.255.0
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if)# ip address 192.168.4.1 255.255.255.0
Ruijie(config)# interface serial 1/0
Ruijie(config-if)# ip address 192.168.24.4 255.255.255.0
```

Configure the BGP.

```
Ruijie(config)# router bgp 4
Ruijie(config-router)# neighbor 192.168.24.2 remote-as 2
Ruijie(config-router)# redistribute connected route-map bgprm
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 192.168.24.2 activate
Ruijie(config-router-af)# neighbor 192.168.24.2 send-community
```

Configure the route-map.

```
Ruijie(config)# route-map bgprm
Ruijie(config-route-map)# match community 22:22
```

The OSPF routes found on Router A:

```
O E1 192.168.30.0/24 [110/101] via 192.168.12.2, 00:04:07, FastEthernet0/1
O E1 192.168.3.0/24 [110/101] via 192.168.12.2, 00:04:07, FastEthernet0/1
```

The RIP routes found on Router C:

```
R    0.0.0.0/0 [120/1] via 192.168.23.2, 00:00:00, Serial1/0
R    192.168.10.0/24 [120/2] via 192.168.23.2, 00:00:00, Serial1/0
```

Example of Fast Reroute Configuration

- Configuration Requirements

Three routers A, B and C are connected with each other via static routes. It is required that when the link between B and C fails, the service will be fast removed to the link between A and C and reach B after passing through C and A.

- Specific Configurations

Router A:

Configure an Ethernet interface

```
Ruijie(config)interface GigabitEthernet 0/1
Ruijie(config-if)ip address 192.168.1.1 255.255.255.0
Ruijie(config-if)bfd interval 200 min_rx 200 multiplier 5
Ruijie(config)interface GigabitEthernet 0/2
Ruijie(config-if)ip address 192.168.2.1 255.255.255.0
Ruijie(config-if)bfd interval 200 min_rx 200 multiplier 5
```

Configure a static route

```
Ruijie(config)ip route 1.1.1.1 255.255.255.255 192.168.2.2
```

Router B:

Configure an Ethernet interface

```
Ruijie(config)interface GigabitEthernet 0/1
Ruijie(config-if)ip address 192.168.2.2 255.255.255.0
Ruijie(config-if)bfd interval 200 min_rx 200 multiplier 5
Ruijie(config)interface GigabitEthernet 0/2
Ruijie(config-if)ip address 192.168.3.1 255.255.255.0
Ruijie(config-if)bfd interval 200 min_rx 200 multiplier 5
Ruijie(config)interface loopback 1
Ruijie(config-if)ip address 1.1.1.1 255.255.255.255
```

Router C:

Configure an Ethernet interface

```
Ruijie(config)interface GigabitEthernet 0/1
Ruijie(config-if)ip address 192.168.1.2 255.255.255.0
Ruijie(config-if)bfd interval 200 min_rx 200 multiplier 5
Ruijie(config-if)carrier-delay 0
Ruijie(config)interface GigabitEthernet 0/2
Ruijie(config-if)ip address 192.168.3.2 255.255.255.0
Ruijie(config-if)bfd interval 200 min_rx 200 multiplier 5
Ruijie(config-if)carrier-delay 0
```

Configure a route map

```
Ruijie(config)access-list 1 permit host 1.1.1.1
Ruijie(config)route-map frr
Ruijie(config-route-map)match ip address 1
```

```
Ruijie(config-route-map)set fast-reroute backup-nexthop GigabitEthernet 0/1 192.168.1.1
```

Configure a static route and a fast reroute

```
Ruijie(config)ip fast-reroute route-map frr
Ruijie(config)ip route 1.1.1.1 255.255.255.255 192.168.3.1
```

Configuring Policy-based Routing

Understanding Policy-based Routing

Overview

Policy-based Routing offers a more flexible packet routing forwarding mechanism than destination address-based routing forwarding, which enables you to route IPv4/IPv6 packets by elements like source address, destination address, port number and packet length.

In general, user networks apply different bandwidths from different ISPs. Meanwhile, to ensure resources for important users in the same user environment, the system needs to selectively forward packets rather than forwarding packets by the general routing table. In this case, policy-based routing takes full advantages of ISP resources and satisfy these flexible and diversified applications.

IP/IPv6 policy-based routing takes effect only on the packets received on interfaces, without any control on the packets sent from interfaces. Applying policy-based routing on an interface will check all the packets received on the interface. The packets not matching any policy of the routing map are forwarded by the general routing table, but the ones matching some policy of the routing map are forwarded by the policy.

Generally, policy-based routing takes preference over general routing and forwards IP/IPv6 packets in accord with defined policies. In other words, packets are forwarded by IP/IPv6 policy-based routing. If no rule of the PBR is matched, the packets are forwarded by general routings. Certainly, users can configure policy-based routing with the priority lower than general routing. Namely, the packets received on an interface are forwarded by general routing or policy-based routing in cast of no matching.

Users can configure forwarding mode like load balance or redundant backup according to real circumstances. Load balance or redundant backup is enabled on more than one next hop. The proportion of load balance can be also set. In redundant backup mode, multiple next hops are applied, that is the previous next hop has priority to take effect and the latter one takes effect only when the previous one fails. You can configure multiple next hops at the same time.

Policy-based routing falls into two types:

Policy-based routing enabled for the IP packets received on an interface. It performs PBR only on packets received on the interface instead of controlling the packets sending from the interface.

Policy-based routing enabled for the IP packets that the local device sends out. It controls IP packets sent from the local device to other devices, not the packets sent from external devices to the local device.

Basic Concepts and Features

Application Process

To use the policy-based routing, you must create a routing map for it and then apply the routing map on the interface. A routing map consists of many policies with corresponding sequence. Smaller sequence means higher priority.

Each policy consists of one or more match statements and corresponding one or more set statements. The match statement defines the matching rule of IP/IPv6 packets, and the set statement defines the processing rules of matched

IP/IPv6 packets. In the course of policy-based routing, packets are matched by priorities in descending order. Once a policy is matched, the system performs corresponding actions and quits policy-based routing.

Policy-based routing for IPv4 packets uses standard or extended ACL as matching rule. Policy-based routing for IPv6 packets, however, uses extended ACL as matching rule. For IPv6 packets, only one match ipv6 address can be configured for a policy at most.

Routing Map Policy Matching Mode

When you configure the routing map, you can specify the match mode of a policy as permit or deny, which is described as below:

- Permit: Specify the matching mode as permit, that is to apply the corresponding set rule to the IPv4/v6 packets meeting the match rules of the policy. If no match rule is met, the system applies the next policy to packets.
- Deny: Specify the matching mode as deny, that is if IPv4/v6 packets meet all match statements; the system performs common routing rather than policy-based routing.

IP/IPv6 packets are matched by the priority of every policy of the routing map in descending order. Once a policy is matched, the system performs corresponding actions and quits policy-based routing. If the packets do not match any policy of the routing map, the system performs common routing.

Next Hop Rules

Policy-based routing offers two forwarding rules-set {ip | ipv6} next-hop and set {ip | ipv6} default next-hop, which set the next hop and the egress, respectively. These two rules are described as follows:

- set {ip | ipv6} next-hop: Configure the policy-based routing's next hop IPv4/IPv6 address, which takes precedence over common routes. The IPv4/v6 packets meeting the match rule received on the interface are first forwarded to the next hop specified by the set {ip | ipv6} next-hop command, no matter whether the real routing of the packets in the routing table and the next hop specified by the policy-based route is valid or not.
- set {ip | ipv6} default next-hop: The policy-based routing specified by this command is of the priority lower than common routes but higher than default route. For the packets meeting the match rule received on the interface, if routing in the routing table is failed or the default route is used, these packets will be forwarded to the next hop specified by this command.

The next hops specified by these two rules must be direct or otherwise the configuration does not take effect.

The priority is subject to the order of set {ip | ipv6} next-hop > network route/host route > set {ip | ipv6} default next-hop > default route. These two commands can be configured simultaneously, but only the one of higher priority takes effect.

Load Balancing Mode for Policy-based Routing Next Hop

More than one next hop can be configured in the sequence of a route map, and one of the following load balancing modes can be configured among them.

- Redundant backup: Only one next hop takes effect at a time if there are many next hops. Once the active next hop failed, another next hop will take over its works immediately.
  - When R1 of the active next hop fails, the system automatically hands over to R2 of the next next hop. When R1 recovers, the system will automatically hand over back to R1.
  - When there are many next hops in the order, for example, R1/R2/R3, R2 takes effect after you deleting and then adding R1 in the order of R2/R3/R1.

- Load balancing: Load balancing is enabled among next hops by traffic. This function is not available for the next hop in egress type.


Caution 1 Only one route map can be configured on a port. Configuring route maps repeatedly on a port will overlap the previous configurations, namely that the latest configuration takes effect.


Caution 2 Only one IPv6 ACL can be configured in the sequence of a route map in sub route map.


Caution 3 If the sub route map is configured with next hop but not ACL, all packets are matched; if the sub route map is configured with ACL but not next hop, the matched packets are forwarding by common routes; if the sub route map is not configured with ACL and next hop, all packets are forwarded by common routes.


Caution 4 The deny rule of ACE forwards packets by common routes. To meet the matching rule of policy-based routing, the deny any any command matches packets starting from the next IPv6 ACL


Caution 5 Enabling PBR will apply to incoming packets at the same time. If you do not need to apply PBR to a specific incoming IPv4/v6 packet, add “deny the specific IPv4/v6 address” in the ACL manually


Caution 6.In redundant backup mode, the IP packets matching the policy of the sub route map are forwarded to the next hop firstly resolved in the sequence. If all next hops are not resolved, the IP packets matching the policy are discarded. If the first next hop is resolved later, the IP packets matching the policy are forwarded to the first next hop.


Note For details on the next hop of PBR set actions, refer to Rns&track Configuration Guide and Rns&track Command Reference or Link Detection Configuration Guide and DLDP Command Reference (for routers). IPv6 PBR is not supported at present


Note For linkup of PBR and BFD, refer to BFD Configuration Guide and BFD Command Reference

Enabling Track Function

Track function can increase the insight of policy-based routing in the change of networks. When the device perceives that the next hop for forwarding failed, policy-based routing will rapidly hand the traffic over to the next valid next hop (in redundant backup mode) or all other valid next hops (in load balancing mode).

For track configuration, refer to Rns&track Configuration Guide. IPv6 PBR does not support linkup with track.

Enabling BFD Function

Linkup between policy-based routing and BFD avoids setting the policy-based routing as forwarding path when it is not reachable. If the backup forwarding path is available, the system rapidly hands over to this path.

VRF Selection using Policy-based Routing

The PBR implementation of the VRF selection feature allows the ports that apply PBR to filter the packets based on the matching rule. If the packet matches this rule, route selection is performed in the specified VRF. Matching rule is defined in an IP access list or based on packet length. Users can balance traffic on different VRF instances as required.

In general, the packets received on an interface of a VRF are routed and forwarded through this VRF. The packets received on an interface of the global routing table are routed and forward through the global routing table. VRF selection using policy based routing can remove this limit. This feature supports VRF successor route, the route across VRFs and the route from VRF to the global routing table. In VRF successor route mode, the packets received on an interface of a VRF are routed and forwarded by the routing table of this VRF. In route across VRFs mode, the packets received on an interface of a VRF are routed and forwarded by the routing table of another specified VRF. In route from VRF to the global routing table mode, the packets received on an interface of a VRF are routed and forwarded by the global routing table.

Version 10.4(3) introduces multi-protocol VRF, which supports VRF selection using IPv6 PBR. If a single-protocol IPv4 VRF is specified, it does not take effect on IPv6 PBR. When a multi-protocol VRF is specified, if it does not configure the IPv4 address family, the multi-protocol VRF does not take effect on IPv4 PBR. Similarly, if the multi-protocol VRF does not configure the IPv6 address family, it does not take effect on IPv6 PBR. If the multi-protocol VRF configures IPv4 and IPv6 address families concurrently, the rules of the set vrf command take effect on both IPv4 and IPv6 PBRs.

Working Principles

For policy-based routing, first of all, you need to define a route map used to specify the policy of packet forwarding. The route map consists of a set of statements with permit or deny action.

Secondly, define a set of set statements in the route map to forward and control packets in order. Each statement does not refer to the previous or latter statements.

Finally, apply the policy-based routing at the inbound direction. If the policy-based routing is applied at the outbound direction, packets are forwarded by common routes.

For routers, outgoing packets can be processed by the specific policy-based routing, not the common routing table.

Protocol Specifications

None

Default Configurations

The default configurations of policy-based routing are described as follows:

Function	Default value
Load balance of many next hops	Redundance (redundant backup mode)
Next hop WCMP weight	1

Configuring Policy-based Routing

The following sections configure the basic functions of IP/IPV6 PBR.

Configuring IPv4 Policy-based Routing

You must specify a route map for the policy-based routing and create the route map before applying the policy-based routing. A route map consists of many policies with corresponding sequences. The smaller the sequence, the higher the priority is. Each policy consists of one or more match statements and corresponding one or more set statements. The match statement defines the matching rule of IPv4/IPv6 packets, and the set statement defines the processing rules of matched IPv4/IPv6 packets. In the course of policy-based routing, packets are matched by priorities in descending order. Once a policy is matched, the system performs corresponding actions and quits policy-based routing.

There are two kinds of match statements; match length and match ip address. The former statement matches packets by packet length and the latter matches packets by ACL. For a policy, you can configure only one match length statement but many match ip address statements. If both statements are configured at the same time, the action specified by the set rule of the policy is executed only when the packets match both.

Similarly, there are two types of set statements. Type 1 modifies the QoS field of IP packet, including set ip tos, set ip precedence and set ip dscp. Type 2 controls IP packet, for example, set vrf, set ip nexthop, set ip default nexthop, set interface and set default interface. Once all match rules are met, Type 1 set statements must be executed and Type 2 set statements are executed by priority in the following order:

- set vrf: Set policy-based routing as the VRF instance for IP packet routing with the priority higher than common route. The command is mutually exclusive with the set ip [default] nexthop and set [default]interface command. The IPv4 packets received on the interface that meet match rules will be routed by the routing table of the VRF instance specified by this command, no matter whether the VRF is the same as the one the interface belongs to.
- set ip nexthop: Set next hop of policy-based routing with the priority higher than common route and the one set by the set interface command. This command takes precedence over one of the following three commands. The IPv4 packets received on the interface that meet match rules will be firstly forwarded to the next hop specified by the set ip nexthop command, no matter whether the real routing of IPv4 packets in the routing table is the same as the one specified by the policy-based routing.
- set interface: Set the egress of policy-based routing with the priority higher than common route. This command takes precedence over set default interface and set ip default nexthop. The IPv4 packets received on the interface that meet match rules will be firstly forwarded through the egress specified by the set interface command, no matter whether the real routing of IPv4 packets in the routing table is the same as the egress specified by the policy-based routing.
- set default interface: Set the default interface with the priority higher than default route and the one specified by the set ip default nexthop command but lower than common route. The IPv4 packets received on the interface that meet match rules will be forwarded through the interface specified by this command in case of routing failure or the default route is used.
- set ip default nexthop: Set the policy-based routing with the priority higher than the default route but lower than common route. The IPv4 packets received on the interface that meet match rules will be forwarded to the next hop specified by this command in case of routing failure or the default route is used.

When you configure the routing map, you can specify the match mode of a policy as permit or deny, which is described as below:

- Permit: Specify the matching mode as permit, that is to apply the corresponding set rule to the IPv4/v6 packets meeting all match rules of the policy. If not all match rules are met, the system applies the next policy of the routing map to match packets.
- Deny: Specify the matching mode as permit, that is if IPv4/v6 packets meet all match statements of this packet's node, the system performs common routing rather than policy-based routing.

IPv4/IPv6 packets are matched by the priority of every policy of the routing map in descending order. Once a policy is matched, the system performs corresponding actions and quits policy-based routing. If the packets do not match any policy of the routing map, the system performs common routing.

The next hop specified by the set ip nexthop command is used for forwarding only when its tracking object is active. Track function greatly increases the insight of policy-based routing in the change of network environments, enabling PBR to adapt to dynamic changed networking topologies.

To configure a policy-based routing, perform the following steps:

1 Define an ACL as the matching rule of IP packets.

Command	Function
Ruijie(config)# ip access-list {extended | standard} {id | name}	Defines an ACL as the matching rule of IP packets.

2 Define a route map, which consists of many policies in sequence order. When a policy is matched, the system quits the execution of the route map.

Use the following command in global configuration mode to define a route map.

Command	Function
Ruijie(config)# route-map route-map-name [permit | deny] sequence	Defines a route map.
Ruijie(config)# no route-map route-map-name {[permit | deny] sequence}	Deletes a route map.

3 Define the match rule of every policy of the route map.

Use the following command in route map configuration mode to define the match rule of a policy.

Command	Function
Ruijie(config-route-map)# match ip address {access-list-number | access-list-name}	Matches the address in the ACL.
Or : Ruijie(config-route-map)# match length min max	Matches packet length.

4 Define the action after meeting match rule.

Use the following command in route map configuration mode to define actions after rules are matched.

Command	Function

Ruijie(config-route-map)# set vrf name	Routes the packets matching PBR by the routing table of the specific VRF instance.
Ruijie(config-route-map)# set ip next-hop ip-address [weight][ip-address[weight]]	Sets the next hop IP address of packets.
Ruijie(config-route-map)# set interface intf_name	Sets the egress of packets.
Ruijie(config-route-map)# set ip default next-hop ip-address[weight] [ip-address[weight]]	Sets the next hop IP address for the packets without route.
Ruijie(config-route-map)# set default interface intf_name	Sets the default egress of IP packets.
Ruijie(config-route-map)# set ip precedence	Modifies the priority of IP packet.
Ruijie(config-route-map)# set ip tos	Modifies the ToS value of IP packet.
Ruijie(config-route-map)# set ip dscp	Modifies the DSCP value of IP packet.


Caution The set vrf, set ip [default] nexthop and set [default] interface commands cannot be configured concurrently for a policy. But the set vrf command can be configured with other set statements. The VRF must exist when you configure the VRF of policy-based routing otherwise the system prompts configuration failure.


Caution The set ip dscp, set ip tos and set ip precedence commands cannot be configured concurrently for a policy or otherwise the corresponding domains of IP packet may be different from the expectation


Caution The priorities of the set vrf, set ip nexthop, and set interface commands take precedence over that of common routes. IP packets matching policy-based routing are forwarded by policy-based routing, but the IP packets not matching the policy-based routing are forwarded by common routes.


Caution The set default ip nexthop and set default interface commands are lower than common route in terms of priority. IP packets are routed and forwarded by policy-based routing only after common route failed

For details on route map configuration, refer to Protocol-independent Configuration Commands.

1 Apply the route map on the specified interface.

Use the following command in interface configuration mode to apply the policy-based routing on the specified interface.

Command	Function
Ruijie(config-if)# ip policy route-map name	Applies policy-based routing on the interface.
Ruijie(config-if)# no ip policy route-map	Removes the configuration.

2. Apply the policy-based routing to the packets sent locally.

Command	Function
Ruijie(config)# ip local policy route-map [name]	Applies the policy-based routing to the packets sent locally.
Ruijie(config)# no ip local policy route-map	Removes the configuration.

For example:

Configure policy-based routing on Fastethernet 0/0 so that all incoming packets are forwarded to the device whose next hop is 192.168.5.5.

```
Ruijie(config)# access-list 1 permit any
Ruijie(config)# route-map name
Ruijie(config-route-map)# match ip address 1
Ruijie(config-route-map)# set ip next-hop 192.168.5.5
Ruijie(config-route-map)# int fastethernet 0/0
Ruijie(config-if)# ip policy route-map name
```

3 Configure load balancing mode for policy-based routing

In redundant backup mode, the policy-based routing will automatically hand over the next valid next hop when the active next hop fails. In load balancing mode, on contrary, the traffic will be balanced on other valid next hop when the active next hop fails.

Use the following command in global configuration mode to configure load balance or redundant backup:

Command	**Function**
Ruijie(config)# ip policy {load-balance | redundance}	Configures load balance or redundant backup for policy-based routing forwarding.
Ruijie(config)# no ip policy	Removes the configuration.


Caution In load balancing mode, Weighted Cost Multiple Path (WCMP) supports up to 4 next hops and Equal Cost Multiple Path (ECMP) supports up to 32 next hops.


Caution In load balancing mode, Weighted Cost Multiple Path (WCMP) supports up to 4 next hops and Equal Cost Multiple Path (ECMP) supports up to 32 next hops.


Caution For default policy-based routing, Weighted Cost Multiple Path (WCMP) supports up to 4 next hops and Equal Cost Multiple Path (ECMP) supports up to 32 next hops.

Caution

In redundant backup mode, the first resolved next hop takes effect. If all next hops are not resolved, the packets matching policy-based routing are dropped. If the originally unresolved next hop of higher priority than active next hop is resolved, the system hands over to this next hop.

Configuring IPv6 Policy-based Routing

Command	Function
Ruijie#configure terminal	Enters global configuration mode.
Ruijie(config)#ipv6 access-list access-list-name	Creates an IPv6 ACL.
Ruijie (config)#route-map route-map-name [permit | deny] sequence	Creates a route map.
Ruijie (config-route-map)#match ipv6 address access-list-name	Matches the IPv6 address in ACL.
Ruijie (config-route-map)#set ipv6 [vrf vrf-name | global] next-hop global-ipv6-address [weight][global-ipv6-address [weight]] [global-ipv6-address...]	Sets the next hop IPv6 address of packets. The [vrf vrf-name | global] parameter is supported since version 10.4(3), that is, cross VRFs and from VRF to global modes are supported. If the vrf vrf-name parameter is specified, the next hop belongs to the VRF, while if the global parameter is specified, the next hop belongs to the global. Note that the specified VRF must be a multi-protocol VRF whose IPv6 address family has been configured. VRF will be inherited when forwarding IPv6 packets if the set ipv6 next-hop command is configured. The next hop belongs to the VRF that receive the IPv6 packets and forward them internally.
Or: Ruijie (config-route-map)#set ipv6 default next-hop global-ipv6-address [weight][global-ipv6-address [weight]] [global-ipv6-address...]	Specifies the next hop IPv6 address for the packets without obvious routes in the routing table.
Ruijie (config)#interface interface-type interface-number	Enters the interface require applying PBR.
Ruijie (config-if- interface-type interface-number)#ipv6 policy route-map route-map-name	Applies policy-based routing on the interface.
Or: Ruijie (config-if- interface-type interface-number)#no pv6 policy route-map	Removes the policy-based routing applied on the interface.
Ruijie#show ipv6 policy	Shows the configuration of policy-based routing.

Or: Ruijie#show route-map	Shows the configuration of route map.

For route map configuration, refer to *Configuring Protocol-independent*.

Configuring Load Balancing Mode

Command	Function
Ruijie#configure terminal	Enters global configuration mode.
Ruijie(config)#Ipv6 policy [load-balance | redundance]	Configures load balance mode.
Ruijie(config)#no Ipv6 policy	Restores the setting to the default value.

Displaying Configuration and States

Command	Function
Ruijie#**show** { **ip** | **ipv6** } **policy**	Shows the configuration of policy-based routing.
Ruijie#**show route-map**	Shows the configuration of route map.
Ruijie#**show access-lists**	Shows the configuration of ACL.

Typical Configuration Examples

Example 1: Source address based PBR

Networking Requirements

There are two egresses of a LAN connecting to the Internet. In general, load balance and backup should be enabled for these two egresses. All streams from subnet 1 to the Internet are transmitted through GigabitEthernet 0/1 and all streams from subnet 2 to the Internet are transmitted through GigabitEthernet 0/2. If GigabitEthernet 0/1 is disconnected, the data streams on this interface should be transferred to GigabitEthernet 0/2, and vice versa.

Networking Topology

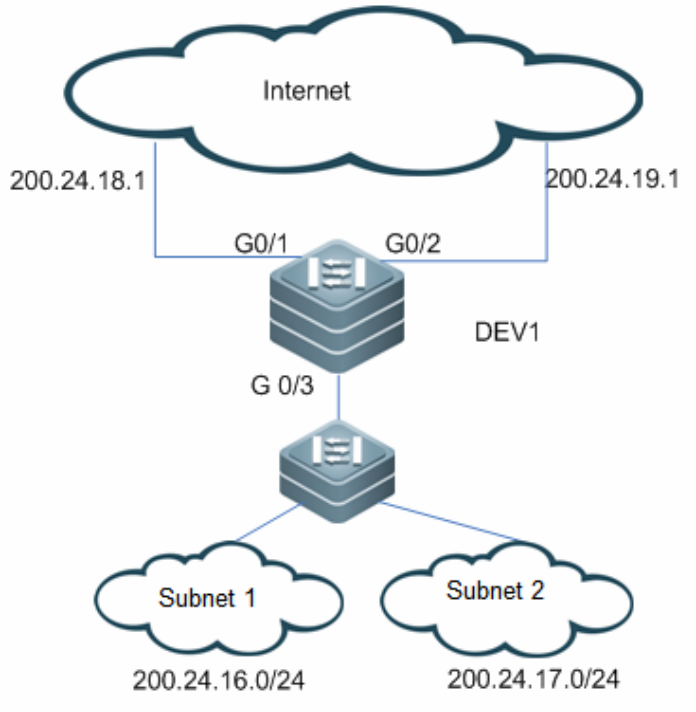


Figure 1 Network topology

As shown in the Figure-1, Layer-3 device DEV1 connects to subnets 1 and 2 through G0/3, and connects to the Internet through G0/1 and G0/2 with the next hop of 200.24.18.1 and 200.24.19.1, respectively. Subnet 1's segment is 200.24.16.0/24 and subnet 2's segment is 200.24.17.0/24.

Configuration Steps

Create ACLs for subnet 1 and subnet 2, respectively.

```
Ruijie(config)#access-list 1 permit 200.24.16.0 0.0.0.255
Ruijie(config)#access-list 2 permit 200.24.17.0 0.0.0.255
```

Configure a route map used to control data streams of subnet 1. Set the next hop of G0/1 prefer.

```
Ruijie(config)#route-map RM_FOR_PBR 10
Ruijie(config-route-map)#match ip address 1
Ruijie(config-route-map)#set ip nexthop 200.24.18.1
Ruijie(config-route-map)#set ip nexthop 200.24.19.1
```

Configure a route map used to control data streams of subnet 2. Set the next hop of G0/2 prefer.

```
Ruijie(config)#route-map RM_FOR_PBR 20
Ruijie(config-route-map)#match ip address 2
Ruijie(config-route-map)#set ip nexthop 200.24.19.1
Ruijie(config-route-map)#set ip nexthop 200.24.18.1
```

Configure redundant backup.

```
Ruijie(config)#ip policy redundance
```

Apply policy-based routing on GigabitEthernet 0/3.

```
Ruijie(config)#interface GigabitEthernet 0/3
Ruijie(config-if)#ip policy route-map RM_FOR_PBR
```

Example 2: Enabling Track function.

Networking Requirements

There are two egresses on a LAN connecting to the Internet. In general, load balance and backup should be enabled for these two egresses. All streams from subnet 1 to the Internet are transmitted through GigabitEthernet 0/1 and all streams from subnet 2 to the Internet are transmitted through GigabitEthernet 0/2. If the next hop 200.24.18.1 fails, the data streams on this interface should be transferred to GigabitEthernet 0/2, and vice versa.

Networking Topology

As shown in Figure 1.

Configuration steps

Track the egress GigabitEthernet 0/1's next hop 200.24.18.1.

```
Ruijie(config)#ip rns 1
Ruijie(config-ip-rns)#icmp-echo 200.24.18.1
Ruijie(config)#track 1 rns 1
```

Track the egress GigabitEthernet 0/2's next hop 200.24.19.1.

```
Ruijie(config)#ip rns 2
Ruijie(config-ip-rns)#icmp-echo 200.24.19.1
Ruijie(config)#track 2 rns 2
```

Enable the routing map to use this track object..

```
Ruijie(config)#route-map RM_FOR_PBR 10
Ruijie(config-route-map)#match ip address 1
Ruijie(config-route-map)#set ip nexthop verify-availability 200.24.18.1 track 1
Ruijie(config-route-map)#set ip nexthop verify-availability 200.24.19.1 track 2
```

Configure a route map used to control data streams of subnet 2. Set the next hop of G0/2 prefer.

```
Ruijie(config)#route-map RM_FOR_PBR 20
Ruijie(config-route-map)#match ip address 1
```

```
Ruijie(config-route-map)#set ip nexthop verify-availability 200.24.19.1 track 2
Ruijie(config-route-map)#set ip nexthop verify-availability 200.24.18.1 track 1
```

Configure redundant backup.

```
Ruijie(config)#ip policy redundance
```

Apply policy-based routing on GigabitEthernet 0/3.

```
Ruijie(config)#interface GigabitEthernet 0/3
Ruijie(config-if)#ip policy route-map RM_FOR_PBR
```

Example 3: Configuring VRF selection using PBR

Networking Requirements

A provider edge (PE) requires applying policy-based routing to the packets received from FastEthernet 0/1. It routes the IP packets from subnet 1 by VRF1, the IP packets from subnet 2 by VRF2, and the IP packets from subnet 3 by VRF3. Other packets are routed in the public network.

Configuration steps

Create VRF instances.

```
Ruijie(config)#ip vrf VRF1
Ruijie(config)#ip vrf VRF2
Ruijie(config)#ip vrf VRF3
```

Create ACLs as matching rules of the routing map.

```
Ruijie(config)#access-list 1 permit 192.168.195.0 0.0.0.255
Ruijie(config)#access-list 2 permit 192.168.196.0 0.0.0.255
Ruijie(config)#access-list 3 permit 192.168.197.0 0.0.0.255
```

Create route maps.

```
Ruijie(config)#route-map PBR-VRF-Selection permit 10
Ruijie(config-route-map)#match ip address 1
Ruijie(config-route-map)#set vrf VRF1

Ruijie(config)#route-map PBR-VRF-Selection permit 20
Ruijie(config-route-map)#match ip address 2
Ruijie(config-route-map)#set vrf VRF2

Ruijie(config)#route-map PBR-VRF-Selection permit 30
Ruijie(config-route-map)#match ip address 3
```

```
Ruijie(config-route-map)#set vrf VRF3
```

Import IP address of the interface to VRFs 1 to 3.

```
Ruijie(config)#interface FastEthernet 0/1
Ruijie(config-if)#ip address 192.168.195.1 255.255.255.0
Ruijie(config-if)#ip vrf receive VRF1
Ruijie(config-if)#ip vrf receive VRF2
Ruijie(config-if)#ip vrf receive VRF3
```

Apply the policy-based routing on the interface.

```
Ruijie(config)#interface FastEthernet 0/1
Ruijie(config-if)#ip policy route-map PBR-VRF-Selection
```

The configurations are as follows if the single protocol IPv4 VRF is replaced with a multi-protocol VRF:

Create a VRF instance.

```
Ruijie(config)#vrf definition VRF1
Ruijie(config-vrf)#address-family ipv4
Ruijie(config-vrf-af)#exit-address-family
Ruijie(config-vrf)#vrf definition VRF2
Ruijie(config-vrf)#address-family ipv4
Ruijie(config-vrf-af)#exit-address-family
Ruijie(config-vrf)#vrf definition VRF3
Ruijie(config-vrf)#address-family ipv4
Ruijie(config-vrf-af)#exit-address-family
Ruijie(config-vrf)#exit
```

Configure an ACL as the matching rule of the routing map.

```
Ruijie(config)#access-list 1 permit 192.168.195.0 0.0.0.255
Ruijie(config)#access-list 2 permit 192.168.196.0 0.0.0.255
Ruijie(config)#access-list 3 permit 192.168.197.0 0.0.0.255
```

Configure the routing map.

```
Ruijie(config)#route-map PBR-VRF-Selection permit 10
Ruijie(config-route-map)#match ip address 1
Ruijie(config-route-map)#set vrf VRF1

Ruijie(config)#route-map PBR-VRF-Selection permit 20
Ruijie(config-route-map)#match ip address 2
```

```
Ruijie(config-route-map)#set vrf VRF2

Ruijie(config)#route-map PBR-VRF-Selection permit 30
Ruijie(config-route-map)#match ip address 3
Ruijie(config-route-map)#set vrf VRF3
```

Import IP address of the interface to VRFs 1 to 3.

```
Ruijie(config)#interface FastEthernet 0/1
Ruijie(config-if)#ip address 192.168.195.1 255.255.255.0
Ruijie(config-if)#vrf receive VRF1
Ruijie(config-if)#vrf receive VRF2
Ruijie(config-if)#vrf receive VRF3
```

Apply the policy-based routing to the interface.

```
Ruijie(config)#interface FastEthernet 0/1
Ruijie(config-if)#ip policy route-map PBR-VRF-Selection
```

Example 4: Appling IPv6 policy-based routing on the interface

Networking Requirements

There are two egresses on a LAN connecting to the Internet. In general, load balance and backup should be enabled for these two egresses.

Specific requirements are as follows:

- All streams from subnet 1 to the Internet are transmitted through GigabitEthernet 0/1.
- All streams from subnet 2 to the Internet are transmitted through GigabitEthernet 0/2.
- If GigabitEthernet 0/1 is disconnected, the data streams on this interface should be transferred to GigabitEthernet 0/2, and vice versa.

Networking Topology

As shown in Figure 2, Lay-3 device Device1 connects to subnets 1 and 2 through G0/3 (routed port), and connects to the Internet through G0/1 and G0/2 with the next hop of 2001::1/64 and 2002::1/64 respectively. Subnet 1’s segment is 2003::/64 and subnet 2’s segment is 2004::/64.

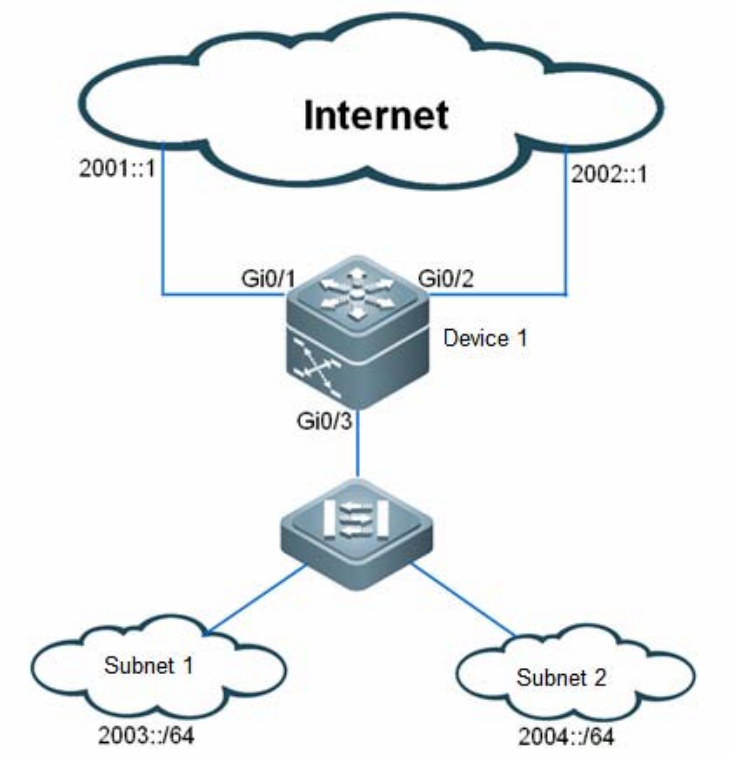


Figure 2 IPV6 PBR topology

Configuration Tips

Configuration Steps

Create ACLs for subnet 1 and subnet 2 respectively.

```
Ruijie(config)#ipv6 access-list net1
Ruijie(config-ipv6-acl)#permit ipv6 2003::/64 any
Ruijie(config)#ipv6 access-list net2
Ruijie(config-ipv6-acl)#permit ipv6 2004::/64 any
```

Configure a route map used to control data streams of subnet 1. Set the next hop of G0/1 prefer.

```
Ruijie(config)#route-map RM_FOR_PBR 10
Ruijie(config-route-map)#match ipv6 address net1
Ruijie(config-route-map)#set ipv6 next-hop 2001::1
Ruijie(config-route-map)#set ipv6 next-hop 2002::1
```

Configure a route map used to control data streams of subnet 2. Set the next hop of G0/2 prefer.

```
Ruijie(config)#route-map RM_FOR_PBR 20
Ruijie(config-route-map)#match ipv6 address net2
Ruijie(config-route-map)#set ipv6 next-hop 2002::1
Ruijie(config-route-map)#set ipv6 next-hop 2001::1
```

Configure redundant backup.

```
Ruijie(config)#ipv6 policy redundance
```

Apply the policy-based routing on the interface GigabitEthernet 0/3.

```
Ruijie(config)#interface GigabitEthernet 0/3
Ruijie(config-if-GigabitEthernet 0/3)#ipv6 policy route-map RM_FOR_PBR
```

Verification

Show the configuration of route map.

```
Ruijie#show route-map
route-map RM_FOR_PBR, permit, sequence 10
  Match clauses:
    ipv6 address net1
  Set clauses:
    ipv6 next-hop 2001::1 2002::1
route-map RM_FOR_PBR, permit, sequence 20
  Match clauses:
    ipv6 address net2
  Set clauses:
ipv6 next-hop 2002::1 2001::1
```

Show the configuration of IPv6 policy-based routing.

```
Ruijie#show ipv6 policy
Interface                          Route map
GigabitEthernet 0/3                 RM_FOR_PBR
```

Show the configuration of ACL.

```
Ruijie#show access-lists
ipv6 access-list net1
 10 permit ipv6 2003::/64 any
 (0 packets matched)
ipv6 access-list net2
 10 permit ipv6 2004::/64 any
 (0 packets matched)
```

Example 5: Configuring IPv4/IPv6 PBRs Concurrently

Networking Requirements

There are two egresses on a LAN connecting to the Internet, one of which is the egress of education network. In general, load balance and backup should be enabled for these two egresses.

Specific requirements are as follows:

- IPv4/IPv6 dual stacks are used in the networks. IPv4 and IPv6 PBRs should be enabled on an interface at the same time.
- All streams from the IPv4 education network of subnet 1 to the Internet are transmitted through the egress of education network.
- All streams from the IPv4 education network of subnet 2 to the Internet are transmitted through the egress of the Internet.
- All streams from the IPv6 education network of subnet 1 to the Internet are transmitted through GigabitEthernet 0/1.
- All streams from the IPv6 education network of subnet 2 to the Internet are transmitted through GigabitEthernet 0/2.
- Internal interactive data, for example, the data from subnet 1 to subnet 2, is transmitted using the internal dynamic route rather than policy-based routing.
- By default, data streams are transmitted through the egress of the Internet by the default route.
- If GigabitEthernet 0/1 fails, the data streams on the interface are switched over to GigabitEthernet 0/2, and vice versa.

Networking Topology

As shown in Figure 3, Device 1 connects to subnets 1 and 2 through G0/3 (routed port), and connects to the Internet through G0/1 and G0/2 with the next hop of 2001::1/64 (210.82.12.1) and 2002::1/64 (59.78.184.1) respectively. Subnet 1's segment is 2003::/64 (202.112.144.0/25) and subnet 2's segment is 2004::/64(218.62.95.0/24).

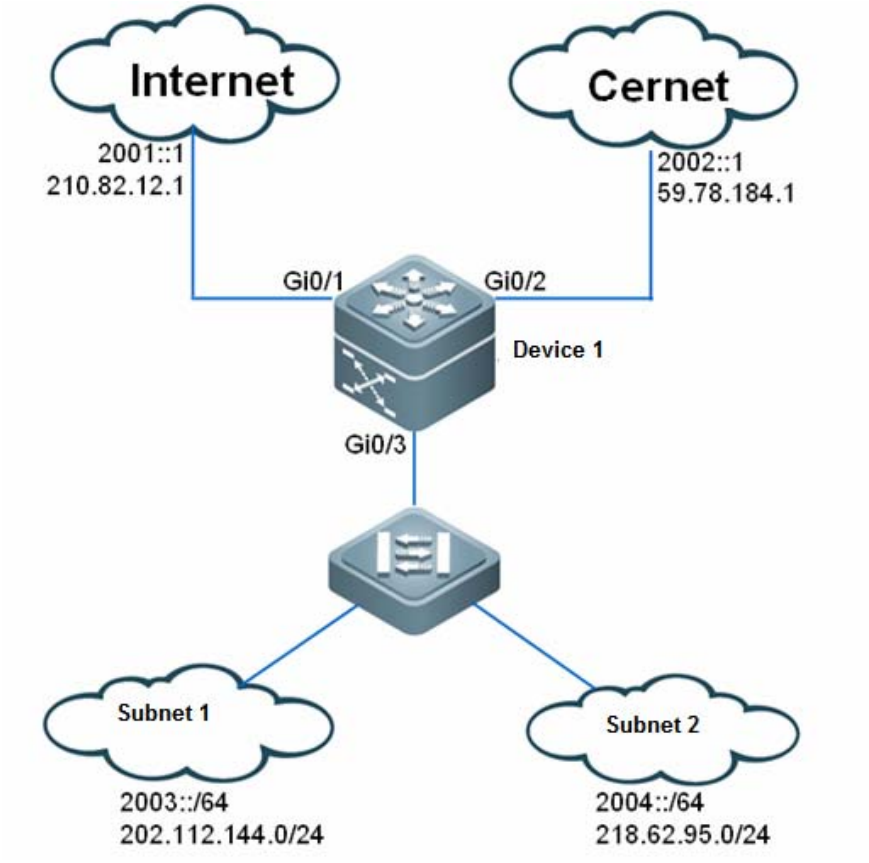


Figure 3 IPv4/IPv6 PBR topology

Configuration Tips

Configuration Steps

Create IPv4 ACLs for subnet 1 and subnet 2, respectively.

```
Ruijie(config)#ip access-list extended 101
Ruijie(config-ip-acl)#permit ip 202.112.144.0 0.0.0.255 any
Ruijie(config)#ip access-list extended 102
Ruijie(config-ip-acl)#permit ip 218.62.95.0 0.0.0.255 any
```

Create IPv6 ACLs for subnet 1 and subnet 2, respectively.

```
Ruijie(config)#ipv6 access-list net1
Ruijie(config-ipv6-acl)#permit ipv6 2003::/64 any
Ruijie(config)#ipv6 access-list net2
Ruijie(config-ipv6-acl)#permit ipv6 2004::/64 any
```

Configure a route map used to control data streams of subnet 1. Set the next hop of G0/1 prefer. The default parameter is included in attributes of the IPv4 next hop.

```
Ruijie(config)#route-map RM_FOR_PBR 10
Ruijie(config-route-map)#match ip address 101
Ruijie(config-route-map)#set ip default next-hop 59.78.184.1
Ruijie(config-route-map)#set ip default next-hop 210.82.12.1

Ruijie(config-route-map)#match ipv6 address net1
Ruijie(config-route-map)#set ipv6 next-hop 2001::1
Ruijie(config-route-map)#set ipv6 next-hop 2002::1
```

Configure a route map used to control data streams of subnet 2. Set the next hop of G0/2 prefer. The default parameter is included in attributes of the IPv4 next hop.

```
Ruijie(config)#route-map RM_FOR_PBR 20
Ruijie(config-route-map)#match ip address 102
Ruijie(config-route-map)#set ip default next-hop 210.82.12.1
Ruijie(config-route-map)#set ip default next-hop 59.78.184.1

Ruijie(config)#route-map RM_FOR_PBR 20
Ruijie(config-route-map)#match ipv6 address net2
Ruijie(config-route-map)#set ipv6 next-hop 2002::1
Ruijie(config-route-map)#set ipv6 next-hop 2001::1
```

Configure redundant backup.

```
Ruijie(config)#ipv6 policy redundance
```

Apply the IPv4/IPv6 policy-based routing on the interface GigabitEthernet 0/3.

```
Ruijie(config)#interface GigabitEthernet 0/3
Ruijie(config-if-GigabitEthernet 0/3)#ip policy route-map RM_FOR_PBR
Ruijie(config-if-GigabitEthernet 0/3)#ipv6 policy route-map RM_FOR_PBR
```

Verification

Show the configuration of the route map.

```
Ruijie#show route-map
route-map RM_FOR_PBR, permit, sequence 10
  Match clauses:
    ip address 101
    ipv6 address net1
  Set clauses:
    ipv6 next-hop 2001::1 2002::1
    ip default next-hop 59.78.184.1 210.82.12.1
route-map RM_FOR_PBR, permit, sequence 20
  Match clauses:
    ip address  102
    ipv6 address net2
  Set clauses:
    ipv6 next-hop 2002::1 2001::1
    ip default next-hop 210.82.12.1 59.78.184.1
```

Show the application of IPv6 policy-based routing.

```
Ruijie#show ipv6 policy
Interface                          Route map
GigabitEthernet 0/3                 RM_FOR_PBR
```

Show the application of IPv4 policy-based routing.

```
Ruijie#show ip policy
Interface                          Route map
GigabitEthernet 0/3                 RM_FOR_PBR
```

Show the configuration of ACLs.

```
Ruijie#show access-lists
Extended IP access list 101
    10 permit ip 202.112.144.0 0.0.0.255 any
Extended IP access list 102
    10 permit ip 218.62.95.0 0.0.0.255 any
```

```
IPv6 access list net1
   permit ipv6 2003::/64 any sequence 10
IPv6 access list net2
   permit ipv6 2004::/64 any sequence 10
```

Example 6: VRF election using IPv6 PBR

Networking Requirements

A provider edge (PE) requires applying policy-based routing to the packets received from FastEthernet 0/1. It routes the IP packets from subnet 1 by VRF1, the IP packets from subnet 2 by VRF2, and the IP packets from subnet 3 by VRF3. Other packets are routed in the public network.

Configuration Steps

Create a VRF instance.

```
Ruijie(config)#vrf definition VRF1
Ruijie(config-vrf)#address-family ipv6
Ruijie(config-vrf-af)#exit-address-family
Ruijie(config-vrf)#vrf definition VRF2
Ruijie(config-vrf)#address-family ipv6
Ruijie(config-vrf-af)#exit-address-family
Ruijie(config-vrf)#vrf definition VRF3
Ruijie(config-vrf)#address-family ipv6
Ruijie(config-vrf-af)#exit-address-family
Ruijie(config-vrf)#exit
```

Configure an ACL as the matching rule of the routing map.

```
Ruijie(config)#ipv6 access-list acl1
Ruijie(config-ipv6-acl)#permit ipv6 1000::/64 any
Ruijie(config-ipv6-acl)#ipv6 access-list acl2
Ruijie(config-ipv6-acl)#permit ipv6 2000::/64 any
Ruijie(config-ipv6-acl)#ipv6 access-list acl3
Ruijie(config-ipv6-acl)#permit ipv6 3000::/64 any
```

Configure the routing map.

```
Ruijie(config-ipv6-acl)#route-map PBR-VRF-Selection permit 10
Ruijie(config-route-map)#match ipv6 address acl1
Ruijie(config-route-map)#set vrf VRF1

Ruijie(config)#route-map PBR-VRF-Selection permit 20
Ruijie(config-route-map)#match ipv6 address acl2
Ruijie(config-route-map)#set vrf VRF2
```

```
Ruijie(config)#route-map PBR-VRF-Selection permit 30
Ruijie(config-route-map)#match ipv6 address acl3
Ruijie(config-route-map)#set vrf VRF3
```

Import IPv6 address of the interface to VRFs 1 to 3.

```
Ruijie(config)#interface FastEthernet 0/1
Ruijie(config-if)#ipv6 address 1000::1/64
Ruijie(config-if)#vrf receive VRF1
Ruijie(config-if)#vrf receive VRF2
Ruijie(config-if)#vrf receive VRF3
```

Apply the IPv6 PBR to the interface.

```
Ruijie(config)#interface FastEthernet 0/1
Ruijie(config-if)#ipv6 policy route-map PBR-VRF-Selection
```

Configuring RIP

Overview

The Routing Information Protocol (RIP) is a relatively old routing protocol, which is widely used in small or homogeneous networks. The RIP uses the distance-vector algorithm, and so is a distance-vector protocol. The RIPv1 is defined in RFC 1058 and the RIPv2 is defined in RFC 2453. Ruijie RGOS supports both two versions.

The RIP exchanges the routing information by using UDP packets with UDP port number 520. Usually, RIPv1 packets are broadcast packets, while RIPv2 packets are multicast packets with the multicast address of 224.0.0.9. The RIP sends an update packet at the interval of 30 seconds. If a device fails to receive the route update packets from the peer within 180 seconds, it will mark all the routes from the device unreachable. After that, the device will delete these routes from its routing table if it still fails to receive any update packets within 120s.

The RIP measures the distance to the destination in hop, known as route metric. In the RIP, zero hop exists when the device directly connects to the network. One hop exists when the destination is reachable through one device and so on. If the destination is unreachable, the hop count is 16.

The RIP-enabled device can learn the default routes from the neighbors or generate its own default route. When any of the following conditions is met, Ruijie products will introduce the default route and advertise it to its neighbor devices by using the **default-information originate** command:

- IP Default-network is configured.
- Other RIPs learn the default routes or are configured with static default routes.

The RIP will send update packets to a specified network interface. If the network is not associated with the RIP routing progress, the interface will not advertise any update packets. The RIP is available in two versions: RIPv1 and RIPv2. The RIPv2 supports plain-text authentication, MD5 cryptographic text authentication, and variable length subnet masks.

Ruijie RIP offers Split Horizon to avoid a loop.

Configuring RIP

The RIP configuration task list contains:

- Create the RIP routing process (mandatory).
- Configure RIP packets in unicast mode (optional).
- Configure Split Horizon (optional).
- Define the RIP Version (optional).
- Configure the Route Aggregation function(optional).
- Configure RIP Authentication.
- Adjust the RIP clock (optional).
- Configure the RIP Route Source Address Validation (optional).
- Control RIP interface status (optional).
- Advertise the default route through the RIP interface (optional).
- Advertise the supernet route through the RIP interface (optional).

- Configure RIP VRF (optional).
- Configure RIP BFD (optional).
- Configure RIP triggered expansion (optional).
- Configure RIP graceful restart (GR) (optional).

For the following topics, see the "IP Routing Protocol Independent Feature Configuration" chapter.

- Filter RIP route information
- Redistribute routes
- Configure default route distribution

The following table describes the default configuration of RIP.

Feature	Default Setting
Network interface	After an interface joins the RIP, it receives RIPv1 and RIPv2 packets and advertises RIPv1 packets by default. By default, when advertising RIPv1 packets: ■ The interface sends the packets in broadcast mode. ■ The interface does not advertise supernet routes. By default, when advertising RIPv2 packets: ■ The interface sends the packets in multicast mode. ■ The interface automatically converges routes into classified routes. ■ The interface advertises supernet routes. The interface enables split horizon.
RIP neighbor	Undefined
Verification of the source IP address of a packet	Enabled
Timer	By default: ■ The update time is 30 seconds. ■ The expiry time is 180 seconds. ■ The clearing time is 120 seconds.
Offset list	Undefined
Automatic convergence	Enabled
Redistribution	By default, routing redistribution is disabled. If it is enabled: ■ Redistribute OSPF, that is, redistribute all sub-type routes of this instance. ■ Redistribute ISIS, that is, redistribute level-2 sub-type routes of this instance. ■ In other cases, redistribute all routes of this type. ■ The metric value for route distribution is the default one.
Default route distribution	By default, default route distribution is disabled. If it is enabled: the metric value for route distribution is the default one.
Default metric	Redistribute metric values used by routes of other protocols. The default value is 1.
Administrative distance	120

Feature	Default Setting
RIP triggered expansion	By default, RIP triggered expansion is disabled. If it is enabled: The default interval is 5 seconds for retransmitting update request and update response packets. By default, a maximum of 36 times are allowed for retransmitting update request and update response packets.
RIP GR	By default, RIP GR is disabled. The default RIP GR period is the smaller value between twice the update time and 60 seconds.

Creating the RIP Routing Process

To run RIP for a device, create the RIP routing process and define networks associated with the RIP routing process.

Use the following commands to create the RIP routing process in global configuration mode.

Command	Function
Ruijie(config)# **router rip**	Creates the RIP routing process.
Ruijie(config-router)# **network** *network-number wildcard*	Defines associated networks.

You can configure the *network-number* and *wildcard* parameters at the same time to enable the network segments of the interface IP address within the IP address range to run RIP.

If the *wildcard* parameter is not configured, by default, RGOS will enable the network segments of the interface IP address within the classified IP address range to run RIP.


Note There are two meanings for associated networks defined by the network command:


Note The RIP only advertises the route information of associated networks.


Note The RIP only advertises and receives route update messages through the interfaces of associated networks.

Configuring RIP Packets in Unicast Mode

The RIP is usually a broadcast or multicast protocol. If the RIP route information needs to be transmitted through non-broadcast networks, a device needs to be configured to support that the RIP advertises route information update packets in unicast mode.

Use the following commands to advertise RIP information update messages in unicast mode in RIP routing process configuration mode.

Command	Function
Ruijie(conf-router)# neighbor ip-address	Configures RIP packet advertising in unicast mode.

This command enables you to control an interface about whether to advertise RIP route update packets and forbid advertising route update packets in broadcast mode through an interface. You need to configure the **passive-interface** command in routing progress configuration mode. For related descriptions on the restriction of route message advertisements, see the "Route Filtering Configuration" of *Configuring Protocol Independent*.

Note

During the configuration of FR and X.25, if the broadcast keyword is specified for IP address mapping, the neighbor command is not required because the command is mainly used for reducing broadcast packets and filtering routes.

Configuring Split Horizon

Split horizon can be used to avoid loop when multiple devices running distance-vectortype routing protocols connect to a network in which IP packets are broadcasted. Split horizon can prevent devices from advertising certain route information through an interface from which the devices learn such information. This optimizes route information exchange among multiple devices.

However, split horizon may cause the failure of some device to learn all the route information in a non-broadcast multi-access network (frame relay or X.25). In this case, you may need to disable split horizon. If an interface is configured with the secondary IP address, you need to pay attention to split horizon.

If the **poisoned-reverse** parameter is configured, split horizon with poisoned reverse is enabled. The device will advertise the route information from the interface where it learns the information, and configure the metric value of the route information as unreachable.

Use the following commands to enable or disable split horizon in interface configuration mode.

Command	Function
Ruijie(config-if)# **no ip split-horizon**	Disables split horizon.
Ruijie(config-if)# **ip split-horizon**	Enables split horizon.

Use the following commands to enable or disable split horizon with poisoned reverse in interface configuration mode.

Command	Function
Ruijie(config-if)# **no ip rip split-horizon poisoned-reverse**	Disable split horizon with poisoned reverse.
Ruijie(config-if)# **ip rip split-horizon poisoned-reverse**	Enable split horizon with poisoned reverse.

By default, all interfaces are configured as enabling split horizon without poisoned reverse.

Defining the RIP Version

Ruijie products support RIP version 1 and version 2, where RIPv2 supports authentication, key management, route convergence, CIDR, and VLSMs. For the information about key management and VLSMs, see the "*IP Routing Protocol Independent Feature Configuration*" chapter.

By default, Ruijie products can receive RIPv1 and RIPv2 packets, but they can send only RIPv1 packets. You can configure them to receive and send only RIPv1 or RIPv2 packets.

Use the following command to enable software to receive and send only the packets of a specific version in routing process configuration mode.

Command	Function
Ruijie(config-router)# **version** {**1** | **2**}	Defines the RIP version.

The above command allows the software to receive or send only the packets of a specific version by default. If necessary, you can modify the default setting of each interface.

Use the following commands to enable an interface to send only the packets of a specific version in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip rip send version 1**	Specifies to send only RIPv1 packets.
Ruijie(config-if)# **ip rip send version 2**	Specifies to send only RIPv2 packets.
Ruijie(config-if)# **ip rip send version 1 2**	Specifies to send only RIPv1 and RIPv2 packets.

Use the following commands to configure an interface to receive only the packets of a specific version in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip rip receive version 1**	Specifies to receive only RIPv1 packets.
Ruijie(config-if)# **ip rip receive version 2**	Specifies to receive only RIPv2 packets.
Ruijie(config-if)# **ip rip receive version 1 2**	Specifies to receive only RIPv1 and RIPv2 packets.

Configuring Route Convergence

Automatic RIP route convergence means that the routes of subnets are automatically converged into the routes of a classful network when they pass through the border of the classful network. By default, RIPv2 will automatically perform route convergence, while the RIPv1 does not support this function.

The automatic route convergence function of the RIPv2 improves the scalability and effectiveness of the network. If there are any converged routes, the sub-routes contained in them cannot be seen in the routing table. This greatly reduces the size of the routing table.

It is more efficient to advertise converged routes than the separated routes. Factors are as follows:

- Converged routes will be handled first when you search the RIP database.
- Any sub-routes will be ignored when you search the RIP database, and thus reducing the handling time.

Sometimes, you want to learn the specific sub-net routes rather than the converged network routes. In this case, you need to disable the automatic route convergence function.

Use the following commands to configure automatic route convergence in RIP routing progress mode.

Command	Function
Ruijie(config-router)# **no auto-summary**	Disables automatic route convergence.
Ruijie(config-router)# **auto-summary**	Enables automatic route convergence.

Use the following commands to configure interface-level convergence in interface mode. Then, configure route convergence within the specified classified subnet range on an interface.

Command	Function

Command	Function
Ruijie(config-if)# **ip summary-address** *rip ip-address ip-network-mask*	Enables route convergence on the interface.
Ruijie(config-if)# **no ip summary-address** *rip ip-address ip-network-mask*	Disables route convergence on the interface.

Configuring RIP Authentication

RIPv1 does not support authentication. If a device is configured with the RIPv2, you can configure authentication on an appropriate interface.

RIPv2 for Ruijie products supports two RIP authentication modes: plain-text authentication and MD5 authentication. The default authentication mode is plain-text authentication.

In plain-text authentication mode, you can run the **ip rip authentication text-password** command to configure the plain-text authentication password or obtain the plain-text authentication password through an associated key chain. The latter takes precedence over the former.

In MD5 authenticaiton mode, you must implement MD5 authentication through an associated key chain.

For plain-text authentication, no authentication occurs if no plain-text authentication password or associated key chain is configured. Similarly, for MD5 authentication, no authentication occurs if no associated key chain is configured.

If a key chain is specified in interface configuration mode, you need to use the **key chain** command in global configuration mode to define the key chain. Otherwise, authentication of RIP data packets may fail.

Use the following commands to configure RIP authentication in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip rip authentication mode** {**text** | **md5**}	Uses the key chain, enables RIP authentication, and configures RIP authentication through the interface. text: indicates plain-text authentication. md5: indicates MD5 authentication.
Ruijie(config-if)# **ip rip authentication text-password** [**0**|**7**] *password-string*	Configures the plain-text authentication password in the length of 1 – 16 bytes. 0 Displays a key in plain text manner. 7 Displays a key in encrypted manner.
Ruijie(config-if)# **ip rip authentication key-chain** *key-chain-name*	Configures authentication using a key chain.

Configuring RIP Clock Adjustment

The RIP provides the clock adjustment function, which allows you to adjust a clock based on network conditions so that the RIP can run in a better way. You can adjust the following clocks:

Route update time: It defines the period in seconds for a device to send route update packets;

Route expiry time: It defines the time in seconds after which the routes in the routing table will become invalid if not updated;

Route clearing timer: It defines the time in seconds after which the routes in the routing table will be cleared;

By adjusting above clocks, the convergence and fault recovery of the routing protocol may be accelerated. Use the following command to adjust an RIP clock in RIP routing process configuration mode.

Command	Function
Ruijie(config-router)# **timers basic** *update invalid flush*	Adjusts the RIP clock.

By default, the update time is 30 seconds, the expiry time is 180 seconds, and the clearing time is 120 seconds.

Note For devices connected on the same network, the values of the RIP clocks must be the same.

Configuring Verification of the Source IP Address of an RIP Route

By default, the RIP will verify the source IP address of a received route update packet. The RIP will discard the packet if the source IP address is invalid. Judging whether the source IP address is valid, that is, judging whether the source IP address is in the same network as the IP address of the interface. No validation authentication will be performed on the interface of no numbered IP address.

Use the following commands to configure verification of route source IP address in RIP routing process configuration mode.

Command	Function
Ruijie(config-router)# **no validate-update-source**	Disables the source IP address validation.
Ruijie(config-router)# **validate-update-source**	Enables the source IP address validation.

Configuring Control of the RIP Interface Status

In some case, it is necessary to configure the RIP flexibly. If you only need to enable a device to learn RIP routes rather than advertising RIP routes, you can configure a passive interface. Or, if you need to configure the status of a certain interface individually, you can use a command to control the sending or receiving of the RIP packets on a specific interface.

Use the following commands to configure an interface as the passive interface in RIP route process configuration mode.

Command	Function
Ruijie(config-router)# **passive-interface** {**default** | *interface-type interface-num*}	Configures a passive interface.
Ruijie(config-router)#**no passive-interface** {**default** | *interface-type interface-num*}	Cancels the configuration.

Caution A passive interface responds the non-RIP requests (such as the route diagnosis program) rather than the RIP requests because these request programs hope to learn about the routes of all devices.

Use the following commands to disable or allow an interface to receive RIP packets in interface configuration mode.

Command	Function

Command	Function
Ruijie(config-if)# **no ip rip receive enable**	Forbids the interface to receive the RIP packets.
Ruijie(config-if)# **ip rip receive enable**	Allows the interface to receive the RIP packets.

Use the following commands to disable or allow an interface to send RIP packets in interface configuration mode.

Command	Function
Ruijie(config-if)# **no ip rip send enable**	Forbids the interface to send the RIP packets.
Ruijie(config-if)# **ip rip send enable**	Allows the interface to send the RIP packets.

Configuring Default Route Advertisement through an Interface

Use the following command to generate a default route (0.0.0.0/0) in the update packet through a specified interface in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip rip default-information originate** [**metric** *metric-value*]	Advertises the default route and other routes.
Ruijie(config-if)# **no ip rip default-information**	Cancels default route advertising through the interface.

In interface configuration mode, use the following commands to generate a default route (0.0.0.0/0) in the update route through a specified interface, and advertise only this default route instead of other RIP routes through this interface.

Command	Function
Ruijie(config-if)# **ip rip default-information only** [**metric** *metric-value*]	Advertises the default route only.
Ruijie(config-if)# **no ip rip default-information**	Cancels default route advertising through the interface.

If both the **ip rip default-information** command on the interface and the **default-information originate** command in the RIP progress are configured, only the default route configured on the interface is advertised.

Configuring Supernet Route Advertisement Through the RIP Interface

A supernet route (for example, 80.0.0.0/6) is defined when the mask length is less than its natural mask length. According to IP address classification, 80.0.0.0 belongs to class-A network and its natural mask legnth is 8. Therefore, 80.0.0.0/6 is a supernet route.

When an RIPv1-enabled device monitors RIPv2 route response packets, it will learn incorrect routes because RIPv1 ignores the subnet masks of the routes in the packets if information about the supernet routes is received. In this case, an RIPv2-enabled device needs to disable advertising super network route on its interface.

Use the following command to configure whether to advertise the supernet route through an interfacein interface configuration mode.

Command	Function
Ruijie(config-if)#**no ip rip send supernet-routes**	Disables advertising the supernet route through the interface.
Ruijie(config-if)# **ip rip send supernet-routes**	Enables advertising the supernetwork route through the interface.

Note

1. When only RIPv1 packets rather than RIPv2 packets are received through the interface, no supernet route is received.
2. Supernet routes can be received when RIPv2 packets are allowed to be received through the interface.
3. No supernet route is sent when RIPv1 packets are sent through the interface.
4. Supernet routes are permitted to be sent by default when RIPv2 packets are sent through the interface.
5. The **no rip rip send supernet-routes** command prohibits sending supernet routes.

The **auto-summary** command takes no effect for supernet routes, that is, supernet routes are not converged.

The **ip rip summary** command does not support configuration of supernet routes.

Configuring RIP VRF

The RIP supports VRFs. Multiple RIP instances can be created to manage the corresponding VRFs in the RIP process. By default, there is only one RIP instance in the RIP process, which is used to manage the global routing table. After a VRF is created, you can manage the routing table of the VRF by creating a new RIP instance.

Run the **address-family** command to enable a router device to enter the address family configuration mode (with the prompt (config-router-af)#). When you specify the VRF associated with the sub mode at the first time, the RIP will create a RIP instance corresponding to the VRF. Under this mode, you can configure the RIP instance of the VRF in the same way as that in global route configuration mode.

To exit the address family configuration sub mode and return to the route configuration mode, run the **exit-address-family** command.

Use the following commands to configure a RIP instance managng the VRF in RIP routing process configuration mode.

Command	Function
Ruijie(config-router)# **address-family ipv4 vrf** *vrf-name*	Creates the RIP instance managing the VRF.
Ruijie(config-router)#**no address-family ipv4 vrf** *vrf-name*	Removes the RIP instance managing the VRF.

Configuring RIP BFD

For details on RIP BFD configuration, see *BFD Configuration Guide*.

Configuring TRIP

Triggered RIP (TRIP) is a RIP extension on a wide area network(WAN), and is mainly used on the on-demand link.

When TRIP is enabled, RIP protocol will no longer periodically send route updates but only send route updates to WAN interfaces in the following cases:

- When route update request packets are received.
- When RIP routing information has changed.
- When interface state changes.
- When routers start.

Since the periodic RIP update is canceled, an acknowledgement and retransmission mechanism is required to guarantee successful update packet transmission and receiving on the WAN. RIP uses three new types of packets which are identified by the value of the command field in the RIP header:

- Update request (Type-9): requests the peer to send the routing information needed.
- Update response (Type-10): contains the route updates requested by the peer.
- Update Acknowledge (Type-11): acknowledges the received update responses, indicating that the route updates sent by peer have been received.

Caution

1. This function can be used in the following cases: (1) The interface is connected to only one neighbor; (2) The interface is connected to multiple neighbors using unicast communication mode. You are advised to enable this feature on PPP, frame relay, X.25, and similar link layer protocols.
2. You are advised to enable split horizon with poisoned reverse on TRIP-enabled interface. Otherwise, there may be residual invalid routing information.
3. It shall be guaranteed that the feature is enabled on all routers on the same link. Otherwise, the function may fail and routing information cannot be exchanged properly.
4. This function cannot be used together with BFD for RIP;
5. When this function is enabled, make sure that the RIP configurations on both ends of the link are identical, such as RIP authentication and version of RIP protocol supported by the interface and etc.
6. With this function enabled on the interface, the valid-update-source will be performed for the packets of this interface no matter whether the valid-update-source function is enabled.

Use the following commands to enable or disable this function in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip rip triggered**	Enables Triggered RIP.
Ruijie(config-if)# **no ip rip triggered**	Disables Triggered RIP.

Configuring RIP GR

RIP graceful restart (GR) guarantees non-stop data forwarding during the process of protocol restart. When RIP GR is enabled on the router, the forwarding table will be maintained during the process of RIP restart, and request packets will be sent to neighbors to re-learn routes in order to complete route re-convergence within the period of graceful restart. Upon expiration of the GR period, GR will exit and forwarding table entries will be updated and advertised to neighbors.

The GR period is the maximum duration from RIP GR execution to RIP GR completion. During this period, the forwarding table will be maintained and RIP route recovery will be implemented in order to restore RIP to the state before GR. Upon expiration of grace period, RIP will exit from the GR state and perform common RIP operations.

graceful-restart grace-period allows users to explicitly change the restart period. Please note that GR must be completed within the RIP expiration time and one RIP route update cycle is completed. If this value is not properly configured, non-stop data forwarding cannot be guaranteed during the GR process. For example, if the GR period is longer than the expiration time of neighbor routers and GR is not completed within such expiration time, the neighbor's routes will not be sent upon expiration of the expiration time, thus causing interruption of data forwarding. Therefore, unless otherwise specified, it is not allowed to adjust the GR period. If the GR period is adjusted, please refer to the configuration of the **timers basic** command and make sure the GR period is longer than the update time and smaller than the expiration time.

Use the following commands to enable or disable this function in RIP routing process configuration mode.

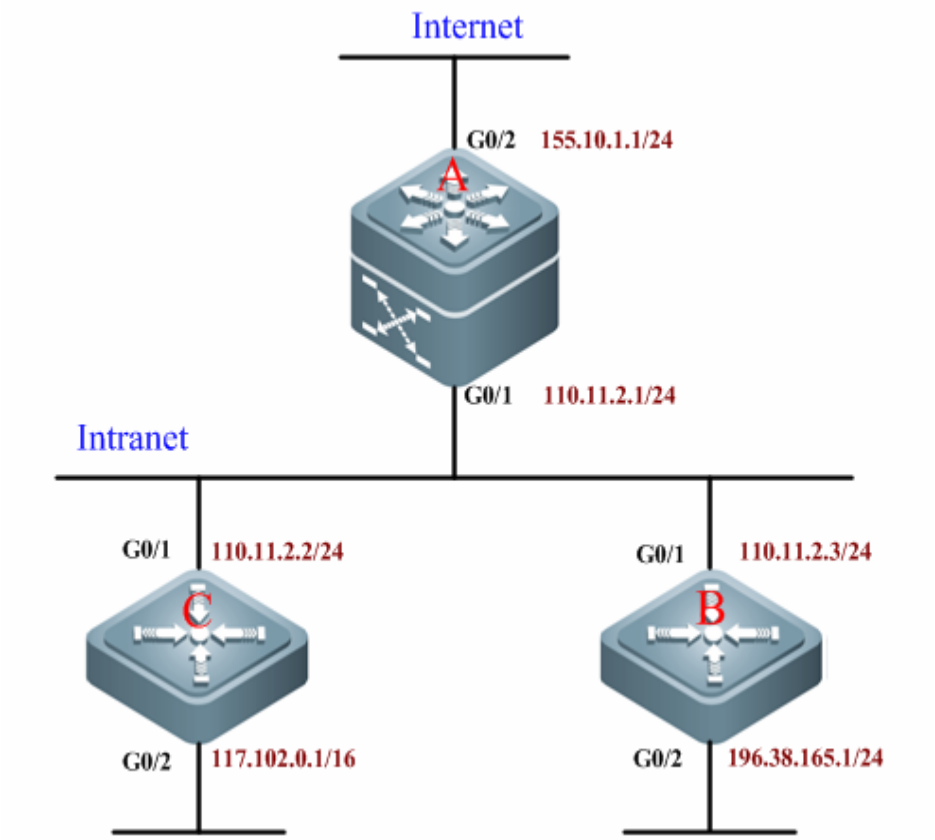
Command	Function
Ruijie(config-router)# **graceful-restart** [**grace-period** *grace-period*]	Enables RIP GR.
Ruijie(config-router)# **no graceful-restart** [**grace-period**]	Disables RIP GR.

RIP Configuration Examples

Configuring RIP Routes and Defining RIP Versions

Networking Topology

Figure 1 Configuring RIP routes and defining RIP versions



Networking Requirements

A small-sized company runs on a small office network, and requires network layer intercommunication between any two nodes. Networking requirements are as follows:

- Devices shall be able to adapt to the changes in the network topology, in order to reduce the workload of manual maintenance;
- Route updates can carry subnet masks;
- Device A only receives the routing information from external networks, but will not advertise routing information of internal network.
- RIP information can be exchanged between devices A, B, and C, so that internal hosts can access Internet.

Configuration Tips

- According to user's requirements and network environment, the RIPv2 routing protocol is selected to achieve user network intercommunication;
- To allow device A to receive routing information sent from external network without advertising the routing information of internal network, the G0/2 port of device A shall be configured as a passive interface.

Configuration Steps

Configure device A

! Configure the IP address of the corresponding port on device A.

```
Ruijie>enable
Ruijie#configure terminal
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if)#ip address 110.11.2.1 255.255.255.0
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitEthernet 0/2
Ruijie(config-if)#ip address 155.10.1.1 255.255.255.0
```

! Create the RIP routing progress.

```
Ruijie(config)#router rip
```

! Configure RIP version as version 2.

```
Ruijie(config-router)#version 2
```

! Configure G0/2 as a passive interface.

```
Ruijie(config-router)#passive-interface gigabitEthernet 0/2
```

! Disable automatic route convergence.

```
Ruijie(config-router)#no auto-summary
```

! Specify the associated network.

```
Ruijie(config-router)#network 110.11.2.0 255.255.255.0
Ruijie(config-router)#network 155.10.1.0
```

Configure device B

! Configure the IP address of the corresponding port on device B.

```
Ruijie>enable
Ruijie#configure terminal
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if)#ip address 110.11.2.2 255.255.255.0
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitEthernet 0/2
Ruijie(config-if)#ip address 196.38.165.1 255.255.255.0
Ruijie(config-if)#exit
```

! Create RIP routing progress.

```
Ruijie(config)#router rip
```

! Configure the RIP version as version 2.

```
Ruijie(config-router)#version 2
```

! Disable automatic route convergence.

```
Ruijie(config-router)#no auto-summary
```

! Specify the associated network.

```
Ruijie(config-router)#network 110.11.2.0
Ruijie(config-router)#network 196.38.165.0
```

Configure device C

! Configure the IP address of the corresponding port on device C.

```
Ruijie>enable
Ruijie#configure terminal
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if)#ip address 110.11.2.3 255.255.255.0
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitEthernet 0/2
Ruijie(config-if)#ip address 117.102.0.1 255.255.0.0
Ruijie(config-if)#exit
```

! Create RIP routing progress.

```
Ruijie(config)#router rip
```

! Configure RIP version as version 2.

```
Ruijie(config-router)#version 2
```

! Disable automatic route convergence.

```
Ruijie(config-router)#no auto-summary
```

! Specify the associated network.

```
Ruijie(config-router)#network 110.11.2.0
Ruijie(config-router)#network 117.102.0.0
```

Verification

View the routing table of each device;

View the routing table on A, as shown below (the bold figures are the routing information learned through RIP):

```
Ruijie#show ip route
Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
```

```
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
C    110.11.2.0/24 is directly connected, GigabitEthernet 0/1
C    110.11.2.1/32 is local host.
R 117.102.0.0/16 [120/1] via 110.11.2.2, 00:00:47, GigabitEthernet 0/1
C    155.10.1.0/24 is directly connected, GigabitEthernet 0/2
C    155.10.1.1/32 is local host.
C    192.168.217.0/24 is directly connected, VLAN 1
C    192.168.217.233/32 is local host.
R  196.38.165.0/24 [120/1] via 110.11.2.3, 00:19:18, GigabitEthernet 0/1
```

View the routing table on B, as shown below (the bold figures are the routing information learned through RIP):

```
Ruijie#show ip route

Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
C    110.11.2.0/24 is directly connected, GigabitEthernet 0/1
C    110.11.2.2/32 is local host.
R 155.10.1.0/24 [120/1] via 110.11.2.1, 00:15:21, GigabitEthernet 0/1
C    196.38.165.0/24 is directly connected, GigabitEthernet 0/2
C    196.38.165.1/32 is local host.
R 117.102.0.0/16 [120/1] via 110.11.2.2, 00:00:47, GigabitEthernet 0/1
```

View the routing table on C, as shown below (the bold figures are the routing information learned through RIP):

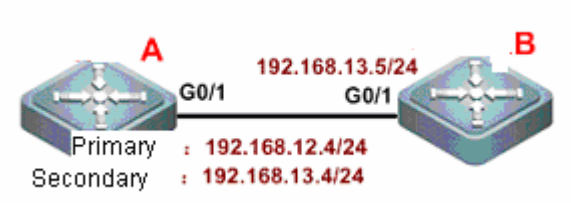
```
Ruijie#show ip route

Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
C    110.11.2.0/24 is directly connected, GigabitEthernet 0/1
C    110.11.2.3/32 is local host.
```

```
C    117.102.0.0/16 is directly connected, GigabitEthernet 0/2
C    117.102.0.1/32 is local host.
R  155.10.1.0/24 [120/1] via 110.11.2.1, 00:20:55, GigabitEthernet 0/1
R  196.38.165.0/24 [120/1] via 110.11.2.3, 00:19:18, GigabitEthernet 0/1
```

RIP Split Horizon

Networking Topology

Figure 2 Topology for RIP split horizon



Networking Requirements

There are two devices on the network. Device A is configured with a secondary IP address.

The following requirements shall be met:

- The RIP routing protocol runs on both devices;
- Device B can learn the routes of network segment 192.168.12.0/24.

Configuration Tips

To meet the above requirements, the following configurations are required:

- RIPv2 routing protocol is run on both devices;
- Split horizon shall be disabled on device A (by default, split horizon is enabled on all interfaces), or else device A won't advertise network segment 192.168.12.0 to device B.

Configuration Steps

Configure device A

! Configure Ethernet ports.

```
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)#ip address 192.168.12.4 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/1)#ip address 192.168.13.4 255.255.255.0 secondary
```

! Disable split horizon.

```
Ruijie(config-if-GigabitEthernet 0/1)#no ip rip split-horizon
```

! Configure the RIP routing protocol.

```
Ruijie(config)#route rip
Ruijie(config-router)#version 2
```

```
Ruijie(config-router)#network 192.168.12.0
Ruijie(config-router)#network 192.168.13.0
```

! Disable automatic route convergence.

```
Ruijie(config-router)#no auto-summary
```

Configure device B

! Configure Ethernet ports.

```
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)#ip address 192.168.13.5 255.255.255.0
```

! Configure the RIP routing protocol.

```
Ruijie(config)#route rip
Ruijie(config-router)#version 2
Ruijie(config-router)#network 192.168.13.0
```

Verification

View the routing table on device B before and after disabling split horizon.

Before split horizon is disabled, view the routing table on device B, as shown below:

```
Ruijie#show ip route

Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default
Gateway of last resort is no set
C    192.168.13.0/24 is directly connected, GigabitEthernet 0/1
C    192.168.13.5/32 is local host.
```

After split horizon is disabled, view the routing table on device B, as shown below (the bold figures are the routing information learned through RIP):

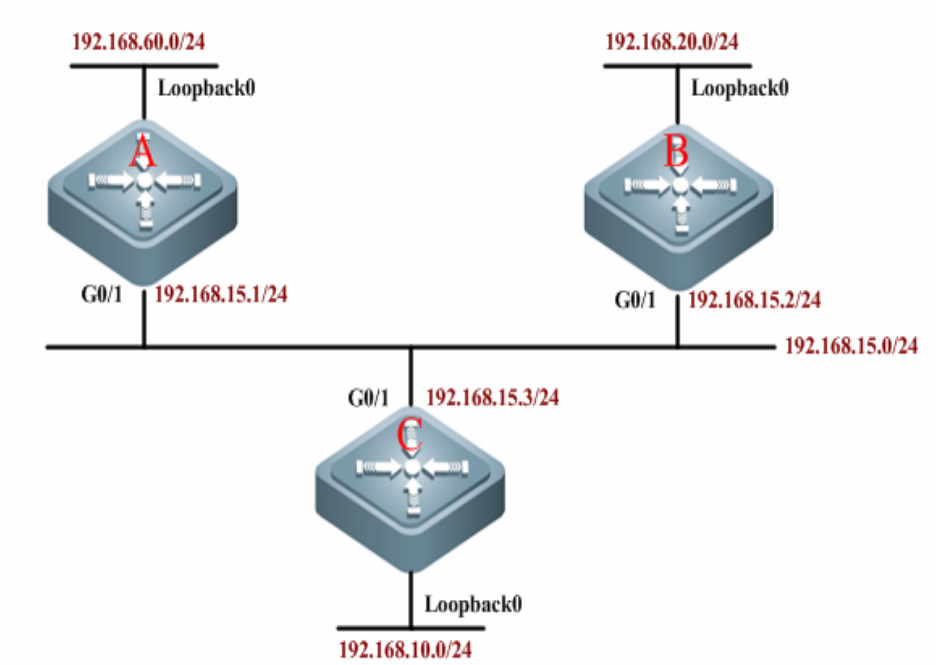
```
Ruijie#show ip route

Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
R    192.168.12.0/24 [120/1] via 192.168.13.4, 00:00:10, GigabitEthernet 0/1
```

```
C    192.168.13.0/24 is directly connected, GigabitEthernet 0/1
C    192.168.13.5/32 is local host.
```

RIP Unicast Update

Networking Topology

Figure 3 Topology for RIP unicast update



Networking Requirements

As shown below, three devices are connected to the LAN and run the RIP routing protocol.

- Device A can learn the routes advertised by devices B and C;
- Device C can learn the routes advertised by devices A and B;
- Device B cannot learn the routes advertised by device C.

Configuration Tips

To meet the above configuration requirements, RIP unicast packets must be configured on device C. Add the command of **neighbor** during the RIP configuration of device C, so that the RIP protocol can send advertisements to the interface of device A in unicast mode. Configure the **passive-interface** command on G0/1 of device C to avoid broadcast update on this link.

Configuration Steps

Configure device A

! Configure the IP address of corresponding interface.

```
Ruijie>enable
Ruijie#configure terminal
```

```
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if)#ip address 192.168.15.1 255.255.255.0
Ruijie(config-if)#exit
Ruijie(config)#interface Loopback 0
Ruijie(config-if)#ip address 192.168.60.1 255.255.255.0
Ruijie(config-if)#exit
```

! Create RIP routing progress.

```
Ruijie(config)#router rip
```

! Specify the associated network.

```
Ruijie(config-router)#network 192.168.60.0
Ruijie(config-router)#network 192.168.15.0
```

 # Configure device B

! Configure the IP address of corresponding interface.

```
Ruijie>enable
Ruijie#configure terminal
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if)#ip address 192.168.15.2 255.255.255.0
Ruijie(config-if)#exit
Ruijie(config)#interface Loopback 0
Ruijie(config-if)#ip address 192.168.20.1 255.255.255.0
Ruijie(config-if)#exit
```

! Create RIP routing progress.

```
Ruijie(config)#router rip
```

! Specify the associated network.

```
Ruijie(config-router)#network 192.168.20.0
Ruijie(config-router)#network 192.168.15.0
```

Configure device C

! Configure the IP address of corresponding interface.

```
Ruijie>enable
Ruijie#configure terminal
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if)#ip address 192.168.15.3 255.255.255.0
Ruijie(config-if)#exit
Ruijie(config)#interface Loopback 0
Ruijie(config-if)#ip address 192.168.10.1 255.255.255.0
Ruijie(config-if)#exit
```

! Create RIP routing progress.

```
Ruijie(config)#router rip
```

! Specify the associated network.

```
Ruijie(config-router)#network 192.168.15.0
Ruijie(config-router)#network 192.168.10.0
```

! Configure G0/1 as a passive interface.

```
Ruijie(config-router)#passive-interface gigabitEthernet 0/1
```

! Enable unicast update.

```
Ruijie(config-router)#neighbor 192.168.15.1
```

Verification

View the routing table of each device (mainly the routing information on devices C and B):

View the routing table on device B, as shown in the following figure:

```
Ruijie#show ip route

Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
C    192.168.20.0/24 is directly connected, Loopback 0
C    192.168.20.1/32 is local host.
C    192.168.15.0/24 is directly connected, GigabitEthernet 0/1
C    192.168.15.2/32 is local host.
R 192.168.60.0/24 [120/1] via 192.168.15.1, 00:15:21, GigabitEthernet 0/1
```

View the routing table on device C, as shown below (the bold figures are the routing information learned through RIP):

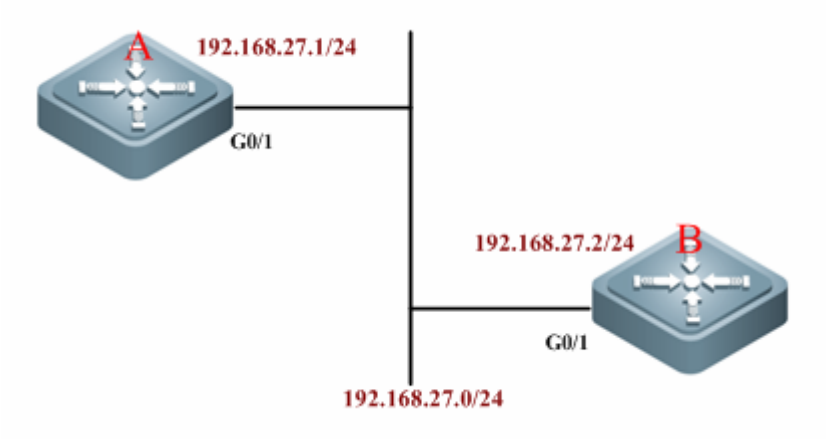
```
Ruijie#show ip route

Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
C    192.168.10.0 is directly connected, Loopback 0
C    192.168.10.1/32 is local host.
R 192.168.60.0/24 [120/1] via 192.168.15.1, 00:15:21, GigabitEthernet 0/1
C    192.168.15.0/24 is directly connected, GigabitEthernet 0/1
```

```
C    192.168.15.3/32 is local host.
R 192.168.20.0 [120/1] via 192.168.15.2, 00:00:47, GigabitEthernet 0/1
```

RIP Authentication

Networking Topology

Figure 4 Topology for RIP authentication



Networking Requirements

Interconnected through Ethernet, two devices run the RIP routing protocol and use MD5 authentication. The requirements are as follows:

- The authentication key for device A to send RIP packets is "Hello", and device A can receive RIP packets with authentication keys being "Hello" and "World";
- The authentication key for device B to send RIP packets is "World", and device B can receive RIP packets with authentication keys being "Hello" and "World";
- The first key is used from 4:30pm October 1st, 2010 for 12 hours (43200s)
- The second key becomes permanently valid from 4:00 am October 2, 2010.

Configuration Tips

Authentication is not supported in RIPv1. If the RIPv2 routing protocol is configured on the device, authentication can then be configured on the corresponding interface.

The key string specifies the key set that can be used by this interface. If the key string is not configured and even if the interface uses the key chain, no authentication occurs. Therefore, before configuring authentication, the key chain and the associated key string must be configured first.

RGOS supports two RIP authentication modes: plain text and MD5, while plain text is the default authentication mode.

- The authentication key for sending RIP packets must be configured with the first key on keychain;
- When configuring the authentication key that can be received, configure any key on the keychain.

Configuration Steps

 # Configure device A:

! Configure the IP address of Ethernet interface.

```
Ruijie>enable
Ruijie#configure terminal
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if)#ip address 192.168.27.1 255.255.255.0
Ruijie(config-if)#exit
```

! Configure the key chain named "ripchain".

```
Ruijie(config)#key chain ripchain
```

! Configure the first key of "Key 1", which contains the key-string of "Hello", and configure the corresponding period needed.

```
Ruijie(config-keychain)#key 1
Ruijie(config-keychain-key)#key-string Hello
Ruijie(config-keychain-key)#accept-lifetime 16:30:00 Oct 1 2010 duration 43200
Ruijie(config-keychain-key)#send-lifetime 16:30:00 Oct 1 2010 duration 43200
Ruijie(config-keychain-key)#exit
```

! Configure the second key of "Key 2", which contains the key-string of "World", and configure the corresponding period needed.

```
Ruijie(config-keychain)#key 2
Ruijie(config-keychain-key)#key-string World
Ruijie(config-keychain-key)#accept-lifetime 04:00:00 Oct 2 2010 infinite    //Beginning time
that the key is valid to be received
Ruijie(config-keychain-key)#send-lifetime 04:00:00 Oct 2 2010 infinite        //Beginning
time that the key is valid to be sent
Ruijie(config-keychain-key)#end
```

! Configure G0/1 to use the MD5 authentication key to authenticate the update messages sent from device B.

```
Ruijie#configure terminal
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if)#ip rip authentication key-chain ripchain
Ruijie(config-if)#ip rip authentication mode md5
Ruijie(config-if)#exit
```

! Configure the RIP routing protocol.

```
Ruijie(config)#router rip
Ruijie(config-router)#version 2
Ruijie(config-router)#network 192.168.27.0
```

#Configure device B:

! Configure the IP address of Ethernet interface.

```
Ruijie>enable
Ruijie#configure terminal
Ruijie(config)#interface gigabitEthernet 0/1
```

```
Ruijie(config-if)#ip address 192.168.27.2 255.255.255.0
Ruijie(config-if)#exit
```

! Configure the key chain.

```
Ruijie(config)#key chain ripchain //The name of key chain is only valid on the local device.
You can also use other names.
```

! Configure the first key of "Key 1", which contains the key-string of "Hello", and configure the corresponding period needed.

```
Ruijie(config-keychain)#key 1
Ruijie(config-keychain-key)#key-string Hello
Ruijie(config-keychain-key)#accept-lifetime 16:30:00 Oct 1 2010 duration 43200
Ruijie(config-keychain-key)#send-lifetime 16:30:00 Oct 1 2010 duration 43200
Ruijie(config-keychain-key)#exit
```

! Configure the second key of "Key 2", which contains the key-string of "World", and configure the corresponding period needed.

```
Ruijie(config-keychain)#key 2
Ruijie(config-keychain-key)#key-string World
Ruijie(config-keychain-key)#accept-lifetime 04:00:00 Oct 2 010 infinite
Ruijie(config-keychain-key)#send-lifetime 04:00:00 Oct 2 2010 infinite
Ruijie(config-keychain-key)#end
```

! Configure G0/1 to use the MD5 authentication key to authenticate the update messages sent from device A.

```
Ruijie#configure terminal
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if)#ip rip authentication key-chain ripchain
Ruijie(config-if)#ip rip authentication mode md5
Ruijie(config-if)#exit
```

! Configure the RIP routing protocol.

```
Ruijie(config)#router rip
Ruijie(config-router)#version 2
Ruijie(config-router)#network 192.168.27.0
```

Verification

Run the show run command to verify the correctness of configurations (taking device A as the example):

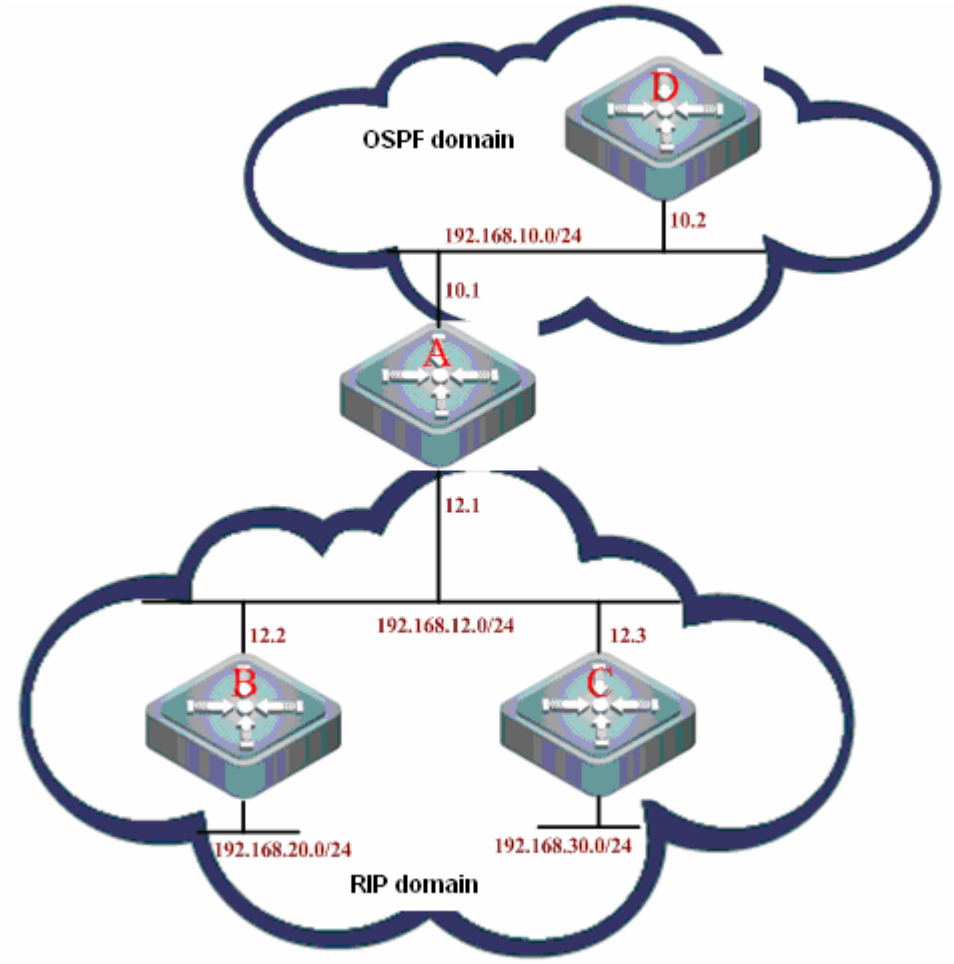
```
Ruijie#show run

Building configuration...
Current configuration : 1561 bytes

!
vlan 1
!
```

```
!
key chain ripchain
 key 1
  key-string Hello
     accept-lifetime 16:30:00 Oct 01 2010 duration 43200
  send-lifetime 16:30:00 Oct 01 2010 duration 43200
 key 2
  key-string World
     accept-lifetime 04:00:00 Oct 02 2010 infinite
     send-lifetime 04:00:00 Oct 02 2010 infinite
!
no service password-encryption
!
interface GigabitEthernet 0/1
      ip rip authentication mode md5
 ip rip authentication key-chain ripchain
 no ip proxy-arp
     ip address 192.168.27.1 255.255.255.0
!
interface GigabitEthernet 0/2
!
interface GigabitEthernet 0/3
!
interface GigabitEthernet 0/4
...
!
!
!
router rip
 version 2
 network 192.168.27.0
!
!
!
line con 0
line vty 0 4
 login
!
!
end
```

RIP Redistribution and Default Route

Networking Topology

Figure 5 Topology for RIP redistribution and default route



Networking Requirements

Devices A, B, and C are interconnected in the same network segment and run the RIP routing protocol. Devices A and D are interconnected in the same network segment and run the OSPF routing protocol. Configure these four devices to achieve the following goals:

- Device A can learn the OSPF routes advertised by device D;
- Device A can redistribute OSPF routes to RIP;
- Device A advertises the redistributed routes to devices B and C;
- Device C advertises the default routing to devices A and B.

Configuration Tips

- Configure to redistribute OSPF routes to RIP in the RIP process of device A;
- Configure to advertise the default routing on the corresponding interface of device C;

Configuration Steps

#Configure device A:

! Configure Ethernet ports.

```
Ruijie(config)#interface FastEthernet 0/1
Ruijie(config-if-FastEthernet 0/1)#ip address 192.168.12.1 255.255.255.0
```

```
Ruijie(config-if-FastEthernet 0/1)#exit
Ruijie(config)#interface FastEthernet0/2
Ruijie(config-if-FastEthernet 0/2)#ip address 192.168.10.1 255.255.255.0
```

Configure the RIP routing protocol.

```
Ruijie(config)#router rip
Ruijie(config-router)#version 2
Ruijie(config-router)#network 192.168.12.0
Ruijie(config-router)#redistribute ospf 10 metric 3
```

//Redistribute the OSPF routing progress in the RIP progress, with metric value being 3

Configure the OSPF routing protocol.

```
Ruijie(config)#router ospf 10
Ruijie(config-router)#network 192.168.10.0 0.0.0.255 area 0
```

#Configure device B:

! Configure Ethernet ports.

```
Ruijie(config)#interface FastEthernet 0/1
Ruijie(config-if-FastEthernet 0/1)#ip address 192.168.12.2 255.255.255.0
Ruijie(config-if-FastEthernet 0/1)#exit
```

! Configure loopback ports.

```
Ruijie(config)#interface Loopback 0
Ruijie(config-if-Loopback 0)#ip address 192.168.20.1 255.255.255.0
```

! Configure the RIP routing protocol.

```
Ruijie(config)#router rip
Ruijie(config-router)#version 2
Ruijie(config-router)#network 192.168.12.0
Ruijie(config-router)#network 192.168.20.0
```

 # Configure device C:

! Configure Ethernet ports.

```
Ruijie(config)#interface FastEthernet 0/1
Ruijie(config-if-FastEthernet 0/1)#ip address 192.168.12.3 255.255.255.0
Ruijie(config-if-FastEthernet 0/1)#ip rip default-information originate metric 5
```

//Advertise default route, with metric value being 5

! Configure loopback ports.

```
Ruijie(config)#interface Loopback 0
Ruijie(config-if-Loopback 0)#ip address 192.168.30.1 255.255.255.0
```

Configure the RIP routing protocol.

```
Ruijie(config)#router rip
```

```
Ruijie(config-router)#version 2
Ruijie(config-router)#network 192.168.12.0
Ruijie(config-router)#network 192.168.30.0
```

 # Configure device D:

! Configure Ethernet ports.

```
Ruijie(config)#interface FastEthernet 0/1
Ruijie(config-if-FastEthernet 0/1)#ip address 192.168.10.2 255.255.255.0
```

! Configure the OSPF routing protocol.

```
Ruijie(config)#router ospf 10
Ruijie(config-router)#network 192.168.10.0 0.0.0.255 area 0
```

Verification

View the routing table of each device (mainly the routing information on devices A, B, and C):

View the routing table on device A, as shown below (the bold figures are the routing information learned through RIP):

```
Ruijie#show ip route

Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
R*   0.0.0.0/0 [120/5] via 192.168.12.3, 00:00:23, FastEthernet 0/1
C    192.168.10.0/24 is directly connected, FastEthernet 0/2
C    192.168.10.1/32 is local host.
C    192.168.12.0/24 is directly connected, FastEthernet 0/1
C    192.168.12.1/32 is local host.
R    192.168.20.0/24 [120/1] via 192.168.12.2, 00:07:09, FastEthernet 0/1
R    192.168.30.0/24 [120/1] via 192.168.12.3, 00:00:23, FastEthernet 0/1
```

View the routing table on device B, as shown below (the bold figures are the routing information learned through RIP):

```
Ruijie#show ip route

Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default
```

```
Gateway of last resort is no set
R    192.168.10.0/24 [120/3] via 192.168.12.1, 00:00:06, FastEthernet 0/1
C    192.168.12.0/24 is directly connected, FastEthernet 0/1
C    192.168.12.2/32 is local host.
C    192.168.20.0/24 is directly connected, Loopback 0
C    192.168.20.1/32 is local host.
R    192.168.30.0/24 [120/3] via 192.168.12.3, 00:00:06, FastEthernet 0/1
```

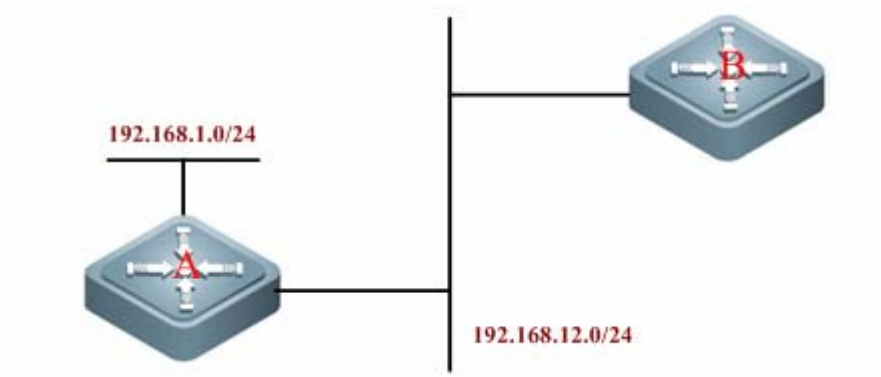
View the routing table on device C, as shown below (the bold figures are the routing information learned through RIP):

```
Ruijie#show ip route

Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
R    192.168.10.0/24 [120/3] via 192.168.12.1, 00:01:49, FastEthernet 0/1
C    192.168.12.0/24 is directly connected, FastEthernet 0/1
C    192.168.12.3/32 is local host.
C    192.168.30.0/24 is directly connected, Loopback 0
C    192.168.30.1/32 is local host.
R    192.168.20.0/24 [120/3] via 192.168.12.2, 00:01:49, FastEthernet 0/1
```

RIP Supernet Route

Networking Topology

Figure6 Topology for the RIP supernet route



Networking Requirements

Two devices are interconnected through Ethernet. Device A runs RIPv2, and device B only supports the RIPv1 protocol and is unable to learn supernet routes.

Requirements:

- Configure supernet route 80.0.0.0/6 on device A, with next hop pointing to interface loopback 1 (192.168.1.0);
- Redistribute the aforementioned static route to RIP;
- Prohibit advertising supernet routes on device A.

Configuration Tips

Device B supports only the RIPv1 protocol. According to RFC 1058, such device is able to receive update packets of higher-version RIP, but such fields as subnet mask and next hop in the packets must be neglected. Therefore, route 80.0.0.0/6 received by device B will be treated as 80.0.0.0/8. To prevent device B from learning incorrect routes, device A must be configured to prohibit supernet route advertisement.

Configuration Steps

 # Configure device A:

! Configure Ethernet ports.

```
Ruijie(config)#interface FastEthernet 0/1
Ruijie(config-if-FastEthernet 0/1)#ip address 192.168.12.1 255.255.255.0
Ruijie(config-if-FastEthernet 0/1)#no ip rip send supernet-routes
```

//Prohibit supernet route advertisement

! Configure loopback ports.

```
Ruijie(config)#interface loopback 1
Ruijie(config-if-Loopback 1)#ip address 192.168.1.1 255.255.255.0
```

! Configure static routes.

```
Ruijie(config)#ip route 80.0.0.0 252.0.0.0 loopback 1
```

! Configure the RIP routing protocol.

```
Ruijie(config)#router rip
Ruijie(config-router)#version 2
Ruijie(config-router)#network 192.168.12.0
Ruijie(config-router)#network 192.168.1.0
Ruijie(config-router)#redistribute static
```

//Redistribute static route

 # Configure device B (supporting RIPv1 only):

! Configure Ethernet ports.

```
Ruijie(config)#interface FastEthernet 0/1
Ruijie(config-if-FastEthernet 0/1)#ip address 192.168.12.3 255.255.255.0
```

! Configure the RIP routing protocol.

```
Ruijie(config)#router rip
Ruijie(config-router)#network 192.168.12.0
```

Verification

View the routing table of each device;

View the routing table on device A, as shown below:

```
Ruijie#show ip route

Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
S    80.0.0.0/6 is directly connected, Loopback 1
C    192.168.1.0/24 is directly connected, Loopback 1
C    192.168.1.1/32 is local host.
C    192.168.12.0/24 is directly connected, FastEthernet 0/1
C    192.168.12.1/32 is local host.
```

View the routing table on device B, as shown below (the bold figures are the routing information learned through RIP):

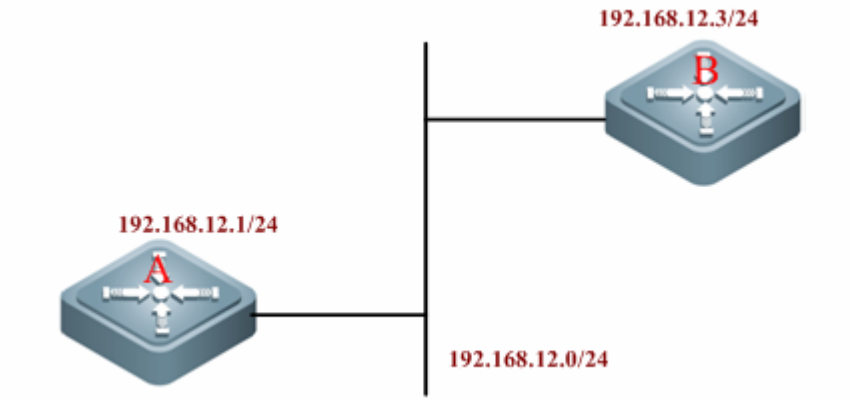
```
Ruijie#show ip route

Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
R    80.0.0.0/6 [120/1] via 192.168.12.1, 00:00:46, GigabitEthernet 0/1
R    192.168.1.0/24 [120/1] via 192.168.12.1, 00:38:17, FastEthernet 0/1
C    192.168.12.0/24 is directly connected, FastEthernet 0/1
C    192.168.12.2/32 is local host.
```

RIP VRF Configuration Examples

Networking Requirements

Two routing devices are interconnected through Ethernet and run the RIP routing protocol. The connection layout and IP address distribution are shown in Figure 7.

Figure7 Example of RIP VRF configuration



Through RIP, routing information is exchanged between VRF "redvpn" of device A and VRF "bluevpn" of device B.

By enabling RIP GR on device A and setting the GR period to 90 seconds, non-stop data forwarding can be realized during hot standby switchover between main and slave management boards on device A. Meanwhile, since the GR period has been changed, timers basic shall be configured to a reasonable value.

Detailed Configurations

Configure device A:

Create VRF.

```
ip vrf redvpn
```

Bind the interface to VRF and configure the interface IP address.

```
interface fastEthernet 0/1
ip vrf forwarding redvpn
ip address 192.168.12.1 255.255.255.0
```

Configure the RIP routing protocol and create a RIP instance.

```
router rip
address-family ipv4 vrf redvpn
network 192.168.12.0
graceful-restart grace-period 90
timers basic 45 270 180
exit-address-family
```

Configure device B:

Create VRF.

```
ip vrf  bluevpn
```

Bind the interface to VRF and configure the interface IP address.

```
interface fastEthernet 0/1
ip vrf forwarding bluevpn
ip address 192.168.12.3 255.255.255.0
```

Configure the RIP routing protocol and create a RIP instance.

```
router rip
address-family ipv4 vrf bluevpn
network 192.168.12.0
timers basic 45 270 180
exit-address-family
```

TRIP Configuration Examples

Networking Requirements

Two routers are interconnected through the PPP link and run the RIP routing protocol. The connection layout and IP address distribution are shown in Figure 8.

Figure 8 Example of TRIP configuration

By configuring TRIP, routing information can be exchanged between devices A and B on the WAN link, and split horizon with poisoned reverse shall be enabled.

Detailed Configurations

Configure device A:

Enable the PPP link protocol on the interface and configure the interface IP address; Enable TRIP and split horizon with poisoned reverse.

```
interface Serial 0/0
encapsulation ppp
ip address 192.168.12.1 255.255.255.0
ip rip triggered
ip rip split-horizon poisoned-reverse
```

Configure the RIP routing protocol.

```
router rip
```

```
network 192.168.12.0
```

Configure device B:

Enable the PPP link protocol on the interface and configure the interface address; Enable TRIP and split horizon with poisoned reverse.

```
interface Serial 0/0
encapsulation ppp
ip address 192.168.12.2 255.255.255.0
ip rip triggered
ip rip split-horizon poisoned-reverse
```

Configure RIP routing protocol

```
router rip
network 192.168.12.0
```

Configuring OSPF

Overview

An open shortest path first (OSPF) routing protocol is an internal gateway routing protocol based on link status developed by the IETF OSPF work group It is designed for the IP environment and directly runs on the IP layer. With the protocol number being 89, this routing protocol exchanges OSPF packets in a manner of multicast by using the multicast address 224.0.0.5 (for all OSPF routers) and 224.0.0.6 (for specified routers).

The link status algorithm is an algorithm totally different from the Huffman vector algorithm (distance vector algorithm). The traditional RIP routing protocol uses the Huffman vector algorithm, while the OSPF routing protocol uses the link status algorithm. Compared with the RIP routing protocol, the OSPF routing protocol uses a different algorithm and introduces new concepts such as route update authentication, VLSMs, and route aggregation. Even if the RIPv2 has been improved greatly and also supports the features such as route update authentication and VLSM, the RIP routing protocol still has the following fatal weaknesses: 1) Slow convergence; 2) Limited network scale (with the maximum number of hops counting less than 16). The OSPF routing protocol overcomes these weaknesses, enabling the IGP protocol to be used in large and complicated network environments.

The OSPF routing protocol establishes and calculates the shortest path to each target network by using this complicated link status algorithm. Brief information about how the link status algorithm works is as follows:

- In the initialization stage, a router generates a link status notification that contains all link status of its own.
- All routers exchange the link status information in the multicast way. Upon receiving a link status update packet, each router copies the packet into the local database and then transmits the packet to other routers.
- After every router has a complete link status database, a router uses the Dijkstra algorithm to calculate the shortest path trees to all target networks. The results include the target network, next-hop address, and cost, which are the key parts of an IP routing table.

When there is no link cost or network change, the OSPF is inactive. When any changes occur on the network, the OSPF advertises the link status changes of only the changed links. The routers involved in the changes will run the Dijkstra algorithm again to generate new shortest path trees.

A group of routers running the OSPF routing protocol form the autonomous system of the OSPF routing area. An autonomous system consists of all the routers that are controlled and managed by one organization. Within the autonomous system, only one IGP routing protocol is run. However, between multiple autonomous systems, the BGP routing protocol is used to exchange routing information. Different autonomous area systems may use the same IGP routing protocol. Every autonomous system needs to request the related organization for the autonomous system number to connect to the Internet.

When the OSPF routing area is large, the hierarchical structure can be used. In other words, the OSPF routing area can be divided into several areas, which are connected via a backbone area. Every non-backbone area must be directly connected to the backbone area.

There are three roles for the routers in the OSPF routing area based on their deployment positions:

1) Area internal router: All interface networks of this router belong to a same area.

2) Area border router (ABR): The interface network of this router belongs at least to two areas, one of which must be the backbone area.

3) Autonomous system boundary router (ASBR): It is the router through which routes are exchanged between the OSPF route area and the external route area.

Ruijie products use the OSPF by fully complying with the OSPFv2 defined in RFC 2328. The main features are described as follows:

- Support multiple OSPF processes.
- Support the VRF. You can run the OSPF routing protocol based on different VRFs.
- Support the definition of the stubby area.
- Support route redistribution of static routes, directly-connected routes, dynamic routes, and the routing information among dynamic routing protocols such as RIP and BGP.
- Support plain-text or MD5 authentication between neighbors.
- Support virtual links.
- Support VLSMs.
- Support area division.
- Support the not so stubby area (NSSA) feature, as defined in RFC 3101.
- Support the graceful restart feature, as defined in RFC 3623.

☑ Ruijie products do not support the following functions now: OSPF line support on demand, as defined in RFC 1793; OSPF fast convergence.

Configuration Task List

The configuration of OSPF should be cooperated with various routers, including internal routers, area border routers, and autonomous system boundary routers. When no configuration is performed on routers, default parameters are used. In this case, packets are sent and received without authentication, and the interface does not belong to any area of an autonomous system. When changing the default parameters, you must ensure that the routers have the same configurations.

To configure an OSPF routing protocol, you must perform the following tasks. Among these tasks, creating the OSPF routing process is mandatory. Other tasks may be optional or mandatory in particular applications. The detailed tasks to configure the OSPF routing protocol are described as follows:

- Creating an OSPF routing process (mandatory)
- Configuring OSPF interface parameters (optional)
- Configuring the OSPF used on different physical networks (optional)
- Configuring OSPF area parameters (optional)
- Configuring an OSPF NSSA (optional)
- Configuring OSPF route aggregation (optional)
- Creating a virtual link (optional)
- Generating a default route (optional)
- Using the loopback interface address as the router ID (optional)
- Changing the default OSPF management distance (optional)
- Configuring the route calculation timer (optional)
- Configuring the link status advertisement (LSA) group pacing timer (optional)

- Configuring the cost for the OSPF interface (optional)
- Configuring an OSPF stub router (optional)
- Configuring whether to perform the MTU check on an interface (optional)
- Disabling an Interface to send the OSPF packets (optional)
- Configuring whether to perform the source address check (optional)
- Configuring the OSPF fast convergence function (optional)
- Configuring the OSPF capacity protection function (optional)
- Configuring the OSPF network management function(optional)
- Configuring the OSPF GR function (optional)
- Configuring the OSPF BFD function (optional)
- Configuring the OSPF VPN function (optional)
- Monitoring and maintaining the OSPF

For the configuration information about the following topics, see related sections in *Configuring Protocol-Independent Information*.

- Filtering the routing information
- Redistributing routes

Default OSPF configurations are described as follows:

Feature	Default Setting
Interface parameters	Interface metric: Not preset. LSA retransmission interval: 5 seconds. LSA transmission delay: 1 second. Interval for transmitting Hello packets: 10 seconds (30 seconds for non-broadcast networks) Failure time of adjacent routers: 4 times the interval for transmitting the Hello packets. Fast Hello: Disabled. Priority: 1. Authentication type: 0 (No authentication). Authentication password: None.
Area	Authentication type: 0 (No authentication). Default metric of aggregated routes to a Stub or NSSA area: 1. Inter-area aggregation scope: Undefined. Stub area: Undefined. NSSA: Undefined. Translator for translating Type-7 LSAs to Type-5 LSAs: Alternative. Interval of stabilizing the translation from Type-7 LSAs to Type-5 LSAs: 40 seconds.
Virtual links	No virtual link is defined. The default parameters of the virtual link are as follows: LSA retransmission interval: 5 seconds. LSA transmission delay: 1 second. Interval for transmitting Hello packets: 10 seconds. Failure time of adjacent routers: 4 times the interval for transmitting the

Feature	Default Setting
	Hello packets. Fast Hello: Disabled. Authentication type: No authentication. Authentication password: None.
Automatic cost calculation	Enabled. Default value automatically calculated is 100 Mbit/s.
Default route generation	Disabled. The default metric is 1 and the type is type-2 if enabled.
Default metric (Default metric)	Default metric used to redistribute other routing protocols
Management distance	Intra-area routing information: 110 Inter-area routing information: 110 External routing information: 110
Database filter	Disabled. All interfaces can receive the status update information (LSA).
Neighbor change log	Enabled.
Neighbor	N/A
Neighbor database filter	Disabled. All output LSAs are sent to all neighbors.
Network area (network area)	N/A
Router ID	Undefined. The OSPF protocol does not run on a router by default.
External route aggregation (summary-address)	Undefined.
Changing time of the status update information	240 seconds
Shortest path first (SPF) calculation timer	The time delay between the time for receiving information about topology changes and the next time for invoking the SPF calculation: 1000 milliseconds. The minimum interval between two calculating operations using the SPF algorithm: 5000 milliseconds. The maximum interval between two calculating operations using the SPF algorithm: 10000 milliseconds.
Optimal path rule used to calculate the external routes	Rules defined in RFC1583
OSPF stub router	Disabled.
OSPF two-way maintenance	Enabled.
Sending LSA packet updates	Time interval for sending data packets: 40 milliseconds. Number of LS-UPD packets in each data packet: 10.
OSPF overflow	Enter the overflow state when the memory lacks.
OSPF GR	GR restarter: Disabled. GR helper: Enabled.
OSPFv2 MIB binding	OSPFv2 process with the smallest process number
OSPFv2 TRAP sending	Disabled.

Creating an OSPF Routing Process

You can create an OSPF routing process and define the range of the IP addresses associated with the OSPF routing process and the OSPF area to which these IP addresses belong. The OSPF routing process only sends and receives the OSPF packets at the interface within the IP address range and advertises the link status of the interface to external routers.

Use the following commands to create the OSPF routing process.

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode.
Ruijie (config)**# ip routing**	Enables the IP routing function (if disabled).
Ruijie (config)**# router ospf** [*process_id* [**vrf** *vrf-name*]]	Enables the OSPF and enters OSPF configuration mode.
Ruijie (config-router)**# network** *address wildcard-mask* **area** *area-id*	Defines an IP address range for an area.
Ruijie (config-router)# end	Returns to privileged EXEC mode.
Ruijie # show ip protocols	Displays the routing protocol that is running currently.
Ruijie # write	Saves the configurations.

Note

You can use the parameter *vrf vrf-name* to specify the VRF which the OSPF belongs to. If you do not specify this parameter when creating the OSPF routing process, the default VRF is used. For the **network** command, 32 bit wildcards are opposed to the mask. The value 1 indicates that the bit is not compared, and the value 0 indicates that the bit is compared. However, if you configure the command with masks, Ruijie products automatically translate the masks into bit wildcards. An interface belongs to the specific area as long as the address of the interface is within the IP address range defined in the **network** command. When the address of an interface is within more than one IP address ranges defined in the **network** command of multiple OSPF processes, the OSPF process that the interface involves in is determined based on the optimal mapping.

To disable the OSPF protocol, use the **no router ospf** *process-id* command. The following example shows how to enable the OSPF protocol:

```
Ruijie (config)# router ospf 1
Ruijie (config-router)# network 192.168.0.0 255.255.255.0 area 0
Ruijie (config-router)# end
```

Configuring OSPF Interface Parameters

You are allowed to change some particular interface parameters and configure the interface parameters on demand. It should be noted that some parameters must match those of the adjacent router of the interface. These parameters are set by using the **ip ospf hello-interval**, **ip ospf dead-interval**, **ip ospf authentication**, **ip ospf authentication-key**, and **ip ospf message-digest-key** commands. When you use these commands, make sure that the adjacent routers have the same configurations.

Use the following commands to configure the OSPF interface parameters in interface configuration mode.

Command	Function
Ruijie**# configure** terminal	Enters global configuration mode.

Command	Function
Ruijie(config)# **ip routing**	Enables the IP routing function (if disabled).
Ruijie(config)# **interface** *interface-id*	Enters interface configuration mode.
Ruijie(config-if)# **ip ospf cost** *cost-value*	(Optional) Defines the cost value for the interface.
Ruijie(config-if)# **ip ospf retransmit-interval** *seconds*	(Optional) Sets the link status retransmission interval.
Ruijie(config-if)# **ip ospf transmit-delay** *seconds*	(Optional) Sets the transmission delay for the link status update packets.
Ruijie(config-if)# **ip ospf hello-interval** *seconds*	(Optional) Sets the interval for sending the Hello packets, which must be same for all the nodes of the entire network.
Ruijie(config-if)# **ip ospf dead-interval** *seconds*	(Optional) Sets the dead interval for the adjacent routers, which must be same for all the nodes of the entire network.
Ruijie(config-if)# **ip ospf priority** *number*	(Optional) Priority, used to select the dispatched routers (DR) and backup dispatched routers (BDR).
Ruijie(config-if)# **ip ospf authentication [message-digest | null]**	(Optional) Sets the authentication type on the interface.
Ruijie(config-if)# **ip ospf authentication-key [0|7]** *key*	(Optional) Configures the text authentication key on the interface.
Ruijie(config-if)# **ip ospf message-digest-key *keyid* md5 [0|7]** *key*	(Optional) Configures the key for the MD5 authentication on the interface.
Ruijie (config-if)# **ip ospf database-filter all out**	(Optional) Prevents the interface from flooding the link status update packets. By default, the OSPF floods the LSA information over all interfaces in the same area except the interface on which the LSA information is received.
Ruijie (config-if)# **end**	Returns to privileged EXEC mode.
Ruijie # show **ip ospf interface** [*interface-id*]	Displays the OSPF interface information.
Ruijie # **write**	(Optional) Saves the configurations.

To restore the default value, use the **no** form of the above commands.

Configuring the OSPF Used on Different Physical Networks

According to the transmission features of different media, the networks are classified into three types according to the OSPF protocol:

- Broadcast network (Ethernet, token network, and FDDI)
- Non-broadcast network (frame relay, X.25)
- Point-to-point network (HDLC, PPP, and SLIP)

The non-broadcast networks include two types of networks according to the operation modes of the OSPF:

1) Non-broadcast multi-access (NBMA) network: The NBMA network requires direct communication for all interconnected routers. Only fully meshed networks can meet this requirement. If the SVC (for example, X.25) networking is used, this requirement can be met. However, it is difficult to use the PVC (for example, frame relay)

networking to meet this requirement. The operation of the OSPF on the NBMA network is similar to that on the broadcast network. That is, a designated router must be specified to advertise the link status on the NBMA network.

2) Point-to-multipoint network: If the network is not a fully meshed non-broadcast network, you need to set the network type of the interface to the point-to-multipoint network type according to the OSPF routing protocol. In a point-to-multipoint network, the connections between all routers are treated as point-to-point links according to the OSPF routing protocol, so you do not need to specify the designated router.

Whatever the default network type of the interface is, you can set it to the broadcast network type. For example, you can set the non-broadcast multi-access network (frame relay, X.25) to a broadcast network. The step to configure the neighbor routers can be omitted during the OSPF routing process configuration. By using the **X.25 map** and **Frame-relay map** commands, you can enable the broadcast function on the X.25 and frame relay networks. In this case, the X.25 and frame relay networks are treated as the broadcast networks.

The point-to-multipoint network interface can be seen as the marked point-to-point interface of one or more neighbors. When the network type of is configured to the point-to-multipoint network type according to the OSPF routing protocol, multiple host routes are generated. Compared with the NBMA network, the point-to-multipoint network has the following advantages:

- Easy configuration without configuring the neighbors or specifying the designated router.
- Low cost without requiring fully meshed topology

Use the following command to configure the network type in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip ospf network** {**broadcast** | **non-broadcast** | **point-to-point** | {**point-to-multipoint** [**non-broadcast**]}}	Configures the OSPF network type.

For different link encapsulation types, the default network types described as follows:

- Point-to-point network type:

For PPP, SLIP, frame relay point-to-point subinterface, and X.25 point-to-point subinterface encapsulation

- NBMA (non-broadcast) network type:

For frame relay, X.25 encapsulation (except the point-to-point subinterface)

- Broadcast network type:

For Ethernet encapsulation

- The point-to-multipoint network type has no default.

It should be noted that the network type should be consistent at both sides. Otherwise, exceptions occur. For instance, the neighbor is Full and the routing calculation is incorrect.

Configuring a Point-to-Multipoint Broadcast Network

When routers are interconnected using the X.25 and frame relay networks, if the network is not a fully meshed network or you do not want to specify the designated router, you can set the network type of the OSPF interface to the point-to-multipoint type. Since the links are treated as point-to-point links on the point-to-multipoint network, multiple host

routes are generated. In addition, all neighbors have the same cost value on the point-to-multiple network. If you want to enable different neighbors to have different cost values, you can set the cost by using the **neighbor** command.

Use the following commands to configure the point-to-multipoint network type in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip ospf network point-to-multipoint**	Sets the broadcast network type for an interface to point-to-multipoint.
Ruijie(config-if)# **exit**	Returns to global configuration mode.
Ruijie(config)# **router ospf** *1*	Enters routing process configuration mode.
Ruijie(config-router)# **neighbor ip-address cost** *cost*	(Optional). Specifies the cost of the neighbor router.

Note

Although the OSPF point-to-multipoint network is a non-broadcast network, the non-broadcast network is allowed to have the broadcast capability by manual configuration or self-learning according to the frame relay and X.25 mapping. Therefore, you do not need to specify neighbors when configuring the point-to-multipoint network.

Configuring a Non-broadcast Network

When the OSPF routing protocol works on a non-broadcast network, you can set the network type to the NBMA or point-to-multipoint non-broadcast type. Since a non-broadcast network do not have the broadcast capability and cannot dynamically discover neighbors, you must manually configure neighbors for the non-broadcast network when the OSPF routing protocol is used.

Set the network type as the NBMA type in the following conditions:

- When a non-broadcast network has the fully meshed topology;
- When a broadcast network is configured as the NBMA network type to reduce the generation of the broadcast packets, save the network bandwidth, and avoid some arbitrary reception and transmission of routers. During the configuration of the NBMA network, you must specify neighbors and the designated router. Therefore, you must configure the priorities for the routers. It is more possible for the route with a higher priority to be specifies as the designated router.

Use the following commands to set the network type to the NBMA type in interface configuration mode.

Command	Function
Ruijie (config-if)# **ip ospf network non-broadcast**	Specifies the network type of the interface to NBMA.
Ruijie (config-if)# **exit**	Returns to global configuration mode.
Ruijie (config)# **router ospf** *1*	Enters routing process configuration mode.
Ruijie(config-router)# **neighbor** *ip-address* [*priority number*] [*poll-interval seconds*]	Specifies the neighbor, its priority, and polling interval of Hello packets.

The best solution is to set the network where the OSPF is used to the point-to-multipoint non-broadcast network when you cannot make sure whether any two routers on a non-broadcast network are reachable directly.

All neighbors on the point-to-multipoint broadcast or non-broadcast network have the same cost value which is configured by using the **ip ospf cost** command. However, the bandwidth of each neighbor may be different, so the cost is different. You can specify the cost for each neighbor by using the **neighbor** command. However, this only applies to the interface used on the point-to-multipoint type (broadcast or non-broadcast) network.

Use the following commands to set the type of the interface as the point-to-multipoint type on a non-broadcast network in interface configuration mode.

Command	Function
Ruijie (config-if)# **ip ospf network point-to-multipoint non-broadcast**	Specifies the network type of the interface to be the point-to-multipoint non-broadcast network type.
Ruijie (config-if)# **exit**	Returns to global configuration mode.
Ruijie (config)# **router ospf** *1*	Enters routing process configuration mode.
Ruijie(config-router)# **neighbor** *ip-address* [*cost number*]	Specifies the neighbor and the cost to the neighbor.

Pay attention to step 4. If you have not specified the cost for the neighbor, the cost referenced in the **ip ospf cost** command in interface configuration mode is used.

Configuring the Broadcast Network Type

It is necessary to specify the designated router (DR) and backup designated router (BDR) for the OSPF broadcast network. The DR advertises the link status of this network to external devices. All routers keep the neighbor relationship with each another and only the adjacent relationship with the designated router and backup designated router. That is to say, each router only exchanges the link status packets with the designated router and backup designated router. Then the designated router advertises the link status information to all other routers. As a result, each router can store a consistent link status database.

You can control the specifying result of the designated router by configuring the OSPF priority. This parameter does not take effect immediately until the new round for specifying the designated router. The new round for specifying the designated router occurs only when the OSPF neighbors do not receive the Hello packets from the designated router within the specified time and judge that the DR is down.

Use the following commands to configure the broadcast network type in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip ospf network broadcast**	Specifies the type of the interface to be the broadcast network type.
Ruijie(config-if)# **ip ospf priority** *priority*	(Optional) Specifies the priority of the interface.

Configuring OSPF Area Parameters

To configure area authentication, stub area, and default route summary cost, you need to configure area commands.

The area authentication is used to prevent from learning non-authenticated and invalid routes and advertising valid routes to non-authenticated routers. In a broadcast network, the area authentication can also prevent the non-authenticated routers from becoming the designated routers, therefore improving the stability and intrusion prevention capability of the routing system.

When an area is an OSPF leaf area, that is, the area neither acts as a transit area nor injects external routes to the OSPF area, you can configure the area as a stub area. The routers in a stub area can only learn about three routes: 1) Routes in the stub area, 2) Routers in other areas, and 3) Default routes advertised by the stub area border router. There are few external routes, so the size of the routing tables of the routers in the stub area is small, and fewer router resources are used. The routers in the stub area may be low- or middle-level routers. To further reduce the number of the LSAs sent to the stub area, you can configure the area as a totally stub area (configured with the **no-summary** option). The routers in the totally stub area can learn two types of routes: 1) Routes in the totally stub area; 2) Default routes advertised by the border router in the totally stub area. After the totally stub area is configured, the router resources occupied by the OSPF are minimized, therefore improving the network transmission efficiency.

If the routers in a stub area can learn multiple default routes, you need to set the costs for these default routes by using the **area default-cost** command, so that the routers in the stub area use the specified default routes with priority.

Pay attention to the following aspects when configuring a stub area:

- A backbone area cannot be configured as a stub area, and the stub area cannot be used as the transmission area of virtual links.
- There is no ASBR in the stub area. In other words, the routes outside an autonomous system cannot be transmitted in this area.
- To set an area as the STUB area, configure all routers in this area with the same attribute.

Use the **no area *area-id*** command to remove the configurations of the specified OSPF area and delete the area, including deleting the area-based configuration commands such as **area authentication**, **area default-cost**, **area filter-list**, **area stub**, and **area nssa**. However, the user cannot remove the OSPF area configurations in the following circumstances:

3) The user needs to remove all configurations of the backbone area, however, configurations of virtual links exist. In this case, the user can delete the backbone area only when the configurations of virtual links are removed.

4) The corresponding **network area** command exists in any area. In this case, the user can delete the area only when all network segment commands added in this area are removed.

Use the following commands to configure the OSPF area parameters in routing process configuration mode.

Command	Function
Ruijie (config-router)**#area** *area-id* **authentication**	Sets plain-text authentication for the area.
Ruijie (config-router)**#area** *area-id* **authentication message-digest**	Sets MD5 authentication for the area.
Ruijie (config-router)#area *area-id* **stub** [**no-summary**]	Sets the area as a stubby area. **no-summary**: Sets the area as a stubby area to prevent the ABR in a stub area from sending summary-LSA information to the stub area.
Ruijie (config-router)**#area** *area-id* **default-cost** *cost*	Configures the cost of the default route sent to the stub area.

Note

When configuring the authentication, you need to configure the authentication parameters on an interface. For more details, see the "Configuring OSPF Interface Parameters" section. You must configure all routers in the area to have the same configuration with the stub area. To configure a totally stub area, you also have to configure the totally stub area parameters on the border routers in the stub area in addition to the basic configuration of the stub area, and you do not need to change the configurations of other routers.

Configuring an OSPF NSSA

The NSSA is an expansion of the OSPF stub area. In the NSSA, the consumption of router resources is reduced by preventing the type-5 LSAs (AS-external-LSA) from flooding to the NSSA. However, unlike the stub area, the NSSA can inject some routing information outside the autonomous system to the OSPF routing area.

Through the route redistribution, the external AS routes (type-7) are allowed to import to the NSSA. These external type-7 LSAs are converted into the type-5 LSAs on an area border router in the NSSA and flooded to the entire autonomous system. In this process, the external routes are aggregated and filtered.

Pay attention to the following aspects when configuring the NSSA:

- A backbone area cannot be configured as an NSSA, and the NSSA cannot be used as the transmission area of virtual links.
- To set an area as the NSSA, configure all routers connected to the NSSA with the NSSA attribute by using the **area nssa** command.

Use the following commands to configure an area as the NSSA area in routing process configuration mode.

Command	Function
Ruijie (config-router)# area *area-id* **nssa** [**no-redistribution**] [**no-summary**] [**default-information-originate[metric** *metric*][**metric-type** [**1** | **2**]]] [**translator** [**stability-interval** *seconds* | **always**]]	(Optional) Defines an NSSA area.
Ruijie (config-router)# **area** *area-id* **default-cost** *cost*	Configures the cost of the default route sent to the NSSA area.

Use the *default-information-originate* parameter to generate the default Type-7 LSA. This option varies slightly between the ARR and ASBR in the NSSA. On the ABR, whether the routing table contains a default route or not, the default Type-7 LSA route is generated. On the ASBR, the default Type-7 LSA route is generated only when the routing table of the ASBR contains a default route.

If the *no-redistribution* parameter is configured on the ASBR, other external routes introduced by using the **redistribute** commands are not allowed to be distributed to the NSSA. This option is usually used when the router in the NSSA is both an ASBR and an ABR. This option can also prevent the external routing information from entering the NSSA.

To further reduce the number of the LSAs sent to the NSSA, you can configure the *no-summary* parameter on the ABR to prevent the ABR from sending the aggregated LSAs (Type-3 LSAs) to the NSSA.

In addition, the *area default-cost* parameter is used on the ABR/ASBR connected to the NSSA. This option is used to configure the cost of the default route sent by the ABR/ASBR to the NSSA. By default, the cost value of this default route is 1.

If two or more than two ABRs exist in an NSSA area, the ABR with the largest ID is selected as the translator to translate the Type-7 LSAs to the Type-5 LSAs by default. You can use the *translator always* parameter to configure the current router as the permanent translator ABR.

If the translator role is acted by other ABRs, the current router keeps the capability within the **stability-interval** time. If the router is not configured as the translator again within this period, after the **stability-interval** time expires, LSAs translated from Type-7 to Type-5 will be removed from the AS.

Note

The Type-5 LSAs aggregated and translated from the Type-7 LSAs are removed immediately after the current router becomes translator-disabled without waiting for the **stability-interval** timeout to prevent routing loop.

In the same NSSA area, it is recommended to configure the *translator always* parameter for only one ABR.

Configuring OSPF Route Aggregation

Configuring the Route Aggregation between Areas

An area border router (ABR) has at least two interfaces that belong to different areas, one of which must be a backbone area. The ABR acts as the pivot in the OSPF routing area. It can advertise the routes of one area to another area. If the network addresses of the routes of this area are continual, the ABR can advertise only one aggregated route to other areas. The route aggregation function between areas greatly reduces the size of the routing table and improves the network efficiency.

Use the following command to configure the route aggregation between areas in routing process configuration mode.

Command	Function
Ruijie (config-router)# **area** *area-id* **range** *ip-address mask* [**advertise** | **not-advertise**] [**cost** *cost*]	Configures the route aggregation between areas.

Note

If the route aggregation is configured, the ABR does not advertise the detailed routes in this area to other areas.

Configuring the External Route Aggregation

When routes are redistributed in other routing processes and imported into the OSPF routing process, every route is advertised to the OSPF-enabled router as a separate link. If the injected routes have continuous IP addresses, an ASBR can advertise only one aggregated route, therefore reducing the size of the routing table significantly.

Use the following command to configure the external route aggregation in routing process configuration mode.

Command	Function
Ruijie (config-router)# **summary-address** *ip-address mask* [**not-advertise** | **tag** *tag-id*]	Configures the external route aggregation.

Controlling the Aggregated Routes to Be Added to the Routing Table

The network range after the route aggregation may exceed the original network range in the routing table. If data are sent to the network beyond the aggregation range, routing loop may incur or load on the router may increase. Therefore, add a discard route to the routing table of the ABR or ASBR to prevent that problem.

Use the following commands to allow or forbid adding the discarded routes to the routing table in routing process configuration mode.

Command	Function
Ruijie (config-router)# **discard-route** {**internal** | **external**}	Allows adding the discarded routes to the routing table.
Ruijie (config-router)# **no discard-route** {**internal** | **external**}	Forbids adding the discarded routes to the routing table.

By default, adding the discarded routes to the routing table is allowed.

Creating a Virtual Link

In an OSPF routing area, the OSPF route update between non-backbone areas is performed by using the backbone area. All non-backbone areas are connected to the backbone area. If the backbone area is disconnected with the non-backbone areas, you need to configure virtual links to connect the non-backbone areas to the backbone area. Otherwise, the network communication fails. Create virtual links for the connections when physical links cannot meet the requirements due to the limitation of the network topology.

A virtual link can be created between two ABRs. The common area that the two ABRs belong to is a transit area. A stub area and NSSA area cannot be used as the transit area. The virtual link can be seen as a logical connection channel established between the two ABRs via the transit area. On both ends of the virtual link deploy ABRs and configuration on both ends must be performed synchronously. The virtual link is identified with the router ID of the peer router. The area that provides the two ends of the virtual link with an internal non-backbone area route is called the transit area, whose number must be specified during the configuration.

The virtual link will be activated after the route in the transit area has been calculated (that is, the route to the peer router). You can see it as a point-to-point link, on which most parameters of the interface, such as the *hello-interval* and *dead-interval* parameters, can be configured like a physical interface.

A logical channel means that multiple routers running the OSPF routing protocol between the two ABRs. The logical channel is only used to forward packets. (Since the destination of the protocol packets are not these routers, the packets are transparent to them and are simply forwarded as common IP packets.) The two ABRs exchange routing information directly, and the synchronization mode in the area is not changed. The routing information means the Type-3 LSAs generated by the ABR.

Use the following command to create a virtual link in routing process configuration mode.

Command	Function
Ruijie (config-router)# **area** *area-id* **virtual-link** *router-id* [[**hello-interval** *seconds*]| [**retransmit-interval** *seconds*] |[transmit-delay *seconds*]|[**dead-interval** *seconds*]| [**authentication** [**message-digest**	**null**] |[[**authentication-key** [**0**|**7**] *key*	**message-digest-key** *keyid* **md5** [**0**|**7**] *key*]]]	Creates a virtual link.


Caution

If the autonomous system is divided into more than one area, one of the areas must be the backbone area to which the other areas must be connected directly or logically. Also, the backbone area must be in good connection.


Note

The *router-id* is the ID of an OSPF neighbor router. If you are not sure of the router-id, you can use the **show ip ospf** or **show ip ospf neighbor** command to check it. For information about how to manually configure the router-id, see the "Using the Loopback Interface Address as the Route ID" section.

Generating a Default Route

An ASBR can be forced to generate a default route, which is injected to the OSPF routing area. If a router is forced to generate the default route, it is configured to be the ASBR automatically. However, the ASBR does not automatically generate the default route.

Use the following command to force the ASBR to generate a default route in routing process configuration mode.

Command	Function
Ruijie (config-router)# **default-information originate** [**always**] [**metric** *metric-value*] [**metric-type** ***type****-value*] [**route-map** ***map****-name*]	Generates a default route.


Note

When the stub area is configured, the ABR generates the default route automatically and advertises the default route to all routers within this stub area.

Using the Loopback Interface Address as the Router ID

In an OSPF routing process, the largest interface IP address is always used as the router ID. If the interface is disabled or the IP address does not exist, the router ID must be calculated again and all the routing information is sent to the neighbors.

If the loopback interface address (local loop address) is configured, then in the routing process, the IP address of the loopback interface is used as the router ID. If there are multiple loopback interfaces, the largest IP address is selected as the router ID. The loopback address always exists, therefore improving the stability of the routing table.

Use the following commands to configure the loopback address in global configuration mode.

Command	Function
Ruijie (config)# **interface loopback** *1*	Creates the loopback interface.
Ruijie (config-if)# **ip address** *ip-address mask*	Configures the loopback IP address.

Note

When the IP address of a common interface is specified as the route identifier in the OSPF routing process, even if the loopback interface is configured, the identifier is not specified once again in the OSPF process.

Changing the Default OSPF Management Distance

The management distance of a route represents the credibility of the route source. The management distance ranges from 0 to 255. The greater this value is, the lower the credibility of the route source is.

The OSPF function supported on Ruijie products supports intra-area, inter-area, and external routes, whose management distances are all 110 by default. A route belongs to a same area is called the intra-area route, a route to another area is called the inter-area route, and a route to another routing area (learned through redistribution) is called the external route.

Use the following command to change the OSPF management distance in routing process configuration mode.

Command	Function
Ruijie(config-router)# **distance** {*distance* | **ospf** {**intra-area** *distance* | **inter-area** *distance* | **external** *distance*}}	Changes the OSPF management distance.

Configuring the Route Calculation Timer

When receiving a notification about route topology changes in the OSPF routing process, the system runs the SPF algorithm for route calculation after a time delay. You can configure this delay and also configure the minimum interval between two SPF calculations.

Use the following command to configure the OSPF route calculation timer in routing process configuration mode.

Command	Function
Ruijie (config-router)# **timers throttle spf** *spf-delay spf-holdtime spf-max-waittime*	Configures the route calculation timer.

Note

The *spf-delay* refers to the delay time from the time when the topology changes to the time when the SPF calculation is performed. The *spf-holdtime* refers to the minimum time interval between two SPF calculations. Later, the time interval of the consecutive SPF calculations shall be at least twice as the last time interval until the time interval reaches the *spf-max-waittime* value. If the time interval between two SPF calculations has exceeded the minimum value, then the time interval is recalculated from the *spf-holdtime*.

Normally, reducing the value of *spf-delay* and *spf-holdtime* can speed up the OSPF convergence if the link turbulence occurs occasionally. Increasing the value of the *spf-max-waittime* can avoid the CPU consumption by the OSPF routing process due to the consecutive link turbulence.

For example, timers throttle spf 1000 5,000 100,000

If the topology changes constantly, the time interval for SPF calculations increases in the ascend order as follows when calculated by using the binary exponential backoff algorithm, but this time interval does not exceed the *spf-max-waittime*:

1 second, 6 seconds, 16 seconds, 36 seconds, 76 seconds, 156 seconds, 256 seconds, 256+100 seconds…

Use the following command to configure only the OSPF route calculation delay and hold-time in routing process configuration mode.

Command	Function
Ruijie (config-router)# **timers spf** *spf-delay spf-holdtime*	Configures the route calculation timer in seconds.

Caution

The **timers spf** and **timers throttle spf** commands overwrite each other during the configuration. The latter configured command takes effect. If neither of the two commands are configured, the default value is the value configured in the **timers throttle spf** command.

The **timers throttle spf** command is more powerful than the **timers spf** command. Therefore, you are advised to use the **timers throttle spf** command.

Changing the LSA Group Pacing Timer

Each LSA has an LSA age. When the LSA age reaches 1800s, LSA should be refreshed to avoid being cleared. Calculating the refresh and aging time for each LSA respectively consumes lots of CPU. To make full use of the CPU, LSAs are refreshed in groups. The interval for refreshing LSAs in groups are referred to as the group pacing interval.

With a fixed amount of LSAs, the longer the group pacing interval lasts, the more the LSAs need to be handled when the interval is due. To maintain CPU stability, it is recommended to shorten the group pacing interval if there are many LSAs. For example, if approximately 10,000 LSAs exist in the database, the shorter the pacing interval, the better. If only 40 to 100 LSAs exist in the database, increasing the pacing interval to 10 to 20 minutes might be better.

Use the following commands in routing process configuration mode.

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode.
Ruijie (config)# **router ospf** *1*	Enables the OSPF and enters OSPF configuration mode.
Ruijie (config-router)# **timers pacing lsa-group** *seconds*	(Optional) Changes the LSA group pacing.
Ruijie (config-router)# **end**	Returns to privileged EXEC mode.

Command	Function
Ruijie # **show running-config**	Verifies the configurations.
Ruijie # **write**	(Optional) Saves the configurations.

To restore the default value, use the **no timers pacing lsa-group** in global configuration mode.

Configuring the Cost for the OSPF Interface

The OSPF system calculates the destination route based on cost. The route with the least cost is the shortest route. The default route cost is based on network bandwidth. When you configure the OSPF-enabled router, you can set the link cost according to the factors such as link bandwidth, time delay or economic cost. The lower the link cost is, the higher the possibility is for the link to be selected as the route. If route aggregation is enabled, the maximum cost of all the aggregated links are used as the cost of the aggregated information.

Routing configuration includes two steps. First, specify a reference value for the generated cost based on the bandwidth. This value and the interface bandwidth are used to calculate the default cost. Second, set the cost for each interface by using the **ip ospf cost** command. In this case, the default cost takes no effective on the interface. For example, if the default reference value is 100 Mbit/s, and the bandwidth of an Ethernet interface is 10 Mbit/s, the default cost of this interface is 100/10 + 0.5 ≈ 10.

The interface cost is selected in the following way according to the OSPF protocol: The cost of the interface specified by the user has the highest priority. If you have specified the interface cost, the cost is used as the interface cost. If you do not specify the interface cost but the automatic cost generation function is enabled, the automatically calculated value is used. If the automatic cost generation function is disabled, the default value 10 is used.

Use the following commands to perform the configuration.

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode.
Ruijie (config)**# router ospf** *1*	Enters routing protocol configuration mode.
Ruijie(config-router)# **auto-cost reference-bandwidth** *ref-bw*	(Optional) Sets the default cost based on the bandwidth on an interface. The cost value is determined based on the *ref-bw* parameter.
Ruijie (config-router)**# end**	Returns to privileged EXEC mode.
Ruijie # **show ip protocols**	Displays the routing protocol that is running currently.
Ruijie # **write**	(Optional) Saves the configurations.

To remove the setting, use the **no ip ospf cost** and **auto-cost** command.

Configuring an OSPF Stub Router

A router that only forwards packets to its directly-connected links is called a stub router. To prevent low-level routers from handling massive LSAs or to enable the routers to smoothly join/exit a network, you can configure such routers as stub routers. The stub router can advertise its maximum cost so that other routers will not preferentially use this router as a transit node during SPF calculation.

After the **max-metric router-lsa** command is enabled, the metric of non-stub links carried in the Router LSA generated by the router will be used as the maximum value (0xFFFF). After the user removes the setting or the timer expires, the default metric of the links is restored.

By default, after this command is enabled, the ordinary metric of stub links is advertised, namely the cost of the egress. If the *include-stub* parameter is configured, the maximum metric of the stub links is advertised.

If you do not want to transmit the data in an area, use the *summary-lsa* parameter to configure the summary LSA as the maximum metric for the ABR.

If you do not want to transmit the data in an external area, use the *external-lsa* parameter to configure the external LSA as the maximum metric for the ASBR.

The **max-metric router-lsa** command is generally used in the following circumstances:

- Restart the router. After the router is restarted, the IGP protocol is converged more quickly, and other routers may try to forward the data through the restarted router. If the router is still building BGP routing tables and certain BGP routes have not be learned, packets sent to such router will be discarded. In this case, use the on-startup parameter to configure a delay timer, so that the restarted router can act as the transit node after the timer runs out.
- Connect the router to the network without using the router to transmit the packets. If alternative paths exist, the current router will not be used to transmit the packets. If no alternative path exists, the current router will still be used to transmit the packets.
- Gracefully remove the router from the network. By using this command, the current router can advertise a maximum metric value, so that other routers on the network will select the alternative paths to transmit the packets before the router is shut down.

Use the following commands to configure a router to advertise a maximum metric in routing process configuration mode.

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode.
Ruijie (config)# **router ospf** *1*	Enables the OSPF and enters OSPF configuration mode.
Ruijie (config-router)# **max-metric router-lsa** [**external-lsa** [*max-metric-value*]] [**include-stub**] [**on-startup** [*seconds*]] [**summary-lsa** [*max-metric-value*]]	(Optional) Configures the router to advertise a maximum metric.
Ruijie (config-router)# **end**	Returns to privileged EXEC mode.
Ruijie # **show ip protocols**	Displays the routing protocol that is running currently.
Ruijie # **write**	(Optional) Saves the configurations.

Caution In the earlier versions of the OSPF (RFC 1247 or earlier versions), links with the maximum metric (0xFFFF) in the LSAs are not involved in the SPF calculation, that is, no packet is sent to routers generating these LSAs.

Configuring Whether to Perform the MTU Check on an Interface

When the OSPF system receives database description packets, it will check whether the MTU of a neighbor interface is the same as its own MTU. If the MTU of the interface indicated in the received database description packets is greater than that of the receiving interface, the adjacency relationship cannot be established. In this case, you can disable the MTU check function.

Use the following command to disable the MTU check on an interface in interface configuration mode.

Command	Function
Ruijie (config-if)# **ip ospf mtu-ignore**	Disables the MTU check on the interface when the interface receives the database description packets.

The MTU check on an interface is disabled by default.

Disabling an Interface to Send the OSPF Packets

To prevent other routers on the network from dynamically learning the routing information of the local router, you can use the **passive-interface** command to set the specified network interface of the local router as a passive interface or set the address of the specified interface as a passive address to prevent the local router from sending the OSPF packets.

Use the following commands to configure an interface as a passive interface in privileged EXEC mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router ospf** *1*	Enters routing protocol configuration mode.
Ruijie(config-router)# **passive-interface** *interface-name*	(Optional) Sets the specified interface as a passive interface.
Ruijie(config-router)# **passive-interface default**	(Optional) Sets all network interfaces as the passive interfaces.
Ruijie(config-router)# **passive-interface** *interface-name ip-address*	(Optional)Sets the address of the specified interface as the passive address.
Ruijie(config-router)# **end**	Returns to privileged EXEC mode.
Ruijie# **write**	Saves the configurations.

By default, all interfaces are allowed to receive and send the OSPF packets. To re-enable the network interface to send the routing information, use the **no passive-interface** *interface-name* [*ip-address*]command. To re-enable all network interfaces, use the keyword **default.**

Configuring Whether to Perform the Source Address Check

According to the OSPF requirements, the source address of the received packets must be in the same network segment with the address of the interface that receives the packets. However, for a point-to-point link, the addresses of the two link ends are configured independently, so the addresses are not required to be in the same network segment. In the negotiation process of a point-to-point link, the address information about the peer end is advertised. Therefore, the OSPF system will check whether the source address of the packets is the address advertised by the peer end during the negotiation. If the two addresses are not consistent, the system will treat the packets as unauthorized packets and discard the packets. The negotiated address may be shielded in some applications. In this case, disable this source address check function to establish the OSPF adjacency relationship properly. In particular, this function is disabled on the unnumbered interface all the time.

Use the following command to configure whether to perform the source address check on a point-to-point link in interface configuration mode.

Command	Function
Ruijie (config-if)# **ip ospf source-check-ignore**	Disables the source address check on the point-to-point link.

The source address check on a point-to-point link is enabled by default.

Configuring the OSPF Fast Convergence Function

Configuring the OSPF Fast Hello

The OSPF Fast Hello function facilitates fast discovery of OSPF neighbors and supports quick detection of lost OSPF neighbors. The OSPF Fast Hello function is enabled by specifying the **minimal** and **hello-multiplier** keywords and the *multiplier* parameter. The **Minimal** keyword is used to set the dead interval to 1 second, and the **hello-multiplier** keyword is used to configure the times for sending Hello packets during the dead interval, therefore the interval for sending the Hello packets is reduced to less than 1 second.

When the Fast Hello function is enabled on the interface, the **Hello interval** field for the interface sending the Hello packets is set to 0. The **Hello interval** field for the interface receiving the Hello packets is ignored.

No matter whether the Fast Hello function is enabled or not, the dead interval must be consistent on a same network segment. However, the *hello-multiplier* parameter is not required to be consistent on a same network segment as long as at least one Hello packet is received within the dead interval.

Use the following commands to configure the Fast Hello on an interface.

Command	Function
Ruijie**# configure terminal**	Enters global configuration mode.
Ruijie(config)**# ip routing**	Enables the IP routing function (if disabled).
Ruijie(config)**# interface** *interface-id*	Enters interface configuration mode.
Ruijie(config-if)**# ip ospf dead-interval minimal hello-multiplie**r *multiplier*	(Optional) Enables the OSPF Fast Hello on the interface.
Ruijie (config-if)**# end**	Returns to privileged EXEC mode.
Ruijie **# show ip ospf** [*process-id*]**interface** [*interface-id*]	Displays the OSPF interface information.
Ruijie **# write**	Saves the configurations.

Use the following commands to configure the Fast Hello on a virtual link.

Command	Function
Ruijie**# configure terminal**	Enters global configuration mode.
Ruijie (config)**# ip routing**	Enables the IP routing function (if disabled).
Ruijie (config)**# router ospf** *process_id* [**vrf** *vrf-name*]	Enables the OSPF and enters OSPF configuration mode.
Ruijie (config-router)**# area** *area-id* **virtual-link** *router-id* [**dead-interval** | **minimal hello-multiplier** *multiplier*]	Enables the Fast Hello on the virtual link
Ruijie (config-router)**# end**	Returns to privileged EXEC mode.
Ruijie **# write**	Saves the configurations.

Caution You cannot configure the *dead-interval minimal hello-multiplier* parameter and the *hello-interval* parameter at the same time.

Configuring the OSPF Two-Way Maintenance

On a large scale network, a large number of packets may be received and transmitted, which occupies high CPU and memory resources, therefore causing the delay or drop of certain packets. If the time for processing the Hello packets goes beyond the dead interval, the corresponding adjacent routers will be disconnected. In this case, enable the OSPF two-way maintenance function. If a large number of packets exist on the network, besides the Hello packets, the DD, LSU, LSR and LSAck packets from a certain neighbor can also be used to maintain the two-way adjacency relationship, therefore avoiding the disconnection of neighbors caused by the delay or drop of the Hello packets.

The OSPF two-way maintenance function is enabled by default. Use the following commands to disable the OSPF two-way maintenance function in routing process configuration mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router ospf** *1*	Enters routing protocol configuration mode.
Ruijie(config-router)# **no two-way-maintain**	(Optional) Disables the OSPF two-way maintenance function.
Ruijie(config-router)# **end**	Returns to privileged EXEC mode.
Ruijie# **write**	Saves the configurations.

Configuring the Interval of Receiving the Same LSA

On a broadcast network or in the environment featured by frequent network oscillation, the router may receive the same LSA updates from one or multiple interfaces and different neighbors. If the same LSAs are processed every time, excessive system resources are wasted. According to the OSPF protocol, the same LSAs are considered to be valid after a period of time. The same LSAs received within a short period of time will be ignored. This time interval is the constant MinLSArrival with the value set to 1 second.

Different types of networks have different requirements on the interval for processing LSA changes. The user can configure this parameter according to different network planning and performance requirements to optimize the network.

Use the following commands to configure the interval of receiving the same LSA in routing process configuration mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router ospf** *1*	Enters routing protocol configuration mode.
Ruijie(config-router)# **timers lsa arrival** ***arrival****-time*	(Optional) Configures the interval of receiving the same LSA. The default value is 1000 milliseconds.
Ruijie(config-router)# **end**	Returns to privileged EXEC mode.
Ruijie# **write**	Saves the configurations.

Configuring to Send the LSA Packet Updates

To relieve the impacts on network devices caused by the flooding of a large number of update packets, the LSP packet update function is introduced. By specifying the delay interval for the update packets, the LSAs to be flooded during the interval can be collected, so that these LSAs can be sent with the least number of packets. Meanwhile, the CPU can process other tasks and the system performance is optimized.

When a large number of LSAs exist on the network and the router loads excessively, you need to configure the **transmit-time** and **transmit-count** commands properly to control the number of LS-UPD packets flooded on the network. When the load of CPU is low and the network bandwidth is small, you can reduce the transmit-time value and increase the transmit-count value to speed up the network convergence.

Use the following commands to configure the LSA to send the packet updates in routing process configuration mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router ospf** *1*	Enters routing protocol configuration mode.
Ruijie(config-router)# **timers pacing lsa-transmit** *transmit-time transmit-count*	(Optional) Configures the LSA to send the packet updates.
Ruijie(config-router)# **end**	Returns to privileged EXEC mode.
Ruijie# **write**	Saves the configurations.

Configuring the **Exponential Backoff Algorithm** for Generating LSAs

To prevent multiple events from triggering the same LSAs within a short time, causing frequent LSA updates, and consuming excess CPU resources, you can specify the minimum time interval "MinLSInterval" for generating the LSAs according to the OSPF routing protocol. The default minimum time interval is 5 seconds. During this time interval, the same LSA instances cannot be generated repeatedly, therefore preventing frequent LSA oscillation from causing impacts on the network. However, this configuration slows down the LSA generation speed and fails to advertise the network topology changes immediately.

To quickly respond to the network topology changes and avoid excessively frequent route calculations, use the exponential backoff algorithm to dynamically change the time interval for generating the LSAs. The **timers throttle lsa all** command has three parameters: *delay-time*, *hold-time*, and *max-wait-time*, which allow the system to automatically adjust the time interval for generating the LSAs according to the frequency of the network topology changes. Generally, *delay-time* is set to a small value or 0 to trigger LSA instances immediately when the network topology is comparatively stable. When the network topology changes frequently, the time interval for generating the LSAs increases from the *hold-time* and follows the algorithm of *hold-time* x 2^{n-1}. n refers to the times of changes. With the times for generating LSAs repeatedly increasing, the time interval for generating the LSAs becomes greater and greater until the *max-wait-time* is reached. When the time interval for generating the LSAs is greater than the *max-wait-time*, the *delay-time* for generating the LSAs restores to the initial value.

By default, the initial value is 0 milliseconds, the *hold-time* is 5000 milliseconds, and the *max-wait-time* is 5000 milliseconds. The shortest interval for consecutively generating the same LSA is the *MinLSInterval*, which complies with the rules defined in RFC 2328.

Use the following commands to configure the exponential backoff algorithm for generating the LSAs in routing process configuration mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router ospf** *1*	Enters routing protocol configuration mode.

Ruijie(config-router)# **timers throttle lsa all** *delay-time hold-time max-wait-time*	(Optional) Configures the exponential backoff algorithm for generating the LSAs. By default, the initial value is 0 milliseconds, the *hold-time* is 5000 milliseconds, and the *max-wait-time* is 5000 milliseconds.
Ruijie(config-router)# **end**	Returns to privileged EXEC mode.
Ruijie# **write**	Saves the configurations.

Caution During the configuration, the *hold-time* cannot be less than the *delay-time*, and the *max-wait-time* cannot be less than the *hold-time*.

Configuring the OSPF Capacity Protection Function

When the memory lacks, the OSPF system enters the overflow state. In the overflow state, the OSPF protocol triggers the following operations:

- For the learned LSAs: receive the inter-area and intra-area LSAs, and only receive the external LSAs indicating that the route to the destination address is a specific non-default route.
- For the external LSAs generated by itself: clear the external LSAs except for the LSAs indicating the default routes.
- The incompleteness of route learning and advertisement may lead to the routing loop on the network. The OSPF system generates a default route to the NULL interface to prevent the routing loop. The generated default route exists in the overflow state all the time.

Use the following commands to configure the OSPF router to enter the overflow state when the memory lacks.

Command	Function
Ruijie(config)#**router ospf** *process-id*	Enters OSPF configuration mode.
Ruijie(config-router)#**overflow memory-lack**	Configures the OSPF system to enter the overflow state when the memory lacks.

Note By default, the OSPF system enters the overflow state automatically when the memory lacks. You can use the **no overflow memory-lack** command to disable this function.

Caution You must use the **clear ip ospf process** command or restart the OSPF protocol to exit from the overflow state.

Configuring the OSPF Network Management Function

Configuring the OSPFv2 MIB Binding

The user can only operate a sole OSPFv2 process by SNMP since the OSPFv2 MIB does not have the OSPFv2 process information. By default, the OSPFv2 MIB is bound to the OSPFv2 process with the smallest scale, and this process takes effect over all user operations.

The user can bind the OSPFv2 MIB to the process manually to operate the specified OSPFv2 process by using SNMP.

Use the following commands in routing process configuration mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router ospf** *1*	Enters routing protocol configuration mode.
Ruijie(config-router)# **enable mib-binding**	(Optional) Binds the OSPFv2 MIB to the specified OSPFv2 process.
Ruijie(config-router)# **end**	Returns to privileged EXEC mode.
Ruijie# **write**	Saves the configurations.

Configuring the OSPFv2 TRAP Binding

The OSPFv2 protocol defines several types of OSPF TRAP information, which is used to report various events about the OSPFv2 protocol. Sending the OSPFv2 TRAP information is not restricted by the MIB binding to the OSPFv2 process. The TRAP switch is allowed to be enabled for different processes at the same time.

Use the following commands in global configuration mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **snmp-server enable traps ospf**	(Optional) Enables the OSPF TRAP sending switch.
Ruijie(config)# **router ospf** *1*	Enters routing protocol configuration mode.
Ruijie(config-router)# **enable traps [error [IfAuthFailure | IfConfigError | IfRxBadPacket | VirtIfAuthFailure | VirtIfConfigError | VirtIfRxBadPacket] | lsa [LsdbApproachOverflow | LsdbOverflow | MaxAgeLsa | OriginateLsa] | retransmit [IfTxRetransmit | VirtIfTxRetransmit] | state-change [IfStateChange | NbrRestartHelperStatusChange | NbrStateChange | NssaTranslatorStatusChange | RestartStatusChange | VirtIfStateChange | VirtNbrRestartHelperStatusChange | VirtNbrStateChange]]**	(Optional) Enables the specified OSPF TRAP switch.
Ruijie(config-router)# **end**	Returns to privileged EXEC mode.
Ruijie# **write**	Saves the configurations.

Configuring the OSPF GR Function

The graceful restart (GR) function is used to enable data packets to be forwarded continuously during the restart process of the OSPF protocol. Currently, the GR function is supported on the switchover between our primary and secondary high-end devices to ensure that the key service is not interrupted.

Working Principles of the OSPF GR

OSPF GR standard:

RFC3623: Graceful OSPF Restart

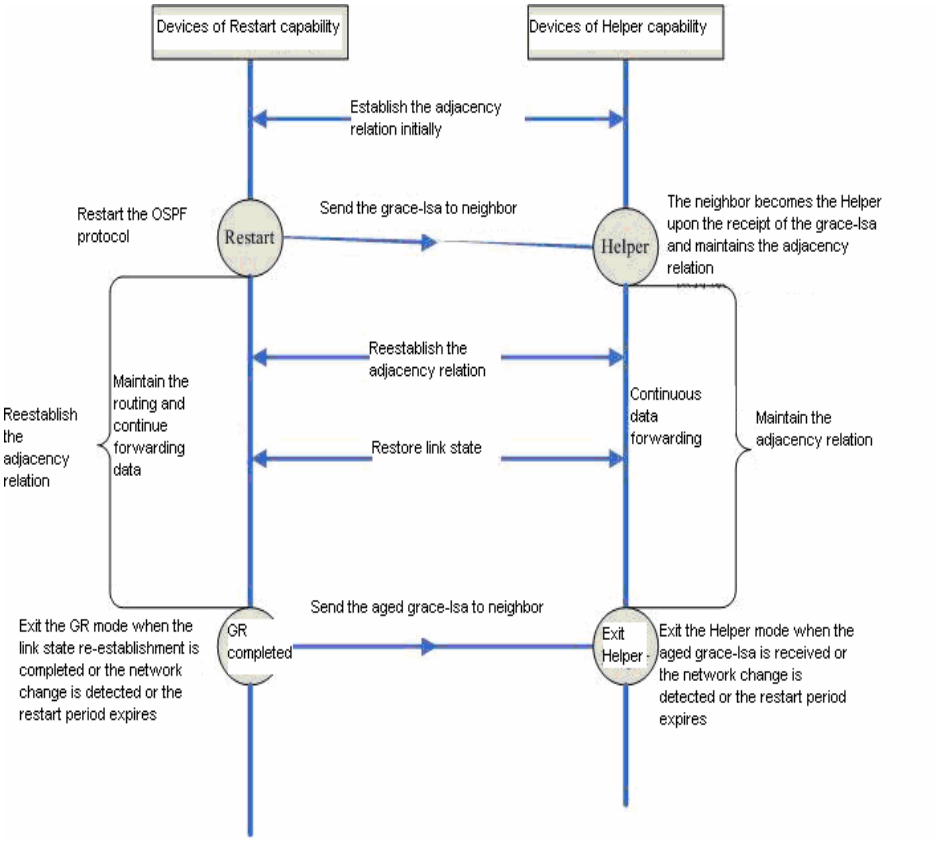
Working principles of RFC3623:

As a standard GR protocol defined by the IETF for the OSPF, RFC3623 defines the conditions, operations and precautions required for executing the Graceful Restart. As specified in RFC3623, two GR principles are important. Namely, the network topology should be stable and the router for restarting the protocols can maintain the forwarding table during the restarting process.

The execution of OSPF GR is not an independent process. The OSPF GR has the GR Restart and GR Help functions. The device with the GR Restart capability can automatically perform the graceful restart operation, and the device with the GR Help capability can receive Grace_LSAs and help the neighbors to perform the graceful restart operation.

Generally, the device that has the GR Restart capability and is performing the GR operation is called the GR Restarter. The device that has the GR Help capability and is helping the GR Restarter to perform the GR operation is called the GR Helper. The GR process begins from the operation where the GR Restarter sends a Grace LSA. The neighbor becomes the GR Helper upon receiving the Grace LSA and assists the GR Restarter to reestablish the adjacency relationship. Meanwhile, the neighbor maintains the adjacency relationship with the GR Restarter for continuous data forwarding.

OSPF GR execution flowchart



The above figure outlines the execution process of the OSPF GR. The GR period is the longest time for reestablishing the link status. When the period for the link reestablishment or the graceful restart expires, the GR Restarter exits the GR operation.

Configuring the OSPF GR Restarter

Use the **graceful-restart** command to enable the OSPF GR restarter.

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode.
Ruijie (config)# **router ospf** *1*	Enables the OSPF and enters OSPF configuration mode.
Ruijie (config-router)# **graceful-restart**	Enables the OSPF GR restarter.
Ruijie (config-router)# **end**	Returns to privileged EXEC mode.
Ruijie # **show running-config**	Verifies the configurations.
Ruijie # **write**	(Optional) Saves the configurations.

By default, the GR restarting period is 120 seconds. Use the **graceful-restart grace-period** command to modify the restarting period.

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode.
Ruijie (config)# **router ospf** *1*	Enables the OSPF and enters OSPF configuration mode.
Ruijie (config-router)# **graceful-restart** grace-period *100*	Enables the OSPF GR restarter and sets the GR restarting period to 100 seconds.
Ruijie (config-router)# **end**	Returns to privileged EXEC mode.

Command	Function
Ruijie # **show running-config**	Verifies the configurations.
Ruijie # **write**	(Optional) Saves the configurations.

Note The routers do not support this function.

Configuring the OSPF GR Helper

The OSPF GR Helper is enabled by default. The software provides the functions to disable the GR Helper and configure the GR Helper to detect the network changes. The following example shows how to disable and re-enable the GR Helper function and how to configure the Helper to detect the network changes.

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode.
Ruijie (config)# **router ospf** *1*	Enables the OSPF and enters OSPF configuration mode.
Ruijie (config-router)# **graceful-restart helper disable**	Disables the OSPF GR Helper (for disabling the GR help to neighbors).
Ruijie (config-router)# **no graceful-restart helper disable**	Enables the OSPF GR Helper again.
Ruijie (config-router)# **graceful-restart helper** {**strict-lsa-checking** | **internal-lsa-checking**}	Enables the OSPF GR Helper to check the LSA changes to detect the network changes. If the network changes, exit the GR Helper. By default, the network changes are not detected after the GR Helper is enabled. **strict-lsa-checking:** checks the changes of types 1 to 5 and type 7 LSAs. **internal-lsa-checking:** checks the changes of types 1 to 3 LSAs.
Ruijie (config-router)# **end**	Returns to privileged EXEC mode.
Ruijie # **show running-config**	Verifies the configurations.
Ruijie # **write**	(Optional) Saves the configurations.

Changes in a part of the network may disable the GR function and cause low convergence performance on the entire network. Therefore, it is not recommended that the user enable the LSA detection function when the network is in a large scale.

Configuring the OSPF BFD Function

For details about the OSPF BFD configuration, see *BFD Configuration Guide*.

Configuring the OSPF VPN Function

For details about the OSPF VPN configuration, see *Configuring the OSPF VPN extension*.

Monitoring and Maintaining the OSPF

The following table shows the data such as the OSPF routing table, cache, and database that can be displayed.

Command	Function
show ip ospf [*process-id*]	Displays the general information about the corresponding processes of the OSPF protocol. All processes are displayed if no process number is specified.
show ip ospf [*process-id area-id*] **database** [**adv-router** *ip-address* | {**asbr-summary** | **external** | **network** | **nssa-external | opaque-area | opaque-as | opaque-link | router** | **summary**} [*link-state-id*] [{**adv-router** *ip-address* | **self-originate}**] | **database-summary** | **max-age** | **self-originate**]	Displays the OSPF database information. You can view the information about each type of LSAs in the specified process.
show ip ospf [*process-id*] **border-routers**	Shows the routing information about the specified process after reaching the ABR and ASBR.
show ip ospf interface [*interface-name*]	Shows the information about the interface involved in the OSPF routing.
show ip ospf [*process-id*] **neighbor**[*interface-name*] [*neighbor-id*] **[detail]**	Shows the information about the adjacent routers of the interface. *interface-name*: local interface connected to the neighbor *neighbor-id*: router ID of the neighbor.
show ip ospf [*process-id*] **virtual-links**	Views the virtual link information about the specified process.
show ip ospf [*process-id*] **route [count]**	Shows the routes in the OSPF routing table.
show ip ospf [*process-id*] **spf**	Shows the times for calculating inter-area routes.

For specific explanations about the commands, see *OSPF Routing Protocol Configuration Command*. The commonly used commands for monitoring and maintenance are described as follows:

5) Show the status of the OSPF neighbors.

Use the **show ip ospf** [*process-id*] **neighbor** command to show all information about neighbors in the OSPF process, including the status, role, router ID, IP address, and BFD state.

```
Ruijie# show ip ospf neighbor
OSPF process 1:
Neighbor ID     Pri State BFD State Dead Time  Address:        Interface
10.10.10.50 1 Full/DR  UP   00:00:38       10.10.10.50     eth0/0
OSPF process 100:
Neighbor ID     Pri State BFD State Dead Time   Address:    Interface
10.10.11.50 1   Full/Backup     DOWN 00:00:31   10.10.11.50     eth0/1
Ruijie# show ip ospf 1 neighbor
OSPF process 1:
Neighbor ID     Pri State BFD State Dead Time  Address:    Interface
10.10.10.50 1   Full/DR         UP 00:00:38     10.10.10.50     eth0/0
Ruijie# show ip ospf 100 neighbor
OSPF process 100:
Neighbor ID     Pri State   BFD State Dead Time    Address:    Interface
10.10.11.50 1   Full/Backup     DOWN 00:00:31   10.10.11.50     eth0/1
```

6) Show the status of the OSPF interfaces

According to the following message, the FastEthernet 0/1 interface belongs to Area 0 in the OSPF routing area, the router ID is 192.168.1.1, and the network type is BROADCAST. Pay special attention to the parameters such as *Area*, *Network Type*, *Hello*, and *Dead*. If these parameters are different from the neighbor, no adjacency relationship is established.

```
Ruijie# sh ip ospf interface fastEthernet 0/1
FastEthernet 1/0 is up, line protocol is up
Internet Address 192.168.1.1/24, Ifindex: 2 Area 0.0.0.0, MTU 1500
Matching network config: 192.168.1.0/24,
Process ID 1, Router ID 192.168.1.1, Network Type BROADCAST, Cost: 1
Transmit Delay is 1 sec, State DR, Priority 1
Designated Router (ID) 192.168.1.1, Interface Address 192.168.1.1
Backup Designated Router (ID) 192.168.1.2, Interface Address 192.168.1.2
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:04
Neighbor Count is 1, Adjacent neighbor count is 1
Crypt Sequence Number is 30
Hello received 972 sent 990, DD received 3 sent 4
LS-Req received 1 sent 1, LS-Upd received 10 sent 26
LS-Ack received 25 sent 7, Discarded 0
```

7) Show the information about the OSPF routing process

Run the following command to show the information about the route ID, router type, area information, and area route aggregation.

```
Ruijie# show ip ospf
Routing Process "ospf 1" with ID 1.1.1.1
Process uptime is 4 minutes
Process bound to VRF default
Conforms to RFC2328, and RFC1583 Compatibility flag is enabled
Supports only single TOS(TOS0) routes
Supports opaque LSA
Enable two-way-maintain
This router is an ASBR (injecting external routing information)
Initial SPF schedule delay 1000 msecs
Minimum hold time between two consecutive SPFs 5000 msecs
Maximum wait time between two consecutive SPFs 10000 msecs
Initial LSA throttle delay 0 msecs
Minimum hold time for LSA throttle 5000 msecs
Maximum wait time for LSA throttle 5000 msecs
Lsa Transmit Pacing timer 40 msecs, 10 LS-Upd
Minimum LSA arrival 1000 msecs
Pacing lsa-group: 240 secs
Number of incoming current DD exchange neighbors 0/5
Number of outgoing current DD exchange neighbors 0/5
Number of external LSA 4. Checksum 0x0278E0
```

```
Number of opaque AS LSA 0. Checksum 0x000000
Number of non-default external LSA 4
External LSA database is unlimited.
Number of LSA originated 6
Number of LSA received 2
Log Neighbor Adjacency Changes: Enabled
Graceful-restart disabled
Graceful-restart helper support enabled
Number of areas attached to this router: 1
Area 0 (BACKBONE)
Number of interfaces in this area is 1(1)
Number of fully adjacent neighbors in this area is 1
Area has no authentication
SPF algorithm last executed 00:01:26.640 ago
SPF algorithm executed 4 times
Number of LSA 3. Checksum 0x0204bf
Routing Process "ospf 20" with ID 2.2.2.2
Process uptime is 4 minutes
Process bound to VRF default
Conforms to RFC2328, and RFC1583 Compatibility flag is enabled
Supports only single TOS(TOS0) routes
Supports opaque LSA
Enable two-way-maintain
Initial SPF schedule delay 1000 msecs
Minimum hold time between two consecutive SPFs 5000 msecs
Maximum wait time between two consecutive SPFs 10000 msecs
Initial LSA throttle delay 0 msecs
Minimum hold time for LSA throttle 5000 msecs
Maximum wait time for LSA throttle 5000 msecs
Lsa Transmit Pacing timer 40 msecs, 10 LS-Upd
Minimum LSA arrival 1000 msecs
Pacing lsa-group: 240 secs
Number of incoming current DD exchange neighbors 0/5
Number of outgoing current DD exchange neighbors 0/5
Number of external LSA 0. Checksum 0x000000
Number of opaque AS LSA 0. Checksum 0x000000
Number of non-default external LSA 0
External LSA database is unlimited.
Number of LSA originated 0
Number of LSA received 0
Log Neighbor Adjacency Changes: Enabled
Number of areas attached to this router: 0
```

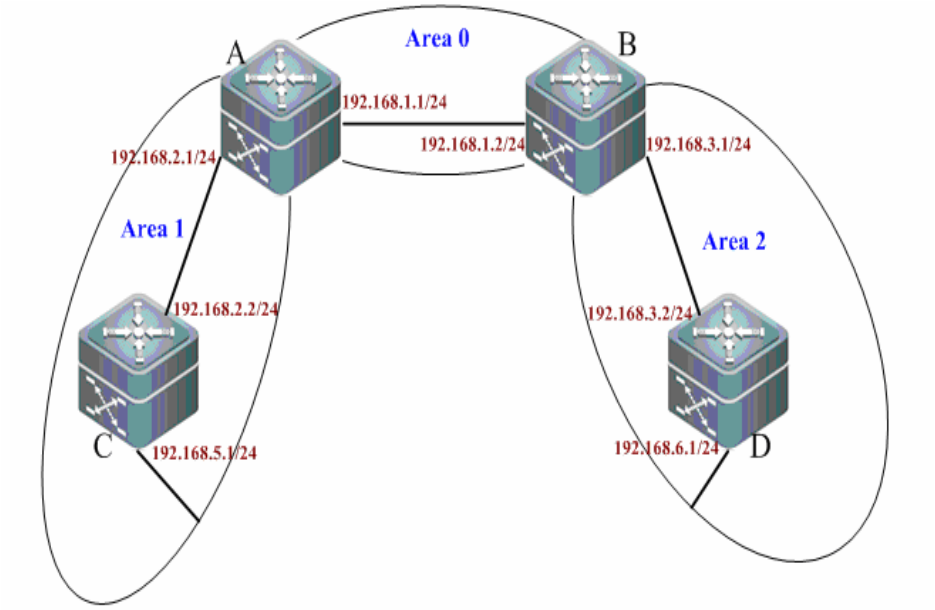
Configuration Examples

Example of Multi-Area OSPF Configuration

Networking Topology

The following figure shows the networking topology of an OSPF autonomous system. The entire autonomous system is divided into three areas: Area 0, Area 1, and Area 2. Each router runs the OSPF routing protocol.

Networking topology for the multi-area OSPF configuration



Applications

Configure Router A and Router B as area border routers (ABR) and Router C and Router D as intra-AS routers. Based on the basic OSPF configurations, every switch can successfully learn the routes in the autonomous system to all network segments.

Configuration Tips

- Configure the IP address for each interface on the routers.
- Enable the basic OSPF functions.
    1. Enable the routing function (enabled by default).
    2. Create an OSPF routing process.
    3. Specify the IP address range associated with this routing process and the OSPF area to which the IP addresses within the range belong.

Configuration Steps

- Configuration steps of A

Step 1: Configure the IP address for the interface.

```
A(config)#interface gigabitEthernet 0/1
A(config-if-GigabitEthernet 0/1)#ip address 192.168.1.1 255.255.255.0
A(config-if-GigabitEthernet 0/1)#exit
A(config)#interface gigabitEthernet 0/2
A(config-if-GigabitEthernet 0/2)#ip address 192.168.2.1 255.255.255.0
A(config-if-GigabitEthernet 0/2)#exit
```

Step 2: Configure the basic OSPF functions.

```
A(config)#router ospf 1
A(config-router)#network 192.168.1.0 0.0.0.255 area 0
A(config-router)#network 192.168.2.0 0.0.0.255 area 1
```

- Configuration steps of B

Step 1: Configure the IP address for the interface.

```
B(config)#interface gigabitEthernet 0/1
B(config-if-GigabitEthernet 0/1)#ip address 192.168.1.2 255.255.255.0
B(config-if-GigabitEthernet 0/1)#exit
B(config)#interface gigabitEthernet 0/2
B(config-if-GigabitEthernet 0/2)#ip address 192.168.3.1 255.255.255.0
B(config-if-GigabitEthernet 0/2)#exit
```

Step 2: Configure the basic OSPF functions.

```
B(config)#router ospf 1
B(config-router)#network 192.168.1.0 0.0.0.255 area 0
B(config-router)#network 192.168.3.0 0.0.0.255 area 2
```

- Configuration steps of C

Step 1: Configure the IP address for the interface.

```
C(config)#interface gigabitEthernet 0/3
C(config-if-GigabitEthernet 0/3)#ip address 192.168.2.2 255.255.255.0
C(config-if-GigabitEthernet 0/3)#exit
C(config)#interface gigabitEthernet 0/4
C(config-if-GigabitEthernet 0/4)#ip address 192.168.5.1 255.255.255.0
C(config-if-GigabitEthernet 0/4)#exit
```

Step 2: Configure the basic OSPF functions.

```
C(config)#router ospf 1
C(config-router)#network 192.168.2.0 0.0.0.255 area 1
C(config-router)#network 192.168.5.0 0.0.0.255 area 1
```

- Configuration steps of D

Step 1: Configure the IP address for the interface.

```
D(config)#interface gigabitEthernet 0/3
D(config-if-GigabitEthernet 0/3)#ip address 192.168.3.2 255.255.255.0
D(config-if-GigabitEthernet 0/3)#exit
D(config)#interface gigabitEthernet 0/4
D(config-if-GigabitEthernet 0/4)#ip address 192.168.6.1 255.255.255.0
D(config-if-GigabitEthernet 0/4)#exit
```

Step 2: Configure the basic OSPF functions.

```
D(config)#router ospf 1
D(config-router)#network 192.168.3.0 0.0.0.255 area 2
D(config-router)#network 192.168.6.0 0.0.0.255 area 2
```

Verification

Step 1: Display information about neighbors (taking A and B as the examples).

```
A#show ip ospf neighbor
OSPF process 1, 2 Neighbors, 2 is Full:
Neighbor ID  Pri  State   Dead Time  Address       Interface
192.168.1.2 1  Full/DR  00:00:40 192.168.1.2 GigabitEthernet 0/1
192.168.2.2 1 Full/BDR  00:00:34 192.168.2.2  GigabitEthernet 0/2
B#show ip ospf neighbor
OSPF process 1, 2 Neighbors, 2 is Full:
Neighbor ID Pri  State Dead Time  Address       Interface
192.168.1.1 1 Full/BDR  00:00:32 192.168.1.1  GigabitEthernet 0/1
192.168.3.2 1 Full/BDR  00:00:30 192.168.3.2  GigabitEthernet 0/2
```

Step 2: Display OSPF routing information about A.

```
A#show ip route
Codes: C - connected, S - static, R - RIP, B - BGP
O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, * - candidate default
Gateway of last resort is no set
C    192.168.1.0/24 is directly connected, GigabitEthernet 0/1
C    192.168.1.1/32 is local host.
C    192.168.2.0/24 is directly connected, GigabitEthernet 0/2
C    192.168.2.1/32 is local host.
O IA 192.168.3.0/24 [110/2] via 192.168.1.2, 00:18:03, GigabitEthernet 0/1   //inter-AS route
O    192.168.5.0/24 [110/2] via 192.168.2.2, 00:00:02, GigabitEthernet 0/2
O IA 192.168.6.0/24 [110/3] via 192.168.1.2, 00:01:02, GigabitEthernet 0/1   //inter-AS route
C#show ip route
Gateway of last resort is no set
O IA 192.168.1.0/24 [110/2] via 192.168.2.1, 00:19:05, GigabitEthernet 0/3   //inter-AS route
```

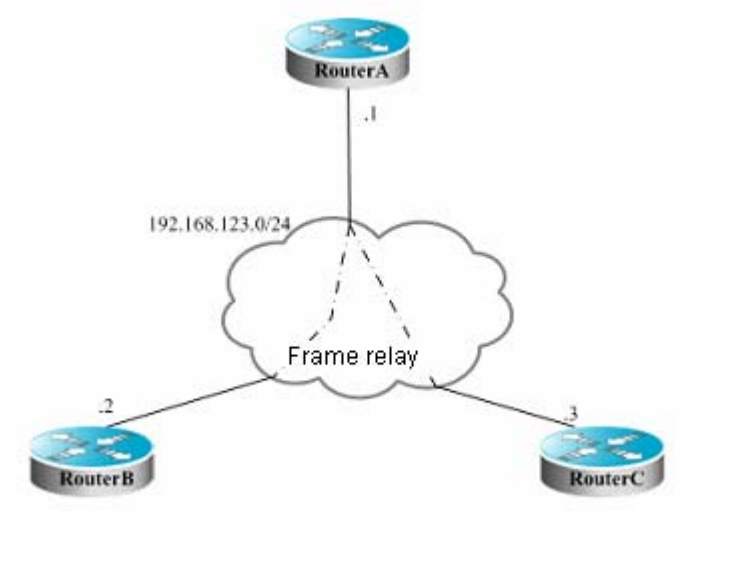
```
C    192.168.2.0/24 is directly connected, GigabitEthernet 0/3
C    192.168.2.2/32 is local host.
O IA 192.168.3.0/24 [110/3] via 192.168.2.1, 00:19:05, GigabitEthernet 0/3
C    192.168.5.0/24 is directly connected, GigabitEthernet 0/4
C    192.168.5.1/32 is local host.
O IA 192.168.6.0/24 [110/4] via 192.168.2.1, 00:03:19, GigabitEthernet 0/3   //inter-AS route
```

Example of OSPF NBMA Network Configuration

Configuration Requirements

Full mesh connection of three routers can be implemented through a frame relay network. Each router has only one frame relay link and the same link bandwidth and PVC rate. The following figure shows details about the IP address assignment and connections of the three routers.

Networking topology for OSPF NBMA network configuration



Requirements:

- The network among A, B, and C must configured as an NBMA network.
- A is the designated router, and B is the backup designated router.
- All networks are in the same area.
- Topological convergence is quickened.

Specific Configurations

Since there is no special configuration about the OSPF, you can detect neighbors in the multicast manner. If the NBMA network has been configured for the interface, the interface does not send OSPF multicast packets. Therefore, you must specify the IP addresses of neighbors. You can configure shorter SPF calculation wait-time to quicken the topological convergence.

Configurations on Router A:

Configure the WAN interface.

```
interface Serial 1/0
ip address 192.168.123.1 255.255.255.0
encapsulation frame-relay
ip ospf network non-broadcast
ip ospf priority 10
```

Configure the OSPF routing protocol.

```
router ospf 1
network 192.168.123.0 0.0.0.255 area 0
neighbor 192.168.123.2  priority 5
neighbor 192.168.123.3
timers throttle spf 500 1000 10000
```

Configurations on Router B:

Configure the WAN interface.

```
interface Serial 1/0
ip address 192.168.123.2 255.255.255.0
encapsulation frame-relay
ip ospf network non-broadcast
ip ospf priority 5
```

Configure the OSPF routing protocol.

```
router ospf 1
network 192.168.123.0 0.0.0.255 area 0
neighbor 192.168.123.1 priority 10
neighbor 192.168.123.3
timers throttle spf 500 1000 10000
```

Configurations on Router C:

Configure the WAN interface.

```
interface Serial 1/0
ip address 192.168.123.3 255.255.255.0
encapsulation frame-relay
ip ospf network non-broadcast
```

Configure the OSPF routing protocol.

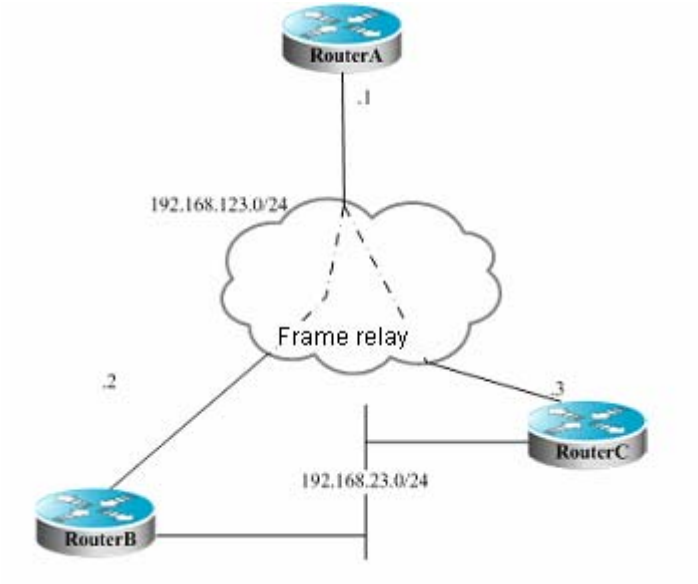
```
router ospf 1
network 192.168.123.0 0.0.0.255 area 0
neighbor 192.168.123.1 10
neighbor 192.168.123.2 5
timers throttle spf 500 1000 10000
```

Example of OSPF Point-to-multipoint Broadcasting Network Configuration

Configuration Requirements

Interconnection of three routers can be implemented through a frame relay network. Each router has only one frame relay link and the same link bandwidth and PVC rate. The following figure shows details about the IP address assignment and connections of the three routers.

Networking topology for OSPF point-to-multipoint network configuration



Requirements:

- The network among A, B, and C must configured as a point-to-multipoint network.

Specific Configurations

The point-to-multipoint network has been configured for the interface. For this network type, there is no need to specify the designated router. The OSPF operations are similar to the steps of configuring the point-to-point network.

Configurations on Router A:

Configure the Ethernet interface.

```
interface FastEthernet 0/1
ip address 192.168.12.1 255.255.255.0
```

Configure the WAN interface.

```
interface Serial 1/0
ip address 192.168.123.1 255.255.255.0
encapsulation frame-relay
ip ospf network point-to-multipoint
```

Configure the OSPF routing protocol.

```
router ospf 1
```

```
network 192.168.12.0 0.0.0.255 area 0
network 192.168.123.0 0.0.0.255 area 0
```

Configurations on Router B:

Configure the Ethernet interface.

```
interface FastEthernet 0/1
ip address 192.168.23.2 255.255.255.0
```

Configure the WAN interface.

```
interface Serial 1/0
ip address 192.168.123.2 255.255.255.0
encapsulation frame-relay
ip ospf network point-to-multipoint
```

Configure the OSPF routing protocol.

```
router ospf 1
network 192.168.23.0 0.0.0.255 area 0
network 192.168.123.0 0.0.0.255 area 0
```

Configurations on Router C:

Configure the Ethernet interface.

```
interface FastEthernet 0/1
ip address 192.168.23.3 255.255.255.0
```

Configure the WAN interface.

```
interface Serial 1/0
ip address 192.168.123.3 255.255.255.0
encapsulation frame-relay
ip ospf network point-to-multipoint
```

Configure the OSPF routing protocol.

```
router ospf 1
network 192.168.23.0 0.0.0.255 area 0
network 192.168.123.0 0.0.0.255 area 0
```

Assuming that there is another configuration requirement for the above figure:

Router A selects Router B with priority to reach the target network 192.168.23.0/24. To meet the routing requirement, you must specify the cost for a neighbor when configuring the neighbor.

You can execute the following commands on Router A:

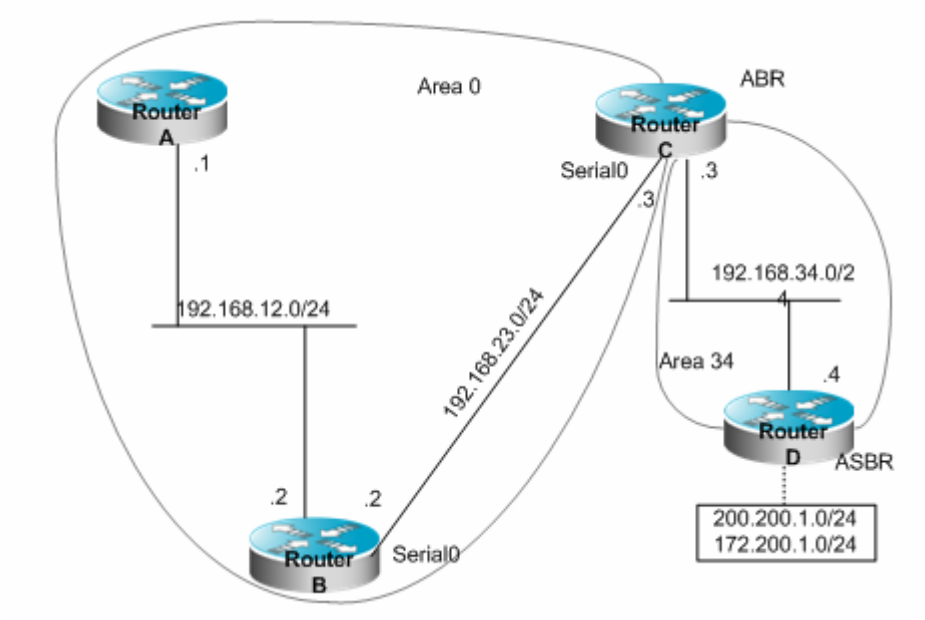
```
router ospf 1
neighbor 192.168.123.2 cost 100
neighbor 192.168.123.3 cost 200
```

Example of OSPF ABR/ASBR Configuration

Configuration Requirements

Four routers form an OSPF routing area. The networks 192.168.12.0/24 and 192.168.23.0/24 belong to Area 0, and the network 192.168.34.0/24 belongs to Area 34. The following figure shows details about the IP address assignment and router connection.

Networking topology for OSPF ABR/ASBR configuration



As shown in the figure, Router A and Router B are intra-area routers. Router C is an area border router. Router D is an AS boundary router. 200.200.1.0/24 and 172.200.1.0/24 are network segments outside the OSPF routing area. All OSPF routers shall be able to learn external routes after configuration. External routes shall be type 1 routes and carry tag 34.

Specific Configurations

While the OSPF redistributes routes of other sources, the routes to be redistributed are type-II routes and carry no tag by default.

Configurations on Router A:

Configure the Ethernet interface.

```
interface FastEthernet 0/1
ip address 192.168.12.1 255.255.255.0
```

Configure the OSPF routing protocol.

```
router ospf 1
network 192.168.12.0 0.0.0.255 area 0
```

Configurations on Router B:

Configure the Ethernet interface.

```
interface FastEthernet 0/1
```

```
ip address 192.168.12.2 255.255.255.0
```

Configure the WAN interface.

```
interface Serial 1/0
ip address 192.168.23.2 255.255.255.0
```

Configure the OSPF routing protocol.

```
router ospf 1
network 192.168.12.0 0.0.0.255 area 0
network 192.168.23.0 0.0.0.255 area 0
```

Configurations on Router C:

Configure the Ethernet interface.

```
interface FastEthernet 0/1
ip address 192.168.34.3 255.255.255.0
```

Configure the WAN interface.

```
interface Serial 1/0
ip address 192.168.23.3 255.255.255.0
```

Configure the OSPF routing protocol.

```
router ospf 1
network 192.168.23.0 0.0.0.255 area 0
network 192.168.34.0 0.0.0.255 area 34
```

Configurations on Router D:

Configure the Ethernet interface.

```
interface FastEthernet 0/1
ip address 192.168.34.4 255.255.255.0
```

Configure interfaces on the Ethernet adapter.

```
interface FastEthernet 0/1
ip address 200.200.1.1 255.255.255.0
interface FastEthernet 0/2
ip address 172.200.1.1 255.255.255.0
```

Configure the OSPF routing protocol and redistribute the RIP routes.

```
router ospf 1
network 192.168.34.0 0.0.0.255 area 34
redistribute rip metric-type 1 subnets tag 34
```

Configure the RIP routing protocol.

```
router rip
network 200.200.1.0
```

```
network 172.200.0.0
```

The OSPF routes generated on Router B are shown as follows: (Note that the type of external routes has changed to E1.)

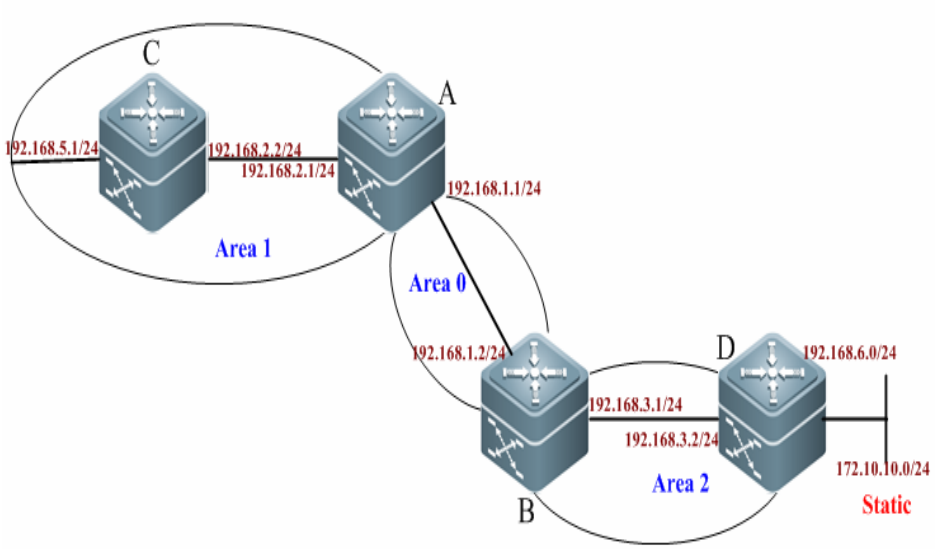
```
O E1 200.200.1.0/24 [110/85] via 192.168.23.3,00:00:33,Serial 1/0
O IA 192.168.34.0/24 [110/65] via 192.168.23.3,00:00:33,Serial 1/0
O E1 172.200.1.0 [110/85] via 192.168.23.3,00:00:33,Serial 1/0
```

Example of OSPF Static Route Redistribution Configuration

Networking Topology

The following figure shows the networking topology of an OSPF autonomous system. The entire autonomous system is divided into three areas: Area 0, Area 1, and Area 2. The network segment 172.10.10.0 is outside the routing area.

Networking topology for OSPF static route redistribution configuration



Applications

Configure Router A and Router B as area border routers (ABR) and Router C as an intra-area router. Configure Router D as an ASBR and introduce an external static route, so that all OSPF routers in non-stub area can successfully learn this external route.

Configuration Tips

- Configure the IP address for interfaces on the routers (omitted).
- Configure the basic OSPF functions (see "Example of Multi-Area OSPF Configuration")
- Introduce and configure the external static route.

Configuration Steps

Step 1: On Router D, configure a static route to the network segment 172.10.10.0.

```
D(config)#ip route 172.10.10.0 255.255.255.0 192.168.6.2
```

Step 2: Display the routing table of Router A.

```
A#show ip route ospf
O IA 192.168.3.0/24 [110/2] via 192.168.1.2, 15:33:00, GigabitEthernet 0/1
O   192.168.5.0/24 [110/2] via 192.168.2.2, 15:14:59, GigabitEthernet 0/2
O IA 192.168.6.0/24 [110/3] via 192.168.1.2, 00:17:58, GigabitEthernet 0/1
```

In this case, there is no route to the network segment 172.10.10.0.

Step 3: Redistribute the static route on Router D

```
D(config)#router ospf 1
D(config-router)# redistribute static subnets
```

Verification

Step 1: Display the routing table of Router D.

```
D#show ip route
Codes:  C - connected, S - static, R - RIP, B - BGP
O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
S   172.10.10.0/24 [1/0] via 192.168.6.2
O IA 192.168.1.0/24 [110/2] via 192.168.3.1, 15:25:19, GigabitEthernet 0/3
O IA 192.168.2.0/24 [110/3] via 192.168.3.1, 15:25:19, GigabitEthernet 0/3
C   192.168.3.0/24 is directly connected, GigabitEthernet 0/3
C   192.168.3.2/32 is local host.
O IA 192.168.5.0/24 [110/4] via 192.168.3.1, 15:11:56, GigabitEthernet 0/3
C   192.168.6.0/24 is directly connected, GigabitEthernet 0/4
C   192.168.6.1/32 is local host.
```

Step 2: View OSPF information about Router D. Key point: Router D is an AS boundary router (ASBR).

```
D#show ip ospf
 Routing Process "ospf 1" with ID 192.168.3.2
 Process uptime is 15 hours 27 minutes
 Process bound to VRF default
 Conforms to RFC2328, and RFC1583 Compatibility flag is enabled
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 Enable two-way-maintain
 This router is an ASBR (injecting external routing information)
 Initial SPF schedule delay 1000 msecs
Minimum hold time between two consecutive SPFs 5000 msecs
```

```
Maximum wait time between two consecutive SPFs 10000 msecs
Initial LSA throttle delay 0 msecs
Minimum hold time for LSA throttle 5000 msecs
Maximum wait time for LSA throttle 5000 msecs
Lsa Transmit Pacing timer 40 msecs, 10 LS-Upd
Minimum LSA arrival 1000 msecs
 Pacing lsa-group: 240 secs
 Number of incoming current DD exchange neighbors 0/5
 Number of outgoing current DD exchange neighbors 0/5
 Number of external LSA 1. Checksum 0x006DB0
 Number of opaque AS LSA 0. Checksum 0x000000
 Number of non-default external LSA 1
 External LSA database is unlimited.
 Number of LSA originated 2
 Number of LSA received 173
 Log Neighbor Adjacency Changes: Enabled
  Number of areas attached to this router: 1: 1 normal 0 stub 0 nssa
    Area 2
        Number of interfaces in this area is 2(2)
        Number of fully adjacent neighbors in this area is 1
        Number of fully adjacent virtual neighbors through this area is 0
        Area has no authentication
        SPF algorithm last executed 00:06:27.540 ago
        SPF algorithm executed 9 times
        Number of LSA 6. Checksum 0x0212ff
```

Step 3: Display the routing table of Router A.

```
A#show ip route ospf
O E2 172.10.10.0/24 [110/20] via 192.168.1.2, 00:07:37, GigabitEthernet 0/1
O IA 192.168.3.0/24 [110/2] via 192.168.1.2, 15:33:00, GigabitEthernet 0/1
O    192.168.5.0/24 [110/2] via 192.168.2.2, 15:14:59, GigabitEthernet 0/2
O IA 192.168.6.0/24 [110/3] via 192.168.1.2, 00:17:58, GigabitEthernet 0/1
```

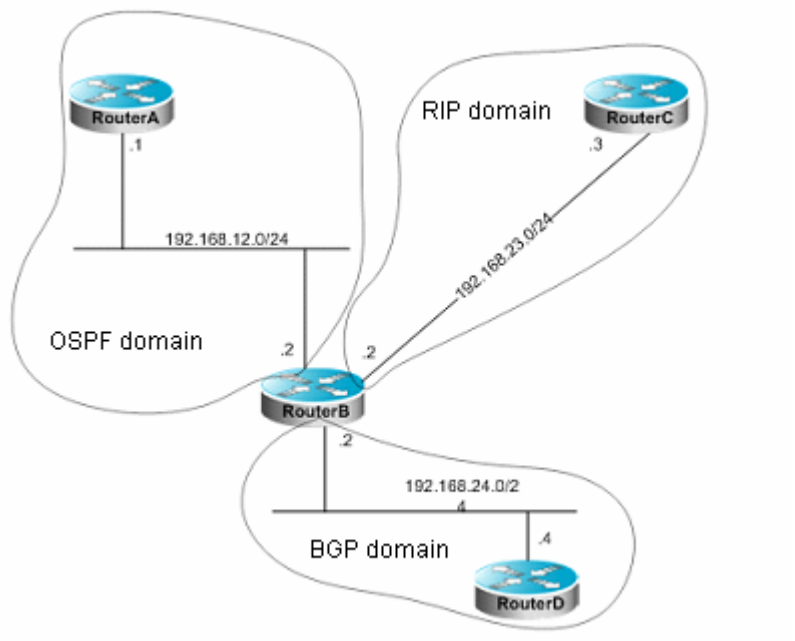
In this case, Router A has successfully learned the route to the network segment 172.10.10.0.

Example of OSPF Dynamic Route Redistribution Configuration

Configuration Requirements

The following figure shows the topology of four routers. Router A belongs to the OSPF routing area. Router C belongs to the RIP routing area. Router D belongs to the BGP routing area. Router B is connected to the three routing areas. Router A advertises two routes: 192.168.10.0/24 and 192.168.100.1/32. Router C advertises two routes: 192.168.3.0/24 and 192.168.30.0/24. Router D advertises two routes: 192.168.4.0/24 and 192.168.40.0/24.

Networking topology for dynamic routing protocol redistribution



On Router B, the OSPF redistributes routes (type-1) in the RIP routing area and the BGP routes that carry the community attribute 11:11 in the BGP routing area. The RIP redistributes the route 192.168.10.0/24 in the OSPF routing area and advertises a default route to the RIP routing area. The metric of this route is set to 2.

Specific Configurations

When the routing protocol redistribute the routes among each other, the simple route filtering can be controlled by using the distribution list. However, different attributes must be set for different routes, which cannot be implemented by using the distribution list. In this case, a route-map must be used for control. The route-map provides more control functions than the distribution list, but the router configuration is more complex. Therefore, do not use the route-map if possible. The following examples use the route-map to match the community attribute of the BGP routes.

Configurations on Router A:

Configure the network interface.

```
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)# ip address 192.168.10.1 255.255.255.0
Ruijie(config)# interface loopback 1
Ruijie(config-if-Loopback 1)# ip address 192.168.100.1 255.255.255.255
Ruijie(config-if-Loopback 1)# no ip directed-broadcast
Ruijie(config)# interface gigabitEthernet 0/2
Ruijie(config-if-GigabitEthernet 0/2)# ip address 192.168.12.1 255.255.255.0
```

Configure the OSPF.

```
Ruijie(config)# router ospf 12
Ruijie(config-router)# network 192.168.10.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.168.12.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.168.100.0 0.0.0.255 area 0
```

Configurations on Router B:

Configure the network interface.

```
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)# ip address 192.168.12.2 255.255.255.0
Ruijie(config)# interface gigabitEthernet 0/2
Ruijie(config-if-GigabitEthernet 0/2)# ip address 192.168.24.2
Ruijie(config)# interface Serial 1/0
Ruijie(config-Serial 1/0)# ip address 192.168.23.2 255.255.255.0
```

Configure the OSPF and specify the type of routes to be redistributed.

```
Ruijie(config)# router ospf 12
Ruijie(config-router)# redistribute rip metric 100 metric-type 1 subnets
Ruijie(config-router)# redistribute bgp route-map ospfrm subnets
Ruijie(config-router)# network 192.168.12.0 0.0.0.255 area 0
```

Configure the RIP and use the distribute list to filter the redistributed routes.

```
Ruijie(config)# router rip
Ruijie(config-router)# redistribute ospf 12 metric 2
Ruijie(config-router)# network 192.168.23.0
Ruijie(config-router)# distribute-list 10 out ospf
Ruijie(config-router)# default-information originate always
Ruijie(config-router)# no auto-summary
```

Configure the BGP.

```
Ruijie(config)# router bgp 2
Ruijie(config-router)# neighbor 192.168.24.4 remote-as 4
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 192.168.24.4 activate
Ruijie(config-router-af)# neighbor 192.168.24.4  send-community
```

Configure the route-map.

```
Ruijie(config)# route-map ospfrm
Ruijie(config-route-map)# match community cl_110
```

Define the access list.

```
Ruijie(config)# access-list 10 permit 192.168.10.0
```

Define the community list.

```
Ruijie(config)# ip community-list standard cl_110 permit 11:11
```

Configurations on Router C:

Configure the network interface.

```
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)# ip address 192.168.30.1 255.255.255.0
Ruijie(config)# interface gigabitEthernet 0/2
```

```
Ruijie(config-if-GigabitEthernet 0/2)# ip address 192.168.3.1 255.255.255.0
Ruijie(config)# interface Serial 1/0
Ruijie(config-if-Serial 1/0)# ip address 192.168.23.3 255.255.255.0
```

Configure the RIP.

```
Ruijie(config)# router rip
Ruijie(config-router)# network 192.168.23.0
Ruijie(config-router)# network 192.168.3.0
Ruijie(config-router)# network 192.168.30.0
```

Configurations on Router D:

Configure the network interface.

```
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)# ip address 192.168.40.1 255.255.255.0
Ruijie(config)# interface gigabitEthernet 0/2
Ruijie(config-if-GigabitEthernet 0/2)# ip address 192.168.4.1 255.255.255.0
Ruijie(config)# interface gigabitEthernet 0/3
Ruijie(config-if-GigabitEthernet 0/3)# ip address 192.168.24.4 255.255.255.0
```

Configure the BGP.

```
Ruijie(config)# router bgp 4
Ruijie(config-router)# neighbor 192.168.24.2 remote-as 2
Ruijie(config-router)# redistribute connected route-map bgprm
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 192.168.24.2 activate
Ruijie(config-router-af)# neighbor 192.168.24.2 send-community
```

Configure the route-map.

```
Ruijie(config)# route-map bgprm
Ruijie(config-route-map)# set community 22:22
```

The OSPF routes learned by Router A:

```
O E1 192.168.30.0/24[110/101]via 192.168.12.2,00:04:07, gigabitEthernet 0/2
O E1 192.168.3.0/24[110/101]via 192.168.12.2,00:04:07, gigabitEthernet 0/2
O E1 192.168.23.0/24[110/101]via 192.168.12.2,00:04:07, gigabitEthernet 0/2
```

The RIP routes learned by Router C:

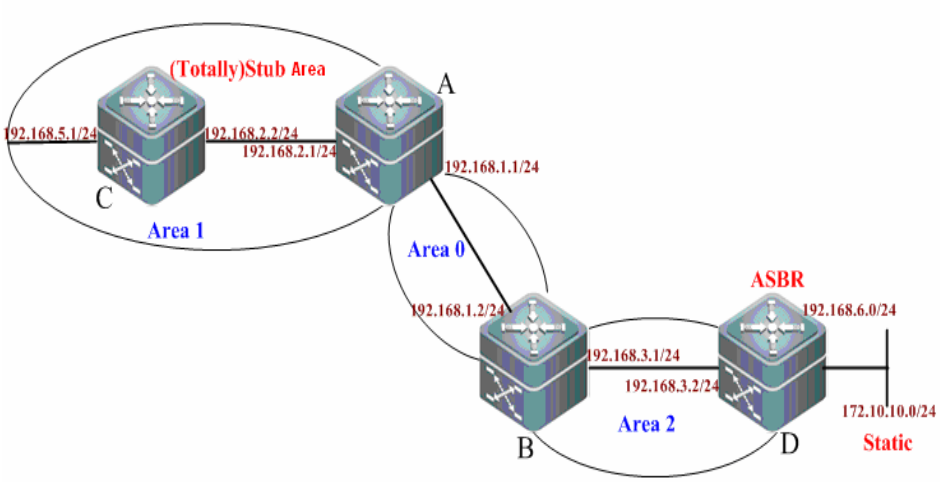
```
R    0.0.0.0/0 [120/1] via 192.168.23.2, 00:00:00, Serial 1/0
R    192.168.10.0/24 [120/2] via 192.168.23.2, 00:00:00, Serial 1/0
```

Example of OSPF (Totally) Stub Area Configuration

Networking Topology

The following figure shows the networking topology of an OSPF autonomous system. The entire autonomous system is divided into three areas: Area 0, Area 1, and Area 2. The network segment 172.10.10.0 is outside the routing area.

Networking topology for OSPF (Totally) Stub area configuration



Applications

Configure Router A and Router B as area border routers (ABR) and Router C as an intra-area router. Configure Router D as an ASBR and introduce one an external static route.

To reduce the size of the routing table inside the AS border and the number of routes exchanged, configure the specific area to be a (Totally) Stub area.

Routing information can be correctly transmitted in the OSPF autonomous system.

Configuration Tips

Do not configure the backbone area (Area 0) cannot be configured as a (Totally) Stub area, and there must be no ASBR exists in the (Totally) Stub area. That is, the external routes of the autonomous system cannot be propagated transmitted in this area. In this example, Area 1 is configured as the (Totally) Stub area.

When configuring an area as a Stub area, you must configure the **stub** command on all routers in this area. In this example, you need to configure this attribute on Router A and Router C.

When configuring an area as a Totally Stub area, you must configure the **stub** command on all routers (Router C) in this area and the **stub [no-summary]** command on the ABR (Router A).

Configuration Steps

The following information only shows how to configure an OSPF (Totally) Stub area. For other configurations, see "Example of Multi-Area OSPF Configuration" and "Example of OSPF Static Route Redistribution Configuration".

Step 1: Display the routing table of Router C when this router is in a normal area.

```
C#show ip route  ospf
O E2 172.10.10.0/24 [110/20] via 192.168.2.1, 4d,02:28:07, GigabitEthernet 0/3
                        //AS external route
O IA 192.168.1.0/24 [110/2] via 192.168.2.1, 4d,17:52:14, GigabitEthernet 0/3
O IA 192.168.3.0/24 [110/3] via 192.168.2.1, 4d,17:52:14, GigabitEthernet 0/3
O IA 192.168.6.0/24 [110/4] via 192.168.2.1, 4d,02:38:27, GigabitEthernet 0/3
```

In this case, the routing table contains AS external routes.

Step 2: Configure the Stub area

- Configurations on Router A:

```
A(config)#router ospf 1
A(config-router)#area 1 stub
```

- Configurations on Router C:

```
C(config)#router ospf 1
C(config-router)#area 1 stub
```

- Display the routing table of Router C when this router is in a stub area.

```
C#show ip route ospf
O*IA 0.0.0.0/0 [110/2] via 192.168.2.1, 00:00:32, GigabitEthernet 0/3
                                        //default route
O IA 192.168.1.0/24 [110/2] via 192.168.2.1, 00:00:32, GigabitEthernet 0/3
O IA 192.168.3.0/24 [110/3] via 192.168.2.1, 00:00:32, GigabitEthernet 0/3
O IA 192.168.6.0/24 [110/4] via 192.168.2.1, 00:00:32, GigabitEthernet 0/3
```

In this case, the routing table contains no AS external route. The original AS external route in the routing table has been replaced with a default route.

Step 3: Configure the Totally Stub area

- Configurations on Router A:

```
A(config)#router ospf 1
A(config-router)#area 1 stub stub no-summary
```

- Configurations on Router C:

```
C(config)#router ospf 1
C(config-router)#area 1 stub
```

- Display the routing table of Router C when this router is in a totally stub area.

```
C#show ip route ospf
O*IA 0.0.0.0/0 [110/2] via 192.168.2.1, 00:30:53, GigabitEthernet 0/3
```

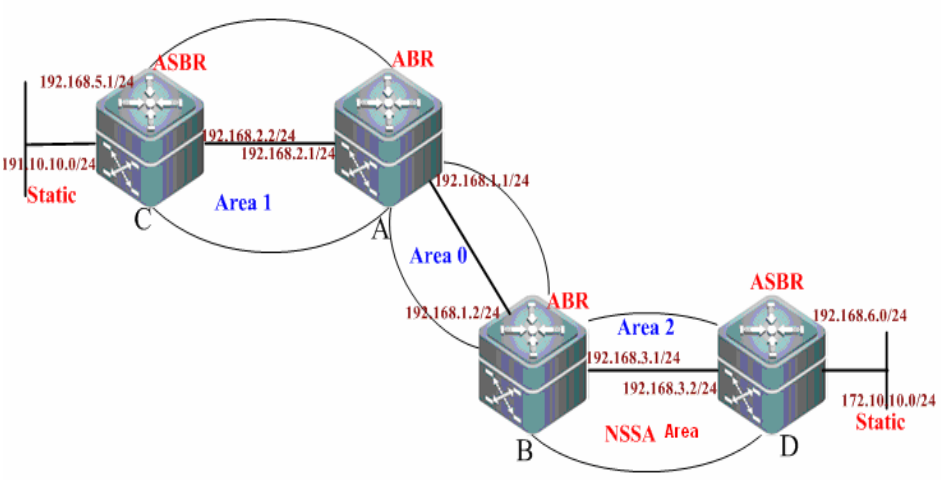
In this case, the routing table only contains one default route to the external area.

Example of OSPF NSSA Area Configuration

Networking topology

The following figure shows the networking topology of an OSPF autonomous system. The entire autonomous system is divided into three areas: Area 0, Area 1, and Area 2. The network segments 192.10.10.0 and 172.10.10.0 are outside the OSPF routing area.

Networking topology for OSPF NSSA area configuration



Applications

1. Configure Router A and Router B as area border routers (ABR). Configure Router C and Router D as ASBRs and introduce an AS external static route for Router C and Router D respectively.
2. Area 2 shall be configured as an NSSA area in order to reduce the size of routing table of the intra-area router and the number of routes exchanged. Meanwhile, prohibit Router B from sending summary LSAs (Type-3 LSA) to the NSSA area.
3. Routing information can be correctly transmitted in the OSPF autonomous system.

Configuration Tips

Tips for configuring the NSSA area are as follows:

1. The backbone area (Area 0) cannot be configured as the NSSA area.
2. The ASBRs can exist in the NSSA area, and certain number of AS external routes can be imported to the OSPF routing area.
3. When configuring an area as the NSSA area, you must use the area nssa command on all routers (Router B and D) connected to the NSSA area.

Configuration Steps

The following information only shows how to configure the NSSA area. For the basic OSPF configurations, see the above examples.

Step 1: Configure static route redistribution.

- Configurations on Router C:

! Configure a static route.

```
C(config)#ip route 191.10.10.0 255.255.255.0 192.168.5.2
```

! Redistribute the static route based on the OSPF.

```
C(config)#router ospf 1
C(config-router)#redistribute static subnets
```

- Configurations on Router D:

! Configure a static route.

```
D(config)#ip route 172.10.10.0 255.255.255.0 192.168.6.2
```

! Redistribute the static route based on the OSPF.

```
C(config)#router ospf 1
C(config-router)#redistribute static subnets
```

Step 2: Configure the NSSA.

- Configurations on Router B (ABR):

```
B(config)#router ospf 1
```

! Define the NSSA area and prohibit this ABR from sending summary LSAs (Type-3 LSA) to the NSSA area.

```
B(config-router)#area 2 nssa no-summary
```

- Configurations on Router D (ASBR):

```
D(config)#router ospf 1
D(config-router)#area 2 nssa
```

Verification

Step 1: Display the routing information when Area 2 is configured as a normal area.

- Display the routing table of Router D (ASBR).

```
D#show ip route
Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default
Gateway of last resort is no set
S    172.10.10.0/24 [1/0] via 192.168.6.2
O E2 191.10.10.0/24 [110/20] via 192.168.3.1, 00:00:21, GigabitEthernet 0/3
```

```
O IA 192.168.1.0/24 [110/2] via 192.168.3.1, 00:00:21, GigabitEthernet 0/3
O IA 192.168.2.0/24 [110/3] via 192.168.3.1, 00:00:21, GigabitEthernet 0/3
C   192.168.3.0/24 is directly connected, GigabitEthernet 0/3
C   192.168.3.2/32 is local host.
O IA 192.168.5.0/24 [110/4] via 192.168.3.1, 00:00:21, GigabitEthernet 0/3
C   192.168.6.0/24 is directly connected, GigabitEthernet 0/4
C   192.168.6.1/32 is local host.
```

- Display the OSPF routing table of Router B (ABR).

```
B#show ip route ospf
O E2 172.10.10.0/24 [110/20] via 192.168.3.2, 17:53:35, GigabitEthernet 0/2   O E2
191.10.10.0/24 [110/20] via 192.168.1.1, 00:57:46, GigabitEthernet 0/1
O IA 192.168.2.0/24 [110/2] via 192.168.1.1, 5d,15:39:01, GigabitEthernet 0/1
O IA 192.168.5.0/24 [110/3] via 192.168.1.1, 01:10:34, GigabitEthernet 0/1
O   192.168.6.0/24 [110/2] via 192.168.3.2, 17:53:36, GigabitEthernet 0/2
```

Step 2: Display the routing information about each router in the NSSA area when Area 2 is configured as an NSSA area.

- Display the OSPF routing table of Router B (ABR).

```
B#show ip route ospf
O N2 172.10.10.0/24 [110/20] via 192.168.3.2, 00:01:00, GigabitEthernet 0/2
O E2 191.10.10.0/24 [110/20] via 192.168.1.1, 01:11:26, GigabitEthernet 0/1
O IA 192.168.2.0/24 [110/2] via 192.168.1.1, 5d,15:52:41, GigabitEthernet 0/1
O IA 192.168.5.0/24 [110/3] via 192.168.1.1, 01:24:14, GigabitEthernet 0/1
O   192.168.6.0/24 [110/2] via 192.168.3.2, 00:01:01, GigabitEthernet 0/2
```

In this case, the ABR in the NSSA area has translated the AS external routes imported into this area into N2 (OSPF NSSA external type 2) routes and transmitted to other areas.

- Display the routing table of Router D (ASBR).

```
D#show ip route
Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default
Gateway of last resort is no set
S   172.10.10.0/24 [1/0] via 192.168.6.2
O IA 192.168.1.0/24 [110/2] via 192.168.3.1, 00:03:20, GigabitEthernet 0/3
O IA 192.168.2.0/24 [110/3] via 192.168.3.1, 00:03:20, GigabitEthernet 0/3
C   192.168.3.0/24 is directly connected, GigabitEthernet 0/3
C   192.168.3.2/32 is local host.
O IA 192.168.5.0/24 [110/4] via 192.168.3.1, 00:03:20, GigabitEthernet 0/3
C   192.168.6.0/24 is directly connected, GigabitEthernet 0/4
C   192.168.6.1/32 is local host.
```

In this case, the AS external routes imported into other areas cannot reach this area when Router D is in an NSSA area.

Step 3: Display the routing information of the NSSA area when configuring the attribute of the NSSA area to be no-summary on Router B (ABR).

```
D#show ip route
Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default
Gateway of last resort is 192.168.3.1 to network 0.0.0.0
O*IA 0.0.0.0/0 [110/2] via 192.168.3.1, 00:00:40, GigabitEthernet 0/3
S   172.10.10.0/24 [1/0] via 192.168.6.2
C   192.168.3.0/24 is directly connected, GigabitEthernet 0/3
C   192.168.3.2/32 is local host.
C   192.168.6.0/24 is directly connected, GigabitEthernet 0/4
C   192.168.6.1/32 is local host.
```

In this case, the routing table contains a default route which replaces the inter-area route.

Step 4: Display the OSPF routing information on routers in other areas. Key point: Note whether there is any AS external route imported into the NSSA area.

```
SwitchA#show ip route ospf
O E2 172.10.10.0/24 [110/20] via 192.168.1.2, 02:08:08, GigabitEthernet 0/1
O E2 191.10.10.0/24 [110/20] via 192.168.2.2, 03:18:35, GigabitEthernet 0/2
O IA 192.168.3.0/24 [110/2] via 192.168.1.2, 5d,17:59:01, GigabitEthernet 0/1
O   192.168.5.0/24 [110/2] via 192.168.2.2, 03:31:25, GigabitEthernet 0/2
O IA 192.168.6.0/24 [110/3] via 192.168.1.2, 02:08:09, GigabitEthernet 0/1
```

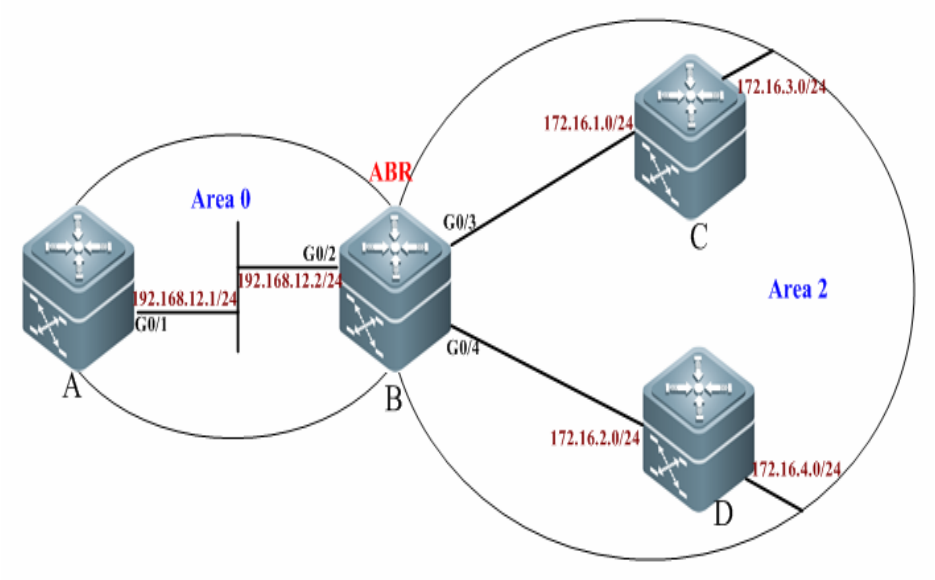
In this case, the routing table of Router A contains an AS external route imported into the NSSA area.

Example of OSPF Inter-area Route Aggregation Configuration

Networking Topology

The following figure shows the topological topology of an OSPF autonomous system, in which the network segment 192.168.12.0/24 belongs to Area 0 and the network segments 172.16.1.0/24, 172.16.2.0/24, 172.16.3.0/24, and 172.16.4.0/24 belong to Area 2.

Networking topology for OSPF inter-area route aggregation configuration



Applications

To reduce the size of routing table, configure Router B so that Router B only advertises the summary route of four network segments (172.16.1.0/24, 172.16.2.0/24, 172.16.3.0/24, and 172.16.4.0/24) instead of separately advertising the routes of these four network segments.

Configuration Tips

1. Since the network segments 172.16.1.0/24, 172.16.2.0/24, 172.16.3.0/24, and 172.16.4.0/24 are consecutive addresses, you can configure route aggregation on the area border router (Router B) to alleviate route calculation. Use this command **area range** to configure the route aggregation between the OSPF inter-areas".

2. During route aggregation, the aggregated route range may exceed the actual network range in the routing table. Routing loop may incur or load on the router may increase if packets are sent to a network that is beyond the aggregated route range. So you need to add a "discard" route into the routing table on the ABR (Router B) or ASBR. Use the inter-area route aggregation command area range to add the discard route. This function is enabled by default.

3. The aggregated route address of 172.16.1.0/24, 172.16.2.0/24, 172.16.3.0/24, and 172.16.4.0/24 is 172.16.0.0/21. Routes falling within this range will not be advertised to other areas by the ABR.

Configuration Steps

Step 1: Configure the IP address for interfaces.(omitted)

Step 2: Configure the basic OSPF functions.

- Configure Router A.

```
A(config)#router ospf 1
A(config)# network 192.168.12.0 0.0.0.255 area 0
```

- Configure Router B.

```
B(config)#router ospf 1
```

```
B(config-router)#network 192.168.12.0 0.0.0.255 area 0
B(config-router)#network 172.16.1.0 0.0.0.255 area 2
B(config-router)#network 172.16.2.0 0.0.0.255 area 2
```

- Configure Router C.

```
C(config)#router ospf 1
C(config-router)#network 172.16.1.0 0.0.0.255 area 2
C(config-router)#network 172.16.3.0 0.0.0.255 area 2
```

- Configure Router D.

```
D(config)#router ospf 1
D(config-router)#network 172.16.2.0 0.0.0.255 area 2
D(config-router)#network 172.16.4.0 0.0.0.255 area 2
```

- Display the OSPF routing table of Router A.

```
A#show ip route ospf
O IA 172.16.1.0/24 [110/2] via 192.168.12.2, 00:06:47, GigabitEthernet 0/1
O IA 172.16.2.0/24 [110/2] via 192.168.12.2, 00:06:47, GigabitEthernet 0/1
O IA 172.16.3.0/24 [110/3] via 192.168.12.2, 00:06:47, GigabitEthernet 0/1
O IA 172.16.4.0/24 [110/3] via 192.168.12.2, 00:06:19, GigabitEthernet 0/1
```

In this case, the detailed routing information about Area 2 is advertised to Area 0.

Step 3: Configure the inter-area route aggregation on the ABR (Router B).

```
B(config)#router ospf 1
B(config-router)#area 2 range 172.16.0.0 255.255.248.0
```

Step 4: On ABR (Router B), configure to control the addition of the aggregated route entry into the core routing table. This function is enabled by default.

```
B(config-router)# discard-route internal
```

Verification

- After configuring route aggregation, display the OSPF routing table of Router A.

```
A#show ip route ospf
O IA 172.16.0.0/21 [110/2] via 192.168.12.2, 00:01:04, GigabitEthernet 0/1
```

In this case, only the aggregated routes are advertised. Specific routes will not be advertised by the ABR to other areas. The size of the routing table is decreased substantially.

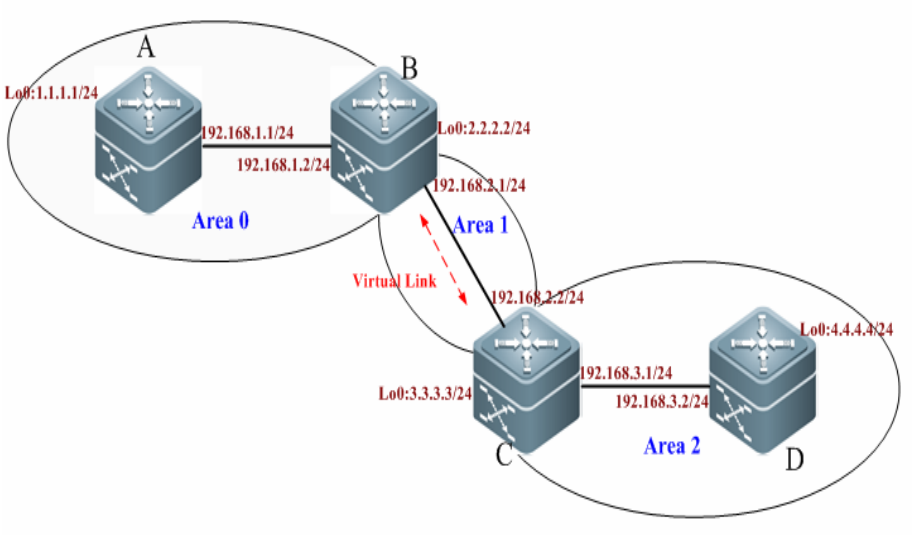
Example of OSPF Virtual Link Configuration

Networking Topology

The following figure shows an OSPF routing area. The network segment 192.168.1.0 belongs to Area 0. The network segment 192.168.2.0 belongs to Area 1. The network segment 192.168.3.0 belongs to Area 2. Due to the limitation of

physical conditions, other specific areas cannot be deployed around the backbone area. As shown in the following figure, Area 2 is not directly connected to Area 0.

Networking topology for OSPF virtual link configuration



Applications

Through configuration, Router D shall be able to receive routes of the network segments 192.168.1.0/24 (Area 0) and 192.168.2.0/24 (Area 1). Meanwhile, Router B shall be able to learn the routes of the network segment 192.168.3.0/24 (Area 2).

Details about IP address assignment are shown as follows:

Router name	Router ID	Interface address
A	1.1.1.1	Gi0/1: 192.168.1.1/24
B	2.2.2.2	Gi0/1: 192.168.1.2/24 Gi0/3: 192.168.2.1/24
C	3.3.3.3	Gi0/3: 192.168.2.2/24 Gi0/5: 192.168.3.1/24
D	4.4.4.4	Gi0/5: 192.168.3.2/24

Configuration Tips

When the OSPF routing area is composed of multiple areas, each area must be directly connected to the backbone area (Area 0). Otherwise, these areas cannot be interconnected. If there is no direct physical link, create virtual links to logically connect each area to the backbone area. Configuration tips are shown as follows:

- Configure the IP address for the interfaces. (Omitted)
- Configure the basic OSPF functions.
- Configure OSPF virtual links

The virtual link must be configured on ABRs. This example configures virtual links on Router B and Router C.

Use the **area** *area-id* **virtual-link** *router-id* command to configure virtual links on the ABRs. The router-id refers to the identifier of a peer device.

Configuration Steps

Step 1: Configure the basic OSPF functions.

- Configurations on Router A:

! Create an OSPF routing process and specify the IP address range associated with this routing process and the OSPF area to which these IP addresses belong.

```
A(config)#router ospf 1
A(config-router)#network 192.168.1.0 0.0.0.255 area 0
A(config-router)#exit
```

! Configure the loopback IP 1.1.1.1 as the router ID of Router A.

```
A(config)#interface loopback 0
A(config-Loopback 0)#ip address 1.1.1.1 255.255.255.0
```

- Configurations on Router B:

! Create an OSPF routing process and specify the IP address range associated with this routing process and the OSPF area to which these IP addresses belong.

```
B(config)#router ospf 1
B(config-router)#network 192.168.1.0 0.0.0.255 area 0
B(config-router)#network 192.168.2.0 0.0.0.255 area 1
B(config-router)#exit
```

! Configure the loopback IP 2.2.2.2 as the router ID of Router B.

```
B(config)#interface loopback 0
B(config-Loopback 0)#ip address 2.2.2.2 255.255.255.0
```

- Configurations on Router C:

! Create an OSPF routing process and specify the IP address range associated with this routing process and the OSPF area to which these IP addresses belong.

```
C(config)#router ospf 1
C(config-router)#network 192.168.2.0 0.0.0.255 area 1
C(config-router)#network 192.168.3.0 0.0.0.255 area 2
C(config-router)#exit
```

! Configure the loopback IP 3.3.3.3 as the router ID of Router C.

```
C(config)#interface loopback 0
C(config-Loopback 0)#ip address 3.3.3.3 255.255.255.0
```

- Configurations on Router D:

! Create an OSPF routing process and specify the IP address range associated with this routing process and the OSPF area to which these IP addresses belong.

```
D(config)#router ospf 1
D(config-router)#network 192.168.3.0 0.0.0.255 area 2
```

```
D(config-router)#exit
```

! Configure the loopback IP 4.4.4.4 as the router ID of Router D.

```
D(config)#interface loopback 0
D(config-Loopback 0)#ip address 4.4.4.4 255.255.255.0
```

- Display the OSPF routing table of Router A.

```
A#show ip route ospf
O IA 192.168.2.0/24 [110/2] via 192.168.1.2, 00:32:48, GigabitEthernet 0/1
```

Since Area 2 is not directly connected to Area 0, the routing table of Router A contains no routing information about Area 2

Step 2: Configure OSPF virtual links.

- Configure Router B.

```
B(config)#router ospf 1
B(config-router)#area 1 virtual-link 3.3.3.3
```

- Configure Router C.

```
C(config)#router ospf 1
C(config-router)#area 1 virtual-link 2.2.2.2
```

Verification

- Display the OSPF routing table of Router B.

```
B#show ip route
Codes:  C - connected, S - static, R - RIP, B - BGP
O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default
Gateway of last resort is no set
C    2.2.2.0/24 is directly connected, Loopback 0
C    2.2.2.2/32 is local host.
C    192.168.1.0/24 is directly connected, GigabitEthernet 0/1
C    192.168.1.2/32 is local host.
C    192.168.2.0/24 is directly connected, GigabitEthernet 0/3
C    192.168.2.1/32 is local host.
O IA 192.168.3.0/24 [110/2] via 192.168.2.2, 00:02:49, GigabitEthernet 0/3
```

In this case, after the virtual link is configured, Router B has successfully learned the routes of the network segment 192.168.3.0/24 (Area 2).

- Display the OSPF routing table of Router D.

```
D#show ip route
Codes:  C - connected, S - static, R - RIP, B - BGP
```

```
O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default
Gateway of last resort is no set
C    4.4.4.0/24 is directly connected, Loopback 0
C    4.4.4.4/32 is local host.
O IA 192.168.1.0/24 [110/3] via 192.168.3.1, 00:04:45, GigabitEthernet 0/5
O IA 192.168.2.0/24 [110/2] via 192.168.3.1, 00:05:02, GigabitEthernet 0/5
C    192.168.3.0/24 is directly connected, GigabitEthernet 0/5
C    192.168.3.2/32 is local host.
```

In this case, after the virtual link is configured, Router D has successfully learned the routes of the network segments 192.168.1.0/24 (Area 0) and 192.168.2.0/24 (Area 1).

- Display the OSPF routing table of Router A.

```
A#show ip route ospf
O IA 192.168.2.0/24 [110/2] via 192.168.1.2, 00:51:22, GigabitEthernet 0/1
O IA 192.168.3.0/24 [110/3] via 192.168.1.2, 00:07:58, GigabitEthernet 0/1
```

In this case, after the virtual link is configured, Router A has successfully learned the routes of the network segment 192.168.3.0/24 (Area 2).

- Display the OSPF virtual link information about Router B.

```
B#show ip ospf 1 virtual-links
Virtual Link VLINK0 to router 3.3.3.3 is up
  Transit area 0.0.0.1 via interface GigabitEthernet 0/3
  Local address 192.168.2.1/32
  Remote address 192.168.2.2/32
  Transmit Delay is 1 sec, State Point-To-Point,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:03
Adjacency state Full
```

- Display the OSPF virtual link information about Router C.

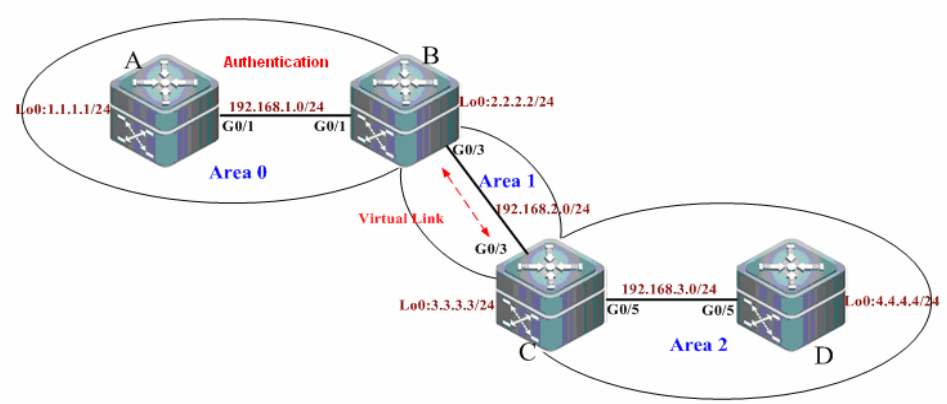
```
C#show ip ospf 1 virtual-links
Virtual Link VLINK0 to router 2.2.2.2 is up
  Transit area 0.0.0.1 via interface GigabitEthernet 0/3
  Local address 192.168.2.2/32
  Remote address 192.168.2.1/32
  Transmit Delay is 1 sec, State Point-To-Point,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:00
    Adjacency state Full
```

Example of OSPF Authentication Configuration

Networking Topology

The following figure shows an OSPF routing area. The network segment 192.168.1.0 belongs to Area 0. The network segment 192.168.2.0 belongs to Area 1. The network segment 192.168.3.0 belongs to Area 2. Due to the limitation of network structures, Area 2 is connected to Area 0 through virtual links.

Networking topology for OSPF authentication configuration



Applications

1. To prevent the device from learning unauthenticated and invalid routes and advertising valid routes to unauthenticated devices, it is required to configure area authentication in the backbone area (Area 0), with the authentication type being MD5.
2. Router D shall be able to learn routes of the network segments 192.168.1.0/24 (Area 0) and 192.168.2.0/24 (Area 1). Meanwhile, Router B shall be able to learn the routes of the network segment 192.168.3.0/24 (Area 2).

Configuration Tips

To configure the OSPF area authentication, configure the area authentication on all routers in the same area with the same authentication type. This example enables the area authentication in Area 0, namely all routers (Router A and Router B) in Area 0 shall be configured with the same authentication type.

When OSPF virtual links are used to connect a non-backbone area (Area 2) with a backbone area, if ID authentication is enabled in the backbone area (Area 0), the identity authentication shall also be configured on the ABR (Router C) in the non-backbone area.

Tips for configuring the OSPF area authentication are shown as follows:

8) In OSPF route configuration mode, specify the authentication type for the area.

9) Configure the authentication type and key on the interface.

Configuration Steps

The following information only shows how to configure the OSPF area authentication. For other configurations, see "Example of OSPF Virtual Link Configuration".

- **Configure Router A.**

Step 1: In OSPF route configuration mode, specify Area 0 to enable the MD5 authentication.

```
A(config)#router ospf 1
A(config-router)#area 0 authentication message-digest
A(config-router)#exit
```

Step 2: Configure the authentication type and key on the interface.

```
A(config)#interface gigabitEthernet 0/1
A(config-if-GigabitEthernet 0/1)#ip ospf message-digest-key 1 md5 hello
```

- **Configure Router B.**

Step 1: In OSPF route configuration mode, specify Area 0 to enable the MD5 authentication.

```
B(config)#router ospf 1
B(config-router)#area 0 authentication message-digest
B(config-router)#exit
```

Step 2: Configure the authentication type and key on the interface.

```
B(config)#interface gigabitEthernet 0/3
B(config-if-GigabitEthernet 0/3)#ip ospf message-digest-key 1 md5 hello
```

- **Configure Router C.**

! Enable the identity authentication of the backbone area (Area 0) on Router C.

```
C(config)#router ospf 1
C(config-router)#area 0 authentication message-digest
```

Verification

Step 1: Display the OSPF information about the routers when the authentication is enabled only on Router A and Router B. (disabled on Router C)

! Display the virtual link configurations of Router B.

```
B#show ip ospf virtual-links
Virtual Link VLINK0 to router 3.3.3.3 is up
  Transit area 0.0.0.1 via interface GigabitEthernet 0/3
  Local address 192.168.2.1/32
  Remote address 192.168.2.2/32
  Transmit Delay is 1 sec, State Point-To-Point,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:09
Adjacency state Down
```

In this case, the adjacency state is down.

! Display the virtual link configurations of Router C.

```
C#show ip ospf virtual-links
Virtual Link VLINK0 to router 2.2.2.2 is up
  Transit area 0.0.0.1 via interface GigabitEthernet 0/3
  Local address 192.168.2.2/32
  Remote address 192.168.2.1/32
  Transmit Delay is 1 sec, State Point-To-Point,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:08
Adjacency state Down
```

In this case, the adjacency state is down.

! Display the OSPF routing information about Router A.

```
A#show ip route ospf
O IA 192.168.2.0/24 [110/2] via 192.168.1.2, 00:10:59, GigabitEthernet 0/1
```

In this case, Router A has failed to learn the routes of Area 2.

Step 1: Display the OSPF information about the routers after the authentication is enabled on Router A and Router B and the identity authentication of Area 0 is enabled on Router C.

! Display the virtual link configurations of Router B.

```
B#show ip ospf virtual-links
Virtual Link VLINK0 to router 3.3.3.3 is up
  Transit area 0.0.0.1 via interface GigabitEthernet 0/3
  Local address 192.168.2.1/32
  Remote address 192.168.2.2/32
  Transmit Delay is 1 sec, State Point-To-Point,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:01
Adjacency state Full
```

In this case, the adjacency state is full.

! Display the virtual link configurations of Router C.

```
C#show ip ospf virtual-links
Virtual Link VLINK0 to router 2.2.2.2 is up
Transit area 0.0.0.1 via interface GigabitEthernet 0/3
Local address 192.168.2.2/32
Remote address 192.168.2.1/32
Transmit Delay is 1 sec, State Point-To-Point,
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:00
Adjacency state Full
```

In this case, the adjacency state is full.

! Display the OSPF routing information about Router A.

```
A#show ip route ospf
O IA 192.168.2.0/24 [110/2] via 192.168.1.2, 00:21:30, GigabitEthernet 0/1
O IA 192.168.3.0/24 [110/3] via 192.168.1.2, 00:03:18, GigabitEthernet 0/1
```

In this case, Router A has successfully learned the routes of Area 2.

Step 3: Display general OSPF information about Router A.

```
A#show ip ospf
 Routing Process "ospf 1" with ID 1.1.1.1
 Process uptime is 18 hours 22 minutes
 Process bound to VRF default
 Conforms to RFC2328, and RFC1583 Compatibility flag is enabled
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 Enable two-way-maintain
 Initial SPF schedule delay 1000 msecs
 Minimum hold time between two consecutive SPFs 5000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Initial LSA throttle delay 0 msecs
 Minimum hold time for LSA throttle 5000 msecs
 Maximum wait time for LSA throttle 5000 msecs
 Lsa Transmit Pacing timer 40 msecs, 10 LS-Upd
 Minimum LSA arrival 1000 msecs
 Pacing lsa-group: 240 secs
 Number of incoming current DD exchange neighbors 0/5
 Number of outgoing current DD exchange neighbors 0/5
 Number of external LSA 0. Checksum 0x000000
 Number of opaque AS LSA 0. Checksum 0x000000
 Number of non-default external LSA 0
 External LSA database is unlimited.
 Number of LSA originated 2
 Number of LSA received 244
 Log Neighbor Adjacency Changes: Enabled
  Number of areas attached to this router: 1: 1 normal 0 stub 0 nssa
    Area 0 (BACKBONE)
        Number of interfaces in this area is 1(1)
        Number of fully adjacent neighbors in this area is 1
        Area has message digest authentication
        SPF algorithm last executed 17:24:38.030 ago
        SPF algorithm executed 11 times
        Number of LSA 7. Checksum 0x032955
```

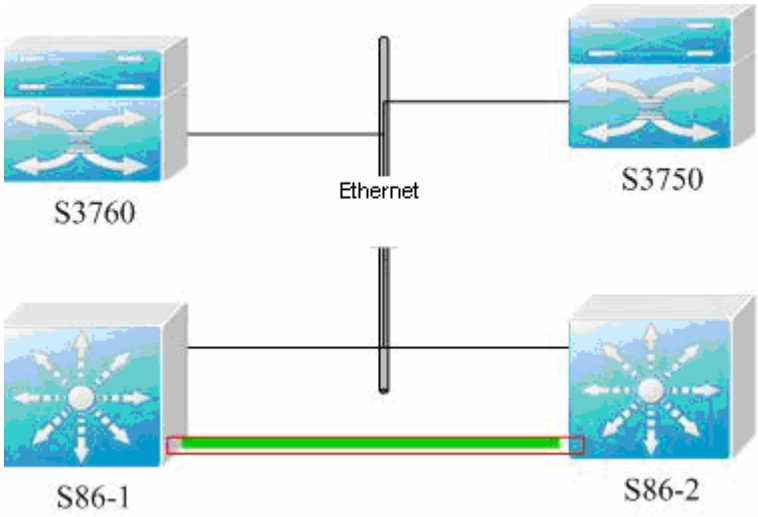
The above information shows that the area authentication has been enabled.

Example of OSPF GR Configuration

Configuration Requirements

The following figure shows that two S86 high-end switches have the GR Restart capability and are equipped with primary and secondary engines to support redundant backup at the control plane. S86-1 establishes the OSPF adjacency relationship with S86-2, S3760, and S3750. The OSPF GR capability is supported by all devices. The connection layout is shown as follows:

OSPF GR configuration



It is required that two S86 devices shall support non-stop packet forwarding to enhance the reliability of core devices.

Specific Configurations

Configure S3760.

```
Ruijie(config)# router ospf 1
Ruijie(config-router)# graceful-restart helper strict-lsa-checking
```

Configure S3750.

```
Ruijie(config)# router ospf 1
Ruijie(config-router)# graceful-restart helper strict-lsa-checking
```

Configure S86-1.

```
Ruijie(config)# router ospf 1
Ruijie(config-router)# graceful-restart
Ruijie(config-router)# graceful-restart helper strict-lsa-checking
```

Configure S86-2.

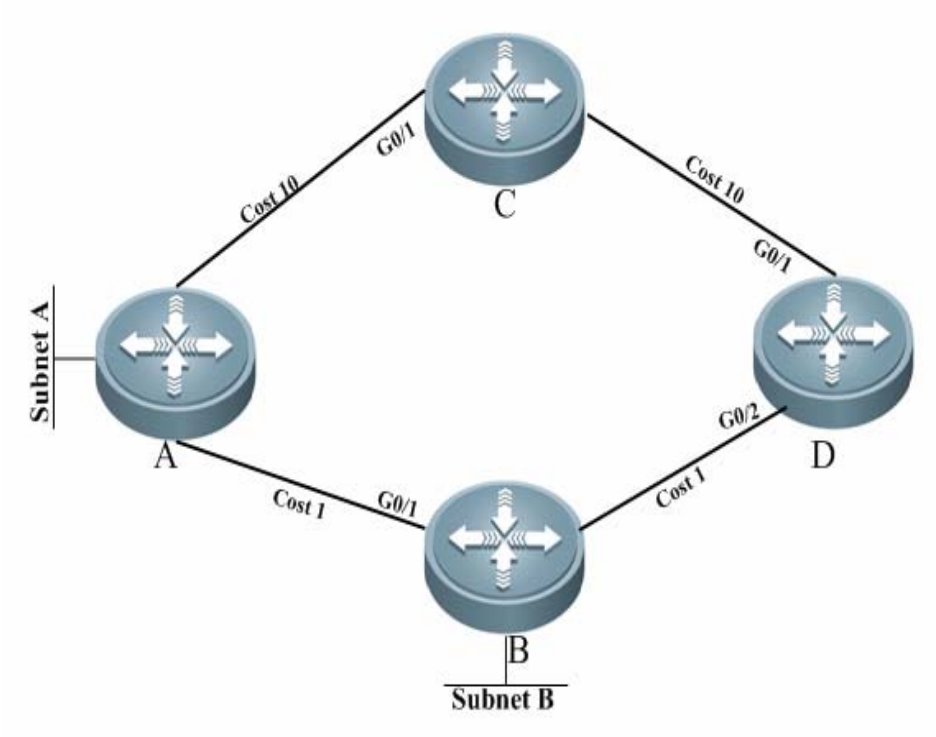
```
Ruijie(config)# router ospf 1
Ruijie(config-router)# graceful-restart
Ruijie(config-router)# graceful-restart helper strict-lsa-checking
```

Example of OSPF Stub Router Configuration

Configuration Requirements

Four routers form an OSPF routing area. The connection layout is shown in the following figure. According to the rule for optimal routing, the route from D to subnet A passes B. It is expected that the route passes C by changing configurations of B only.

OSPF Stub Router configuration



It is required that B only transmit routes to Subnets B and C transmit other routes.

Specific Configurations

Configure IP addresses and OSPF processes on the four routers, and make the following configurations after the adjacency relationship have been established successfully.

Configurations on D:

Configure the Ethernet interface.

```
interface gigabitEthernet 0/1
ip ospf cost 10
interface gigabitEthernet 0/2
ip ospf cost 1
```

Configurations on C:

Configure the Ethernet interface.

```
interface gigabitEthernet 0/1
ip ospf cost 10
```

Configurations on B:

Configure the Ethernet interface.

```
interface gigabitEthernet 0/1
ip ospf cost 1
```

Configure the OSPF routing protocol.

```
router ospf 1
max-metric router-lsa
```

Example of OSPF Fast Convergence Configuration

Configuration Requirements

Routers A and B are interconnected through a layer-2 switch. Run the OSPF protocol on them to establish routes. The following figure shows details about IP address assignment and connection layout.

OSPF fast convergence configuration

After link failure between B and the layer-2 switch occurs, A shall be able to detect adjacency changes within 1 second and quickly respond to the network changes.

Specific Configurations

The Fast Hello function reduces the time for detecting adjacency changes to less than 1 second. Meanwhile, the LSA fast convergence function facilitates to adaptation to the swift network changes.

Configurations on A:

Configure the Ethernet interface.

```
interface gigabitEthernet 0/1
ip address 192.168.1.1 255.255.255.0
interface gigabitEthernet 0/2
ip address 192.168.2.1 255.255.255.0
ip ospf dead-interval minimal hello-multiplier 5
```

Configure the OSPF routing protocol.

```
router ospf 1
network 192.168.1.0 0.0.0.255 area 0
network 192.168.2.0 0.0.0.255 area 0
```

```
timers arrival-time 100
timers throttle lsa all 0 100 500
```

Configurations on B:

Configure the Ethernet interface.

```
interface gigabitEthernet 0/1
ip address 192.168.3.1 255.255.255.0
interface gigabitEthernet 0/2
ip address 192.168.2.2 255.255.255.0
ip ospf dead-interval minimal hello-multiplier 5
```

Configure the OSPF routing protocol.

```
router ospf 1
network 192.168.2.0 0.0.0.255 area 0
network 192.168.3.0 0.0.0.255 area 0
timers arrival-time 100
timers throttle lsa all 0 100 500
```

Configuring OSPFv3

OSPFV2 (RFC2328, OSPFv2) runs under the IPv4. The RFC5340 describes OSPFV3, the extension of OSPFv2 that provides support for IPv6 routes. This document briefly describes the OSPFv3 protocol and its configuration.

Before learning this document, you must know the OSPFv2 protocol and related configuration.
The OSPFv3 protocol extends the OSPFv2 protocol with the main operating mechanisms and most configuration the same as the OSPFv2.

Overview

As an Interior Gateway Protocol (IGP), the OSPF runs among the layer 3 devices within an Autonomous System (AS).

Unlike a vector distance protocol, the OSPF is a link-state protocol. By exchanging various types of link-state advertisements (LSAs) recording link state between devices, it synchronizes link state information between devices and then calculates OSPF route entries through the Dijkstra algorithm.

The OSPFv3 is described in the RFC5340 and supports the IPv6. This section describes the differences from the OSPFv2 in implementation.

- LSA Association Change
- Interface Configuration
- Router ID Configuration
- Authentication Mechanism Configuration

LSA Association Change

Just as described above, the OSPF is a link-state protocol and its implementation is based on LSAs. Through LSAs, we can know the topologies of networks and address information. In contrast to the IPv4, the IPv6 uses 128-bit IP addresses. The design of LSAs is modified accordingly. Firstly, the LSA types are described as follows:

Router-LSAs (Type 1)

Each device generates this type of LSAs by itself. They describe the states of its links in specified areas and the cost spent in reaching the links. In contrast to the OSPFv2, the Router-LSAs of the OSPFv3 only indicate the state information of links. They do not record the information about the network addresses connected to routers. The information will be acquired by newly added types of LSAs. Additionally, in the OSPFv2, only one Router-LSA is allowed to be generated for each device in each area. While in the OSPFv3, multiple Router-LSAs are allowed to be generated. Thus, when performing the SPF calculation, we must consider all the Router-LSAs generated by the device. Router-LSAs and Network-LSAs describe the link topology of areas together.

Through the flag bits on Router-LSAs, we can know whether the routers are Area Border Routers (ABR), AS boundary routers (ASBR) or those at one end of a virtual link.

Network-LSAs (Type 2)

Network-LSAs only exist in broadcast networks or NBMA networks and are generated by DRs (Designated Routers) in a network. They describe the information about all the routers connected in specified areas on a network. Like Router-LSAs, Network-LSAs also only indicate the link-state information and do not record the network address information. Network-LSAs and Router-LSAs describe the link topology of areas together.

Inter-Area-Prefix-LSAs (Type 3)

They are generated for an area by the ABRs in the area and used to describe the network information about reaching other areas. They replace type 3 summary-LSAs in OSPFv2. In contrast to the OSPFv2, they use a prefix structure to describe the destination network information.

Inter-Area-Router-LSAs (Type 4)

They are generated for an area by the ABRs in the area, used to describe the path information about reaching the ASBRs in other areas, and replace type 4 summary-LSAs in OSPFv2.

AS-external-LSAs (Type 5)

This type of LSAs is generated by ASBRs and used to describe the network information about reaching outside the AS. Usually, the network information is generated through other routing protocols. In contrast to the OSPFv2, it uses a prefix structure to describe the destination network information.

NSSA-LSA (Type 7)

Their function is same as that of type 5 AS-external-LSAs. However, they are generated by ASBRs in the NSSA area.

Link-LSAs (Type 8)

In the OSPFv3, the newly added LSA type is generated by each device for each connected link and describes the local link address of the device in the current link and all set IPv6 address prefix information.

Intra-Area-Prefix-LSAs (Type 9)

It is a newly added LSA type in the OSPFv3 and provides additional address information for Router-LSAs or Network-LSAs. Therefore, it plays two roles:

- Associating network-LSAs and recording the prefix information of a transit network.
- Associating router-LSAs and recording the prefix information on all Loopback interfaces, point-to-point links, point-to-multipoint links, virtual links and stub networks of the router in the current area.

Other major changes associated with LSA:

LSA flooding scope

In the OSPFv2, the LSA flooding occurs inside areas and ASs. In the OSPFv3, flooding occurs also in local links. Type 8 Link-LSAs is the type that can flood only inside a local link.

Handling an unknown LSA type

This is an improvement of OSPFv3 based on OSPFv2.

In the OSPFv2, database synchronization is necessary in the initial establishment of the adjacency relationship. If there is an unrecognizable LSA type in the database description message, this relationship cannot be established properly. If there is an unrecognizable LSA type in a link-state updating message, then the type of LSAs will be dropped.

In the OSPFv3, it is allowed to receive an unknown LSA type. By using the information recorded in the LSA header, we can determine how to handle the unrecognizable LSA type received.

Interface Configuration

In the OSPFv3, the changes based on interface configuration are as follows:

In order for an interface to run OSPFv3, enable the OSPFv3 directly in the interface configuration mode. For OSPFv2, however, run the **network** command in the OSPF route configuration mode.

If an interface runs OSPFv3, all the addresses on the interface will run IPv6. In the OSPFv2,however, all the addresses are enabled via the **network** command.

In the environment where the OSPFv3 runs, a link can support multiple OSPF entities and different devices connecting this link can run one of these OSPF instances. The OSPFv3 adjacency can only be established between the devices with the same instance ID. The OSPFv2 does not support this function.

Router ID Configuration

RFC5340 specifies the OSPFv3 Router ID is in the format of 32-bit IPv4 address but not the IPv6 address.

By default, the methods of electing OSPFv3 Router ID are the same as the OSPFv2 process . The automatic election method is adopted. Firstly, the largest IPv4 address for the loopback interface is elected as the Router ID. if the loopback interface of IPv4 addresses has not been configured, OSPFv3 process will select the largest IPv4 address for other interfaces as the Router ID. With multiple OSPFv3 processes running on the device, the OSPFv3 process selects the Router ID with the highest priority from the unselected IPv4 addresses in the above way. Different Router IDs are for the different processes.

If the IPv4 addresses available for the Router ID selection are insufficient, the OSPFv3 process will fail to auto-obtain the Router ID. You can use the **router-id** command to configure a Router ID to enable the OSPFv3 process.

The Router ID for each router in the AS must be unique. With multiple OSPFv3 processes running on the same device, the Router ID for each process must also be unique.

Authentication Mechanism Configuration

OSPFv2 itself supports two authentication modes: plain text authentication and key authentication based on MD5. Authentication fields have been removed from OSPFv3 packet headers. OSPFv3 does away its support for authentication entirely, instead relying on IPsec framework offered by IPv6. When OSPFv3 runs on IPv6, OSPFv3 requires the IPv6 authentication header (AH) or IPv6 encapsulating security payload (ESP) to ensure integrity and confidentiality of routing exchanges.

Configure authentication commands to enable IP AH, which only provides authentication on data integrity and consistency. Configure encryption commands to enable IP ESP, which covers AH functions and ensures confidentiality. Namely, authentication and encryption are performed simultaneously.

OSPFv3 authentication configuration can be based on an interface, an area or a virtual link. If you want to achieve higher security, configure different IPsec authentications on every interface. Area configuration is effective for all interfaces except the virtual link within this area. If area configuration and interface configuration are both performed, IPsec of interface configuration has a higher priority.

Basic Configuration of OSPFv3

The OSPFv3 protocol of Ruijie Network has the following features:

Supports multi-instance OSPF;
Supports network type setting;
Supports virtual links;
Supports passive interfaces;
Supports an interface to select a participant OSPF instance;
Supports stub area;
Supports route redistribution;
Supports route aggregation;
Supports timer setting;
Supports link detection using BFD mechanism
To be implemented:
Supports NSSA areas;

Supports authentication. The OSPFv3 will use the IPSec authentication mechanism.

Default OSPFv3 Configuration:

Router ID		Undefined
Interface Configuration	Interface type	Broadcast network
	Interface cost	Undefined
	Hello message sending interval	10 seconds
	Dead interval of adjacent device	4 times of the hello interval.
	LSA sending delay	1 seconds
	LSA retransmitting interval	5 seconds
	Priority	1
	MTU check of database description messages	Enabled
Virtual Link	Virtual Link	Undefined
	Hello message sending interval	10 seconds
	Dead interval of adjacent device	4 times the hello interval.
	LSA sending delay	1 seconds
	LSA retransmitting interval.	5 seconds
	Fast Hello function	Disabled
Area Configuration	Area	Undefined
	Default router cost for stub areas	1
Routing information Aggregation	Inter-area route aggregation	Off
	External route aggregation	Off
Management Distance	Intra-area route	110
	Inter-area route	110
	External route	110
Auto cost generation		Enabled The default cost reference is 100 Mbps.

Shortest path first (SPF) timer	Time from receiving the topology change to running next SPF calculation :5 seconds The least interval between two calculations: 10 seconds
Route redistribution	Off
Route filtering	Off
Passive interface	Off

Enabling OSPFv3

Perform the following steps in the privileged mode to enable the OSPFv3:

Command	Function
configure terminal	Enter the global configuration mode
ipv6 router ospf *process-id*	Start an OSPFv3 routing process and enter the OSPFv3 configuration mode.
router-id *router-id*	Configure the Router ID used for OSPFv3 running on this device.
interface interface-id	Enter the interface configuration mode
ipv6 ospf process-id **area** *area-id* **[instance** *instance-id***]**	Enable the OSPFv3 on the interface. instance-id：Set the interface instance ID that participates the OSPFv3. The interfaces of different devices connected to the same network can choose different OSPFv3 instances to participate.
copy running-config startup-config	Save the configuration.

The OSPFv3 instance ID and process ID are different. OSPFv3 process ID is valid for the device itself only, not influencing the interaction with other routers. While the OSPFv3 instance ID influences the interaction with other routers. Only the devices with the same instance ID can set up the OSPFv3 neighbor relationship.

First enable the interface to participate in the OSPFv3 and then configure the OSPFv3 process in the interface configuration mode. Once the process is configured, the interface will automatically participate in the corresponding process. Currently, our products can support up to 32 OSPFv3 processes.

Configuring OSPFv3 Parameters on the Interface

You can modify the interface parameters in the interface configuration mode according to the actual application.

To configure the OSPFv3 interface parameters, execute the following commands in the interface configuration mode:

Command	Function
ipv6 ospf *process-id* **area** *area-id* [**instance** *instance-id*]	Set the interface to participate in the OSPFv3 routing process.
ipv6 ospf network {**broadcast** | **non-broadcast** | **point-to-point** | **point-to-multipoint** [**non-broadcast**]} [**instance** *instance-id*]	Set the network type of an interface. The default is the broadcast network type.
ipv6 ospf neighbor *ipv6-address* {[**cost** <*1-65535*>] | [**poll-interval** <*0-2147483647*> | **priority** <*0-255*>]} [**instance** *instance-id*]	(Optional) Set the OSPFv3 neighbor.
ipv6 ospf cost *cost* [**instance** *instance-id*]	(Optional) Define the interface cost.
ipv6 ospf hello-interval *seconds* [**instance** *instance-id*]	(Optional) Set the interval for sending the Hello packets on the interface. For all nodes in adjacency on the network, this value must be identical.
ipv6 ospf dead-interval *seconds* [**instance** *instance-id*]	(Optional) Set the adjacency dead-interval on the interface. For all nodes in adjacency on the network, this value must be identical.
ipv6 ospf transmit-delay *seconds* [**instance** *instance-id*]	(Optional) Set the delay in sending LSA on the interface.
ipv6 ospf retransmit-interval *seconds* [**instance** *instance-id*]	(Optional) Set the interval for retransmitting LSA on the interface.
ipv6 ospf priority *number* [**instance** *instance-id*]	(Optional) Set the priority of the interface for elect the DR and BDR.
ipv6 ospf authentication ipsec spi *spi* [**md5** | **sha1**] [**0** | **7**] *key*	(Optional) Sets the same interface authentication parameters on both sides.. *spi*: security parameter index within the ragne from 256 to 4294967295. **md5**: specifies md5 authentication mode. **sha1**: specifies sha1 authentication mode. **0**: specifies the key to be displayed as plain text. **7**: specifies the key to bedisplayed as cipher text. *key*: authentication key.

Command	Function
ipv6 ospf encryption ipsec spi *spi* **esp** *null* [**md5** | **sha1**] [**0** | **7**] *key*	(Optional) Sets the same interface authentication parameters on both sides.. *spi*: security parameter index within the ragne from 256 to 4294967295. **null**: specifies null encryption mode. **md5**: specifies md5 authentication mode. **sha1**: specifies sha1 authentication mode. **0**: specifies the key to be displayed as plain text. **7**: specifies the key to bedisplayed as cipher text. *key*: authentication key.

Use the **no** form of the above command to invalidate the configuration.

You can modify the parameter settings according to the actual needs. But note that some parameter settings must be consistent with those of neighbors otherwise no adjacency can be established. These parameters include the following: **instance**, **hello-interval**, **dead-interval**, **authentication** and **encryption**

Configuring OSPFv3 Area Parameter

The OSPF protocol applies the concept of “hierarchical structure”, allowing a network to be divided into a group of parts connected through a “backbone” in a mutual independence way. These parts are called Areas. The backbone part is called Backbone Area and always indicated by the numerical value 0 (or 0.0.0.0).

By using this hierarchical structure, each device is allowed to keep the link state database in the area where it resides and the topology inside the area is invisible to the outside. In this way, the link state database of each device can be always in a reasonable size, the route calculation time is not too much and the number of packets is not too big.

In the OSPF, the following types of special areas have been defined to meet actual needs:

stub Area.

If an area is at the end of the whole network, then we can design the area as a stub area.

A stub area cannot learn the external routing information of an AS (type 5 LSAs). In practical application, external routing information takes a great proportion in the link state database. Therefore, the devices inside a stub area will learn very little routing information, thus reducing the system resources for running the OSPF protocol.

A device inside a stub area can reach outside of an AS through the default route entry (type3 LSA) generated from the default routing information published by Area Border Routers in the stub area.

NSSA area (Not-So-Stubby Area)

NSSA is the extension of the stub area. By preventing from flooding type 5 LSAs to the devices in the NSSA, it reduce the consumption of device resources. However, unlike a stub area, it allows a certain amount of external routing information of the AS to enter an NSSA in other ways, namely, inject into the NSSA in the form of type 7 LSAs.

So far, the NSSA area functions of the OSPFv3 have not be implemented.

To configure the OSPFv3 area parameters, execute the following commands in the OSPFv3 configuration mode:

Command	Function
area *area-id* **stub** [**no-summary**]	Configure a stub area. no-summary: configure the area to a totally stub area, preventing the area border router in the stub area from sending type3 and type4 LSAs to the stub area.
area *area-id* **default-cost** *cost*	Configure the cost of the default route sent to a stub area.

Use the **no** form of the above command to invalidate the configuration.

You can configure the parameter **default-cost** after the configuration of the stub area is made.If the stub area is changed into an ordinary area, the default-cost configuration will be deleted automatically.

Configuring OSPFv3 Virtual Link

In the OSPF, all areas must be connected to the backbone area to ensure the communication with other areas. If some areas cannot be connected to the backbone area, virtual links are required to connect the backbone area.

To establish a virtual link, execute the following commands in the OSPFv3 configuration mode:

Command	Function
area *area-id* **virtual-link** *router-id* [**hello-interval** *seconds*] [**dead-interval** *seconds*] [**transmit-delay** *seconds*] [**retransmit-interval** *seconds*] [**instance** *instance-id*] [**authentication ipsec spi** *spi* [**md5** | **sha1**] [**0** | **7**] *key*] [**encryption ipsec spi** *spi* **esp null** [**md5** | **sha1**] [**0** | **7**] *key*]	Configure a virtual link. By default, the virtual link is not configured. *area-id:* the ID for the area where the virtual link is. *router-id:* the router-id for the virtual link neighbor. *spi*: security parameter index within the ragne from 256 to 4294967295. **null**: specifies null encryption mode. **md5**: specifies md5 authentication mode. **sha1**: specifies sha1 authentication mode. **0**: specifies the key to be displayed as plain text. **7**: specifies the key to bedisplayed as cipher text. *key*: authentication key. Other parameters have the same meanings as the interface parameters.

Use the **no** form of the command to invalidate the configuration.

It is not allowed to create a virtual link in the stub area .A virtual link can be taken as a special interface, so its configuration are the same as that of a normal interface. You must ensure that the configuration of **instance, hello-interval**, **dead-interval**, **authentication** and **encryption** configured at the two ends of the virtual link are identical.

Configuring OSPFv3 Route Aggregation

Without route aggregation, each device on the network has to maintain the routing information to every network.By aggrgating some information together, route aggregation can alleviate the burden on the L3 device and network bandwidth. As the size of a network is growing, the importance of route aggregation increases..

Ruijie's L3 devices support two types of route aggregation configuration: inter-area route aggregation and external route aggregation.

Configuring Inter-area Route Aggregation

The ABR in an area needs to advertise the routes in an area to other areas. If the route addresses are continual, the ABR aggregates the routing information and then advertises it.

To configure the inter-area route aggregation, execute the following commands in the OSPFv3 configuration mode:

Command	Function
area *area-id* **range** *ipv6-prefix*/*prefix-length* [**advertise** | **not-advertise**]	Configure inter-area route aggregation. *area-id*: ID of the area for aggregation. *ipv6-prefix/prefixlength*: Set the ipv6 prefix of the aggregated route. **advertise|not-advertise**: Advertise the summary-LSA created by aggregation or not.

Use **no area** *area-id* **range** *ipv6-prefix /prefix-length* to remove the inter-area aggregation configured.

Configuring External Route Aggregation

The route aggregation is allowed when redistributing the generated Type-5 LSA on the ASBR.

To configure the external route aggregation, execute the following commands in the OSPFv3 configuration mode:

Command	Function
summary-prefix *ipv6-prefix* / *prefix-length* [**not-advertise** | **tag** *tag-value*]	Configure external route aggregation. *ipv6-prefix/prefixlength*: Set the ipv6 prefix of the aggregated route. **not-advertise**: Not advertise the LSA created by aggregation. *tag-value*: The valid range is <*0-4294967295*>, used to specify the tag value for the LSA created by aggregation.

Use **no summary-prefix** *ipv6-prefix*/*prefix-length* to remove the external route aggregation configured.

Configuring Bandwidth Reference Value of OSPFv3 Interface Metric

The metric for the OSPF protocol is a bandwidth value based on the interface. The cost value of the interface is calculated based on its bandwidth.

For example, if the bandwidth reference value of an interfaces is 100 Mbps and the bandwidth of the network interfaces is 10Mbps, the automatically calculated interface cost is 100/10=10.

Currently, the default reference value of the network interface bandwidth of our products is 100Mbps.

To modify the reference value of the OSPFv3 interface bandwidth, execute the following commands in the OSPFv3 configuration mode:

Command	Function
auto-cost [**reference-bandwidth** *ref-bw*]	Configure the bandwidth reference value for interface metric, in Mbps.

You can run the **ipv6 ospf cost** *cost-value* command in the interface configuration mode to set the cost for a specified interface, which takes precedence over the one calculated based on bandwidth reference value.

Configuring MTU Check of DD Packets Received on OSPFv3 Interfaces

When the OSPFv3 receives the DD(Database Description) packets, it checks whether the MTU for the neighbor interface is the same as the MTU for its own interface. If the former is larger than the latter, the adjacency relationship cannot be established.

By default, this function of MTU check is disabled. To enable the MTU check on an interface, execute the following command in the interface configuration mode:

Command	Function
no ipv6 ospf mtu-ignore [**instance** *instance-id*]	Enable the MTU check on the interface when receiving database description (DD) packets.

By default, the MTU check function of the interface is disabled.

Configuring OSPFv3 Default Route

In the OSPFv3 protocol, the default route can be generated in many ways.

As described in section “Configuring OSPFv3 Area Parameters”, the default route represented by Type-3 LSA will be automatically generated in a stub area.

You can configure a default route represented by Type 5 LSA and advertise it to the whole OSPF AS.

Execute the following command in the OSPFv3 configuration mode:

Command	Function
default-information originate [always] [metric *metric-value***] [metric-type** *type-value***] [route-map** *map-name***]**	Configure the generation of a default route. **always:** With this parameter configured, no matter what the condition the system routing is in, a default route LSA is always generated. With this parameter not configured, only when the default routing existd in the core routing table, the default route LSA is generated and advertised. *metric:* Initial metric value of the route. The valid range is 0-16777214. **metric-type:** The external routing type corresponding to the default routing. **route-map:** the corresponding route-map rule to set the generated LSA.

Use **no default-information originate** to remove the default routing generated.

This command cannot be configured on the devices in a stub area.

Once configured, the device automatically becomes the ASBR.

Configuring OSPFv3 Routing Redistribution

Routing information redistribution allows the routing information of a routing protocol to be redistributed to another routing protocol.

To configure the OSPFv3 route redistribution, execute the following commands in the OSPFv3 configuration mode:

Command	Function
redistribute {**bgp** | **connected** | **isis** [*area-tag*] | **ospf** *process-id* | **rip** | **static**} [{**level-1** | **level-1-2** | **level-2**} | **match** {**internal** | **external** [**1**|**2**]} | **metric** *metric-value* | **metric-type** {*1*|*2*} | **route-map** *route-map-name* | **tag** *tag-value*]	Redistribute the routing information of other routing protocols. And set the conditions of redistribution. At present, the OSPFv3 supports redistribution of static, connect, rip, bgp, isis and ospf routes. When redistributing ISIS routes, you can configure the level parameter to redistribute the ISIS routes at the specified level. When redistributing OSPF routes, you can configure the match parameter to redistribute the OSPF routes of the specific sub type.
default-metric *number*	Configure the default metric for route redistribution.

Use the **no** redistribute *protocol* to disable the routing information redistribution.

- The isis parameter is not supported by S8600 and S12000 series in v10.4(3b17).

Configuring OSPFv3 Timer

After receiving the notice of network topology changes, the OPSPFv3 routing process will wait for a period of time before starting the SPF calculation. The SPF calculation delay is configurable, you can also use the command to configure the minimum and maximum interval between two SPF calculations.

To configure the OSPFv3 routing calculation timer, execute the following command in the routing process configuration mode:

Command	Function
timers throttle spf *spf-delay spf-holdtime spf-max-waittime*	Configure the OSPFv3 timer of routing calculation, in ms.

The parameter *spf-delay* refers to the delay from the topology change to the beginning of the SPF calculation.

The parameter *spf-holdtime* refers to the minimum interval of the first and the second SPF calculations triggered. Afterwards, the next SFP holdtime shall at least be twice as the last interval till the interval reaches the configured *spf-max-waittime*. If the SPF calculation intervals have exceeded the minimum value, it will re-calculate the SPF calculation interval from the *spf-holdtime.*

In normal conditions, when the link changes occassionally, reducing the *spf-delay* and *spf-holdtime* value can speed up the OSPF convergence. Setting a large *spf-max-waittime* avoids high CPU consumption by OSPF due to the continuous link fluctuation.

For example, **timers throttle spf** *1000 5,000 100,000*

If the topology keeps changing, the SPF calculation intervals(the SPF calculation interval increases by the binary exponential backoff algorithm, but cannot exceed the max-wait-time) are 1s, 6s, 16s, 36s, 76s, 156s, 256s, 256+100, ……

To configure the delay and holdtime for OSPFv3 routing calculation only, execute the following command in the routing process configuration mode:

Command	Function
Ruijie (config-router)# timers spf *spf-delay spf-holdtime*	Configure the routing calculation timer in second.

The **timers spf** and **timers throttle spf** commands are overwritten, and the one configured later is valid. With both commands not configured, the default value is **timers throttle spf.**

The function of the command **timers throttle spf** has covered the function of **timers spf**, and is even stronger. It is recommended to use the **timer throttle spf** command.

Configuring OSPFv3 Passive Interface

To prevent other Layer 3 devices in the network from learning the routing information of this device, you can set a network interface to a passive interface in the routing protocol configuration mode

For the OSPFv3 protocol, if a network interface is configured as a passive network interface, then this network interface will receive/send no OSPF message.

To configure an OSPFv3 passive interface, execute the following command in the OSPFv3 configuration mode:

Command	**Function**
passive-interface {**default** | *interface-type interface-number* }	Configure a passive interface. default: with this parameter configured, all interfaces will be set as the passive interfaces. Interface: set the specified interface as the passive interface. Combining **passive-interface default** and **no passive-interface *interface*** can specify some interfaces as non-passive interfaces and the others as passive interfaces.

Use the command **no passive-interface** {*interface-id* | **default**} to remove the passive interface setting.

Configuring OSPFv3 Authenticated Encryption

Authenticated encryption is configured to avoid learning unauthenticated encryption and invalid routes, and prevent valid routes from being announced to the unauthenticated encryption device. On a broadcast network, authenticated encryption can also help avoid the possibility of specifying the unauthenticated encryption device to ensure stability and invasion-resistance of the routing system.

Run the following demands to configure OSPFv3 authenticated encryption in routing process configuration mode or interface configuration mode:

Command	Function
area *area-id* authentication ipsec spi *spi* [**md5** | **sha1**] [**0** | **7**] *key*	Enables authentication on the area. Sets authentication mode and key.
area *area-id* **encryption ipsec spi** *spi* **esp null** [**md5** | **sha1**] [**0** | **7**] *key*	Enables authenticated encryption on the area. Sets encrypted authentication mode and key.
ipv6 ospf authentication ipsec spi *spi* [**md5** | **sha1**] [**0** | **7**] *key*	Enables authentication on the interface. Sets authentication mode and key.
ipv6 ospf encryption ipsec spi *spi* **esp null** [**md5** | **sha1**] [**0** | **7**] *key*	Enables authenticated encryption on the interface. Sets encrypted authentication mode and key.

Use the **no** form of this command to disable configuration.

Note

Connected interfaces within the same area must be configured with the same authenticated encryption parameters. Authenticated encryption configured on the area is effective for all interfaces (except the virtual link) within this area but authenticated encryption configured on the interface has a higher priority.
Authenticated encryption parameters configured on two ends of the virtual link must be the same. All *spi* parameters must be unique.
Please refer to *configuring OSPFv3 virtual link* section for virtual link authentication configuration.

Configuring the OSPFv3 Route Management Distance

The route management distance, representing the reliability of the route source, is used to compare the priorities for different routing protocols. The valid range for the management distance is 0-255. The smaller the management distance is, the higher the route priority is, and the higher the route source reliability is.

By default, the OSPFv3 route management distance is 110. You can set different management distances for different OSPFv3 routes, the intra-area, inter-area and external routes.

To change the OSPFv3 route management distance, execute the following command in the routing process configuration mode:

Command	Function
distance {*distance* | **ospf** { **intra-area** *distance* | **inter-area** *distance* | **externa**l *distance* }}	Modify the OSPFv3 route management distance.

The management distance must be used to compare the priorities of the different routes originated from different OSPFv3 processes.

Configuring the OSPFv3 BFD

Refer to relevant sections in BDF Configuration Guide for the OSPFv3 BFD configuration.

OSPFv3 Debugging & Monitoring

OSPFv3 supports a large range of debugging and monitoring commands.

OSPFv3 Debugging Commands

Use the following commands to enable the OSPFv3 process debugging in the privileged configuration mode:

Command	Function
debug ipv6 ospf events	Show the OSPFv3 event information.
debug ipv6 ospf ifsm	Show the state machine events and changes of an egress interface.
debug ipv6 ospf lsa	Show the related OSPFv3 LSA information.
debug ipv6 ospf nfsm	Show state machine events and changes of a neighbor.
debug ipv6 ospf nsm	Show the related OSPFv3 and NSM module information.
debug ipv6 ospf packet	Show the OSPFv3 packet information.
debug ipv6 ospf route	Show the OSPF routing calculation and addition information.

Use the **undebug** form of the above commands to disable the above **debug** commands.

The **debug** commands are provided for technicians.

Running a **debug** command will affect the performance of the system in a certain extent. Therefore, after running a **debug** command, use an **undebug** command to disable the debug command.

OSPFv3 Monitoring Commands

Use the following commands to enable the OSPFv3 process monitoring in the privileged configuration mode:

Command	Function
show ipv6 ospf	Show the OSPFv3 process information.
show ipv6 ospf [*process-id*] **database** [**isa-type** [**adv-router** *router-id*]]	Show the database information of the OSPF process.
show ipv6 ospf interface *[interface-type interface-number]*	Show the interface information of the OSPFv3 process.
show ipv6 ospf [*process-id*] **neighbor** [*interface-type interface-number* [**detail**]] *[neighbor-id*] [**detail**]	Show the neighbor information of the OSPFv3 process.
show ipv6 ospf [*process-id*] **route**	Show the OSPFv3 routing information.
show ipv6 ospf [*process-id*]**summary-prefix**	Show the OSPFv3 external route summary information
show ipv6 ospf [*process-id*] **topology** [**area** *area-id*]	Show each area topology of the OSPFv3.
show ipv6 ospf [*process-id*] **virtual-links**	Show the virtual link information of the OSPFv3 process.

OSPFv3 Configuration Examples

OSPFv3 Basic Configuration Example

The following configuration example shows the commands related to OSPF configuration.

Topological Diagram

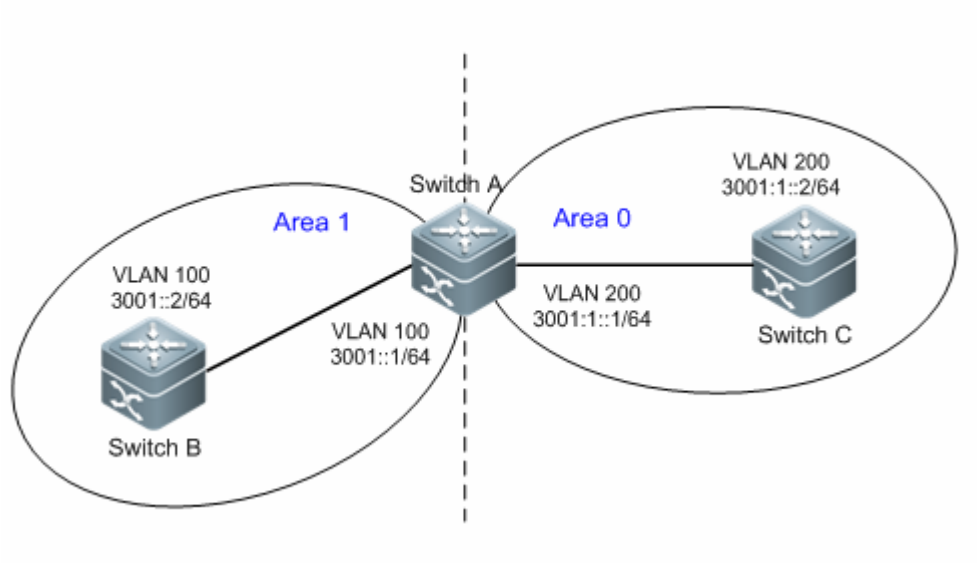


Figure 1 OSPFv3 basic configuration

SwitchA and SwitchB belong to Area 0, while Switch A and Switch C belong to Area 1. The intercommunication between three switches is realized via the vlan interface.

Application Requirements

Enable the OSPFv3 on all switches and divide them into two areas between which IPv6 packets can be communicated.

Configuration Tips

Key points

Configure Area0 and Area1, and enable OSPFv3 on the corresponding VLAN interface of the switch (interface vlan 100 or vlan 200 of SwtichA/SwitchB/SwitchC in this example)

Cautions

The router-id must be specified, or else the adjacency cannot be created. Automatic acquisition of router-id is supported in 10.4 and subsequent releases.

Vlan must be created first, or else the VLAN interface cannot join OSPFv3.

Configuration Steps

Configuring SwitchA

Step 1, Create a VLAN and set the IPv6 address

```
SwitchA# config terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

! Create and configure interface vlan100

```
SwitchA(config)# vlan 100
SwitchA(config-vlan)#exit
SwitchA(config-vlan)#interface vlan 100
SwitchA(config-if-VLAN 100)#ipv6 enable
SwitchA(config-if-VLAN 100)#ipv6 address 3001::1/64
SwitchA(config-if-VLAN 100)#exit
```

! Create and configure interface vlan200

```
SwitchA(config)#vlan 200
SwitchA(config-vlan)#interface vlan 200
SwitchA(config-if-VLAN 200)#ipv6 enable
SwitchA(config-if-VLAN 200)#ipv6 address 3001:1::1/64
SwitchA(config-if-VLAN 200)#exit
```

Step 2, Create an OSPFv3 process and specify the router-id

```
SwitchA(config)#ipv6 router ospf  10
SwitchA(config-router)#router-id 1.1.1.1
Change router-id and update OSPFv3 process! [yes/no]:y
SwitchA(config-router)#exit
```

Step 3, Enable OSPFv3 on interface vlan 100, with the area being Area0

```
SwitchA(config)#interface vlan 100
SwitchA(config-if-VLAN 100)#ipv6 ospf 10 area 0
SwitchA(config-if-VLAN 100)#exit
```

Step 4, Enable the OSPFv3 on interface vlan 200, with the area being Area1

```
SwitchA(config)#interface vlan 200
SwitchA(config-if-VLAN 200)#ipv6 ospf 10 area 1
SwitchA(config-if-VLAN 200)#end
```

Configuring SwitchB

Step 1, create a VLAN and configure the IPv6 address

SwitchB# conf

Enter configuration commands, one per line. End with CNTL/Z.

! Create and configure interface vlan100

```
SwitchB(config)# vlan 100
SwitchB(config-vlan)#interface vlan 100
```

```
SwitchB(config-if-VLAN 100)#ipv6 enable
SwitchB(config-if-VLAN 100)#ipv6 address 3001::2/64
SwitchB(config-if-VLAN 100)#exit
```

Step 2, Create an OSPFv3 process and specify the router-id

```
SwitchB(config)#ipv6 router ospf 10
SwitchB(config-router)#router-id 2.2.2.2
Change router-id and update OSPFv3 process! [yes/no]:y
SwitchB(config-router)#exit
```

Step 3, Enable the OSPFv3 on interface vlan 100, with the area being Area0

```
SwitchB(config)#interface vlan 100
SwitchB(config-if-VLAN 100)#ipv6 ospf 10 area 0
SwitchB(config-if-VLAN 100)#end
```

Configuring SwitchC

Step 1, create a VLAN and configure the IPv6 address

SwitchC#configure terminal

Enter configuration commands, one per line. End with CNTL/Z.

! Create and configure interface vlan200

```
SwitchC(config)#vlan 200
SwitchC(config-vlan)#interface vlan 200
SwitchC(config-if-VLAN 200)#ipv6 enable
SwitchC(config-if-VLAN 200)#ipv6 address 3001:1::2/64
SwitchC(config-if-VLAN 200)#exit
```

Step 2, Create an OSPFv3 process and specify the router-id

```
SwitchC(config)#ipv6 router ospf 10
SwitchC(config-router)#router-id 3.3.3.3
Change router-id and update OSPFv3 process! [yes/no]:y
SwitchC(config-router)#exit
```

Step 3, Enable the OSPFv3 on interface vlan 200, with the area being Area1

```
SwitchC (config)#interface vlan 200
SwitchC (config-if-VLAN 200)#ipv6 ospf 10 area 1
SwitchC (config-if-VLAN 200)#end
```

Verifying configuration

Step 1: Verify whether the configuration are correct. Pay attention: whether the router-id is specified, whether the OSPFv3 is enabled on the interface, and whether such parameters as OSPFv3 timer are identical in the same area.

Configuring SwitchA

```
vlan 100
!
vlan 200
!
```

```
interface VLAN 100
 no ip proxy-arp
 ipv6 address 3001::1/64
 ipv6 enable
 ipv6 ospf 10 area 0
!
interface VLAN 200
 no ip proxy-arp
 ipv6 address 3001:1::1/64
 ipv6 enable
 ipv6 ospf 10 area 1
!
ipv6 router ospf 10
 router-id 1.1.1.1
```

Configuring SwitchB

```
vlan 100
!
interface VLAN 100
 no ip proxy-arp
 ipv6 address 3001::2/64
 ipv6 enable
 ipv6 ospf 10 area 0
!
ipv6 router ospf 10
 router-id 2.2.2.2
```

Configuring SwitchC:

```
vlan 200
!
interface VLAN 200
 no ip proxy-arp
 ipv6 address 3001:1::2/64
 ipv6 enable
 ipv6 ospf 10 area 1
!
ipv6 router ospf 10
 router-id 3.3.3.3
```

Step 2: Display OSPFv3 neighbors. Pay attention: whether the adjacencies have been created.

```
SwitchA#show ipv6 ospf neighbor
OSPFv3 Process (10), 2 Neighbors, 2 is Full:
Neighbor ID   Pri  State      Dead Time   Instance ID   Interface
2.2.2.2       1   Full/BDR    00:00:37    0           VLAN 100
3.3.3.3       1   Full/DR     00:00:34    0           VLAN 200
```

The information displayed on SwitchB and SwitchC is similar to the information displayed on SwitchA.

Step 3: Display OSPFv3 routes and ping IPv6 address in another area. Pay attention: whether all the IPv6 routes are learned and whether the routes can be pinged.

```
SwitchC#show ipv6 route
IPv6 routing table name is Default(0) global scope - 7 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       O - OSPF intra area, OI - OSPF inter area,  OE1 - OSPF external type 1, OE2 - OSPF external
type 2
       ON1 - OSPF NSSA external type 1, ON2 - OSPF NSSA external type 2
       [*] - NOT in hardware forwarding table
L      ::1/128  via Loopback, local host
OI     3001::/64  [110/2] via FE80::21A:A9FF:FE15:4CB9, VLAN 200
C      3001:1::/64  via VLAN 200, directly connected
L      3001:1::2/128  via VLAN 200, local host
L      FE80::/10  via ::1, Null0
C      FE80::/64  via VLAN 200, directly connected
L      FE80::21A:A9FF:FE01:FB1F/128  via VLAN 200, local host
```

```
SwitchC#ping ipv6 3001::2
Sending 5, 100-byte ICMP Echoes to 3001::2, timeout is 2 seconds:
  < press Ctrl+C to break >
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/10 ms
```

The information displayed on SwitchA and SwitchB is similar to the information displayed on SwitchC.

OSPFv3 Redistribution Configuration Example

Configuration Requirements

There are three devices which are connected as shown in Figure 2.

- Enable the OSPFv3 protocol on RouterA; Enable BGP protocol and configure the static route on RouterC; For RouterB, redistribute the static route redistributed on RouterC to the OSPFv3 domain. Set the specified community attributes for the static route redistributed to BGP on RouterC and redistribute BGP route with the specified community attributes to the OSPFv3 domain on RouterB.
- Configure the external route summary on RouterB: aggregate the routes within the range of 2001:db8:77::/48 and advertise the summary to the OSPFv3 domain.
- To speed up the convergence, set the SPF calculation delay, holdtime and max-waittime for RouterA and RouterB to 5ms, 1000ms and 90000ms respectively.

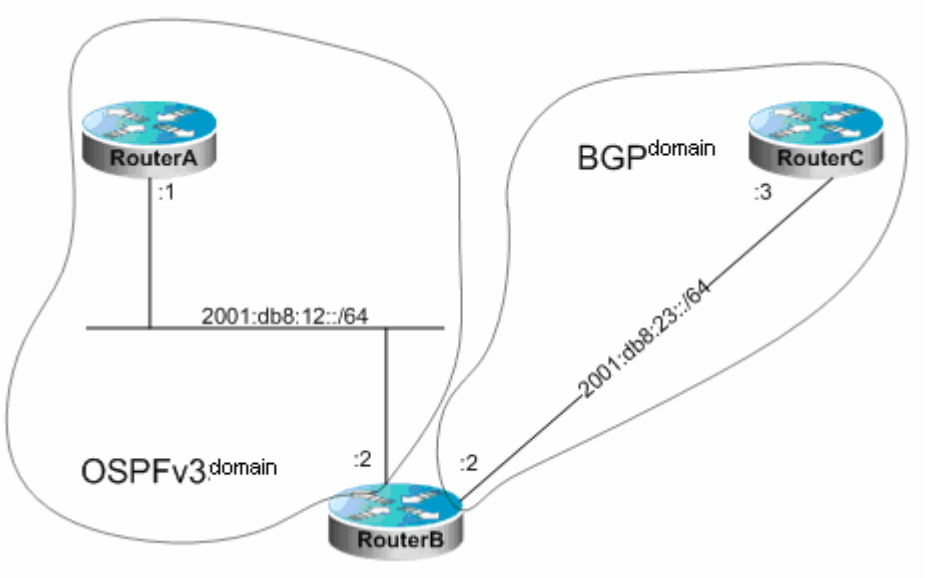


Figure 2 OSPFv3 Redistribution Configuration Example

Configuration Details

Router A configuration:

Configure the network interface

```
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if)# ipv6 enable
Ruijie(config-if)# ipv6 address 2001:db8:12::1/64
Ruijie(config-if)# ipv6 ospf 12 area 0
```

Configure OSPFv3

```
Ruijie(config)# ipv6 router ospf 12
Ruijie(config-router)# router-id 1.1.1.1
Ruijie(config-router)# timers throttle spf 5 1000 90000
```

Router B Configuration:

Configure the network interface

```
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if)# ipv6 enable
Ruijie(config-if)# ipv6 address 2001:db8:12::2/64
Ruijie(config-if)# ipv6 ospf 12 area 0
Ruijie(config)# interface gigabitEthernet 0/2
Ruijie(config-if)# ipv6 enable
Ruijie(config-if)# ipv6 address 2001:db8:23::2/64
```

Configure OSPFv3

```
Ruijie(config)# ipv6 router ospf 12
Ruijie(config-router)# router-id 2.2.2.2
```

```
Ruijie(config-router)# redistribute bgp route-map ospfrm
Ruijie(config-router)# timers throttle spf 5 1000 90000
Ruijie(config-router)# summary-prefix 2001:db8:77::/48
```

Configure BGP

```
Ruijie(config)# router bgp 2
Ruijie(config-router)# neighbor 2001:db8:23::3 remote-as 3
Ruijie(config-router)# address-family ipv6
Ruijie(config-router-af)# neighbor 2001:db8:23::3 activate
```

Configure route-map

```
Ruijie(config)# route-map ospfrm
Ruijie(config-route-map)# match community cl_110
```

Define community list

```
Ruijie(config)# ip community-list standard cl_110 permit 22:22
```

Router C Configuration:

Configure the network interface

```
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if)# ipv6 enable
Ruijie(config-if)# ipv6 address 2001:db8:23::3/64
```

Configure BGP

```
Ruijie(config)# router bgp 3
Ruijie(config-router)# neighbor 2001:db8:23::2 remote-as 2
Ruijie(config-router)# address-family ipv6
Ruijie(config-router-af)# redistribute static route-map bgprm
Ruijie(config-router-af)# neighbor 2001:db8:23::2 activate
Ruijie(config-router-af)# neighbor 2001:db8:23::2 send-community
```

Configure static route

```
Ruijie(config)# ipv6 route 2001:db8:77:88::/64 null 0
Ruijie(config)# ipv6 route 2001:db8:77:99::/64 null 0
```

Configure route-map

```
Ruijie(config)# route-map bgprm
Ruijie(config-route-map)# set community 22:22
```

Example of stub area configuration

Typology Diagram

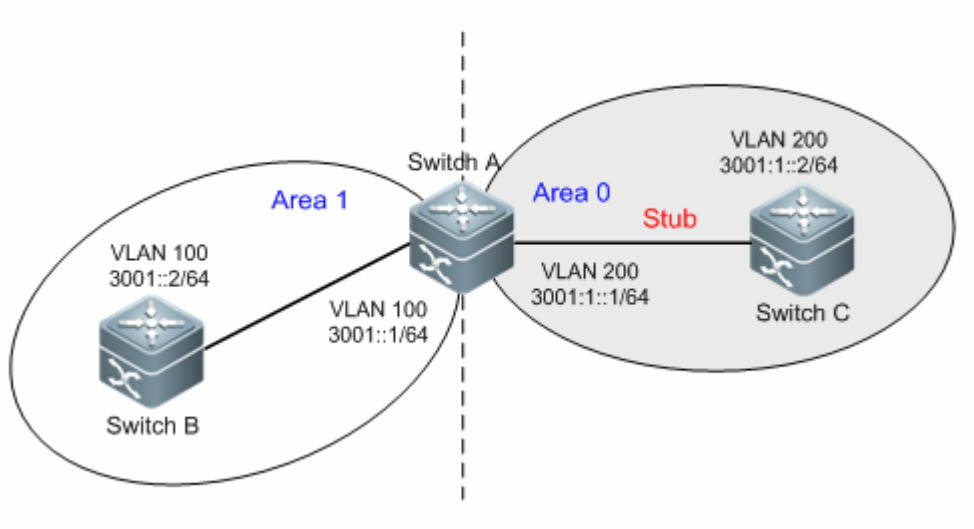


Figure 3 OSPFv3 stub area (the same as Figure 1)

Application Requirements

Configure Area 1 as a stub area in order to reduce the system overhead of switches in this area.

Configuration tips

Use the parameter of "stub no-summary" on the area border router (ABR) (Switch A in this example)

Use the parameter of "stub" on the non-area-border router (Switch C in this example)

Configuration Steps

Configuring SwitchA

Step 1: Enable OSPFv3 basic configuration, as in the OSPFv3 basic configuration example.

Step 2: Configure stub no-summary

```
SwitchA# conf
Enter configuration commands, one per line.  End with CNTL/Z.
SwitchA(config)#ipv6 router ospf 10
SwitchA(config-router)#area 1 stub no-summary
SwitchA(config-router)#exit
```

Configuring SwitchC

Step 1: Enable OSPFv3 basic configuration, as in the OSPFv3 basic configuration example.

Step 2: Configure stub

```
SwitchC# conf
Enter configuration commands, one per line.  End with CNTL/Z.
SwitchA(config)#ipv6 router ospf 10
SwitchA(config-router)#area 1 stub
SwitchA(config-router)#exit
```

Verifying configuration

Step 1: Verify whether the configuration are correct. While making sure the OSPFv3 basic configuration are correct, pay attention to the differences in stub parameters between ABR and the other router.

SwitchA Configuration

```
vlan 100
!
vlan 200
!
interface VLAN 100
 no ip proxy-arp
 ipv6 address 3001::1/64
 ipv6 enable
 ipv6 ospf 10 area 0
!
interface VLAN 200
 no ip proxy-arp
 ipv6 address 3001:1::1/64
 ipv6 enable
 ipv6 ospf 10 area 1
!
ipv6 router ospf 10
 router-id 1.1.1.1
area 1 stub no-summary
!
```

SwitchC Configuration

```
vlan 200
!
interface VLAN 200
 no ip proxy-arp
 ipv6 address 3001:1::2/64
 ipv6 enable
 ipv6 ospf 10 area 1
!
ipv6 router ospf 10
```

```
 router-id 3.3.3.3
area 1 stub
!
```

Step 2: Display OSPFv3 neighbors. Pay attention: whether the adjacencies have been created.

```
SwitchA#show ipv6 ospf neighbor
OSPFv3 Process (10), 2 Neighbors, 2 is Full:
Neighbor ID   Pri  State      Dead Time   Instance ID   Interface
2.2.2.2       1   Full/BDR    00:00:37    0           VLAN 100
3.3.3.3       1   Full/DR     00:00:34    0           VLAN 200
```

Similar information will be displayed on SwitchC.

Step 3: Display OSPFv3 routes. Pay attention: whether the default route is generated, and whether the inter-area route exists

```
SwitchC #show ipv6 route
IPv6 routing table name is Default(0) global scope - 7 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
  I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
  O - OSPF intra area, OI - OSPF inter area,  OE1 - OSPF external type 1, OE2 - OSPF external
type 2
ON1 - OSPF NSSA external type 1, ON2 - OSPF NSSA external type 2
      [*] - NOT in hardware forwarding table
OI    ::/0  [110/2] via FE80::21A:A9FF:FE15:4CB9, VLAN 200
L     ::1/128  via Loopback, local host
C     3001:1::/64  via VLAN 200, directly connected
L     3001:1::2/128  via VLAN 200, local host
L     FE80::/10  via ::1, Null0
C     FE80::/64  via VLAN 200, directly connected
L     FE80::21A:A9FF:FE01:FB1F/128  via VLAN 200, local host
```

Example of OSPFv3 DR election configuration

Typology Diagram

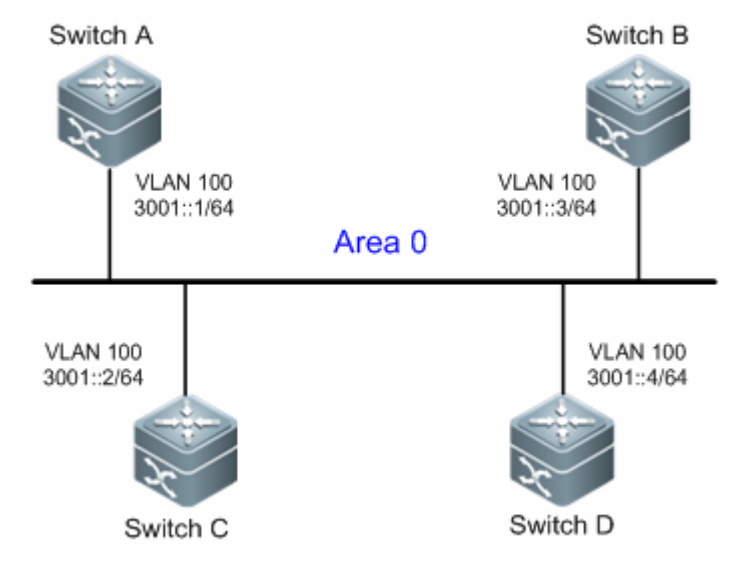


Figure 4 OSPFv3 DR election

SwitchA, SwitchB, SwitchC and SwitchD are in the same area (Area 0) and are interconnected via vlan 100. Switch A and Switch B are devices with the best configuration and the highest stability on the network

Application Requirements

Corresponding requirements: By adjusting the parameter **priority**, configure SwitchA as the DR and SwitchB as the BDR in order to avoid network route flap.

Configuration Tips

Configuration tips

Configure the priority of the interface of expected DR (Switch A in this example) to the highest (150 in this example) and the priority of the interface of BDR (Switch B) to the second highest (50 in this example)

Cautions

The default priority of interface is 1, and DR/BDR can be determined according to the router-id. Generally, the router with the largest router-id will be the DR, and the router with the second largest router-id will be the BDR.

Configuration Steps

Configuring SwitchA

Step 1, create a VLAN and configure the IPv6 address

SwitchA# conf

Enter configuration commands, one per line. End with CNTL/Z.

! Create and configure interface vlan100

```
SwitchA(config)# vlan 100
SwitchA(config-vlan)#exit
SwitchA(config)#interface vlan 100
SwitchA(config-if-VLAN 100)#ipv6 enable
SwitchA(config-if-VLAN 100)#ipv6 address 3001::1/64
SwitchA(config-if-VLAN 100)#exit
```

Step 2, Create an OSPFv3 process and specify the router-id

```
SwitchA(config)#ipv6 router ospf 10
SwitchA(config-router)#router-id 1.1.1.1
SwitchA(config-router)#exit
```

Step 3, Enable the OSPFv3 on interface vlan 100, with the area being Area0 and the priority being 150

```
SwitchA(config)#interface vlan 100
SwitchA(config-if-VLAN 100)#ipv6 ospf 10 area 0
SwitchA(config-if-VLAN 100)# ipv6 ospf priority 150
SwitchA(config-if-VLAN 100)#end
```

Configuring SwitchB

Step 1, create a VLAN and configure the IPv6 address

SwitchB# conf

Enter configuration commands, one per line. End with CNTL/Z.

! Create and configure interface vlan100

```
SwitchB(config)# vlan 100
SwitchB(config-vlan)#exit
SwitchB(config)#interface vlan 100
SwitchB(config-if-VLAN 100)#ipv6 enable
SwitchB(config-if-VLAN 100)#ipv6 address 3001::2/64
SwitchB(config-if-VLAN 100)#exit
```

! Create an OSPFv3 process and specify the router-id

```
SwitchB(config)#ipv6 router ospf 10
SwitchB(config-router)#router-id 2.2.2.2
SwitchB(config-router)#exit
```

Step 2, Enable the OSPFv3 on interface vlan 100, with the area being Area0 and the priority being 50

```
SwitchB(config)#interface vlan 100
SwitchB(config-if-VLAN 100)#ipv6 ospf 10 area 0
SwitchB(config-if-VLAN 100)# ipv6 ospf priority 50
SwitchB(config-if-VLAN 100)#end
```

Configuring SwitchC

Step 1, create a VLAN and configure the IPv6 address

SwitchC# conf

Enter configuration commands, one per line. End with CNTL/Z.

! Create and configure interface vlan100

```
SwitchC(config)#vlan 100
SwitchC(config-vlan)#exit
SwitchC(config)##interface vlan 100
SwitchC(config-if-VLAN 100)#ipv6 enable
SwitchC(config-if-VLAN 100)#ipv6 address 3001::3/64
SwitchC(config-if-VLAN 100)#exit
```

Step 2, Create an OSPFv3 process and specify the router-id

```
SwitchC(config)#ipv6 router ospf 10
SwitchC(config-router)#router-id 3.3.3.3
SwitchC(config-router)#exit
```

Step 3, Enable OSPFv3 on interface vlan 100, with the area being Area0 and the priority using the default value.

```
SwitchC(config)#interface vlan 100
SwitchC(config-if-VLAN 100)#ipv6 ospf 10 area 0
SwitchC(config-if-VLAN 100)#end
```

Configuring SwitchD

Step 1, create a VLAN and configure the IPv6 address

SwitchD# conf

Enter configuration commands, one per line. End with CNTL/Z.

! Create and configure interface vlan100

```
SwitchD(config-vlan)#vlan 100
SwitchD(config-vlan)#exit
SwitchD(config)#interface vlan 100
SwitchD(config-if-VLAN 100)#ipv6 enable
SwitchD(config-if-VLAN 100)#ipv6 address 3001::4/64
SwitchD(config-if-VLAN 100)#exit
```

Step 2, Create an OSPFv3 process and specify the router-id

```
SwitchD(config)#ipv6 router ospf 10
SwitchD(config-router)#router-id 4.4.4.4
SwitchD(config-router)#exit
```

Step 3, Enable OSPFv3 on interface vlan 100, with the area being Area0 and the priority using the default value.

```
SwitchD(config)#interface vlan 100
SwitchD(config-if-VLAN 100)#ipv6 ospf 10 area 0
SwitchD(config-router)#end
```

Verifying configuration

Step 1: Verify whether the configuration are correct. Pay attention: whether the OSPF basic parameters and interface priority are correct

SwitchA Configuration:

```
vlan 100
!
interface VLAN 100
 no ip proxy-arp
 ipv6 address 3001::1/64
 ipv6 enable
 ipv6 ospf 10 area 0
ipv6 ospf priority 150
!
ipv6 router ospf 10
 router-id 1.1.1.1
```

SwitchB Configuration

```
vlan 100
!
interface VLAN 100
 no ip proxy-arp
 ipv6 address 3001::2/64
 ipv6 enable
 ipv6 ospf 10 area 0
ipv6 ospf priority 50
!
ipv6 router ospf 10
 router-id 2.2.2.2
```

SwitchC Configuration

```
vlan 100
!
interface VLAN 100
 no ip proxy-arp
 ipv6 address 3001::3/64
 ipv6 enable
 ipv6 ospf 10 area 0
!
ipv6 router ospf 10
 router-id 3.3.3.3
```

SwitchD Configuration:

```
vlan 100
!
interface VLAN 100
 no ip proxy-arp
 ipv6 address 3001::4/64
 ipv6 enable
 ipv6 ospf 10 area 0
!
ipv6 router ospf 10
 router-id 4.4.4.4
```

Step 2: Display OSPFv3 neighbors. Pay attention: whether the adjacencies have been created, and whether each switch plays the correct role.

```
SwitchD#show ipv6 ospf neighbor
Neighbor ID  Pri   State    Dead Time   Interface ID    Interface
3.3.3.3      1   2WAY/DROTHER  00:00:33    4196         Vlan100
1.1.1.1      150   FULL/DR     00:00:35    4196           Vlan100
2.2.2.2      50   FULL/BDR     00:00:35    4196           Vlan100
```

Adjacencies before priority configuration are shown below. We can see that DR/BDR can be specified by adjusting the priority.

```
SwitchA#show ipv6 ospf neighbor
OSPFv3 Process (10), 3 Neighbors, 2 is Full:
Neighbor ID  Pri   Stat     Dead Time   Instance ID   Interface
2.2.2.2      1   Full/BDR       00:00:33    0           VLAN 100
3.3.3.3      1   2-Way/DROther   00:00:35   0           VLAN 100
4.4.4.4      1   Full/DR        00:00:33    0           VLAN 100
```

Configuration Example of OSPFv3 multiple instances on one link

Topological Diagram

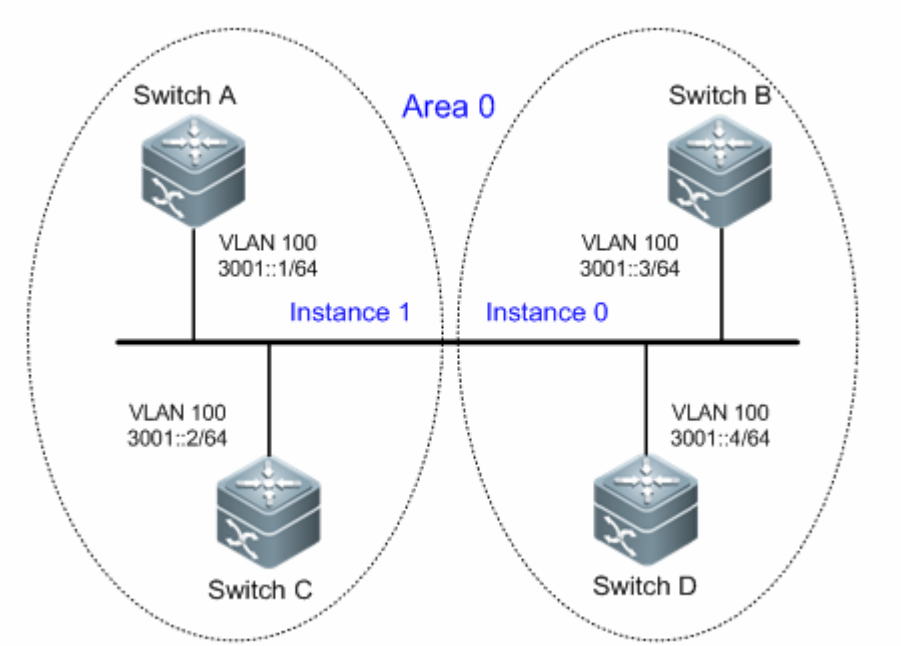


Figure 1-5 Multiple instances on one link

SwitchA, SwitchB, SwitchC and SwitchD are in the same area (Area 0) and are interconnected via vlan 100.

Application Requirements

On a broadcast link, especially within a vlan, adjacencies will be established among all the switches. This may result in increased system overhead and network oscillation.

Application requirements: Switches in the same area are divided into several groups, and OSPFv3 adjacencies can only be established between switches belonging to the same group.

Configuration tips

Key points

By configuring multiple instances on the same link (the link on interface vlan100 in this example), adjacency establishment by group can be implemented (in this example, SwitchA and SwitchB form a group, with instance ID being 1; SwitchC and SwitchD form a group, with instance ID being 0).

Cautions

By default, the instance ID of the interface is 0. In this example, you only need to configure the instance ID on Switch A and Switch B.

Configuration Steps

Configuring SwitchA

Step 1, Create a VLAN and configure the IPv6 address

SwitchA# conf

Enter configuration commands, one per line. End with CNTL/Z.

! Create and configure interface vlan100

```
SwitchA(config)# vlan 100
SwitchA(config-vlan)#interface vlan 100
SwitchA(config-if-VLAN 100)#ipv6 enable
SwitchA(config-if-VLAN 100)#ipv6 address 3001::1/64
SwitchA(config-if-VLAN 100)#exit
```

Step 2, Create an OSPFv3 process and specify the router-id

```
SwitchA(config)#ipv6 router ospf 10
SwitchA(config-router)#router-id 1.1.1.1
SwitchA(config-router)#exit
```

Step 3, Enable the OSPFv3 on interface vlan 100, with the area being Area0 and the instance ID being 1

```
SwitchA(config)#interface vlan 100
SwitchA(config-if-VLAN 100)#ipv6 ospf 10 area 0 instance 1
SwitchA(config-if-VLAN 100)# end
```

Configuring SwitchB

Step 1, Create a VLAN and configure the IPv6 address

SwitchB# conf

Enter configuration commands, one per line. End with CNTL/Z.

! Create and configure interface vlan100

```
SwitchB(config)# vlan 100
SwitchB(config-vlan)#interface vlan 100
SwitchB(config-if-VLAN 100)#ipv6 enable
SwitchB(config-if-VLAN 100)#ipv6 address 3001::2/64
SwitchB(config-if-VLAN 100)#exit
```

Step 2, Create an OSPFv3 process and specify the router-id

```
SwitchB(config)#ipv6 router ospf 10
SwitchB(config-router)#router-id 2.2.2.2
SwitchB(config-router)#exit
```

Step 3, Enable the OSPFv3 on interface vlan 100, with the area being Area0 and the instance ID being 1

```
SwitchB(config)#interface vlan 100
SwitchB(config-if-VLAN 100)#ipv6 ospf 10 area 0 instance 1
SwitchB(config-if-VLAN 100)# end
```

Verifying configuration

Step 1: Verify whether the configuration is correct. Pay attention: whether the instance ID for establishing adjacency between switches is correct.

SwitchA Configuration:

```
vlan 100
!
interface VLAN 100
 no ip proxy-arp
 ipv6 address 3001::1/64
 ipv6 enable
 ipv6 ospf 10 area 0 instance 1
!
ipv6 router ospf 10
 router-id 1.1.1.1
```

SwitchB Configuration:

```
vlan 100
!
interface VLAN 100
 no ip proxy-arp
 ipv6 address 3001::2/64
 ipv6 enable
ipv6 ospf 10 area 0 instance 1
!
ipv6 router ospf 10
 router-id 2.2.2.2
```

SwitchC Configuration:

```
vlan 100
!
interface VLAN 100
 no ip proxy-arp
 ipv6 address 3001::3/64
 ipv6 enable
 ipv6 ospf 10 area 0
!
```

```
ipv6 router ospf 10
 router-id 3.3.3.3
```

SwitchD Configuration:

```
vlan 100
!
interface VLAN 100
 no ip proxy-arp
 ipv6 address 3001::4/64
 ipv6 enable
 ipv6 ospf 10 area 0
!
ipv6 router ospf 10
 router-id 4.4.4.4
```

Step 2: Display the instance ID of the interface link and reconfirm that the switches in the same group have the same instance ID

```
SwitchA#show ipv6 ospf interface vlan 100
VLAN 100 is up, line protocol is up
  Interface ID 4196
  IPv6 Prefixes
    fe80::21a:a9ff:fe15:4cb9/64 (Link-Local Address)
    3001::1/64
  OSPFv3 Process (10), Area 0.0.0.0, Instance ID 1
    Router ID 1.1.1.1, Network Type BROADCAST, Cost: 1
    Transmit Delay is 1 sec, State BDR, Priority 1
    Designated Router (ID) 2.2.2.2
      Interface Address fe80::2d0:f8ff:fe22:88b1
    Backup Designated Router (ID) 1.1.1.1
      Interface Address fe80::21a:a9ff:fe15:4cb9
    Timer interval configured, Hello 10, Dead 40, Wait 40, Retransmit 5
      Hello due in 00:00:08
    Neighbor Count is 1, Adjacent neighbor count is 1
  Hello received 7 sent 8, DD received 3 sent 5
  LS-Req received 1 sent 1, LS-Upd received 5 sent 4
  LS-Ack received 3 sent 3, Discarded 0
```

```
SwitchB#show ipv6 ospf interface vlan 100
VLAN 100 is up, line protocol is up
  Interface ID 4196
  IPv6 Prefixes
    fe80::2d0:f8ff:fe22:88b1/64 (Link-Local Address)
    3001::2/64
  OSPFv3 Process (10), Area 0.0.0.0, Instance ID 1
    Router ID 2.2.2.2, Network Type BROADCAST, Cost: 1
```

```
   Transmit Delay is 1 sec, State DR, Priority 1
   Designated Router (ID) 2.2.2.2
     Interface Address fe80::2d0:f8ff:fe22:88b1
   Backup Designated Router (ID) 1.1.1.1
     Interface Address fe80::21a:a9ff:fe15:4cb9
   Timer interval configured, Hello 10, Dead 40, Wait 40, Retransmit 5
     Hello due in 00:00:05
   Neighbor Count is 1, Adjacent neighbor count is 1
 Hello received 16 sent 21, DD received 10 sent 8
 LS-Req received 2 sent 2, LS-Upd received 10 sent 9
 LS-Ack received 6 sent 6, Discarded 0
```

Step 3: Display OSPFv3 neighbors. Pay attention: whether the adjacencies have been created, and whether the adjacencies are established only between the switches in the same group.

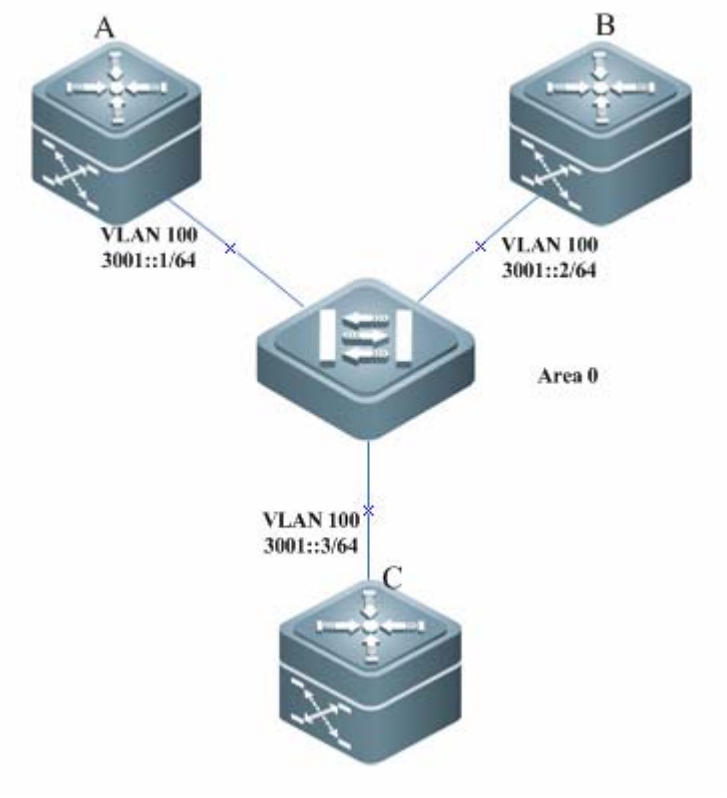
```
SwitchA#show ipv6 ospf neighbor
OSPFv3 Process (10), 1 Neighbors, 1 is Full:
Neighbor ID  Pri State     Dead Time   Instance ID   Interface
2.2.2.2      1   Full/DR   00:00:39     1           VLAN 100
```

```
SwitchB#show ipv6 ospf neighbor
OSPFv3 Process (10), 1 Neighbors, 1 is Full:
Neighbor ID  Pri  State       Dead Time   Instance ID   Interface
1.1.1.1      1   Full/BDR    00:00:34    1            VLAN 100
```

Configuration example of OSPFv3 authenticated encryption

Topological Diagram

Figure 1-6 Encrypted authentication instance



Application Requirements

The OSPFv3 protocol runs on Device A, B and C, which belong to the same area. Connected interfaces establish adjacency only if the same authenticated encryption is configured on them.

The interfaces connecting Device A and B are configured with the same authentication parameters. Device C is not configured with authentication. Device A establishes adjacency with Device B and no adjacency with Device C.

Configuriation Tips

According to the topological requirements, the OSPFv3 protocol is configured to run on Device A, B and C, which belong to the same area

The Interfaces connecting Device A and B are configured with the same authentication parameters.

Configuration Steps

- Configuring Switch A

Step1, Enable the same OSPFv3 basic configuration on Device A, B and C as OSPFv3 basic configuration example.

Step2. Configure authentication parameters on interfaces connecting Device A and B.

```
Ruijie(config)# vlan 100
Ruijie(config-vlan)# exit
Ruijie(config)# interface vlan 100
Ruijie(config-if-vlan 100)# ipv6 address 3001::1/64
Ruijie(config-if-vlan 100)# ipv6 ospf 1 area 0
```

```
Ruijie(config-if-vlan 100)# ipv6 ospf authentication ipsec spi 400 md5
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
Ruijie(config-if-vlan 100)# exit
```

- Configuring Switch B

Step1, Enable the same OSPFv3 basic configuration on Device A, B and C as OSPFv3 basic configuration example.

Step2. Configure authentication parameters on interfaces connecting Device A and B.

```
Ruijie(config)# vlan 100
Ruijie(config-vlan)# exit
Ruijie(config)# interface vlan 100
Ruijie(config-if-vlan 100)# ipv6 address 3001::2/64
Ruijie(config-if-vlan 100)# ipv6 ospf 1 area 0
Ruijie(config-if-vlan 100)# ipv6 ospf authentication ipsec spi 400 md5
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
Ruijie(config-if-vlan 100)# exit
```

- Configuring Switch C

Step1, Enable the same OSPFv3 basic configuration on Device A, B and C as OSPFv3 basic configuration example.

Step2. Configure authentication parameters on interfaces connecting Device A and B.

```
Ruijie(config)# vlan 100
Ruijie(config-vlan)# exit
Ruijie(config)# interface vlan 100
Ruijie(config-if-vlan 100)# ipv6 address 3001::2/64
Ruijie(config-if-vlan 100)# ipv6 ospf 1 area 0
Ruijie(config-if-vlan 100)# ipv6 ospf authentication ipsec spi 400 md5
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
Ruijie(config-if-vlan 100)# exit
```

Verifying Configuration

- Step 1: Run the **show ipv6 ospf neighbor** command on Device A, B and C. It is shown that each two devices establish adjacency.
- Step 2: Neighbors.are shown only on Device A and B. Device C shows no neighbor. Run the **debug ipv6 ospf packet** command. Device A and B can receive packets from each other while Device C cannot receive packets.

```
Ruijie#show ipv6 ospf neighbor
OSPFv3 Process (1), 1 Neighbors, 1 is Full:
Neighbor ID   Pri   State     Dead Time   Instance ID   Interface
2.2.2.2       1     Full/BDR  00:00:37    0           VLAN 100

Ruijie#show ipv6 ospf neighbor
OSPFv3 Process (1), 1 Neighbors, 1 is Full:
Neighbor ID   Pri   State     Dead Time   Instance ID   Interface
1.1.1.1       1     Full/BDR  00:00:37    0           VLAN 100

Ruijie#show ipv6 ospf neighbor
```

```
OSPFv3 Process (1), 0 Neighbors, 0 is Full:
```

Configuring BGP

About BGP

The border gateway protocol (BGP) is an exterior gateway protocol (EGP) used for routers to communicate with one another in different autonomous systems. The protocol is designed to exchange information about network reachability among these autonomous systems (AS) and eliminate loops based on the characteristics of the BGP protocol.

The BGP protocol relies on the TCP protocol for reliable packet transmission.

A router which operates on the BGP protocol is referred to as a “BGP Speaker”, and BGP Speakers that have set up a BGP session are referred to as “BGP Peers”.

There are two modes of BGP session: IBGP (Internal BGP) and EBGP (External BGP). The IBGP refers to a BGP session in an AS, while the EBGP refers to a BGP session between different ASs. To summarize, the EBGP exchanges routing information among different ASs. The IBGP transmits routing information in an AS.

The BGP protocol has the following features:

- Supports BGP-4
- Supports path attributes
  - ✓ ORIGN Attribute
  - ✓ AS_PATH Attribute
  - ✓ NEXT_HOP Attribute
  - ✓ MULTI_EXIT_DISC Attribute
  - ✓ LOCAL-PREFERENCE Attribute
  - ✓ ATOMIC_AGGREGATE Attribute
  - ✓ AGGREGATOR Attribute
  - ✓ COMMUNITY Attribute
  - ✓ ORIGINATOR_ID Attribute
  - ✓ CLUSTER_LIST Attribute
  - ✓ AS4_PATH Attribute
  - ✓ AS4_AGGREGATOR Attribute
  - ✓ Connector Attribute
- Supports BGP peer groups
- Supports loopback interface
- Supports MD5 authentication of TCP
- Supports the synchronization of BGP and IGP
- Supports the aggregation of BGP routes
- Supports BGP route flap dampening
- Supports BGP routing reflector
- Supports AS confederation
- Supports BGP soft reset
- Supports BGP Graceful Restart (defined in RFC4724)

Enabling the BGP Protocol

To enable the BGP protocol, execute the following commands in privileged EXEC mode:

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)# **ip routing**	Enables the routing function (if the switch is disabled).
Ruijie(config)# **router bgp** *as-number*	Enables the BGP and configures the AS number. The range of *AS-number* is 1 to 65535.
Ruijie(config-router)# **bgp router-id** *router-id*	(Optional) Configures the ID used when this switch runs the BGP protocol.
Ruijie(config-router)# **end**	Returns to privileged EXEC mode.
Ruijie# **show run**	Shows current configuration.
Ruijie# copy running-config startup-config	Saves the configuration.

Use the **no router bgp** command to disable the BGP protocol**.**

Default BGP Configuration

The BGP protocol is not enabled by default.

After the BGP protocol is enabled, the default BGP configuration is shown as follows:

Feature		Default Setting
Router ID		To configure a loopback interface, select the maximum address from loopback interface addresses. Otherwise, select the maximum interface address from the directly connected interface.
Synchronization of BGP and IGP		Enabled
Generation of Default Route		Disabled
Multi hops of EBGP	Status	Off
	Number of hops	255
TCP MD5 Authentication		Disabled
Timer	Keepalive Time	60 seconds
	Holdtime	180 seconds
	ConnectRetry Time	120 seconds
	AdvInterval(IBGP)	15 seconds
	AdvInterval(EBGP)	30 seconds
Path Attribute	MED	0
	LOCAL_PREF	100
Route Aggregate		Off
Route Flap Dampening	Status	Off
	Suppress Limit	2000
	Half-life-time	15 minutes
	Reuse Limit	750

Feature		Default Setting
	Max-suppress-time	4*half-life-time
Route Reflector	Status	Off
	Cluster ID	Undefined
	Route among reflection clients	Enabled
AS Confederation		Off
Soft Reset		Off
Traceful Restart		Disabled
Management Distance	External-distance	20
	Internal-distance	200
	Local-distance	200

Injecting Routing information into the BGP Protocol

The BGP protocol has no routing information when running for the first time. There are two ways to inject routing information to the BGP:

Manually inject routing information to the BGP by using the **network** commands.

Inject routing information to the BGP from the IGP protocol through interaction with the IGP protocol.

The BGP will advertise the injected routing information to its neighbors. This section outlines the manual injection of routing information. For injecting routing information from the IGP protocol, refer to the *Configuration of BGP and IGP Interaction* in related sections.

To manually inject network information advertised by the BGP Speaker to other BGP Speaker, execute the following commands in BGP configuration mode:

Command	Function
Router(config-router)# **network** *network-number* **mask** *network-mask*[**route-map** *map-tag*]	Configures the network whose routing information will be injected into the BGP routing table.

Use the **no network** *network-number* **mask** *network-mask* command to remove the configuration. To cancel the used route-map, reconfigure it by using the r*oute-map not added* option. If the configured network information comes under standard class A, class B or class C network address, the mask option of this command cannot be used.

In BGP4+, you can use this command in IPv6 address family configuration mode to configure IPv6 routes.

Caution

■ The **network** command is used to inject IGP routes into the routing table of BGP, and the advertised networks can be direct-connected, static and dynamic routes.

■ For the external gateway protocol (EGP), the **network** command indicates the network to be advertised. This is different from the internal gateway protocol (IGP, such as OSPF and RIP). The IGP uses the **network** commands to determine where the routing update message will be sent to.

Sometimes, you may need to use an IGP route rather than an EBGP route. This can be done by using the **network backdoor** command. Execute the following operations in BGP configuration mode:

Command	Function
Ruijie(config-router)# **network** *network-number* **mask** *network-mask* **backdoor**	Sets the backdoor route.

Use the **no network** *network-number* **mask** *network-mask* **backdoor** command to remove the configuration.

Caution

By default, the distance for network information management learned from the BGP Speakers which have established the EBGP connection is 20. Set the distance by using the **network backdoor** command as 200. As such, identical network information learned from the IGP presents a higher priority. The networks learned from the IGP are considered as backdoor networks, and will not be advertised.

Controlling Route Advertisement

The BGP protocol can control the routes advertised to the core routing table by using the **table-map** command. If a route is matched, the command modifies its attribute and advertises it. If a route is not matched or denied, the command advertises it without modifying its attribute.

By default, the **table-map** command advertises all routes without modifying their attributes.

To configure the **table-map** command, execute it in BGP configuration mode or IPv4 address family confiugration mode:

Command	Function
Router(config-router)# **table-map** *route-map-name*	Configures table-map. route-map-name indicates the name of the route-map you want to associate.

Use the **no table-map** command to remove the configuration.

For the configuration of the **table-map** command to take effect immediately, run the **clear ip bgp** [vrf *vrf-name*] **table-map** command to update the core routing table. The **clear ip bgp** [vrf *vrf-name*] **table-map** command will clear but add the routes in the core routing table. Instead, it uses the table-map to advertise route update messages without causing forwarding oscillation..

The **table-map** command supports the following options: rules-match, as-path/community/ip address/ip next-hop/metric/origin/route-type, set, metric/tag/next-hop.

Controlling the route redistribution from IBGP to IGP

The BGP protocol controls the redistribution of routes learnded from the IBGP protocol to IGP protocol by using the **bgp redistribute-internal** command. The routes learned from the EBGP protocol or confederation can be redistriubted to the IGP protocol.

This command is enabled by default in either VRF or global mode. Specifically, routers learned from the IBGP can be redistributed to the IGP protocol.

To redistribute a route to the IGP protocol (inclding RIP/OSPF/ISIS), execute the following command in BGP configuration mode, IPv4/IPv6 address family configuration mode or IPv4 VRF address family configuraiton mode:

Command	Function
Router(config-router)# **bgp-redistirbute-internal**	Redistributes IBGP routes to the IGP protocol.

Use the **no bgp redistribute-internal** command to remove the configuration.

Configuring BGP Peer (Group) and Its Parameters

Since the BGP is an external gateway protocol (EGP), it is necessary for a BGP Speaker to know who its peer (BGP Peer) is.

As mentioned in the overview of the BGP protocol, two modes can be used to set up the connection among BGP Speakers: IBGP (Internal BGP) and EBGP (External BGP). The protocol determines which connection will be established among BGP Speakers by using the AS of BGP Peer and BGP Speakers.

The BGP protocol supports IPv4 and IPv6. To check IPv6 function, verify whether the **address-family ipv6** command is executed in BGP configuration mode. Otherwise, IPv6 is not supported. An IPv4 address represents an IPv4 neighbor. An IPv6 address represents an IPv6 neighbor. Note that you should activate neighbors in the right address family.

In general, BGP Speakers with EBGP connection should be physically connected. BGP Speakers with IBGP connection, however, can be located anywhere within an AS.

To configure the BGP peer, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name* } **remote-as** *as-number*	Configures the BGP peer. *address* indicates the IP addresses of the BGP peer. *peer-group-name* indicates the name of the BGP peer group.

Command	Function
	The range of *as-number* is 1 to 65535.

Use the **no neighbor** {*address*|*peer-group-name*} to delete one peer or peer group.

The BGP Speakers have some configurations in common (including the executed routing policy). To simplify configuration and improve efficiency, it is recommended that you use the BGP peer group.

To configure the BGP peer group, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **neighbor** *peer-group-name* **peer-group**	Creates a BGP peer group.
Ruijie(config-router)# **neighbor** *peer-group-name* **remote-as** *as-number*	(Optional) Configures the BGP peer group. The range of *as-number* is 1 to 4294967295.
Ruijie(config-router)# **neighbor** *address* **peer-group** *peer-group-name*	(Optional) Sets the BGP peer as the member of the BGP peer group.

Use the **no neighbor** *address* **peer-group** to delete some members of the BGP peer group.

Use the **no neighbor** *peer-group-name* **peer-group** to delete the entire peer group.

Use the **no neighbor** *peer-group-name* **remote-as** to delete all members of the BGP peer group and AS numbers of the peer group.

To configure the peer of the BGP Speakers or the optional parameter of the BGP peer group, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router-af)# **neighbor** {*address* | *peer-group-name*} **activate**	(Optional) Activates the address family of the neighbor so that the router can exchange routing information with the address family.
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **update-source** *interface*	(Optional) Configures the network interfaces to establish the BGP session with specified BGP peer (group).
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **ebgp-multihop** [*ttl*]	(Optional) Allows you to establish a BGP session among non-direct-connected EBGP peers (group). The range of TTL is 1 to 255, the EBGP is one hop by default, and the IBGP is 255 hops by default.
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **password** *string*	(Optional) Enables the TCP MD5 authentication when the connection is established among specified BGP peer (group), and configures the password.
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **times** *keepalive holdtime*	(Optional) Configures the Keepalive and Holdtime value to establish a connection with the specified BGP peer (group). The range of the *keepalive* is 0 to 65535 seconds, 60 seconds by default. The range of the *holdtime* is 0 to 65535 seconds, 180 seconds by default.
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **advertisemet-interval** *seconds*	(Optional) Configures the minimal time interval of sending the routing update message to the specified BGP peer (group). The range of advertisement-interval is 1 to 600 seconds, 15

Command	Function
	seconds for the IBGP peer by default, and 30 seconds for the EBGP peer by default.
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **default-originate** [**route-map** *map-tag*]	(Optional) Configures the router to send a default route to the specified BGP peer (group).
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **next-hop-self**	(Optional) Configures the router to set the next routing information as this BGP speaker when the route is distributed to the specified BGP peer (group).
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **remove-private-as**	(Optional) Configures the router to delete the private AS number in the AS path attribute when distributing the routing information to the EBGP peer (group).
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **send-community**	(Optional) Configures the router to send the community attribute to the specified BGP peer (group).
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **maximum-prefix** *maximum* [**warning-only**]	(Optional) Limits the number of the messages received from the specified BGP peer (group).
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **distribute-list** *access-list-name* {**in** | **out**}	(Optional) Configures the router to implement the routing police according to the access control list when routing information is received from and sent to the specified BGP peer (group).
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **prefix-list** *prefix-list-name* {**in** | **out**}	(Optional) Configures the router to implement the routing policy according to the prefix list when the routing information is received from and sent to specified BGP peer (group).
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **route-map** *map-tag* {**in** | **out**}	(Optional) Configures the router to implement the routing policy according to the route-map when the routing information is received from and sent to the specified BGP peer (group).
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **filter-list** *path-list-name* {**in** | **out**}	(Optional) Configures the router to implement the routing policy according to the AS path list when the routing information is received from and sent to the specified BGP peer (group).
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **unsuppress-map** *map-tag*	(Optional) Configures the router to selectively advertise the routing information suppressed by the **aggregate-address** command previously when it is distributed to the specified BGP peer.
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **soft-reconfiguration** inbound	(Optional) Restarts the BGP session and reserve the unchanged routing information sent by the BGP peer (group).
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **route-reflector-client**	(Optional) Configures this switch as the route reflector and specify its client.
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **shutdown**	(Optional) Disables the BGP peer (group).

Use the **no** form of the above commands to disable the configurations.

If a peer does not support **remote-as**, each of its members can use the **neighbor remote-as** command to configure it independently.

By default, each member of the BGP peer group will inherit all its configurations. However, each member can support the optional configurations without affecting the output update independently to replace the unified configuration of the BGP peer group.


Caution

Each member of the BGP peer group can support the optional configurations without affecting the output update independently to replace the unified configuration of the BGP peer group. That is to say, each member of the BGP peer group will inherit the following configurations: **remote-as**, **update-source**, **local-as**, **reconnect-interval**, **times**, **advertisemet-interval**, **default-originate**, **next-hop-self**, **password remove-private-as**, **send-community**, **distribute-list out**, **filter-list out**, **prefix-list out**, **route-map out**, **unspress-map**, **route-reflector-client.**

The **neighbor update-source** command can be used to select any valid interface for establishing a TCP connection. This command is designed mostly to provide available Loopback interfaces, which increase the stability of the connection to the IBGP Speaker.

By default, direct physical connection with BGP peers is required for establishing an EBGP connection. To establish the EBGP peers among non-direct-connected external BGP Speakers, the **neighbor ebgp-multihop** command can be used.


Caution

To avoid route loop and oscillation, the EBGP peers who need multiple hops for BGP connection must have non-default routes to each other.

For the sake of security, you can set the authentication for the BGP peers (group) which will establish the connection based on the MD5 algorithm. The authentication password for the BGP peer should be identical. The process of enabling the MD5 authentication on a BGP peer is shown as follows:

Command	Function
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **password** *string*	Enables the TCP MD5 authentication and set the password when the BGP connection with the BGP peer is established.

Use the **no neighbor** {*address* | *peer-group-name*} **password** command to disable the BGP peer (group) from MD5 authentication.

Use the **neighbor shutdown** command to disable the valid connection established with the BGP peer (group), and delete all routing information related to the BGP peer (group).


Caution

To break the connection established with the specified BGP peer (group) and reserve the configuration information set for this specified BGP peer (group), use the **neighbor shutdown** command. If such configuration information is no longer required, use the **no neighbor** [**peer-group**] command.

Configuring the Management Policy

Whenever the routing policy (including the **neighbor distribute-list**, **neighbor route-map**, **neighbor prefix-list and neighbor filter-list)** changes, you need implement the new routing policy. The traditional way is to break and re-establish the BGP session.

This product supports implementing a new routing policy without ending the BGP session by using soft reset for BGP effectively.

To facilitate the description of BGP soft reset, the following section will refer to the routing policy that affects the input routing information as the input routing policy (such as the **In-route-map** and **In-dist-list**) and the policy that affects the output routing information as the output routing policy (such as the **Out-route-map** and **Out-dist-list**).

If the output routing policy changes, execute the following commands in BGP configuration mode:

Command	Function
Ruijie# **clear ip bgp** {* | peer *address* | **peer-group** *peer-group-name* | **external**} **soft out**	Soft-resets the BGP session and executes the routing policy without resetting the BGP session.

A change in input routing policy changes complicates operations compared with the output routing policy, because the output routing policy is based on the routing table of this BGP Speaker. The implementation of the input routing policy is based on the routing information received from a BGP peer. To reduce memory consumption, the local BGP Speaker will not retain the original routing information received from BGP peers.

To modify the input routing policy if necessary, save the original routing information for each specified BGP peer in this BGP Speaker by using the **neighbor soft-reconfiguration inbound** command. The aim is to provide the original foundation of routing information to modify the input routing policy.

At present, the standard implementation method is referred to as the “Route Refresh Performance”, which can support modifying the routing policy without storing the original routing information. This product supports the feature.

If the input routing policy changes, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **soft-reconfiguration inbound**	Restarts the BGP session and reserve the unchanged routing information from the BGP peer (group). This command may consume more memory. If both parties support route refreshing performance, this command becomes unnecessary.
Ruijie# clear **ip bgp** {* | *peer-address* | **peer-group** *peer-group-name* | **external**} **soft in**	Soft-resets the BGP session and executes the routing policy without resetting the BGP session.

You can determine whether the BGP peer supports route refreshing performance by the **show ip bgp neighbors** command. If so, you need to execute the **neighbor soft-reconfiguration inbound** command when the input routing policy changes.

Configuring Synchronization between BGP and IGP

The routing information can be transmitted to another AS through the local AS only when it passes through this AS and reaches another AS. The routing information will be advertised to all the routers in the local AS. Otherwise, if some routers running the IGP protocol within this AS have not learned this routing information, data packets may be discarded, because these routers do not know this route when these packets traverses this AS, which may cause a route black hole.

The BGP-IGP synchronization is designed to ensure all routers within this AS can learn the outgoing routing information. Simply, the BGP Speakers redistribute all of the routes learned by the BGP protocol to the IGP protocol to ensure that the routers within the AS learn such routing information.

The BGP-IGP synchronization mechanism can be cancelled in two situations:

10) There is no routing information passing through the local AS (In general, this AS is an end AS).

11) All routers within this AS run the BGP protocol and a full connection is established among all BGP Speakers (An adjacent relationship is established between any two BGP Speakers).

Caution By default, synchronization is disabled. Enable synchronization when not all the routers are running BGP when traversing an AS.

To enable synchronization of BGP speakers, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **synchronization**	Enables synchronization of BGP and IGP.

Execute the **no synchronization** command to disable the synchronization mechanism.

Configuring Interaction between BGP and IGP

To inject the routing information generated by the IGP protocol into the BGP protocol, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **redistribute** [**connected** | **rip** | **static**] [**route-map** *map-tag*] [**metric** *metric-value*]	(Optional) Redistributes static route, direct route and the routing information generated by RIP.
Ruijie(config-router)# **redistribute ospf** *process-id* [**route-map** *map-tag*] [metric *metric-value*] [**match internal external** [**1** | **2**] **nssa-external** [**1** |**2**]]	(Optional) Redistributes the routing information generated by OSPF.
Ruijie(config-router)# **redistribute isis** [*isis-tag*] [**route-map** *map-tag*] [**metric** *metric-value*] [**level-1**| **level-1-2**| **level-2**]	(Optional) Redistributes the routing information generated by ISIS.

By default, distribution of a default route is disabled. To enable this function, execute the following command:

Command	Function
Ruijie(config-router)# **default-information originate**	Redistributes the default route.

Configuring BGP Timer

The BGP uses the Kepalive timer to maintain an effective connection with the peers, and takes the Hldtime timer to determine whether the peers are valid. By default, the value of the Kepalive timer is 60s, and the value of the Holdtime timer is 180s. When a BGP session is established between BGP Speakers, both parties will negotiate with the Holdtime timer and the one with a smaller value will be selected. The selection of the Keepalive timer is based on the smaller one between 1/3 of the negotiated Holdtime timer and the configured Keepalive timer.

To adjust the value of the BGP timer based on all peers, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **timers bgp** *keepalive holdtime*	Adjusts the keepalive and holdtime values of BGP based on all peers. The range of the *keepalive* is 0 to 65535 seconds, and 60 seconds by default. The range of the *holdtime* is 0 to 65535 seconds, 180 seconds by default.

Certainly, you can adjust the value of the BGP timer based on the specified peers, and execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **times** *keepalive holdtime*	Configures the Keepalive and Holdtime value to establish a session with the specified BGP peer (group). The range of the keepalive is 0 to 65535 seconds, 60 seconds by default. The range of the holdtime is 0 to 65535 seconds, 180 seconds by default.

Use the **no** form of the right command to clear the value of configured timer.

Configuring BGP Path Attributes

AS_PATH Attribute

The BGP protocol controls the distribution of routing information in the following ways:

- IP address by using the **neighbor distribute-list** and **neighbor prefix-list** commands
- AS_PATH Attribute (refer to this section)
- COMMUNITY Attribute (refer to the COMMUNITY Attribute configuration)

You can use the AS path-based access control list to control the distribution of the routing information, where the AS path-based ACL will use Regular Expression to resolve the AS path.

To configure the AS path-based distribution of routing information, execute the following commands in privileged EXEC mode:

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **ip as-path access-list** *path-list-name* {**permit** | **deny**} *as-regular-expression*	(Optional) Defines an AS path list.
Ruijie(config)# **ip routing**	Enables the routing function (if disabled)

Command	Function
Ruijie(config)# **router bgp** *as-number*	Enables the BGP and configures this AS number to enter BGP configuration mode.
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **filter-list** *path-list-name* {**in** | **out**}	(Optional) Implements the routing policy according to the AS path list when the routing information is received from and sent to the specified BGP peer (group).
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **route-map** *map-tag* {**in** | **out**}	(Optional) Implements the routing policy according to the route-map when the routing information is received from and sent to the specified BGP peer (group). In route-map configuration mode, you can use the match as-path to operate the AS path attribute based on the AS path list, or take the set as-path to operate the AS attribute value.

The BGP protocol will not consider the length of the AS path when selecting the optimal path as specified in RFC1771. In general, the shorter the AS path, the higher its priority. Hence, we take the length of the AS path as the optimal path. You can determine whether to consider the length of the AS path when selecting the optimal path according to actual condition.

If you wish to ignore the length of the AS path when selecting the optimal path, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **bgp bestpath as-path ignore**	Compares the length of the AS path when selecting the optimal path.

Caution Within the AS, all BGP Speakers consider the length of the AS path as consistent when selecting the optimal path. Otherwise, the optimal path information selected by different BGP Speakers will be different.

NEXT_HOP Attribute

To set the next hop as the local BGP Speaker for sending the routing information to the specified BGP peer, you can use the **neighbor next-hop-self** command, which is mainly used in non-mesh networks, such as frame relay and X.25. Execute the follwing commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **next-hop-self**	Sets the next hop as the local BGP speaker for distributing the routing information to the specified BGP peer (group).

You can also modify the next hop of the specified path by using the **set next-hop** command of Route-map.

Caution This command is not recommended for a fully meshed network such as Ethernet, because it may cause additional hops and incur unnecessary overhead.

MULTI_EXIT_DISC Attribute Configuration

The BGP takes the MED value as the foundation for priority comparision of the paths learned from the EBGP Peers. The smaller the MED value, the higher the path priority.

By default, the protocol only compares it with the MED value for the path of the peers from the same AS when the optimal path is selected. If you hope to compare it with the MED value for the path of the peers from different ASs, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **bgp always-compare-med**	Compares with the MED value for the path of different ASs.

By default, it will not compare with the MED value for the path of the peers for other ASs within the AS when the optimal path is selected. If you hope to compare with the MED value for the path of the peers from different AS confederations, execute the following commands in the BGP configuration mode.

Command	Function
Ruijie(config-router)# **bgp bestpath med confed**	Compares with the MED value for the path of the peers from other ASs within the confederation.

By default, if a path with an undefined MED attribute is received, the MED value of this path will be taken as 0. The smaller the MED value, the higher the path priority. The MED value of this path reaches the highest priority. If you want the MED attribute for the path with undefined MED attribute to present the lowest priority, execute the following command in BGP configuration mode:

Command	Function
Ruijie(config-router)# **bgp bestpath med missing-as-worst**	Sets the priority of the path whose MED attribute is not set as the lowest.

By default, they are compared with each other in the sequence the paths are received when the optimal path is selected. If you want to first compare with the path of the peers from the same AS, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **bgp deterministic-med**	Compares first with the path of the peers from the same AS. By default, they will be compared with by the receiving sequence. The later received path will be compared with first.

LOCAL_PREF Attribute Configuration

The BGP takes the LOCAL_PREF as the foundation for priority comparision of the path learned from the IBGP peers. The larger the LOCAL_PREF value, the higher the path priority.

The BGP Speakers will add the local preference when they send the received external routes to the IBGP peers. To modify the local preference, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **bgp default local-preference** *value*	Changes the default local preference. The range of the value is 0 to 4294967295, 100 by default.

You can also modify the local preference of the specified path by using the **set local-preference** command of Route-map.

COMMUNITY Attribute Configuration

COMMUNITY Attribute provides another way to control the distribution of the routing information.

The community is a set of destinations. The purpose is to implement the community-based routing policy so as to simplify the configuration for the distribution of the routing information in the BGP Speakers.

Each destination may have more than one community, and the manager of the AS can define the community destination.

By default, all destinations belong to the Internet community carried in the community attribute of the path.

At present, totally four common community attributes are predefined:

- **Internet**: Indicates the Internet community, and all paths are in this community.
- **no-export**: Indicates this path will not be exported to BGP peers.
- **no-advertise**: Indicates this path will not be advertised to BGP peers.
- **local-as**: Indicates this path will be advertised only in the local AS or the AS confederation if it is configured.

You can control the receiving, priority and distribution of the routing information by using the community attribute.

The BGP supports up to 32 COMMUNITY attributes for every route. When configuring the **route-map** command, you can set up to 32 COMMUNITY attributes for the parameters **match** and **set COMMUNITY.**

The BGP Speakers can set, add or modify the community attribute value when they learn, issue or redistribute a route. The aggregated path includes the community attribute of all aggregated paths when route aggregation is carried out.

To configure the community attribute-based distribution of routing information, execute the following commands in privileged EXEC mode:

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.

Command	Function
Ruijie(config)# **ip community-list standard** *community-list-name* {p**ermit** | **deny**} *community-number*	(Optional) Creates the community list. The *community-list-name* is the name of the community list. The community-number is the concrete value of the community list in the range 1 to 4,294,967,295, or the well-known community attribute such as Internet, local-AS, no-advertise and no-export.
Ruijie(config)# **ip routing**	Enables the routing function (if disabled).
Ruijie(config)# **router bgp** *as-number*	Enables the BGP and configure this AS number to enter into BGP configuration mode.
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **send-community**	(Optional) Configures the router to send the community attribute to the specified BGP peer (group).
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **route-map** *map-tag* {**in** | **out**}	(Optional) Configures the router to implement the routing policy according to the route-map when the routing information is received from and sent to the specified BGP peer (group). In the route-map configuration mode, you can use the match community-list [exact] and set community-list delete to operate the community attribute by the community list, or use the set community command to operate the community attribute value directly.

Other Related Configuration

By default, if two paths with identical path attributes are received from different EBGP peers during the selection of the optimal path, we will select the optimal path based on the path receiving sequence. You can select the path with a smaller router ID as the optimal path by using the following commands.

Command	Function
Ruijie(config-router)# **bgp bestpath compare-routerid**	Allows the BGP to compare with the router ID when the optimal path is selected.

Selecting the Optimal Path for BGP

Optimal route selection forms an important part of the BGP protocol. The following section describes the selection process of the BGP route protocol in detail:

- An invalid routing table entry is not allowed in the selection of optimal routes.

Caution Invalid entries include those unreachable for the next hop and those in oscillation.

- Select the route with the high LOCAL_PREF attribute value.
- Select the route generated by the local BGP speaker.

The route generated by the local BGP speaker includes the one generated by the **network, redistribute, aggregate** command.

- Select the route with the shortest AS length.
- Select the route with the lowest ORIGIN attribute.
- Select the route with the smallest MED value.
- The EBGP path has a higher priority than the IBGP path and the AS confederation, and the priority is identical for the IBGP path and the AS confederation.
- Select the route with the smallest IGP metric to reach the next hop.
- Select the route received earlier from the EBGP routes.
- Select the route which advertises that the router ID of the BGP speaker is small.
- Select the route with the greater cluster length.
- Select the route: the value of neighbor address for which is high.


Caution

Discussed above is the process of select the optimum route under the default configuration. You can change the selection process of the route by the CLI command. For instance, you can use the **bgp bestpath as-path ignore** command to make step 4 part of the process of invalidating the optimal route. Use the bgp bestpath compare-routerid command to invalidate Step 9 of the selection.

Configuring BGP Route Aggregation

Since the BGP-4 supports CIDR, aggregated entries can be created to downsize the BGP routing table. Certainly, BGP aggregated entries can be added to the BGP routing table only when there is a valid path within the aggregation scope.

To configure the BGP route aggregation, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **aggregate-address** *address mask*	(Optional) Configures the aggregated address.
Ruijie(config-router)# **aggregate-address** *address mask* **as-set**	(Optional) Configures the aggregated address, and remain the AS path information of the path within the scope of the aggregated address.
Ruijie(config-router)# **aggregate-address** *address mask* **summary-only**	(Optional) Configures the aggregated address and only advertise the aggregated path.
Ruijie(config-router)# **aggregate-address** *address mask* **as-set summary-only**	(Optional) Configures the aggregated address, and remain the AS path information of the path within the scope of the aggregated address. At the same time, only the aggregated path is advertised.

Use the **no** form of the above commands to disable the configuration.


Caution

By default, the BGP will advertise all routing information both before and after aggregation. If you want to advertise only the aggregated path information, use the **aggregate-address summary-only** command.

Configuring Route Reflector for BGP

To speed up the convergence of routing information, all BGP Speakers within one AS will usually establish the full connection (The adjacent relationship is established between any two BGP Speakers). Too many BGP Speakers within the AS may increase the resource overhead of the BGP Speakers, raise the configuration workload and complexity of network administrators, and reduce the network scalability.

Therefore, route reflector and AS confederation are preferrably used to reduce the connections of the IBGP peers within an AS.

The route reflector provides a way to reduce the connections of the IBGP peer within the AS. One BGP Speaker is set as the route reflector, which divides the IBGP peer within this AS into two types, such as client and non-client.

The rule to implement the route reflector within the AS is shown as follows:

- Configure the route reflector and specify its client, so the route reflector and other clients form a cluster. The route reflector establishes the connection with clients.
- The clients of the route reflector within one cluster should not establish the connection with other BGP Speakers of other clusters.
- Within an AS, a full connection is established among the IBGP peer of non-clients. The IBGP peer of non-clients involves the following scenarios: among several route reflectors within one cluster, among the route reflector within the cluster and the BGP Speakers not involved in the route reflector function out of the cluster (In general, the BGP Speakers don't support the route reflector function), among the route reflector within the cluster and the route reflector of other cluster.

The following rules applies when the route reflector receives one route:

- The route update received from the EBGP Speaker will be sent to all clients and non-clients.
- The route update received from the clients will be sent to other clients and all non-clients.
- The route update received from the IBGP non-clients will be sent to all its clients.

To configure the BGP route reflector, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **route-reflector-client**	Configures this product as the route reflector and specifies its clients.

In general, one group is only configured with one reflector. In this case, the Router ID of the route reflector can be used to identify this cluster. To increase the redundancy, you can set more than one route reflector within this cluster. You must configure the cluster ID, so that one route reflector can identify the route update from other route reflectors of this cluster.

Caution To set several route reflectors for one cluster, you need to configure a cluster ID for this cluster.

To configure the cluster ID of the BGP, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **bgp cluster-id** *cluster-id*	Configures the cluster ID of the route reflector.

In general, it is not necessary to establish a connection between the clients of the route reflector within the cluster, as the route reflector will reflect the routes among clients. However, this function can be disabled if a full connection is established among all clients.

To disable the function of reflecting the client routes, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **no bgp client-to-client reflection**	Disables route reflection on clients.

Configuring Route Flap Dampening for BGP

Route flap means that a route changes between the valid status and the invalid status. The route flap usually causes instable routes to be transmitted on the Internet, thus resulting an unstable network. BGP route flap dampening provides a way to reduce route flap by monitoring the routing information of EBGP peers.

The route flap dampening of BGP uses the following terminologies:

- Route Flap: A route changes between the valid status and the invalid status.
- Penalty: The route flap dampening-enabled BGP Speakers will add a penalty for the route each time when a route flaps. The penalty will be accumulated to exceed the suppress limit.
- Suppress Limit: When the penalty of a route exceeds this value, the route will be suppressed.
- Half-life-time: The time elapsed when the penalty is reduced to half of its value.
- Reuse Limit: When the penalty of the route is lower than this value, route suppression is released.
- Max-suppress-time: The maximum amount of time the route can be suppressed.

Overview of route flap dampening: The BGP Speakers will add a penalty for the route each time when a route flaps. The penalty is accumulated. Once the penalty value reaches the suppress limit, the route will be suppressed. When the half-life-time is reached, the penalty value is reduced to half of its value. Once the penalty value is reduced to the reuse limit, the route will be activated again. A route can be suppressed for the maximum suppress time.

To configure the route flap dampening of the BGP, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **bgp dampening**	Enables the route flap dampening of the BGP protocol.
Ruijie(config-router)# **bgp dampening** *half-life-time reuse suppress max-suppress-time*	(Optional) Configures the parameters of the route flap dampening. half-life-time: in the range of 1 to 45minutes, 15minutes by default. reuse: in the range of 1 to 20000, 750 by default. suppress: in the range of 1 to 20000, 2000 by default. max-suppress-time: in the range of 1 to 255 minutes, 4*half-life-time by default.

To monitor the route flap dampening information if necessary, execute the following commands in privileged EXEC mode:

Command	Function
Ruijie# **show ip bgp dampening flap-statistics**	(Optional) Shows the flap statistics information of all routers.
Ruijie# **show ip bgp dampening dampened-paths**	(Optional) Shows the dampened statistics.

To clear the route flap dampening information or the dampened routes, execute the following commands in BGP configuration mode:

Command	Function
Ruijie# **clear ip bgp flap-statistics**	(Optional) Clears flap statistics about all un-dampened route.
Ruijie# **clear ip bgp flap-statistics** address mask	(Optional) Clears flap statistics about the specified route (excluding the dampened routes).
Ruijie# **clear ip bgp dampening** [*address mask*]	(Optional) Clears flap statistics about all routes, and releases the suppressed routes.

Configuring AS Confederation for BGP

Confederation provides a way to reduce the connections of the IBGP peer within the AS.

One AS is divided into multiple sub ASs that can form a confederation by setting a unified confederation ID (namely, confederation AS number). An external confederation is still considered an AS and only the AS number of the confederation is visible. Within the confederation, the full IBGP peer connection is still established among the BGP Speakers, and the EBGP connection is established among the BGP Speakers within the sub AS. Although the EBGP connection is established among BGP Speakers within the sub ASs, the path attribute information of NEXT_HOP, MED and LOCAL_PREF remains intact when the information is exchanged.

To implement the AS confederation, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **bgp confederation identifier** *as-number*	Configures the AS confederation number. The range of *as-number* is 1 to 4294967295.
Ruijie(config-router)# **bgp confederation peers** *as-numbe* [as-number..]	Configures other sub AS numbers within the AS confederation. The range of *as-number* is 1 to 4294967295.

Use the **no** form of the above commands to disable the configuration.

Configuring BGP Management Distance

The management distance indicates the reliability of the routing information resource, within the range of 1 to 255. The larger the value of the management distance, the lower the reliability is.

The BGP sets different management distances for different information sources that have been learned, such as External-distance, Internal-distance and Local-distance.

- **External-distance:** The management distance of the route learned from the EBGP peers.
- **Internal-distance:** The management distance of the route learned from the IBGP peers.
- **Local-distance:** The management distance of the route learned from the peers. However, the optimal one can be learned from the IGP. In general, these routes are indicated by the **Network Backdoor** command.

To modify the management distance of the BGP protocol, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **distance bgp** *external-distance internal-distance local-distance*	Configures the management distance. The range of the distance is 1 to 255. For the default configuration: *external-distance 20* *internal-distance 200* *local-distance 200*

Use the **no** form to restore the default management distance of the BGP protocol.


Caution

It is not recommended that you change the management distance of the BGP route. If the change is necessary, please make sure:

- The External-distance is lower than the management distance of other IGP route protocol (OSPF and RIP).
- The Internal-distance and Local-distance is higher than the management distance of other IGP route protocol.

Configuring BGP Route Update Mechanism

The BGP route update mechanism comprises two parts: timing scanning update and event trigger update. The former means that the timer is used in the BGP to start the scanning mechanism periodically to update the routing table. The latter means that when BGP configuration or the next hop of BGP route changes, the BGP protocol starts the scanning mechanism to update the routing table.

To configure the BGP route update mechanism, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **bgp scan-rib disable**	Enables the event trigger mechanism. By default, the timing scanning update mechanism is used.
Ruijie(config-router)# **bgp scan-time** *scan-time*	(Optional) Sets the scanning interval. *scan-time*: In the range of 5 to 60 seconds, 60 seconds by default

You can also configure this command in IPv4/IPv6/VPNv4/IPv4 vrf address family mode.

Use the **no** form to remove the configuration.


Caution

When you run the **bgp scan-rib disable** command to enable the event trigger mechanism, the synchronization should be disabled and the BGP next hop trigger mechanism should be enabled. When synchronization is enabled or the BGP next hop trigger mechanism is disabled, the BGP updates the routing table in timing scanning mode.

Configuring BGP Nexthop Trigger Update Mechanism

The BGP next hop trigger update mechansim improves the converge of BGP routes. It monitors the next hop of BGP routes to speed up converge in stable network topology.

By default, the BGP next hop trigger update mechansim is enabled. After establishing connections with neighbors, the BGP will automatically monitor the next hops of the routes learned from neighbors. When the next hop changes, the BGP will receive a notification of updating the routing tble. This can reduce the time to check the change of next hop for better converge of BGP routes.

If the function is disabled, scan-timer will periodically scan updates to the next hope of BGP.

To configure the BGP next hop trigger update mechanism, execute the following commands in BGP configuration mode:

Command	Function
Ruijie(config-router)# **bgp nexthop trigger enable**	Enables the function of triggering the next BGP route. This function is enabled by default.
Ruijie(config-router)# **bgp nexthop trigger delay** ***delay****-time*	(Optional) Sets the delay of the BGP next hop trigger update. *delay-time*: In the range of 0 to 100 seconds, 5 seconds by default

You can also configure this command in IPv4/IPv6/VPNv4/IPv4 vrf address family mode.

Use the **bgp nexthop trigger enable** command to restore the setting to the default value.

The **bgp nexthop trigger enable** command and the bgp scan-time command control the same timer. When the timing scanning mechanism is enabled (bgp scan is enabled by default. The **bgp scan-rib disable** command is used to disable **bgp scan**), the time of larger than 60 seconds set by the **bgp nexthop trigger enable** command does not take effect because the timing scanning mechanism is always activated before the delay time.

Caution In an unstable network (the next hop changes frequently), especially when there are a large number of routes, this function carries out unnecessary route calculation and consumes more CPU resources. In this case, it is recommended that you disable the BGP next hop trigger update mechanism.

Configuring BGP GR

GR (Graceful Restart) can ensure continuous data forwarding during the resetting of the BGP protocol. Currently, Ruijie supports GR during active and standby switching on its high-end devices to ensure service continuity.

Working Mechanism of GR

12) Standard

RFC4724: Graceful Restart Mechanism for BGP, which is represented by BGP GR later.

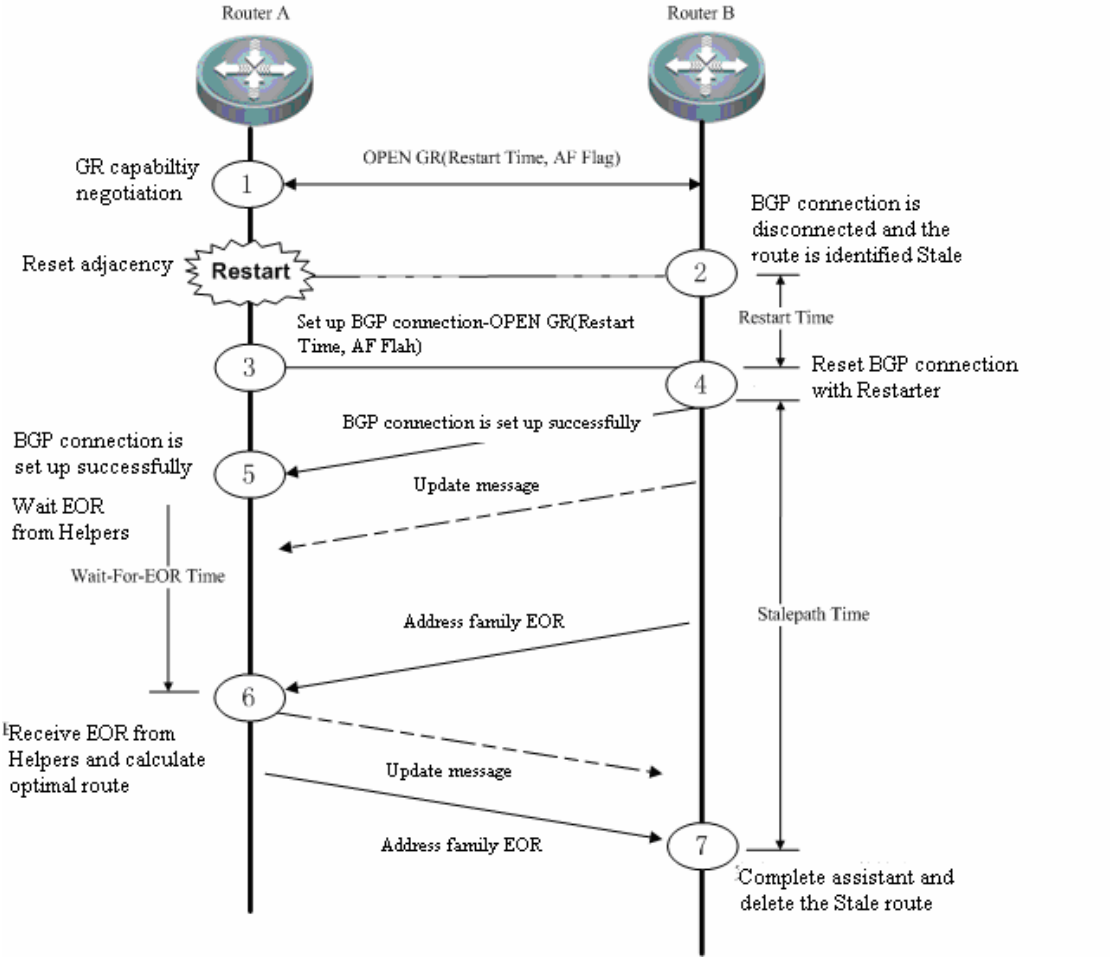
13) Working mechanism

RFC4724 is a standard GR protocol that IETF especially defines for the BGP protocol. This document outlines the principles of BGP GR, including:

- Graceful Restart Capability is added to the OPEN message of the BGP protocol, indicating that the BGP supports GR. The GR capability is negotiated by neighbors during the initiation of BGP connection.
- GR Restarter and GR Helper. GR Restarter means that the router restarts the BGP protocol, which can ensure continuous route forwarding when the route control panel fails. GR Helper is the BGP neighbor of the GR Restarter that assists the GR Restarter in BGP GR for continous forwarding across the network.
- In the update message, EOR (End-of-RIB) is added to indicate that the route message update is complete.

The following ffigure illustrates the process of BGR GR.

Figure 1 Process of graceful restart for BGP



Initially, the BGP protocol establishes a adjacency and negotiates respective GR capability with the GR Capability field of the OPEN message. At a point, the device reboots and the BGP session is disconnected. The neighbor detects disconnection. With GR supported, the BGP neighbor keeps the route of the GR Restarter valid but identifies it in Stale (aged, not updated) state. The GR Restarter reboots and re-establishes connection with the GR Helper and waits the route update message and EOR label from the GR Helper. After receiving an EOR label from all neighbors, the BGP Restarter calculates routes and update the routing table, and begins to send update routes to the GR Restarter. Upon the receipt of these routes, the GR Helper removes the Stale tag from these routes and then deletes the routes (these routes have not been updated) tagged with Stale after receiving the EOR label from the BGP Restarter, calculates routes and updates the routing table.

Some key timers are defined to assist the implemetation of BGP GR:

- **Restart-Timer**: The GR Restarter notifies the GR Helper of restart time that the GR Helper needs to wait before reestablishing the BGP connection. You can modify this value by using the **bgp graceful-restart restart-time** command.
- **Wait-For-EOR Timer**: Time the GR Restarter needs to wait for the EOR label of all GR Helpers. After receiving the EOR label of all GR Helpers or the timer expires, the GR Restarter calculates optimal routes and updates the routing table. You can modify this value by using the **bgp update-delay** command.
- **StalePath Timer**: Time the GR Helper needs to wait before receiving the EOR label from the GR Restarter after reestablishing the connection with the GR Restarter. During this period, the GT Helper keeps alive the route of the

GR Restarter. It will delete the rotue tagged with Stale after receiving the EOR lable or the StalePath timer expires. You can modify this value by using the **bgp graceful-restart stalepath-time** command.

Implementation of BGP GR

Implementation of BGP GR is not an independent process. All BGP peers are necessary to enable BGP GR capability for normal operation. Failed GR may cause a temporary route black hole or loop and affect the network operation. Consequently, it is recommended that you ensure the GR capability is negotiatied successfully by using the **show ip bgp neighbors** command. To enable BGP GR, exeucte the **bgp graceful-restart** command in BGP route configuration mode.

Configuring BGP GR Capability

BGP GR capability is an extended capability of the BGP protocol, which is disabled by default. When enabling GR, the BGP reestablishes the connection with its neighbor and negotiates GR capability. The GR is enabled only when both sides support GR capability.

To enable the GR capability, execute the following commands:

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *500*	Enters BGP configuration mode.
Ruijie(config-router)# **bgp graceful-restart**	Enables GR.
Ruijie(config-router)# **end**	Returns to privileged EXEC mode.
Ruijie # **show running-config**	Shows the configuration.
Ruijie # **write**	(Optional) Saves the configuration.

☑ All the BGP-enabled products support this command.

Caution

The **bgp graceful-restart** command does not take effect for established BGP connections. Namely, the BGP connection will not negotiate GR capability immediately when it is in Established status. In this case, you need to forcibly restart the peer to renegotiate the GR capability, for instance, **clear ip bgp 192.168.195.64**. This is to prevent the restart of neighboring relations for capability renegotiation when GR is enabled or disabled, as renegotiation may cause network oscillation. Therefore, you can decide whether to restart neighbors.

Supporting BGP GR capability does not mean a device can serve as the GR Restarter for graceful restart, which also depends on the hardware. The GR Restarter device of Ruijie Networks needs to support dual-engine redundant hot backup.

Configuring BGP GR Timer

After the GR capability is enabled, the BGP automatically configures relevant timers with default values. By default, the Restart Timer is 120s, the Wait-For-EOR Timer is 120s and the StalePath Timer is 360s.

To configure these timers, execute the following commands:

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *500*	Enters BGP configuration mode.
Ruijie(config-router)# **bgp graceful-restart**	Enables GR capability.
Ruijie(config-router)# **bgp graceful-restart restart-time** *150*	Sets the Restart Timer to 150s.
Ruijie(config-router)# **bgp update-delay** *150*	Sets the Wait-For-EOR Timer to 150s.
Ruijie(config-router)# **bgp graceful-restart stalepath-time** *400*	Sets the StalePath Timer to 400s.
Ruijie(config-router)# **end**	Returns to privileged EXEC mode.
Ruijie # **show running-config**	Shows the configuration.
Ruijie # **write**	(Optional) Saves the configuration.

☑ All the BGP-enabled products support this command.

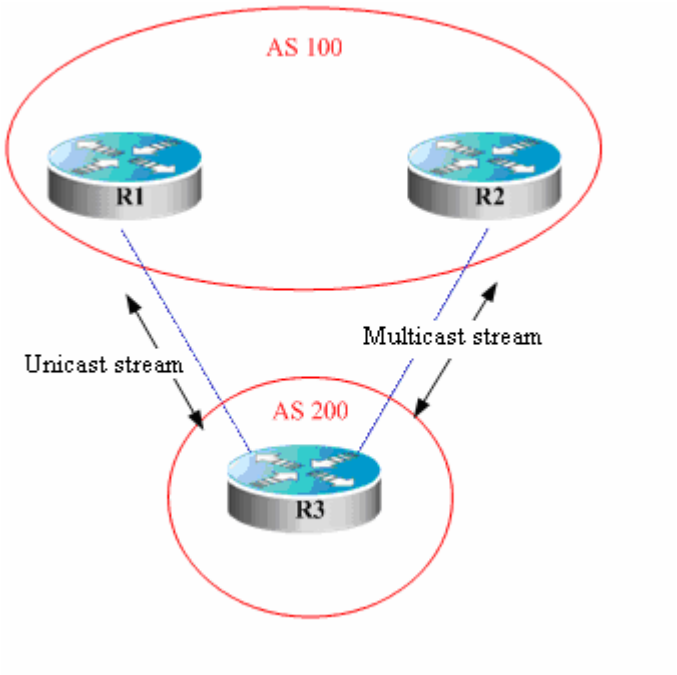

Caution

The restart time configured by using the **bgp graceful-restart restart-time** command should not exceed the Hold time of the BGP peer. Otherwise, the Hold Time will be used as the restart time and be notified to the peer for GR capability negotiation.

Configuring BGP Multicast

The BGP multicast route is used for multicast RFC check. In general, the multicast forwarding topology is similar to the unicast forwarding topology. You can design different multicast topologies by using BGP multicast, which is used for the multicast topology between ASs, as shown in the following figure.

Figure 2



There are two routers in AS100. In terms of design, unicast streams are sent to R1 and multicast streams to R2. In this case, MPBGP is required between R2 and R3.

Step 1: Enable BGP on R1, R2 and R3 and establish neighbors among them.

Take R3 as an example. Configures R1 and R2 as its BGP neighbors.

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *200*	Enters BGP configuration mode with the AS number of 200.
Ruijie(config-router)# **neighbor** *R2* **remote-as** *100*	Configures R2 as the BGP neighbor with the AS number of 100.
Ruijie(config-router)# **neighbor** *R1* **remote-as** *100*	Configures R1 as the BGP neighbor with the AS number of 100.

Step 2: Since R3 does not need to transmit multicast routes with R1, disable the multicast address of R1.

Command	Function
Ruijie(config-router)# **address-family ipv4 multicast**	Enters the IPv4 multicast address family configuration mode.
Ruijie(config-router-af)# **no neighbor** *R1* **active**	Disable the multicast address of R1.

Step 3: Since R2 needs to transmit multicast rotues with R1, enable the multicast address of R2.

Command	Function
Ruijie(config-router)# **address-family ipv4 multicast**	Enters IPv4 multicast address family configuration mode.
Ruijie(config-router-af)# **neighbor** *R2* **active**	Enables the multicast address of R2.

Step 4: Import the routes that R3 needs to advertise to R2 in multicast address family mode.

Routes are imported by using **redistribute**, network advertising, and aggregate route publishing. They are configured in a multi-address family, for example:

Command	Function
Ruijie(config-router)# **address-family ipv4 multicast**	Enters IPv4 multicast address family configuration mode.
Ruijie(config-router-af)# **redistribute ospf** 1	Redistributes OSPF routes.

Caution

During the process of redistribution, the routes imported are unicast routes. For instance, the **redistribute ospf 1** command imports OSPF unicast routes. This is because that multicast routes depend on the egress of unicast routes for the establishment of a multicast spanning tree.

Configuring BGP Local AS

This function configures a local AS different from the real AS (rotuer BGP AS) for one peer, which is equivalent to virtualizing an AS. When the real AS changes, you still can establish a BGP connection without modifying the BGP configuration of the peer. Local AS applies to AS migration and converge of large networks without affecting the configurations of the devices in other interconenected ASs.

When establishing the BGP connection, the local device will advertise the local AS number to the peer in an OPEN message. The peer checks whether the AS number matches the local one and rejects the BGP connection if there is a difference. By default, the local AS of the BGP connection is the real BGP AS. With this function, the local device replaces the real AS with the configured one to establish a BGP connection.

By default, no peer is configured with Local AS. The Local AS of the peer is real AS over BGP. To configure a local AS for one peer, execute the following commands:

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *500*	Enters BGP configuration mode.
Ruijie(config-router)# **neighbor** *192.168.195.64* **remote-as** *100*	Configures the peer.
Ruijie(config-router)# **neighbor** *192.168.195.64* **local-as** *300*	Configures AS 300 as the local AS for the peer

The local AS function applies only to EBGP peers, instead of IBGP peers, confederation EBGP peers. Meanwhile, there are some limitations as described below:

- The local AS cannot be configured as the remote peer.
- Local AS cannot be configured for one member of the peer group.
- The local AS cannot be configured as the real BGP AS.
- The local AS cannot be configured as the AS number of the confederation if the device is a member of the confederation.

For details about the **neighbor** *peer-address* **local-as** *as-num* command, refer to the *Command Reference*.

Monitoring BGP

You can use the **Shows** commands to view the BGP route table, buffer and database. Execute the follwing commands in privileged EXEC mode:

Command	Function
Ruijie# **show ip bgp**	Shows the information on all BGP routes.
Ruijie# **show ip bgp** {*network* | *network-mask* } [longer-prefixes]	Shows the BGP routing information of the specified destination.
Ruijie# **show ip bgp prefix-list** *prefix-list-name*	Shows the BGP routing information of the specified matching against the prefix list.
Ruijie# show **ip bgp community** [**exact**] *community-number*	Shows the BGP routing information including the specified community.
Ruijie# **show ip bgp community-list** *community-lister-number* [exact]	Shows the BGP routing information which matches against the specified community list.
Ruijie# **show ip bgp filter-list** ***path-list**-number*	Shows the BGP routing information which matches against the specified AS path list.
Ruijie# **show ip bgp regexp** *as-regular-expression*	Shows the BGP routing information of the specified regular expression which matches against the AS path attribute.
Ruijie# **show ip bgp dampening dampened-paths**	Shows the suppressed flap statistics information.
Ruijie# **show ip bgp dampening flap-statistics**	Shows the flap statistics information of all routes with the flap record.
Ruijie# **show ip bgp neighbors** [*address*] [**received-routes** | **routes** | **advertised-routes** | **received]**	Shows the information of the BGP peer.
Ruijie# **show ip bgp summary**	Shows the configuration of the BGP router and the information about the peer.
Ruijie# show **ip bgp peer-group** [*peer-group-name*]	Shows the configuration of the BGP peer group.

Protocol Independent Configuration

route-map Configuration

The BGP protocol follows the Route-map policy. For detailed configurations, refer to the Protocol Independent Configuration.

Regular Expression Configuration

The regular expression is a formula used to match the string based on a template. The regular expression is used to evaluate the text data and return a true or false value, that is to say, it determines whether the expression can describe this data correctly.

Description of Control Characters for Regular Expression

The BGP path attribute uses the regular expression. The following table describes the use of the special characters for the regular expression:

Characters	Signs	Special Functions
Period	.	Matched with any single character.
Asterisk	*	Matched with none or any sequence of the string.
Plus	+	Matched with one or any sequence of the string.
Interrogation Mark	?	Matched with none or one sign of the string.
Plus Sign	^	Matched with the starting of the string.
Dollar	$	Matched with the end of the string.
Underlining	_	Matched with the comma, bracket, the starting and end of the string and blank.
Square Brackets	[ ]	Matched with the single character within the specified scope.

Application Example of Regular Expression

Run the **show ip bgp** command on the device:

```
Ruijie# show ip bgp
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete
Status Network           Next Hop     Metric  LocPrf  Path
------ -----------------  ---------------   --------  --------  -------------------
*>  211.21.21.0/24   110.110.110.10  0     1000   200 300
*>  211.21.23.0/24   110.110.110.10  0     1000   200 300
*>  211.21.25.0/24   110.110.110.10  0     1000   300
*>  211.21.26.0/24   110.110.110.10  0     1000   300
*> 1.1.1.0/24      192.168.88.250  444        0   606
*> 179.98.0.0      192.168.88.250  444        0   606
*> 192.92.86.0     192.168.88.250  8883       0   606
*> 192.168.88.0    192.168.88.250  444        0   606
*> 200.200.200.0   192.168.88.250  777        0   606
```

Use the regular expression in the **show** command:

```
Ruijie# show ip bgp regexp _300_
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete
Status Network       Next Hop          Metric  LocPrf  Path
------ -----------------  ---------------   --------  --------  -------------------
*>  211.21.21.0/24  110.110.110.10  0     1000   200 300
*>  211.21.23.0/24  110.110.110.10  0     1000   200 300
*>  211.21.25.0/24  110.110.110.10  0     1000   300
*>  211.21.26.0/24  110.110.110.10  0     1000   300
```

BGP Load Protection Configuration

Too many BGP routes may overload a switch, especially a switch with a small memory size. BGP load protection can prevent unforeseen switch problems caused by switch resource usage.

Limiting BGP Routes

To limit BGP routes, configure the maximum number of routes in the BGP address-family mode. Configure the maximum number of routes learned from a BGP neighbor.

Use the following commands to configure the maximum number of routes learned from a BGP neighbor:

Command	Function
Ruijie(config)# **router bgp** *as-num*	Enters BGP configuration mode.
Ruijie(config-router)#**neighbor** {*address* | *peer-group-name*} **remote**-as *as-num*	Configures the BGP neighbor.
Ruijie(config-router)# **neighbor** {*address* | *peer-group-name*} **maximum-prefix** *maximum* [**threshold**] [**warning-only**]	Configures the maximum number of routes learned from the BGP neighbor.

Use the following commands to configure the maximum number of routes in the specified BGP address-family mode:

Command	Function
Ruijie(config)# **router bgp** *as-num*	Enters BGP configuration mode.
Ruijie(config-router)#**address-family ipv4 unicast**	Enters the BGP ipv4 unicast address-family mode.
Or： Ruijie(config-router)#**address-family ipv4** vrf *vrf-name*	Enters the BGP ipv4 VRF address-family mode.
Or： Ruijie(config-router)#a**ddress-family vpnv4 unicast**	Enters the BGP VPNV4 address-family mode.
Ruijie(config-router)# **maximum-prefix** *maximum*	Configures the maximum number of routes in the specified BGP address-family mode.

Configuring Overflow Memory-lack

BGP can be in the overflow state when the memory is insufficient. In OVERFLOW mode, BGP generates a default route to the NULL interface. A newly learned route will be discarded if it is not a default route in the current routing table. In general, the routes BGP learned in the overflow state are dropped, and the system memory stays in a steady state to protect the network from routing loops. In other words, BGP is safe and also preferred in OVERFLOW state.

Use the following commands to move BGP into the overflow state:

Command	Function
Ruijie(config)# **router bgp** *as-num*	Enters BGP configuration mode.
Ruijie(config-router)# **overflow memory-lack**	Brings BGP into the overflow state when memory is running short.

Note

By default, BGP switches to OVERFLOW state automatically when the memory is running short. Use the **no overflow memory-lack** command for the BGP to exit the OVERFLOW state.

Caution

In OVERFLOW state, BGP supports the **clear bgp** { *addressfamily* | **all** } * command. Alternatively, you can disable and re-enable BGP to exit the OVERFLOS state. When the memory becomes sufficient, BGP exits the OVERFLOW state automatically.

BGP Configuration Examples

The following section lists BGP configurations.

Configuring BGP Neighbor

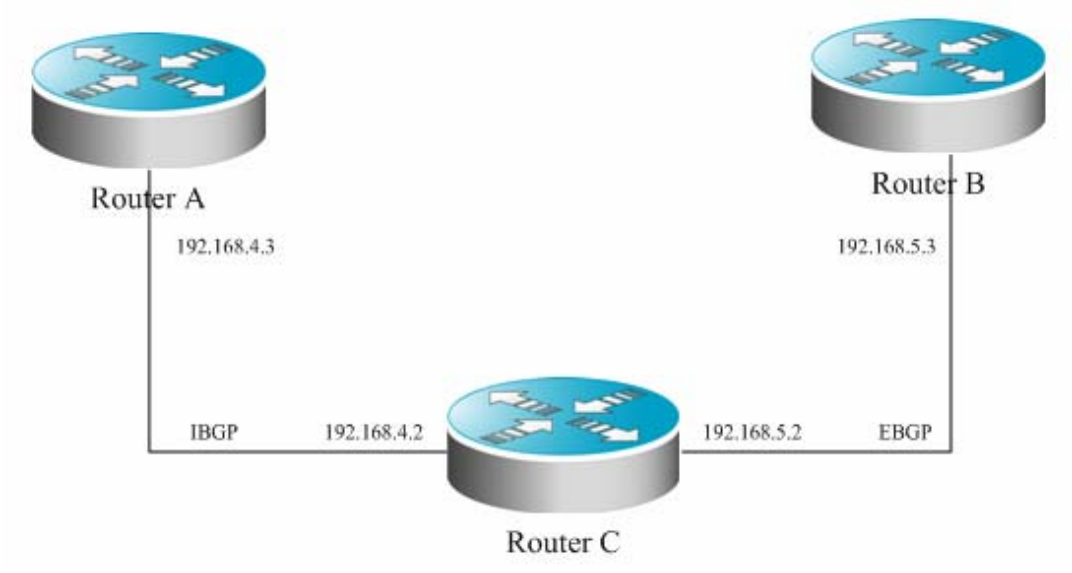
The following section shows how to configure a BGP neighbor. Use the **neighbor remote-as** command to configure the BGP neighbor. Configuration details are shown as follows:

```
router bgp 109
neighbor 131.108.200.1 remote-as 167
neighbor 131.108.234.2 remote-as 109
neighbor 150.136.64.19 remote-as 99
```

Configure one IBGP peer 131.108.234.2 and two EBGP peers 131.108.200.1 and 150.136.64.19.

The following example shows how to configure the BGP neighbor. For the relationship among routers and the assignment of IP addresses, see the figure.

Figure 3



This example shows the BGP configuration of different routers:

Router A configuration:

```
!
router bgp 100
 neighbor 192.168.4.2 remote-as 100
```

Router B configuration:

```
!
router bgp 100
 neighbor 192.168.4.3 remote-as 100
 neighbor 192.168.5.3 remote-as 200
```

Router C configuration:

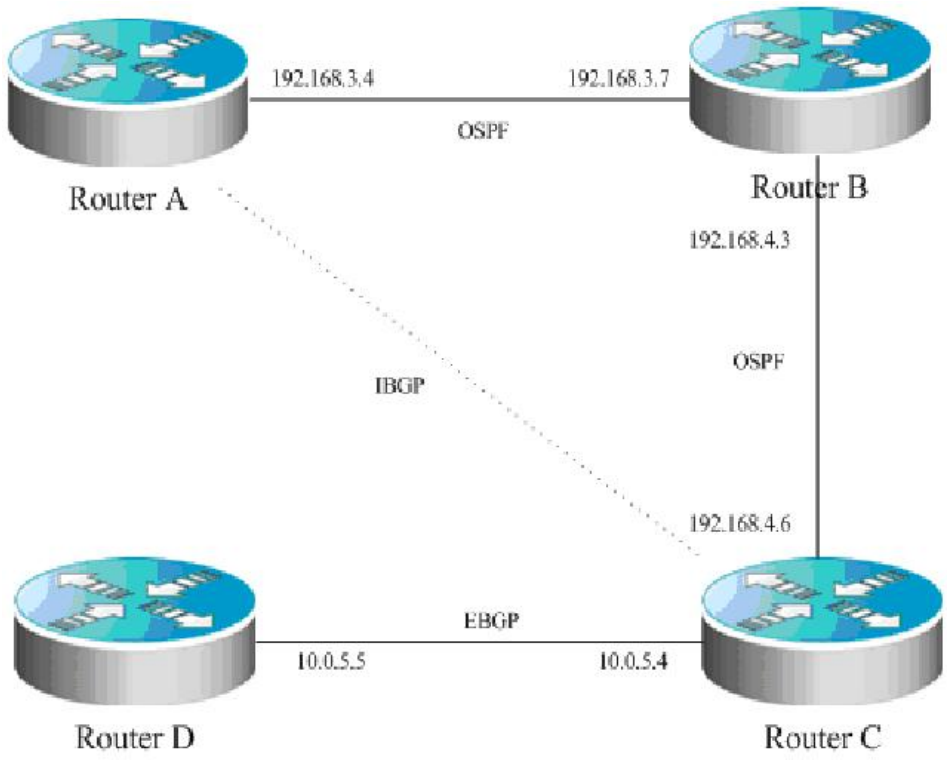
```
!
router bgp 200
 neighbor 192.168.5.2 remote-as 100
```

Configuring BGP Synchronization

Use the **synchronization** command to configure synchronization in BGP routing configuration mode, and use the **no synchronization** command to cancel the configured synchronization.

The following example shows the function of synchronization. The following figure illustrates the relationship between devices and the assignment of IP addresses:

Figure 4



In the figure, route p in router A is sent to router C based on the IBGP adjacency. If router C is configured with BGP synchronization, it is necessary for the router to wait for the IGP (this example uses the OSPF protocol) to receive the same routing information p, and send the route p to the EBGP neighbor, router D. If router C is configured asynchronously, it is not necessary for the BGP to wait for the IGP to receive the route p, and send the route p to the EBGP neighbor router D.

Configuring Neighbors to Use as-path Filter

Configure the **as-path access-list** command for filtering first in configuration mode. Enter BGP route configuration mode after configuration, and use the **neighbor filter-list** command to apply the configured as-path access list among the BGP neighbors to filter AS paths.

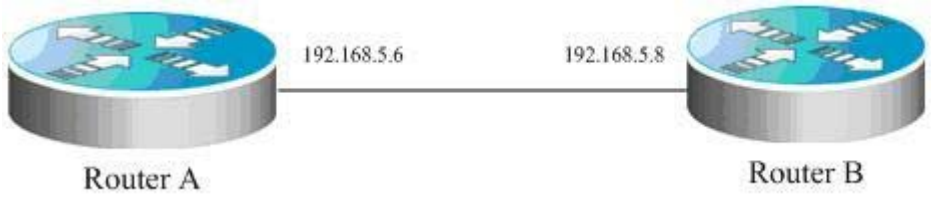
The configurations are detailed below:

```
router bgp 200
neighbor 193.1.12.10 remote-as 100
neighbor 193.1.12.10 filter-list 2 out
neighbor 193.1.12.10 filter-list 3 in
ip as-path access-list 2 permit _200$
ip as-path access-list 2 permit ^100$
ip as-path access-list 3 deny _690$
ip as-path access-list 3 permit .*
```

This configuration indicates that only the routes permitted by the **as-path access-list** *2* can be advertised to the neighbor 193.1.12.10. The advertised routes from the neighbor 193.1.12.10 can be received only when they are permitted by the **as-path access-list** *3*.

The following figure provides a configuration eaxmple that shows the relationship and IP addresses of devices:

Figure 5



Do AS path-based filter on Router A.

The following example shows the configuraitons of different devices:

Router A configuration:

```
!
ip as-path access-list 4 deny ^300_
ip as-path access-list 4 permit .*
ip as-path access-list 5 deny ^450_65_
ip as-path access-list 5 permit .*
!
router bgp 100
 bgp log-neighbor-changes
```

```
 neighbor 192.168.5.8 remote-as 200
 neighbor 192.168.5.8 filter-list 5 in
 neighbor 192.168.5.8 filter-list 4 out
```

Router B configuration:

```
!
router bgp 200
 bgp log-neighbor-changes
 neighbor 192.168.5.6 remote-as 100
```

Configuring Route Aggregation

Use the **aggregate-address** command to configure an aggregated route in route configuration mode. When any route falls within the configured range, this aggregated route will become active.

The configuration is detailed as follows:

```
router bgp 100
aggregate-address 193.0.0.0 255.0.0.0
```

Configure one aggregate route:

```
router bgp 100
aggregate-address 193.0.0.0 255.0.0.0 as-set
```

The **as-path** segment of the aggregated route is an collection of **ASs**:

```
router bgp 100
aggregate-address 193.0.0.0 255.0.0.0 summary-only
```

The aggregated route is not advertised.

Configuring Confederation

When configuring a confederatin, you need to use the **bgp confederation identifier** command to configure the AS number for external connection, and use the **bgp confederation peers** command to configure confederation members.

The configuration is detailed as follows:

```
router bgp 6003
bgp confederation identifier 666
bgp confederation peers 6001 6002
neighbor 171.69.232.57 remote-as 6001
neighbor 171.69.232.55 remote-as 6002
neighbor 200.200.200.200 remote-as 701
```

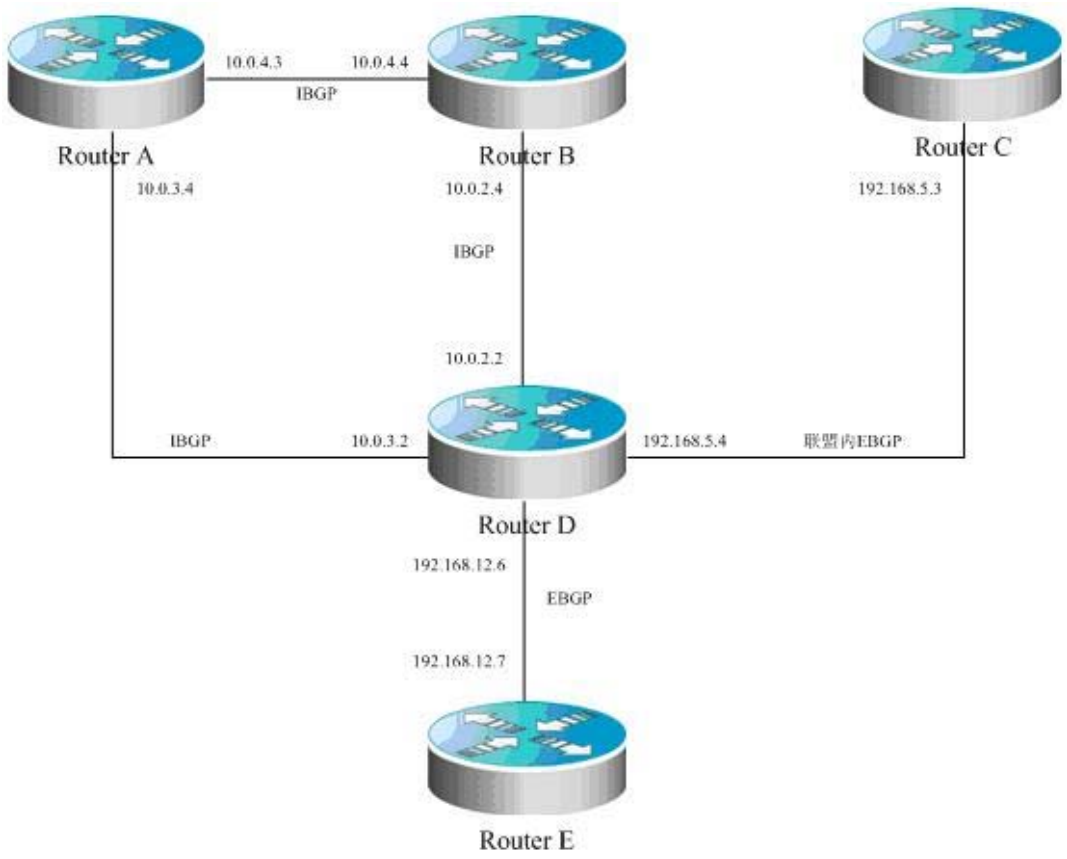
The configuration of peer 200.200.200.200 outside the confederation is shown as follows:

```
router bgp 701
neighbor 171.69.232.56 remote-as 666
neighbor 200,200,200,205 remote-as 701
```

For the configuration, the first device is in the confederation, while the second device is outside the confederation. Therefore, they are EBGP neighbors.

The following example shows their relastionship and IP addresses:

Figure 6



The following example shows the configurations of different devices:

Router A configuration:

```
!
router bgp 65530
 bgp confederation identifier 100
 bgp confederation peers 65531
 bgp log-neighbor-changes
 neighbor 10.0.3.2 remote-as 65530
 neighbor 10.0.4.4 remote-as 65530
```

Router B configuration:

```
!
router bgp 65530
 bgp confederation identifier 100
 bgp log-neighbor-changes
 neighbor 192.168.5.4 remote-as 65530
```

Router C configuration

```
!
router bgp 65531
 bgp confederation identifier 100
```

```
 bgp confederation peers 65530
 bgp log-neighbor-changes
 neighbor 10.0.3.2 remote-as 65530
 neighbor 10.0.4.4 remote-as 65530
```

Router D configuration:

```
!
router bgp 65530
 bgp confederation identifier 100
 bgp confederation peers 65531
 bgp log-neighbor-changes
 neighbor 10.0.2.4 remote-as 65530
 neighbor 10.0.3.4 remote-as 65530
 neighbor 192.168.5.3 remote-as 65531
 neighbor 192.168.12.7 remote-as 200
```

Router E configuration:

```
!
router bgp 200
 bgp log-neighbor-changes
 neighbor 192.168.12.6 remote-as 100
```

Configuring Route Reflector

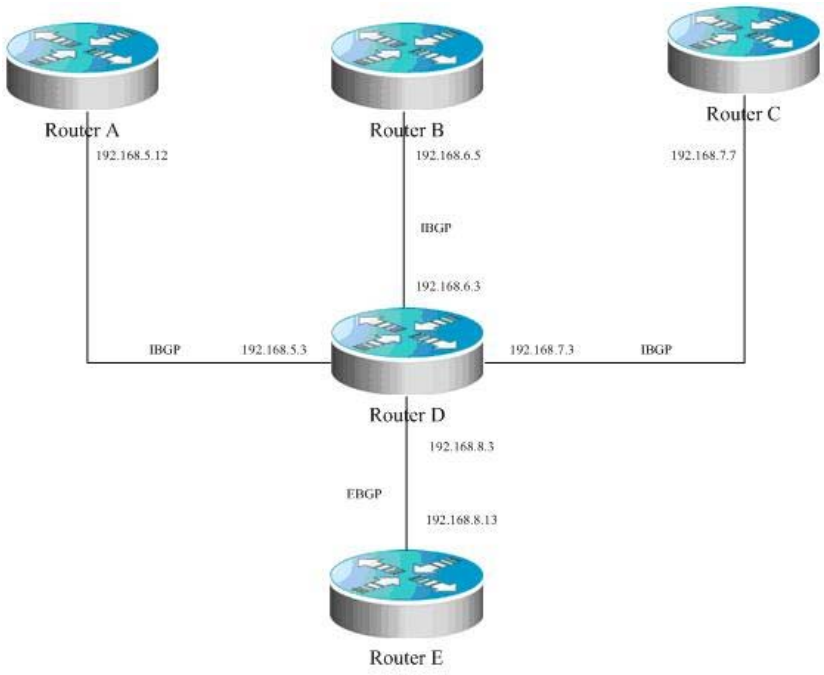
When a route reflector is configured, use the **bgp client-to-client reflection** command to enable the route reflection function on the device. If there are more than one route reflector within one cluster, use the **bgp cluster-id** command to configure the cluster ID of the reflector, and use the **neighbor route-reflector-client** command to add the peer to the client for route reflection.

The configuration is detailed as follows:

```
router bgp 601
bgp cluster-id 200.200.200.200
neighbor 171.69.232.56 remote-as 601
neighbor 200,200,200,205 remote-as 701
neighbor 171.69.232.56 route-reflector-client
```

The following example shows the relastionship between and IP addresses of the devices:

Figure 7



In this example, Router D is a route reflector. The following section shows the configurations of different devices:

Router A configuration:

```
!
router bgp 100
 bgp log-neighbor-changes
 neighbor 192.168.5.3 remote-as 100
 neighbor 192.168.5.3 description route-reflector server
```

Router B configuration:

```
!
router bgp 100
 bgp log-neighbor-changes
 neighbor 192.168.6.3 remote-as 100
 neighbor 192.168.6.3 description route-reflector server
```

Router C configuration:

```
!
router bgp 100
 bgp log-neighbor-changes
 neighbor 192.168.7.3 remote-as 100
 neighbor 192.168.7.3 description not the route-reflector server
```

Router D Configuration:

```
!
router bgp 100
```

```
 bgp log-neighbor-changes
 neighbor 192.168.5.12 remote-as 100
 neighbor 192.168.5.12 description route-reflector client
 neighbor 192.168.5.12 route-reflector-client
 neighbor 192.168.6.5 remote-as 100
 neighbor 192.168.6.5 description route-reflector client
 neighbor 192.168.6.5 route-reflector-client
 neighbor 192.168.7.7 remote-as 100
 neighbor 192.168.7.7 description not the route-reflector client
 neighbor 192.168.8.13 remote-as 200
```

Router E configuration:

```
!
router bgp 500
 bgp log-neighbor-changes
 neighbor 192.168.8.3 remote-as 100
```

Configuring peergroup

This section uses the configuration of **peergroup** for IBGP and EBGP as an example.

Configuring IBGP peergroup

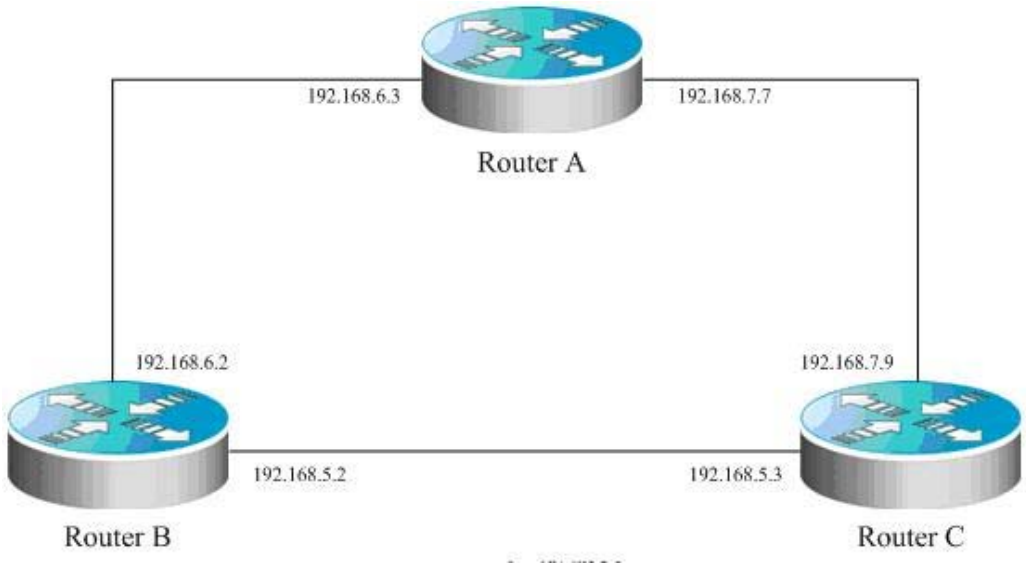
Use the **neighbor** *internal* **peer-group** command to create a peer group named *internal*, and configure a remote AS, and other options for the peer group. Use the **neighbor** *A.B.C.D* **peer-group** *internal* command to add peers A.B.C.D into the peer group.

The configuration commands are described as follows:

```
router bgp 100
neighbor internal peer-group
neighbor internal remote-as 100
neighbor internal update-source loopback 0
neighbor internal route-map set-med out
neighbor internal filter-list 1 out
neighbor internal filter-list 2 in
neighbor 171.69.232.53 peer-group internal
neighbor 171.69.232.54 peer-group internal
neighbor 171.69.232.55 peer-group internal
neighbor 171.69.232.55 filter-list 3 in
```

The following example shows the relastionship between and IP addresses of the devices:

Figure 8



Router A configuration

```
!
router bgp 100
 bgp log-neighbor-changes
 neighbor ibgp-group peer-group
 neighbor ibgp-group description peer in the same as
 neighbor 192.168.6.2 remote-as 100
 neighbor 192.168.6.2 peer-group ibgp-group
 neighbor 192.168.6.2 description one peer in the ibgp-group
 neighbor 192.168.7.9 remote-as 100
 neighbor 192.168.7.9 peer-group ibgp-group
```

Router B configuration:

```
!
router bgp 100
 bgp log-neighbor-changes
 neighbor ibgp-peer peer-group
 neighbor ibgp-peer remote-as 100
 neighbor ibgp-peer route-map ibgp-rmap out
 neighbor 192.168.5.3 peer-group ibgp-peer
 neighbor 192.168.5.3 route-map set-localpref in
 neighbor 192.168.6.3 peer-group ibgp-peer
```

Router C configuration:

```
!
router bgp 100
 bgp log-neighbor-changes
 neighbor ibgp-group peer-group
 neighbor 192.168.5.2 remote-as 100
```

```
neighbor 192.168.5.2 peer-group ibgp-group
neighbor 192.168.7.7 remote-as 100
neighbor 192.168.7.7 peer-group ibgp-group
```

Configuring EBGP peergroup

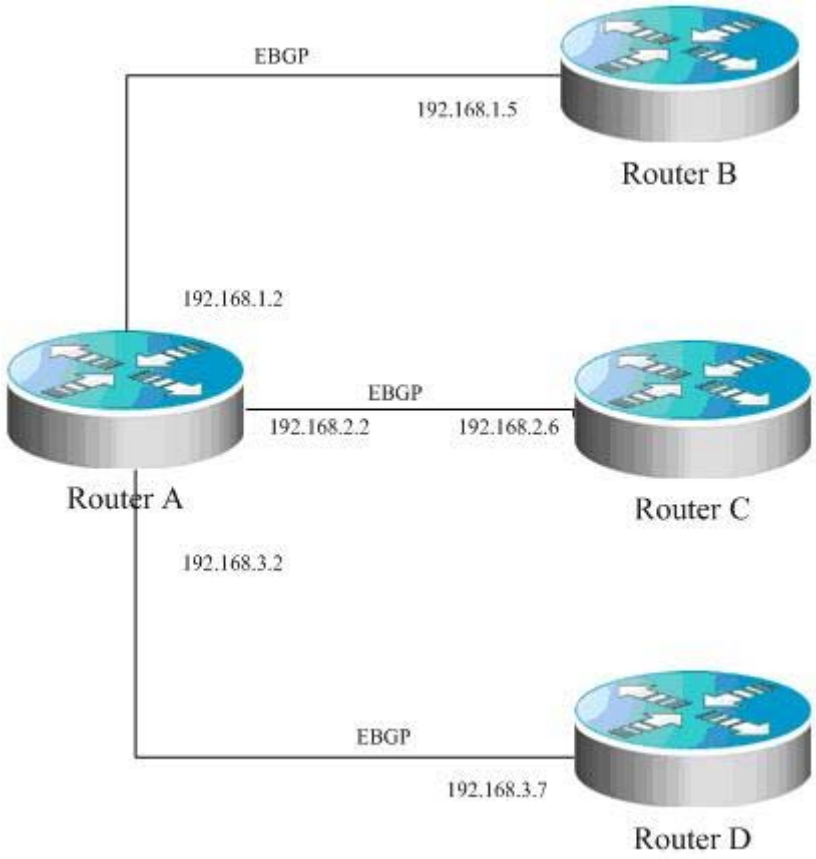
Use the **neighbor** *A.B.C.D* **remote-as** *num* command to configure an EBGP peer. Use the **neighbor** *external* **peer-group** command to create a peer group named **external**, and apply the **neighbor** *A.B.C.D* **peer-group** *external* command to add the peers A.B.C.D into the peer group *external*.

Here is an example of the specific configuration:

```
router bgp 100
neighbor external-peers peer-group
neighbor external-peers route-map set-metric out
neighbor external-peers filter-list 99 out
neighbor external-peers filter-list 101 in
neighbor 171.69.232.90 remote-as 200
neighbor 171.69.232.90 peer-group external-peers
neighbor 171.69.232.100 remote-as 300
neighbor 171.69.232.100 peer-group external-peers
neighbor 171.69.232.110 remote-as 400
neighbor 171.69.232.110 peer-group external-peers
neighbor 171.69.232.110 filter-list 400 in
```

The following figure shows the configuration of peer-group:

Figure 9



The figure illustrates the relationship between devices and the assignment of IP address.

Router A configuration:

```
!
router bgp 100
 bgp log-neighbor-changes
 neighbor ebgp-group peer-group
 neighbor ebgp-group distribute-list 2 in
 neighbor ebgp-group route-map set-med out
 neighbor 192.168.1.5 remote-as 200
 neighbor 192.168.1.5 peer-group ebgp-group
 neighbor 192.168.2.6 remote-as 300
 neighbor 192.168.2.6 peer-group ebgp-group
 neighbor 192.168.2.6 distribute-list 3 in
 neighbor 192.168.3.7 remote-as 400
 neighbor 192.168.3.7 peer-group ebgp-group
!
```

Router B configuration:

```
!
router bgp 200
```

```
 bgp log-neighbor-changes
 neighbor 192.168.1.2 remote-as 100
!
```

Router C configuration:

```
!
router bgp 300
 bgp log-neighbor-changes
 neighbor 192.168.2.2 remote-as 100
!
```

Router D configuration:

```
!
router bgp 400
 bgp log-neighbor-changes
 neighbor 192.168.3.2 remote-as 100
!
```

Configuring TCP MD5

Use the CLI command **neighbor password** to configure TCP MD5 for the BGP connection in BGP configuration mode.

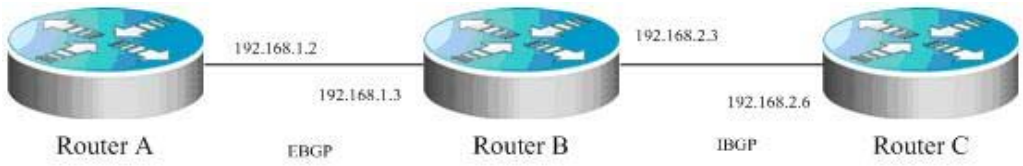
The configuration format is shown as follows:

```
router bgp 100
neighbor 171.69.232.54 remote-as 110
neighbor 171.69.232.54 password peerpassword
```

Configure the *password* of peer 171.69.232.54 as *peerpassword.*

The following figure shows the configuration of MD5 and IP addresses on different devices：

Figure 10



The AS of router A is 100, and the AS of router B and router C is 200. Router A establishes EBGP adjacency with router B and uses EBGP as the MD5 password. Router B establishes IBGP adjacency with router C and uses IBGP as the MD5 password.

router A configuration:

```
!
router bgp 100
 bgp log-neighbor-changes
 neighbor 192.168.1.3 remote-as 200
```

```
 eighbor 192.168.1.3 password ebgp
!
```

Router B configuration:

```
!
router bgp 200
 bgp log-neighbor-changes
 neighbor 192.168.1.2 remote-as 100
 neighbor 192.168.1.2 password ebgp
 neighbor 192.168.2.6 remote-as 200
 neighbor 192.168.2.6 password ibgp
!
```

Router C configuration:

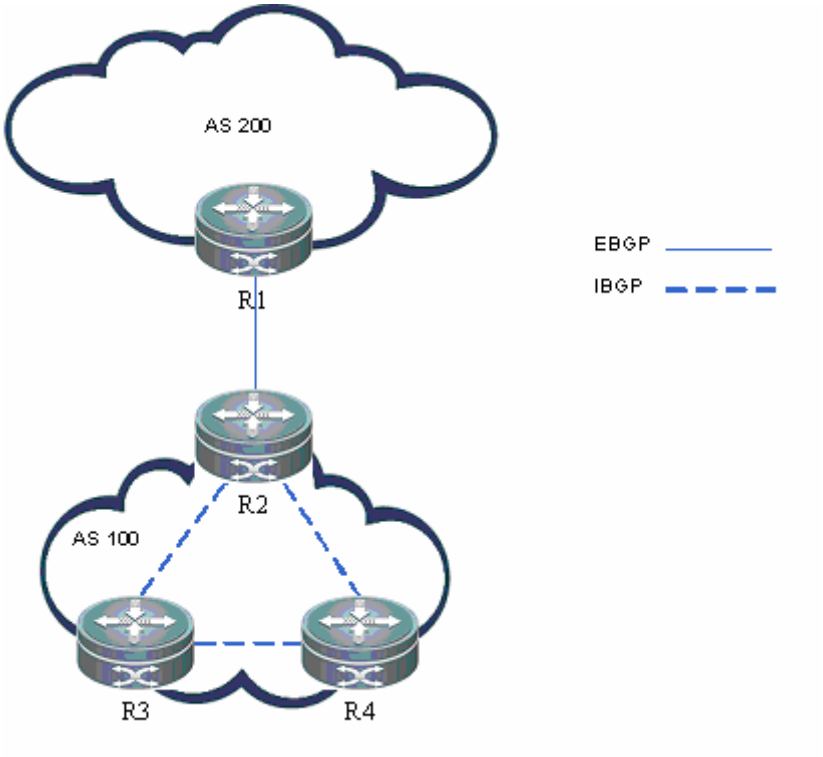
```
!
router bgp 200
 bgp log-neighbor-changes
 neighbor 192.168.2.3 remote-as 200
 neighbor 192.168.2.3 password ibgp
!
```

Configuring BGP GR

Networking requirements

As shown in the following figure, R2 is the border device of AS100 and AS200. R1 is the access device of AS200. In AS100, R2, R3 run OSPF to offer IBGP connection for the BGP protocol. At the same time, IBGP connections are established between them. R2 establishes an EBGP conneciton with R1. R2, as the border device connecting AS100 and AS200, must be more reliable. R2 is configured to support dual-system redundant bakcup for continuous forwarding and graceful restart of routing protocols (OSPF and BGP in this example). The graceful restart of routing protocols involves adjacent devices. Hence, R1, 3 and R4 need to support the BGP GR capability, and R3 and R4 need to support the GR Helper of OSPF to support the OSPF GR capabiltiy. In this way, when one engine of R2 fails, the transmission of data is not interrupted and therefore reliability is enhanced.

Figure 11 BGP GR configuration example



Confiugration precautions:

Before configuration, ensure that R2 can serve as the GR Restarter for graceful restart and the software on all devices support OSPF GR and BRP GR capability. If not, continuous data forwarding cannot be peformed when the backup engine takes over the work of the master engine in case of failures. Meanwhile, the BGP protocol depends on the BGP connection from OSPF. Hence, both the BGP and OSPF protocols should have GR enabled. Therefore, R2 must support OSPF GR.

14) R2 enables dual-eningle redundnat hot backup;

15) The software of all devices support OSPF GR and BGP GR capability

16) OSPF GR is enabled on R2

17) BGP GR is enabled on R2

18) BGP GR is enabled on neighbors to support the GR Helper of BGP

19) All BGP connections restart on R2 to negotitate GR capabitliy

Configuration steps

20) Ensure that R2 enables dual-eningle redundnat hot backup

21) Ensure that the software of all devices supports OSPF GR and BGP GR capabilities.

Check that these devices support the configuration commands of BGP GR and OSPF GR. For details, refer to Step 3 and Step 4.

22) Enables OSPF GR on R2

```
Ruijie(config)# router ospf 1
Ruijie(config-router)# graceful-restart
```

23) Enable BGP GR on R2

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# graceful-restart
```

24) Enable BGP GR on neighbors to support the GR Helper of BGP

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# bgp graceful-restart
```

For BGP GR negotiation, both sides of the BGP connection must enable BGP GR. Hence, R2 needs to negotiate with its neighbors which serve as the GR Helper to assist BGP GR.

25) Restart all BGP connections on R2 to neotitate GR capabitliy

You must manually restart the BGP connection for GR capability renegotiation, because the **bgp graceful-restart** command cannot take effect immediately.

```
Ruijie# clear ip bgp *
```

Configuration check

For R2 to enable continuous data forwarding during engine handover, check the negotiation of BGP GR and OSPF GR configration.

26) Ensure that BGP GR can negitate with all neighbors.

```
 Ruijie# show ip bgp neighbors
BGP neighbor is 192.168.195.183, remote AS 200, local AS 100, external link
Using BFD to detect fast fallover - BFD session state up
  BGP version 4, remote router ID 10.0.0.1
  BGP state = Established, up for 00:06:37
  Last read 00:06:37, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
Address family IPv4 Unicast: advertised and received
Graceful restart: advertised and received
  Remote Restart timer is 120 seconds
  Address families preserved by peer:
    None
```

Graceful restart: advertised and received means BGP GR negotiation of the BGP connection is successful. Ensure that BGP GR can negotiate with all BGP connections.

27) Ensure that OSPF GR is enabled on R2.

```
Ruijie# show ip ospf
Routing Process "ospf 1" with ID 10.0.0.2
Process uptime is 4 minutes
```

```
Process bound to VRF default
Conforms to RFC2328, and RFC1583Compatibility flag isenabled
Supports only single TOS(TOS0) routes
Supports opaque LSA
This router is an ASBR (injecting external routing information)
SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
LsaGroupPacing: 240 secs
Number of incomming current DD exchange neighbors 0/5
Number of outgoing current DD exchange neighbors 0/5
Number of external LSA 4. Checksum 0x0278E0
Number of opaque AS LSA 0. Checksum 0x000000
Number of non-default external LSA 4
External LSA database is unlimited.
Number of LSA originated 6
Number of LSA received 2
Log Neighbor Adjency Changes : Enabled
Graceful-restart enabled
Graceful-restart helper support enabled
Number of areas attached to this router: 1
Area 0 (BACKBONE)
```

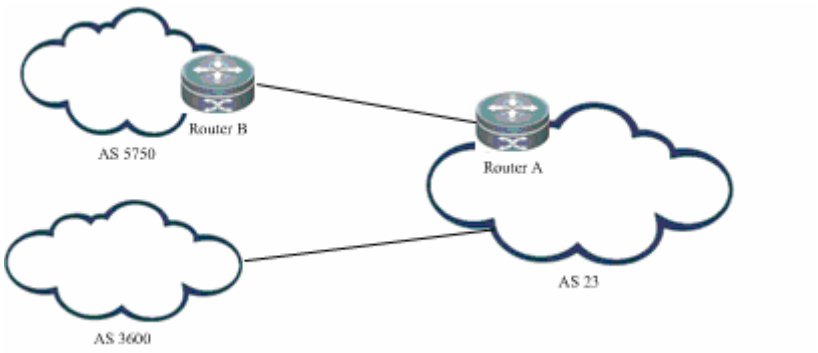
Graceful restart enabled means OSPF GR is enabled.

Configuring BGP Local AS

Networking requirements

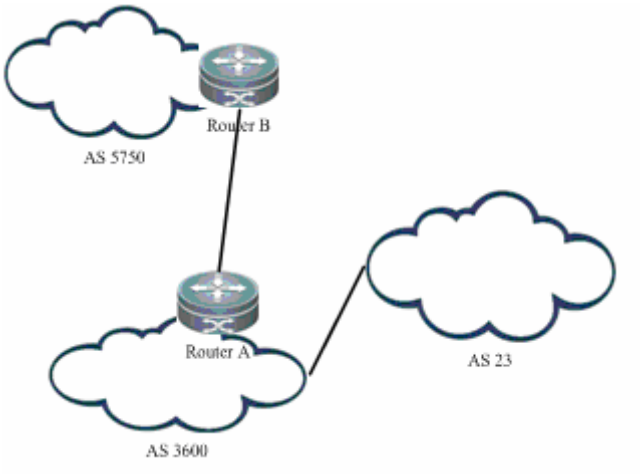
As shown in the following figure, Router A and its home network are located in AS 23, which connects AS 3600 through EBGP. The routing information of AS 5750 is transmitted to AS 3600 via AS 23.

Figure 12 Logical topology before AS migration



You must migrate Router A and its home network to AS 3600.

Figure 13 Logical topology after AS migration

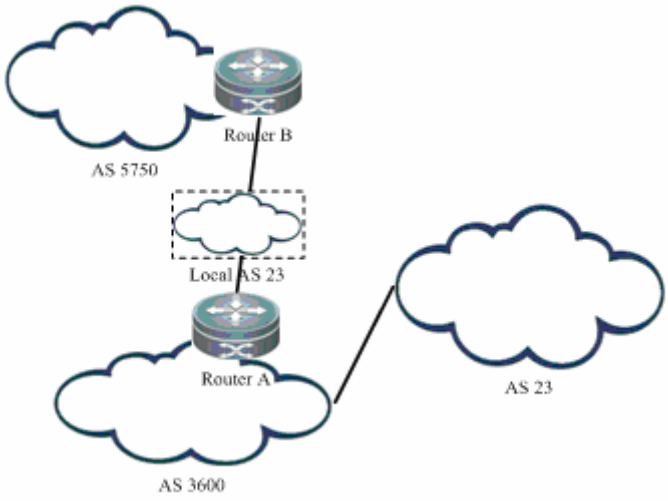


AS 23 and AS 3600 belong to one management domain. The configurations of these two ASs are modified after negotiation. At this point, Router A configures AS 3600 as the AS of the BGP protocol. In this case, you need to maintain the BGP connection between Router A and Router B, and modify related peer configuration on Router B of AS 5750. Sometimes Router B may not modify the configuration immediately. As a result, Router B cannot establish the BGP connection with Router A. On Router A, you can configure local AS for Router B to establish a BGP connection between them wihtout affecting the transmisison and calculation of routes.

Networking topology:

The following figure illustrates how to configure local AS for Router B.

Figure 14 Configuration of local AS



After configuration, a virtual AS 23 is set up between Router A and Router B. Router B considers that it is directly connected to AS 23 and can transmit routes to AS 23. This removes the need to modify Router B's configuration. When AS 3600 reaches an agreement with AS 5750 in terms of management, Router B can modify the remote AS of Router A as AS 3600 and Router A deletes the corresponding local AS for migration of network in different ASs.

Configuration steps

28) Enter BGP configuration mode

```
Ruijie-A(config)# router bgp 3600
```

29) Configures local AS for the peer

```
Ruijie-A(config-router)# neighbor 57.50.1.1 local-as 23 no-prepend replace-as dual-as
```

30) Delete local AS after Router B modifies its configuration

```
Ruijie-A(config-router)#no neighbor 57.50.1.1 local-as
```

Configuration check

```
Use the show ip bgp neighbors command to verify the local AS used by a neighbor to establish a BGP connection as follows:
Ruijie-A#show ip bgp neighbors 57.50.1.1
BGP neighbor is 57.50.1.1,  remote AS 5750, local AS 23(using Peer's Local AS, no-prepend, replace-as, dual-as), external link
  BGP version 4, remote router ID 0.0.0.0
  BGP state = Idle
  Last read        , hold time is 180, keepalive interval is 60 seconds
  Received 0 messages, 0 notifications, 0 in queue
    open message:0 update message:0 keepalive message:0
    refresh message:0 dynamic cap:0 notifications:0
  Sent 0 messages, 0 notifications, 0 in queue
```

Detailed configuration:

Router A configuration

```
router bgp 3600
neighbor 57.50.1.1 remote-as 5750
neighbor 57.50.1.1 local-as 23 no-prepend replace-as dual-as
neighbor 57.50.1.1 update-source loopback 0
neighbor 57.50.1.1 ebgp-multihop 255
```

Router B configuration

```
router bgp 5750
neighbor 36.0.1.1 remote-as 23
neighbor 36.0.1.1 update-source loopback 0
neighbor 36.0.1.1 ebgp-multihop 255
```

Configuring BGP MCE

About BGP MCE

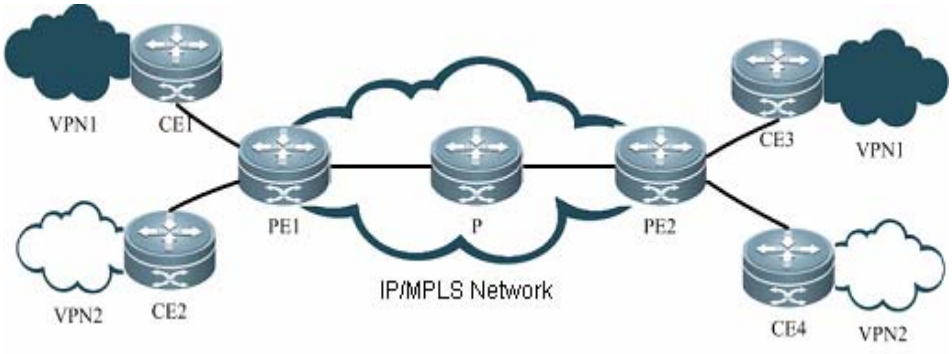
MCE Overview

MCE refers to Multi-CE. MCE enabled network devices can function as CEs of multiple VPN instances in a BGP/MPLS VPN network. This helps reduce the need for additional network equipment.

Working principle of BGP MCE

With BGP/MPLS VPN, private network data can be securely transmitted in a public network through tunnels. However, in a typical BGP/MPLS VPN network, each VPN is connected to the PE through a CE, as shown in Figure 15:

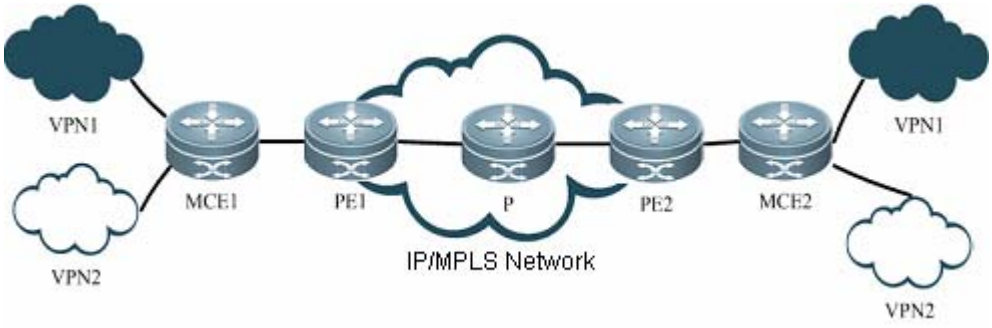
Figure 15 BGP/MPLS VPN network



As users' demand surges for service segmentation and security, a private network may be divided into multiple VPNs, and the users of different VPNs are usually isolated from each other. As a result, equipment and maintenance costs may be increased by assigning a CE for each VPN, while data security cannot be guaranteed by sharing one CE and using the same routing entry among multiple VPNs. MCE can balance data security and networking cost. By binding the VLAN interfaces of a CE device to the VPNs, you can create and maintain a routing table for each of the VPNs (Multi-VRF). In this way, packets of different VPNs in the private network can be isolated. Moreover, the PE enables the routes of each VPN to be advertised to the corresponding remote PE. As such, packets of each VPN can be transmitted securely through the public network.

The following example shows how the MCE maintains routing entries of multiple VPNs and how the MCE exchanges VPN routes with PEs.

Figure 16 MCE functions



As shown in Figure 16, two VPN sites on the left side (VPN1 and VPN2) are connected to the MPLS backbone through an MCE device. Users of VPN1 and VPN2 need to establish VPN tunnels with remote VPN1 and VPN2 users. MCE enables routing tables to be created for VPN1 and VPN2 individually on the MCE device. VLAN-interface 2 can be bound to VPN1, and VLAN-interface 3 can be bound to VPN 2. When receiving routing information, MCE determines the source of information based on the number of the interface receiving the information and then maintains the corresponding VPN routing table. Meanwhile, you need to bind the MCE-connecting interfaces on PE1 to the VPNs in the same way as those on the MCE device. The MCE device is connected to PE1 through a trunk, which permits packets of VLAN2 and VLAN3 carrying VLAN tags. In this way, PE1 can determine the home VPN of a received packet according to the VLAN tag and passes the packet to the corresponding tunnel.

How does MCE device accurately transmit private routing information of multiple VPN instances to PEs? This involves two steps: routing information exchange between MCE and VPN site, and between MCE and PE. There are several ways to exchange routing information, such as static route, RIP, OSPF, ISIS and BGP. If BGP routing protocol is used to exchange routing information, BGP MCE applies. Specifically, BGP MCE allows BGP protocol to support VRF and enable BGP routing information exchange under VRF. We need to configure the BGP peer for each VRF instance on MCE and introduce IGP routing information of corresponding VPN. As each VPN is generally in different ASs, EBGP is therefore used to advertise routes.

Protocol specification

NA.

Default configurations

The following table describes the default configurations of BGP MCE.

Function	Default setting
VRF instance	No VRF instance is created by default.
BGP-VRF binding	No BGP-VRF binding by default

The following products support BGP MCE: the RSR30, RSR50 and RSR50E series of routers.

Configuring BGP MCE

Configuring VRF instance and route-related attributes

Before configuring the BGP MCE, VRF instance and route-related attributes must be configured first:

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode
Ruijie(config)# **ip vrf** *VRF1*	Creates a VRF named VRF1 and enters VRF mode.
Ruijie(config-vrf)# **rd** *rd-value*	Configures VRF RD value, which is identified using XX:XX format, such as RD 1:100. 1 refers to the AS ID of backbone network, while 100 is a user-defined numerical value.
Ruijie(config-vrf)# **route-target both** | **export** | **import**} *rt-value*	Configures the route export and import RT attribute of VRF.
Ruijie(config-vrf)# {**export** | **import**} **map** *map*	Configures the route map for import and export routes to support policy-based filtering of import and export routes.
Ruijie(config-vrf)# **exit**	Exits VRF mode and enters global configuration mode
Ruijie(config)# **interface vlan** *2*	Enters VLAN 2 interface configuration mode.
Ruijie(config-if)# **ip vrf forwarding** *VRF1*	Associates interface with VRF instance of VRF2
Ruijie(config-if)# **ip address 172.16.25.18 255.255.255.0**	Configures IP address for VLAN 2
Ruijie(config-if)# **end**	Returns to privileged EXEC mode
Ruijie # **show running-config**	Verifies the configurations
Ruijie # **write**	(Optional) Saves configurations.

Configuring BGP route exchange between MCE and VPN site

To use the BGP protocol to exchange routing information between MCE and VPN sites, you need to bind BGP to the corresponding VRF instance on MCE, and configure site device as EBGP neighbor, as shown below:

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode
Ruijie(config)# **router bgp** *23*	Enables the BGP protocol and enters BGP routing process mode
Ruijie(config-router)# **address-family ipv4 vrf** *VRF1*	Enters the IPv4 address family configuration mode of VRF1
Ruijie(config-router-af)# **neighbor** 172.16.25.57 **remote-as** 65531	Configures EBGP neighbor and learns routing information advertised by VPN site through BGP.
Ruijie(config-router-af)# **redistribute** *ospf 1*	Introduces the routing information of remote VPN as advertised by PE. We assume that MCE and PE exchange routing information through OSPF protocol.
Ruijie(config- router-af))# **end**	Returns to privileged EXEC mode.
Ruijie # **show running-config**	Verifies the configurations.
Ruijie # **write**	(Optional) Saves configurations.

BGP protocol must also be enabled on CE devices at a VPN site, allowing the site to exchange routing information with MCE devices through BGP protocol.

Configuring BGP route exchange between MCE and PE

To use the BGP protocol to exchange routing information between MCE and PE, bind BGP to the corresponding VRF instance on MCE, and configure PE device as EBGP neighbor, as shown below:

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** ***23***	Enables BGP protocol and enter BGP routing mode.
Ruijie(config-router)# **address-family ipv4 vrf** *VRF1*	Enters IPv4 address family configuration mode of VRF1.
Ruijie(config-router-af)# **neighbor** 172.16.25.157 **remote-as** 65532	Configures EBGP neighbor and study the routing information advertised by PE through BGP.
Ruijie(config-router-af)# **redistribute** *ospf 1*	Introduces the routing information of local VPN. We assume that MCE and local VPN site exchange routing information through OSPF protocol.
Ruijie(config- router-af))# **end**	Returns to privileged EXEC mode.
Ruijie # **show running-config**	Verifies the configurations.
Ruijie # **write**	(Optional) Saves configurations.

BGP protocol must also be enabled on the PE device, and MCE must be configured as EBGP neighbor, allowing PE to exchange routing information with the MCE device through BGP protocol.

Displaying configurations

The "show" commands used in BGP MCE are similar to the "show" commands used in ordinary BGP. The following information is displayed: neighbor state, routing information and neighbor summary.

Command	Function
Ruijie # **show ip vrf**	Displays all VRF summary information on the device.
Ruijie # **show ip vrf detail [*VRF1*]**	Displays the detailed configurations of all VRFs or a specified VRF.
Ruijie # **show ip vrf interfaces** [*VRF1*]	Displays the interface binding information and state of all VRFs or a specified VRF.
Ruijie# show **ip bgp vrf** *VRF1* [**summary**| **neighbors**| *A.B.C.D*]	Displays the summary information, detailed information, specific routing information, and all routing information of BGP neighbor under VRF1. Similar to those "show" commands used in ordinary BGP, other sub-commands are not discussed herein.
Ruijie# **show bgp vpnv4 unicast** [**all** | **rd** *rd* | **vrf** *vrf-name*] [**neighbors** | **summary** | *A.B.C.D*]	This command is similar to the above command, but the routes displayed are different: "all" will display all vpn routes, "rd" will display vpn routes with a specified RD value, and "vrf" will display vpn routes under a specified VRF.

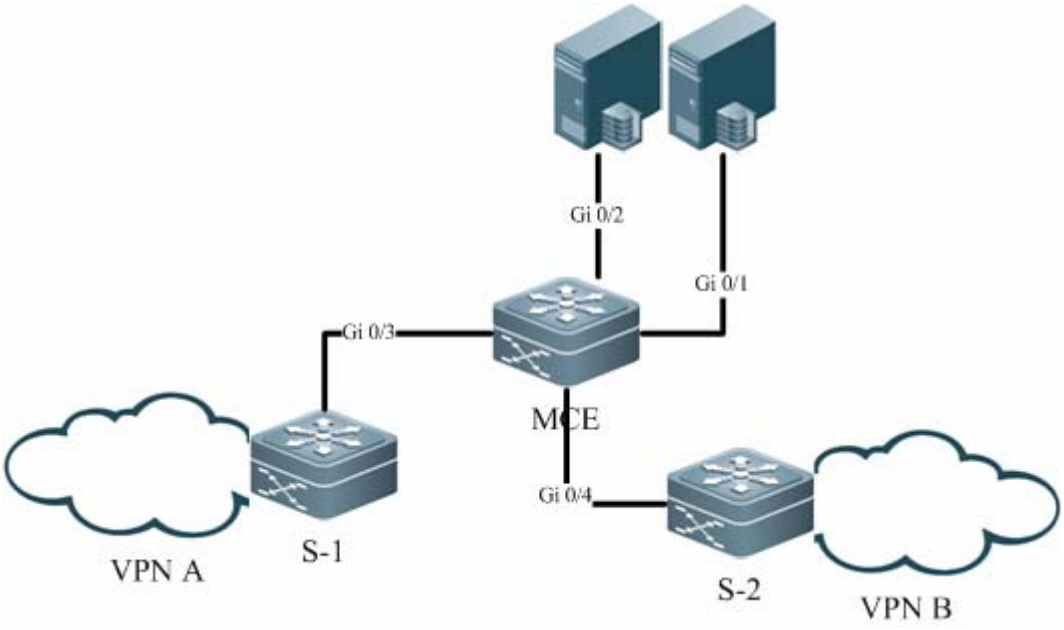
Typical BGP MCE Configuration Examples

Networking Requirements

A company needs to isolate the networks of two subsidiaries: A and B, and expects both subsidiaries to access the resource servers at the same time. OSPF protocol operates on the networks of subsidiary A and subsidiary B. An MCE device is used to isolate A and B. The device is directly connected with multiple resource servers.

Network Topology

Figure 17 Network topology of BGP MCE



S-1 is the convergence device on the network of subsidiary A; S-2 is the convergence device on the network of subsidiary B. S-1 and S-2 are both connected with the MCE device, with connecting interfaces belonging to different VRF instances and running the OSPF routing protocol. Gi 0/1 and Gi 0/2 of the MCE is directly connected with resource servers, and belong to another separate VRF instance.

Configuration Tips

We assume that OSPF protocol is running normally on VPN A connected directly with S-1 and VPN B connected directly with S-2. The following configurations are related to the MCE device.

31) Configure VRF instances and associate with interfaces to allow network isolation;

32) Configure OSPF routing protocol and associate with VRF, so that MCE can learn the routes to respective subsidiaries;

33) Configure BGP routing protocol and import OSPF routes and directly connected routes, allowing route exchange between different VRFs;

34) Configure the import and export route attributes of VRF instance, so that both subsidiaries can access the resource servers;

Configuration Steps

35) Configures VRF instances and associate with interfaces;

Create three VRF instances: VRF1, VRF2 and VRF3

```
Ruijie# config terminal
Ruijie(config)# ip vrf VRF1
Ruijie(config-vrf)# rd 100:1
```

```
Ruijie(config-vrf)# exit
Ruijie(config)# ip vrf VRF2
Ruijie(config-vrf)# rd 100:2
Ruijie(config-vrf)# exit
Ruijie(config)# ip vrf VRF3
Ruijie(config-vrf)# rd 100:3
Ruijie(config-vrf)# exit
```

Bind Gi0/1 and Gi0/2 to VRF3, Gi0/3 to VRF1 and Gi0/4 to VRF2

```
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-GigabitEthernet 0/1)#ip vrf forwarding VRF3
Ruijie(config-GigabitEthernet 0/1)#ip address 10.1.1.1 255.255.255.0
Ruijie(config)#interface gigabitEthernet 0/2
Ruijie(config-GigabitEthernet 0/2)#ip vrf forwarding VRF3
Ruijie(config-GigabitEthernet 0/2)#ip address 10.1.2.2 255.255.255.0
Ruijie(config)#interface gigabitEthernet 0/3
Ruijie(config-GigabitEthernet 0/3)#ip vrf forwarding VRF1
Ruijie(config-GigabitEthernet 0/3)#ip address 172.16.25.18 255.255.255.0
Ruijie(config)#interface gigabitEthernet 0/4
Ruijie(config-GigabitEthernet 0/4)#ip vrf forwarding VRF2
Ruijie(config-GigabitEthernet 0/4)# ip address 192.168.25.18 255.255.255.0
```

36) Configure OSPF routing protocol and associate with VRF;

Create OSPF 1 and OSPF 2 and associate with VRF1 and VRF2

```
Ruijie# config terminal
Ruijie(config)# router ospf 1 vrf VRF1
Ruijie(config-router)# network 172.16.25.0 0.0.0.255 area 0
Ruijie(config-router)# exit
Ruijie(config)# router ospf 2 vrf VRF2
Ruijie(config-router)# network 192.168.25.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

37) Configure BGP protocol and import routes

Configure BGP protocol and import OSPF routes to BGP VRF instance

```
Ruijie# config terminal
Ruijie(config)# router bgp 100
Ruijie(config-router)# address-family ipv4 vrf VRF1
Ruijie(config-router-af)# redistribute ospf 1
Ruijie(config-router-af)# exit
Ruijie(config-router)# address-family ipv4 vrf VRF2
Ruijie(config-router-af)# redistribute ospf 2
```

Import the directly connected routes of VRF3 to BGP VRF3 instance

```
Ruijie(config-router)# address-family ipv4 vrf VRF3
```

```
Ruijie(config-router-af)# redistribute connect
```

38) Configure the import and export route attributes of VRF instance

Configure the import route attribute of VRF1 as 100:3 and export attribute as 100:1

```
Ruijie(config)# ip vrf VRF1
Ruijie(config-vrf)# route-target import 100:3
Ruijie(config-vrf)# route-target export 100:1
Ruijie(config-vrf)# exit
```

Configure the import route attribute of VRF2 as 100:3 and export attribute as 100:2

```
Ruijie(config)# ip vrf VRF2
Ruijie(config-vrf)# route-target import 100:3
Ruijie(config-vrf)# route-target export 100:2
Ruijie(config-vrf)# exit
```

Configure the import route attribute of VRF3 as 100:1 and 100:2 and export attribute as 100:3

```
Ruijie(config)# ip vrf VRF2
Ruijie(config-vrf)# route-target import 100:1 100:2
Ruijie(config-vrf)# route-target export 100:3
Ruijie(config-vrf)# exit
```

Verification

Execute the following steps to verify configurations:

39) Verify the state of interfaces bound to VRF. Execute the **show ip vrf interface** command to verify interface binding information and the interface state.

40)

```
Ruijie#sh ip vrf interfaces
Interface           IP-Address     VRF                Protocol
GigabitEthernet 0/1  10.1.1.1       VRF3               up
GigabitEthernet 0/2  10.1.2.1       VRF3               up
GigabitEthernet 0/3  172.16.25.18   VRF1               up
GigabitEthernet 0/4  192.168.25.18  VRF2               up
```

41) Verify whether OSPF protocol bindings are correct and whether OSPF protocol runs normally. Execute the **show ip ospf** command to verify whether the OSPF instance is properly bound to VRF;

42) Verify whether the routes imported by BGP instance are correct. Execute the **show ip bgp vrf** or **show bgp vpnv4 unicast** command to verify whether the imported routes are correct, as shown below:

```
Ruijie#sh ip bgp vrf VRF3
BGP table version is 1, local router ID is 10.14.219.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network         Next Hop          Metric  LocPrf     Weight Path
*> 10.1.1.0/24    0.0.0.0            0       32768      ?
```

```
*> 10.1.2.0/24    0.0.0.0             0        32768      ?
Total number of prefixes 2
```

43) Execute the **show ip bgp vrf** command to verify whether routes of other VRFs have been properly imported to local VRF. Execute the **show ip route vrf** command to verify whether routes are correct.

```
Ruijie#sh ip bgp vrf VRF3
BGP table version is 1, local router ID is 10.14.219.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network          Next Hop          Metric  LocPrf     Weight Path
*> 10.1.1.0/24    0.0.0.0             0        32768      ?
*> 10.1.2.0/24    0.0.0.0             0        32768      ?
*> 172.16.22.0/24 0.0.0.0             0        32768      ?
*> 172.16.23.0/24 0.0.0.0             0        32768      ?
*> 172.16.25.0/24 0.0.0.0             0        32768      ?
*> 192.168.22.0    0.0.0.0            0        32768      ?
*> 192.168.23.0    0.0.0.0            0        32768      ?
*> 192.168.25.0    0.0.0.0            0        32768      ?
Total number of prefixes 8
Ruijie#sh ip route vrf VRF1
Routing Table: VRF1
Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default
Gateway of last resort is no set
C    10.1.1.0/24 is directly connected, GigabitEthernet 0/1
C    10.1.1.1/32 is local host.
C    10.1.2.0/24 is directly connected, GigabitEthernet 0/2
C    10.1.2.1/32 is local host.
B    172.16.22.0/24 [20/0] via 0.0.0.0, 00:10:46, GigabitEthernet 0/3
B    172.16.23.0/24 [20/0] via 0.0.0.0, 00:10:46, GigabitEthernet 0/3
B    172.16.25.0/24 [20/0] via 0.0.0.0, 00:10:46, GigabitEthernet 0/3
B    192.168.22.0/24 [20/0] via 0.0.0.0, 00:10:46, GigabitEthernet 0/4
B    192.168.23.0/24 [20/0] via 0.0.0.0, 00:10:46, GigabitEthernet 0/4
B    192.168.25.0/24 [20/0] via 0.0.0.0, 00:10:46, GigabitEthernet 0/4
```

Configuring BGP 4-Octet AS

About 4-octet AS

Overview

A traditional AS number consists of two octets within the range of 1-65535. The AS number defined by RFC4893 consists of four octets falling within the range of 1-4294967295 to ease the burden of AS number resources. According to RFC5396, a 4-octet AS number supports two representation formats: asplain and asdot+. The two representations take the same format. Specifically, the 4-octet AS number will be represented using decimal value. The asdot+ representation contains ([high order 2 octets.] low order 2 octets). The high order 2 octets are not displayed if the value is 0. In other words, the AS number of 65536 in asplain format will be represented as 1.0 in asdot+ format. In addition, the AS number of 65534 in asplain format will be represented as 65534 in asdot+ format (without displaying the 0 value).

Working principle

The 4-octet AS number requires a BGP connection between an old bgp speaker supporting only 2-octet AS number and a new bgp speaker supporting 4-octet AS number. If the autonomous system for the new bgp speaker uses a 4-octet AS number, the old bgp speaker must use the reserved AS number of 23456 to replace the 4-octet AS number of new bgp speaker while creating a neighbor. In the packets sent from the new bgp speaker to the old bgp speaker, 23456 will replace the 4-octet AS number in the domain of "My Autonomous System". Meanwhile, in the UPDAT packets sent to the old bgp speaker, 23456 will replace the 4-octet AS number found in AS-PATH and AGGREGATOR attributes. These packets also carry the true 4-octet AS number reserved in the optional transitive attributes of AS4-PATH and AS4-AGGREGATOR. Therefore, the true AS-PATH attribute and AGGREGATOR attribute can be restored when this route reaches the next new bgp speaker.

In other cases, the true AS number of peer side is directly used to create a neighbor.

Protocol Specification

RFC 4893

RFC 5396

Default Configurations

By default, BGP protocol is not enabled. After BGP protocol is enabled, the decimal value is used by default to represent 4-octet AS numbers.

Configuring BGP 4-octet AS

Configuring BGP instance with 4-octet AS number

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode
Ruijie(config)# **router bgp 65538**	Enables BGP protocol and configure device AS number as 65538
Ruijie(config)# **router bgp 1.2**	Uses asdot+ format 1.2 to represent four-octet AS number of 65538
Ruijie(config-router)# **end**	Returns to privileged EXEC mode.
Ruijie # **write**	(Optional) Saves configurations.

Configuring the display format of 4-octet AS number

By default, the asplain format is used to display a 4-octet AS number. You can also configure the display format as asdot+. Meanwhile, after changing the display format of a 4-octet AS number, the 4-octet AS number in regular expression will be matched using asdot+ format.

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode
Ruijie(config)# **router bgp 65538**	Enables BGP protocol and configures the device AS number as 65538
Ruijie(config-router)# **bgp asnotation dot**	Use the asdot+ format to display 4-octet AS number, namely 1.2
Ruijie(config-router)# **end**	Returns to privileged EXEC mode.
Ruijie # **clear ip bgp** *	Resets BGP protocol for re-matching the regular expression.
Ruijie # **write**	(Optional) Saves configurations.

After executing the **bgp asnotation dot** command, you must execute the **clear ip bgp *** command to reset BGP protocol, so that the regular expression can be rematched.

Displaying configurations

Execute the **show** command to view the configuration of the 4-octet AS number. This command is similar to the **show** command used in BGP mode.

Command	Function
Ruijie # **show ip bgp summary**	Displays the connection state of all BGP neighbors.

Typical BGP 4-Octet AS Configuration Examples

Interconnection between 4-octet AS and 2-octet AS

Networking requirements

44) A BGP connection is established between the router supporting 2-octet AS number and the router supporting 4-octet AS number (using 2-octet AS number);

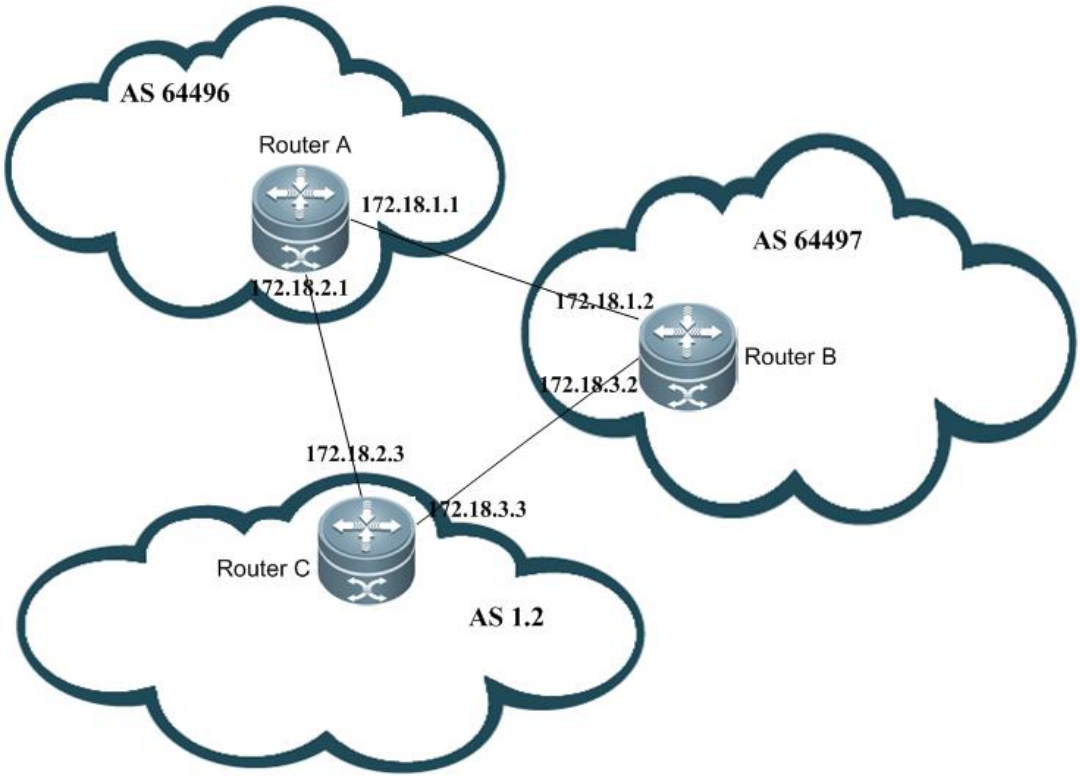
45) A BGP connection is established between the router supporting 2-octet AS number and the router supporting 4-octet AS number (using 4-octet AS number);

46) A BGP connection is established between routers supporting 4-octet AS number, with one router using 2-octet AS number and the other router using 4-octet AS number.

Network topology

As shown in the figure below, Router A, Router B and Router C are edge routers of three autonomous systems, and BGP connections have been established between them. Router A only supports 2-octet AS numbers; Router B and Router C support 4-octet AS numbers. The autonomous system of Router A uses a 2-octet AS number of 64496; the autonomous system of Router B uses a 2-octet AS number of 64497; the autonomous system of Router C uses a 4-octet number of 1.2.

Figure 18 BGP 4-Octet AS configuration



Configuration tips

47) Router A cannot recognize the 4-octet AS number of 1.2 used by the autonomous system of Router C. When a neighbor is created, the reserved AS number of 23456 must replace 1.2 during the configuration of remote-as.

48) Although Router B supports 4-octet AS numbers, it still uses a 2-octet AS number. Therefore, the AS number of the peer can be used as remote-as while neighbor interconnection is created between Router A and Router B.

49) Router B can recognize the 4-octet AS number used by the autonomous system of Router C. The AS number of the peer can be used as remote-as while a neighbor is created.

Configuration Steps

1. Router A

```
Ruijie# conf t
Ruijie(config)# router bgp 64496
Ruijie(config-router)# neighbor 172.18.1.2 remote-as 64497
Ruijie(config-router)# neighbor 172.18.2.3 remote-as 23456
```

2. Router B

```
Ruijie# conf t
Ruijie(config)# router bgp 64497
Ruijie(config-router)# neighbor 172.18.1.1 remote-as 64496
Ruijie(config-router)# neighbor 172.18.3.3 remote-as 1.2
```

Use "bgp asnotation dot" command to change the display format of 4-octet AS number

```
Ruijie(config-router)# bgp asnotation dot
Ruijie(config-router)# end
Ruijie# clear ip bgp *
```

3. Router C

```
Ruijie# conft
Ruijie(config)# router bgp 1.2
Ruijie(config-router)# neighbor 172.18.2.1 remote-as 64496
Ruijie(config-router)# neighbor 172.18.3.2 remote-as 64497
```

Verification

50) Display the state of neighbor connection on Router A:

```
Ruijie# show ip bgp summary
BGP router identifier 172.18.1.1, local AS number 64496
BGP table version is 1, main routing table version 1
Neighbor        V         AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  Statd
172.18.1.2      4      64497       7       7        1    0    0 00:03:04     0
172.18.2.3      4      23456       4       4        1    0    0 00:00:15     0
```

51) Display the state of neighbor connection on Router B:

```
Ruijie# show ip bgp summary
```

```
BGP router identifier 172.18.3.2, local AS number 64497
BGP table version is 1, main routing table version 1
Neighbor       V         AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  Statd
172.18.1.1     4      64496      7      7       1    0    0 00:03:04     0
172.18.3.2     4      65538      4      4       1    0    0 00:01:18     0
```

After executing "bgp notation dot" command, the following information will be displayed:

```
Ruijie# show ip bgp summary
BGP router identifier 172.18.3.2, local AS number 64497
BGP table version is 1, main routing table version 1
Neighbor       V         AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  Statd
172.18.1.1     4      64496      7      7       1    0    0 00:00:04     0
172.18.3.2     4        1.2      4      4       1    0    0 00:00:16     0
```

52) Display the state of neighbor connection on Router C:

```
Ruijie# show ip bgp summary
BGP router identifier 172.18.3.3, local AS number 65538
BGP table version is 1, main routing table version 1
Neighbor       V         AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  Statd
172.18.2.1     4      64496      7      7       1    0    0 00:00:15     0
172.18.3.2     4      65597      4      4       1    0    0 00:01:19     0
```

Configuring the BGP MDT Address Family

About the MDT Address Family

When using PIM-SSM to create Default-MDT during multicast VPN network configuration, configure a BGP MDT address family. Through routing based on the MDT address family, PE can discover other PE addresses and initiate the grating of SPT to other PEs (Configuration steps are detailed in "MD-SCG.doc").

Default configurations

No address family is configured.

Configuring MDT address family

Configuring VRF instance and route-related attributes

Before configuring the MDT address family, VRF instance and route-related attributes must be configured:

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode
Ruijie(config)# **ip vrf** *VRF*	Creates a VRF named VRF1 and enters VRF mode.
Ruijie(config-vrf)# **rd** *rd-value*	Configures VRF RD value, which is identified using XX:XX format, such as RD 1:100. 1 refers to the AS ID of backbone network, while 100 is a numerical value specified by the user.
Ruijie(config-vrf)# **route-target** {**both** | **export** | **import**} *rt-value*	Configures route export and import RT attribute of VRF.
Ruijie(config-vrf)# {**export** | **import**} **map** *map*	Configures the route map for import and export routes, allowing policy-based filtering of import and export routes.
Ruijie(config-vrf)# **mdt default** *group-address*	Configures MDT group address of VRF.
Ruijie(config-vrf)# **exit**	Exit VRF mode and enter global configuration mode
Ruijie(config)# **interface** *IFNAME*	Enters interface configuration mode
Ruijie(config-if)# **ip vrf forwarding** *VRF*	Associates interface with VRF instance
Ruijie(config-if)# **ip address** *ip-address mask*	Configures an IP address for the interface
Ruijie(config-if)# **end**	Returns to privileged EXEC mode
Ruijie # **show running-config**	Verifies the configurations.
Ruijie # **write**	(Optional) Saves configurations.

Configuring MDT address family

The following part describes the steps of configuring an MDT address family:

Command	Function
Ruijie**# configure terminal**	Enters global configuration mode.
Ruijie(config)**# router bgp** *asn-num*	Creates BGP and enters BGP configuration mode.
Ruijie(config-router)**# neighbor** *ip-address* **remote-as** *asn-number*	Configures BGP session.
Ruiije(config-router)**# neighbor** *ip-address* **update-source** *interface-name*	Configures the router to use interface address as the source address when MP-IBGP session is established. Usually, a Loopback interface address is used as the source address.
Ruiije(config-router)**# address-family ipv4** mdt	Enters MDT address family.
Ruijie(config-router-af)**# neighbor** *ip-address* **activate**	Activates the route to exchange MDT address family on BGP session.
Ruijie(config-router-af)**# neighbor** *ip-address* **next-hop-self**	Changes the next-hop route. This command can be executed on ASBR in OptionB.

Displaying configurations

The BGP MDT address family can be viewed by executing the **show bgp ipv4 mdt** commands, as listed in the following table:

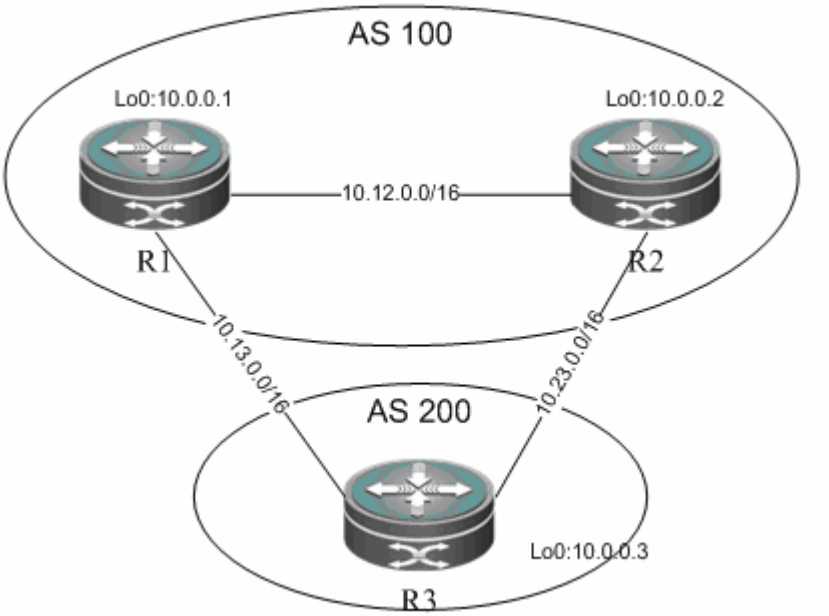
Command	Function
Ruijie **# show bgp ipv4 mdt all** [*ip-address* | neighbor [*ip-address*] | **summary**]	Displays all routes under all RDs, a specified route, neighbor information and summary information of the MDT address family.
Ruijie **# show bgp ipv4 mdt rd** *rd* [*ip-address*]	Displays all routes or a specified route under a specified RD of the MDT address family.

Typical Configuration Examples

Networking requirements

R1 and R2 belong to the same AS. R3 belongs to another AS. Multicast VPN must be established between them, and BGP is used to transmit information about the MDT address family.

Network topology



R1 and R2 belong to AS100. An IBGP connection is established between R1 and R2 to transmit routes of the MDT address family. R3 belongs to AS200 and establishes EBGP connections with R1 and R2 to transmit the MDT address family.

Configuration tips

53) Configure VRF instances and associate with interfaces for network isolation;

54) Configure BGP routing protocol to advertise routes of the MDT address family

Configuration Steps

55) Configure VRF instances and associate with interfaces;

- R1

Create a VRF instance named "VRF1"

```
Ruijie# config terminal
Ruijie(config)# ip vrf VRF1
Ruijie(config-vrf)# rd 100:1
Ruijie(config-vrf)# route-target both 123:123
Ruijie(config-vrf)# mdt default 232.1.1.1
Ruijie(config-vrf)# exit
```

Associate Gi0/1 with VRF1

```
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-GigabitEthernet 0/1)# ip vrf forwarding VRF1
Ruijie(config-GigabitEthernet 0/1)# ip address 10.1.1.1 255.255.255.0
Ruijie(config-GigabitEthernet 0/1)# exit
```

```
R2 and R3 are configured to be the same as R1.
```

56) Configure the BGP routing protocol to advertise routes of the MDT address family

- R1

Configure the MDT address family

```
Ruijie# configure terminal
Ruijie(config)# router bgp 100
```

Configure R2 and R3 as BGP neighbors

```
Ruijie(config-router)# neighbor 10.0.0.2 remote-as 100
Ruijie(config-router)# neighbor 10.0.0.2 update-source loopback 0
Ruijie(config-router)# neighbor 10.13.0.3 remote-as 200
```

Activate R2 and R3 under the MDT address family

```
Ruijie(config-router)# address-family ipv4 mdt
Ruijie(config-router-af)# neighobr 10.0.0.2 activate
Ruijie(config-router-af)# neighobr 10.13.0.3 activate
```

Activate R2 and R3 under the VPNv4 address family

```
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighobr 10.0.0.2 activate
Ruijie(config-router-af)# neighobr 10.13.0.3 activate
```

Bind VRF to BGP

```
Ruijie(config-router)# address-family ipv4 vrf VRFi
Ruijie(config-router)# exit
R2 and R3 are configured to be the same as R1.
```

Verification

Take the following steps to verify configurations:

57) Verify the state of interfaces bound to VRF. Execute the **show ip vrf interface** to verify interface binding information and state.

```
Ruijie#show ip vrf interfaces
Interface           IP-Address     VRF                Protocol
GigabitEthernet 0/1  10.1.1.1       VRF1                up
```

58) Ensure MDT routes exist in BGP protocol, as shown below:

```
Ruijie#show bgp ipv4 mdt all
BGP table version is 1, local router ID is 10.0.0.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network        Next Hop          Metric  LocPrf     Weight Path
Route Distinguisher: 100:1
```

```
*> 10.0.0.1/32    0.0.0.0             0        32768      ?
*>i10.0.0.2/32    10.0.0.2            0        100        ?
*> 10.0.0.3/32    10.13.0.3           0                  200 ?
Total number of prefixes 3
```

Configuring BGP Multi-Path Load Balancing

Understanding BGP Multi-Path Load Balancing

Overview

Multi-path load balancing means data packets are equally forwarded from a number of paths to the same network, and multiple next hops are present in the routing table. Based on the type of equivalent route, BGP multi-path load balancing comes under the following two categories:

- EBGP load balancing: through routes from EBGP neighbors.
- IBGP load balancing: through routes from IBGP neighbors.

Caution The protocol currently does not support load balancing between IBGP and EBGP routes.

Currently, IPv4 and IPv6 protocol stacks support multi-path load balancing, a maximum number of 32 equivalent next hops. The BGP does not limit the number of equivalent routes. This also applies to IBGP and EBGP load balancing.

Working Principle

BGP selects the route with the highest priority from multiple routes that are contained in the BGP routing table and destined to the same network. If several routes have the same priority and are all optimal, BGP will select the only one based on comparison and advertises the route to the forwarding plane for data flow control. When multi-path load balancing is enabled, BGP will list the routes with the same priority as the only optimal route as equivalent routes and advertise the optimal route and its equivalent routes to the forwarding plane for load balancing. Equivalent routes have the same priority and basic attributes.

Protocol Specifications

N/A

Default Configuration

BGP load balancing is disabled.

Configuring BGP Multi-Path Load Balancing

Configuring EBGP Load Balancing

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *as-number*	Enables BGP and specifies the *as-number* range (1 to 4294967295).
Ruijie(config-router)# **maximum-paths ebgp** *number*	Sets the number of equivalent routes that support EBGP multi-path load balancing. *number* ranges from 1 to 32.
Ruijie(config-router)# **end**	Returns to privilege mode.
Ruijie # **write**	(Optional) Saves configuration.

Configuring IBGP Load Balancing

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *as-number*	Enables BGP and specifies the *as-number* range (1 to 4294967295).
Ruijie(config-router)# **maximum-paths ibgp** *number*	Sets the number of equivalent routes that support IBGP multi-path load balancing. *number* ranges from 1 to 32.
Ruijie(config-router)# **end**	Returns to privilege mode.
Ruijie # **write**	(Optional) Saves configuration.

Configuring AS-PATH Loose Comparison

By default, equivalent routes must have equal AS-PATH. This requirement is too strict in some cases. For load balancing, AS-PATH loose comparison is recommended. Under the AS-APTH loose comparison mode, equivalent routes only need to have equal AS-PATH and AS-PATH in addition to meeting other criteria.

Command	Function
Ruijie # **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *number*	Enables BGP and specifies the *as-number* range (1 to 4294967295).
Ruijie(config-router)# **bgp bestpath as-path multipath-relax**	Enables BGP AS-PATH loose comparison.
Ruijie(config-router)# **maximum-paths ibgp** *number*	Sets the number of equivalent routes that support IBGP multi-path load balancing. *number* ranges from 1 to 32.
Ruijie(config-router)# **end**	Returns to privilege mode.
Ruijie # write	(Optional) Saves configuration.

Checking Configuration

Use the **show** command to view information about equivalent routes.

Command	Function

Ruijie # **show ip bgp**	Displays BGP routing information.
Ruijie # **show ip route**	Checks information in the core routing table.

Typical Configuration Examples of BGP Multi-Path Load Balancing

Configuring IBGP Non-Equivalent Load Balancing

Networking Requirements

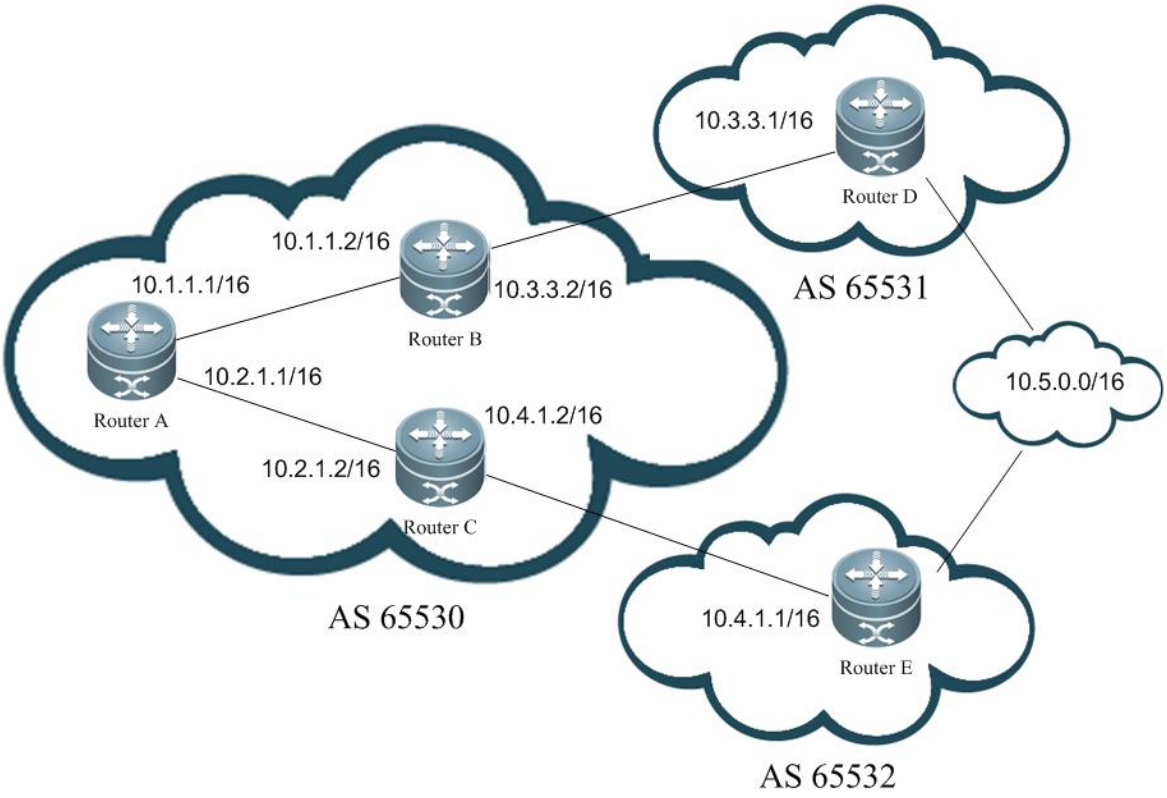
59) Achieves load balancing based on routes learned from IBGP neighbors;

60) Supports BGP AS-PATH loose comparison.

Network Topology

As shown in the following figure, Routers A, B and C belong to the same AS numbered 65530. Routers D and E belong to AS 65531 and 65532, which are linked by a BGP connection. AS 65531 and AS 65532 contain the route 10.5.0.0/16 with the same prefix and send the route to AS 65530. Router A learn the route 10.5.0.0/16 from Router B and Router C.

Figure 19 Configuring BGP ECMP



Configuration Precautions

61) Enables IBGP load balancing on Router A, and AS-PATH loose comparison.

62) Routers B and D, Routers C and E are connected to EBGP neighbors through a single hop.

63) Routers B and C consider Router A as IBGP neighbors.

Configuration Steps

64) Configuration on Router A

```
Ruijie# conf t
Ruijie(config)# interface fastEthernet 0/0
Ruijie(config-if-FastEthernet 0/0)# ip address 10.1.1.1 255.255.0.0
Ruijie(config-if-FastEthernet 0/0)# exit
Ruijie(config)# interface fastEthernet 0/1
Ruijie(config-if-FastEthernet 0/1)# ip address 10.2.1.1 255.255.0.0
Ruijie(config-if-FastEthernet 0/1)# exit
Ruijie(config)# ip route 10.3.0.0 255.255.0.0 10.1.1.2
Ruijie(config)# ip route 10.4.0.0 255.255.0.0 10.2.1.2
Ruijie(config)# router bgp 65530
Ruijie(config-router)# neighbor 10.1.1.2 remote-as 65530
Ruijie(config-router)# neighbor 10.2.1.2 remote-as 65530
Ruijie(config-router)# bgp maximum-paths ibgp 2
```

```
Ruijie(config-router)# bgp bestpath as-path multipath-relax
```

65) Configuration on Router B

```
Ruijie# conf t
Ruijie(config)# interface fastEthernet 0/0
Ruijie(config-if-FastEthernet 0/0)# ip address 10.1.1.2 255.255.0.0
Ruijie(config-if-FastEthernet 0/0)# exit
Ruijie(config)# interface fastEthernet 0/1
Ruijie(config-if-FastEthernet 0/1)# ip address 10.3.1.2 255.255.0.0
Ruijie(config-if-FastEthernet 0/1)# exit
Ruijie(config)# router bgp 65530
Ruijie(config-router)# neighbor 10.1.1.1 remote-as 65530
Ruijie(config-router)# neighbor 10.3.1.1 remote-as 65531
```

66) Configuration on Router C

```
Ruijie# conf t
Ruijie(config)# interface fastEthernet 0/0
Ruijie(config-if-FastEthernet 0/0)# ip address 10.2.1.2 255.255.0.0
Ruijie(config-if-FastEthernet 0/0)# exit
Ruijie(config)# interface fastEthernet 0/1
Ruijie(config-if-FastEthernet 0/1)# ip address 10.4.1.2 255.255.0.0
Ruijie(config-if-FastEthernet 0/1)# exit
Ruijie(config)# router bgp 65530
Ruijie(config-router)# neighbor 10.2.1.1 remote-as 65530
Ruijie(config-router)# neighbor 10.4.1.1 remote-as 65532
```

67) Configuration on Router D

```
Ruijie# conf t
Ruijie(config)# interface fastEthernet 0/0
Ruijie(config-if-FastEthernet 0/0)# ip address 10.3.1.1 255.255.0.0
Ruijie(config-if-FastEthernet 0/0)# exit
Ruijie(config)# interface loopback 1
Ruijie(config-if)#ip address 10.5.1.1 255.255.0.0
Ruijie(config-if-FastEthernet 0/1)# exit
Ruijie(config)# router bgp 65531
Ruijie(config-router)# neighbor 10.3.1.2 remote-as 65530
Ruijie(config-router)# redistribute connected
```

68) Configuration on Router E

```
Ruijie# conf t
Ruijie(config)# interface fastEthernet 0/0
Ruijie(config-if-FastEthernet 0/0)# ip address 10.4.1.1 255.255.0.0
Ruijie(config-if-FastEthernet 0/0)# exit
Ruijie(config)# interface loopback 1
Ruijie(config-if)#ip address 10.5.1.2 255.255.0.0
Ruijie(config-if-FastEthernet 0/1)# exit
Ruijie(config)# router bgp 65532
```

```
Ruijie(config-router)# neighbor 10.4.1.2 remote-as 65530
Ruijie(config-router)# redistribute connected
```

Checking Configuration

69) Check the status of neighbor connection on Router A:

```
Ruijie#show ip bgp summary
BGP router identifier 10.2.1.1, local AS number 65530
BGP table version is 9
2 BGP AS-PATH entries
0 BGP Community entries
3 BGP Prefix entries (Maximum-prefix:4294967295)
Neighbor        V   AS     MsgRcvd   MsgSent   TblVer   InQ   OutQ   Up/Down    State/PfxRcd
172.16.23.140   4   65530   29        25        8        0     0      00:18:48   2
172.16.23.141   4   65530   24        21        8        0     0      00:17:58   2
Total number of neighbors 2
```

70) Check BGP routes on Router A.

```
Ruijie#show ip bgp
BGP table version is 9, local router ID is 10.2.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network        Next Hop   Metric   LocPrf   Weight   Path
*>i10.3.0.0/16    10.3.1.1   0        100      0        65531 ?
*>i10.4.0.0/16    10.4.1.1   0        100      0        65532 ?
* i10.5.0.0/16    10.3.1.1   0        100      0        65531 ?
*>i               10.4.1.1   0        100      0        65532 ?
Total number of prefixes 3
```

71) Check BGP route 10.5.0.0 on Router A:

```
Ruijie#show ip bgp 10.5.0.0
BGP routing table entry for 10.5.0.0/16
Paths: (2 available, best #1, table Default-IP-Routing-Table)
  Not advertised to any peer
  65532
    10.4.1.1 from 10.2.1.2 (172.16.24.1)
      Origin incomplete, metric 0, localpref 100, valid, internal, multipath, best
      Last update: Mon Mar 21 03:45:14 2011
  65531
    10.3.1.1 from 10.1.1.2 (172.16.25.1)
      Origin incomplete, metric 0, localpref 100, valid, internal, multipath
      Last update: Mon Mar 21 03:45:14 2011
```

72) Check routes in Router A's core routing table:

```
Ruijie#show ip route
```

```
Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default
Gateway of last resort is no set
C    10.1.0.0/16 is directly connected, FastEthernet 0/0
C    10.1.1.1/32 is local host.
C    10.2.0.0/16 is directly connected, FastEthernet 0/1
C    10.2.1.1/32 is local host.
S    10.3.0.0/16 [1/0] via 10.1.1.2
S    10.4.0.0/16 [1/0] via 10.2.1.2
B    10.5.0.0/16 [200/0] via 10.3.1.1, 00:27:56
                 [200/0] via 10.4.1.1, 00:27:56
```

Configuring BGP/MPLS VPN

Please refer to the section "BGP/MPLS L3VPN Configuration" in the "MPLS Configuration Guideline" for details.

Configuring BGP/MVPN

Please refer to the section "Multicast VPN Configuration" in the "Multicast VPN Configuration Guideline" for details.

Configuring IS-IS

Understanding IS-IS Protocol

Overview

IS-IS (Intermediate System-to-Intermediate System) is a routing protocol defined in ISO10589. It was initially a dynamic routing protocol designed by ISO for CLNP (Connectionless Network Protocol). With IP getting more and more popular, IETF enables IS-IS to support IP in RFC1195 and develops IS-IS into Integrated IS-IS. After years of development, Integrated IS-IS has become a scalable, robust and easy-to-use IGP protocol, which is applicable to IP and ISO CLNS based dual-environment network.

As a link-state protocol, IS-IS has certain features shared by link-state protocols. It discovers and maintains adjacencies by sending Hello packets, and advertises its own link state by sending LSP (Link State PDU) to its neighbors. IS-IS has a two-level hierarchy (level 1 and level 2 routing), with all devices at the same level having the same LSDB, which stores the LSP generated by all devices at the same level. In this way, all devices at the same level are aware of the network topology of their level, and each device uses Dijkstra SPF algorithm to optimize route calculation, select path and achieve fast convergence.

Hierarchical Structure of IS-IS Network

Figure 1

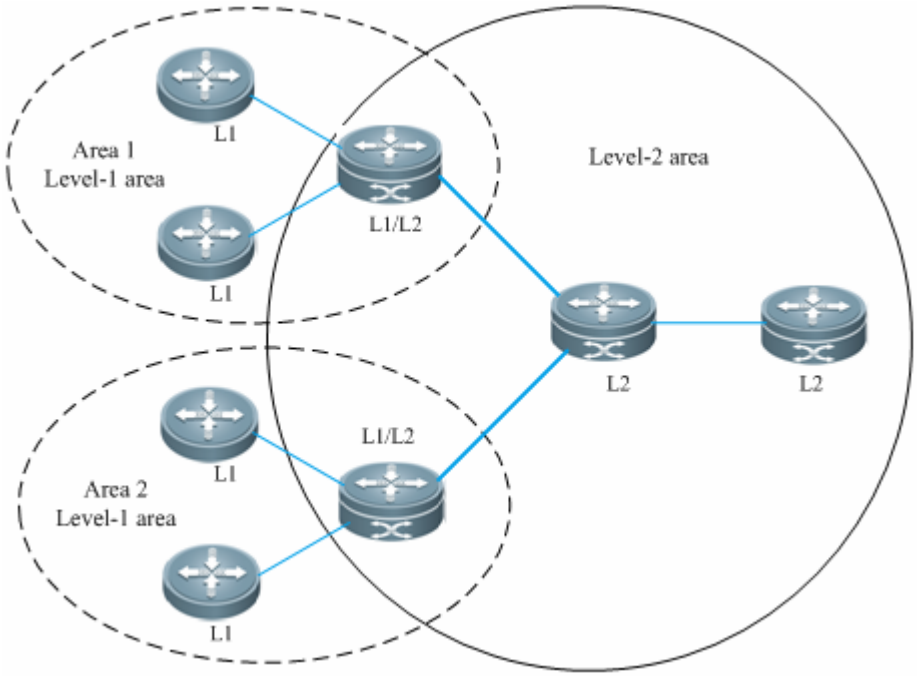


Figure 1 IS-IS hierarchy

This network is divided into Level-1 and Level-2. All nodes for exchanging information among devices in the same area form Level-1. All intra-area devices are aware of the network topology of entire area and carry out Inter-area data exchange. Level-1-2 devices are the boundary devices to connect different areas. Inter-area connection is achieved by connecting Level-2 devices, while the boundary devices of respective areas jointly form a backbone network (Level-2). Inter-area data exchange is carried out at level-2.

Level-1 devices only concern about the topology structure of the local area, including all nodes and next-hop devices reaching these nodes in the local area. Level-1 device accesses other areas through the Level-2 device, and forwards data packets in the destination network outside the area to the closest Level-2 device.

Address Encoding of IS-IS Protocol

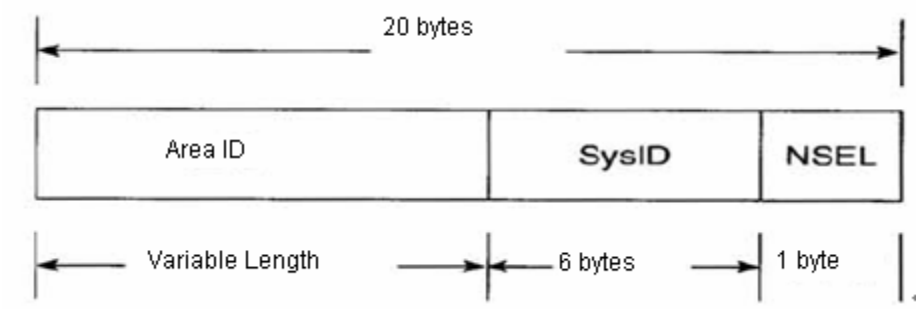


Figure 2 NET address format

IS-IS protocol address is called NET, which can be divided into three parts: Area address, System ID and NSAP selector. The total length of NSAP address ranges from 8 to 20 bytes.

The length reserved for area address is variable. The area ID is the length of route domain, and is fixed in the route domain. The length of area address ranges from 1 to 13 bytes.

The length of System ID is 6 bytes, and is unique in the autonomous system.

NSAP is the network selector, and is sometimes called SEL, with length being 1 byte. In IS-IS, SEL is usually set to 00 to represent the routing device.

IS-IS Packet Types

There are three types of packets:

- Link-state PDUs (LSP)
- IS-IS Hello PDUs

Sequence number PDUs (SNP)
Link-state PDUs (LSP) are used to advertise link-state logs within the area. They can be divided into: Level 1 Link State PDU and Level 2 Link State PDU. LSP will only be flooded at its own level.

IS-IS Hello PDUs (IIH PDU) are used to maintain adjacencies. Hello PDUs will send multicast MAC address to detect whether IS-IS is operated in other systems.

Sequence number PDUs (SNP) can be divided into CSNP and PSNP.

Complete sequence number PDU (CSNP) is used to synchronize LSDB. In a broadcast network, DIS will send CSNP packets once every 10 seconds by default. In a point-to-point network, CSNP packets will only be sent once after adjacency is formed.

Partial sequence number PDU (PSNP) is also used to synchronize LSDB.

DIS

DIS: Designated IS, the designated routing device in on the broadcast network, equivalent to the DR in OSPF.

Pseudonode: The pseudonode is generated by DIS and establishes contacts with all devices in the network.

DIS will model the multi-access link as a pseudonode to create pseudonode LSPs. All routing devices on the local network contact with the pseudonode, and no direct contact between them is allowed. The broadcast subnet and NBMA network are regarded as a pseudonode externally. All non-DIS devices on the network will report their link state to the DIS, which will report the link state on behalf of all ISs on the entire network. The reason to elect DIS is the same as the reason to elect DR in OSPF: to reduce unnecessary adjacencies and routing information exchange.

DIS is created through election. The DIS election in IS-IS is pre-emptive, which is different from DR in OSPF.

The result of DIS election can be controlled by configuring the "Priority" of interface. The one with the highest "Priority" value will be elected.

TLVs Supported by IS-IS

Currently, Ruijie IS-IS supports the following TLV codes:

TLV CODE	Description
Code=1	Area addresses
Code=2	Priority level information of IS neighbor
Code =3	ES neighbors
Code=6	MAC address of IS neighbor
Code=8	Padding
Code=9	LSP entries
Code=10	Authentication information
Code=14	Buffer size of source LSP
Code=22	Extended IS reachability
Code=128	IP internal reachability information
Code=129	Protocols supported
Code =130	IP external reachability information
Code=131	IDRP information
Code=132	IP interface address
Code=133	Authentication information

Code=135	Extended IP reachability TLV
Code=137	Dynamic host name
Code = 211	Graceful Restart
Code=232	IPV6 interface
Code =236	IPV6 IP Reachability TLV
Code =240	P2P 3-way handshake TLV

LSP Fragments Extension

IS-IS informs devices of link-state information by flooding LSP packets. The size of LSP packets is restricted by link MTU and cannot be extended. When the information to be informed exceeds the size of a LSP packet, IS-IS will create LSP fragments to carry new link-state information. According to the ISO standard, the LSP fragment is recognized by the 1-byte LSP Number. Therefore, the maximal number of LSP fragments produced by an IS-IS node is 256.

There are several reasons causing 256 fragments not enough:

- New TLV or Sub-TLV extended by new application, such as TE
- Constant expansion of network scale
- Informing routes with smaller chip or redistributing other routes to IS-IS.

When LSP fragments are filled, subsequent routing information and neighbor information will be discarded directly. There will be network anomaly, such as routing blackhole or routing loops. LSP fragments need to be extended to carry more link-state information to ensure normal operation of the network.

Definitions of fragments extension are listed as follows:

- Normal system-id: It refers to the current system ID defined by ISO, which is used to form adjacency and learn routes. “Nornal” differentiates this kind of system-id from additional system-id produced by fragments extension.
- Additional system-id: It is configured by the administrator and used to extend LAP, in comparison with normal system-id. Additional system-id does not appear in Hello packets for adjacency formation. Except that, additional system-id adopts the same rules as normal system-id, for example, it must be unique and cannot be repeated in the whole intra-area.
- Originating System: It refers to the routing device running the IS-IS protocol. It is in comparison with the virtual system identified by the additional system ID.
- Virtual System/Vritual IS: It refers to the system identified by additional system-id, which is used to generate extended LSP. RFC proposes this notion and differentiate it from the originating system. Every virtual system generates up to 256 LSP fragment packets. The administrator can configure several additional system IDs , which represent virtual systems, to generate more LSP fragment packets to meet the demand.
- Original LSP: The LSP packet is generated by the originating system. The system-id is normal system-id.
- Extended LSP: The LSP packet is generated by the virtual system. The system-id is additional system-id.

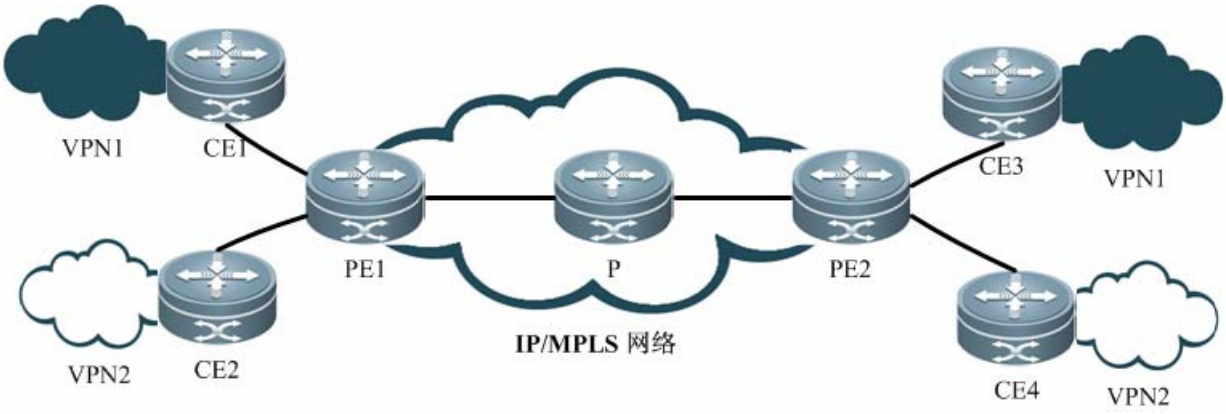
IS-IS can inform devices of more link-state information with extended LSP by setting additional system-id and enabling fragments extension. Every virtual system can be regarded as a virtual routing device which establishes adjacency with the originating system. The metric between them is 0. Extended LSP is the LSP packet released by the neighbor of originating system, namely the virtual system,

IS-IS VRF

VRF is short for VPN Routing and Forwading. It is mainly used to perform local routing, segregate data packets and address routing conflicts caused by VPNs using the same prefix. Most IPv4 and IPv6 VPNs are MPLS VPN. Combined with MPLS's advantage in service quality and security guarantee, MPLS VPN has become the preferred solution to enable interconnection among branches of enterprises and industries in different areas.

The following figure is a typical VRF networking application, which is to enable VPN segregation control by configuring VRF on PE devices.

Figure 1-3 Enabling VPN segregation control by configuring VRF on PE devices



As figure 1-3 shows, two site users (CE1 and CE3) under VPN1 should be able to visit each other. Two site users (CE2 and CE4) under VPN2 should be able to visit each other. VPN1 and VPN2 should not be able to visit each other for two reasons:

- The two VPNs belong to different users or departments. Mutual visit is prevented for security's sake.
- There may be the same IP address on VPN1 and VPN2.

CE is used to connect the user network to PE and exchange VPN routing information with PE: release local routes to PE and learn remote site routes from PE.

PE is used to learn routing from directly connected CE and exchange learned VPN routes with other PEs through BGP. The PE device is responsible for the access of VPN business.

The device P is a device that is not directly connected with CE on the operator network. The device is only required to support MPLS forwarding and cannot sense VPN.

The IS-IS routing protocol runs between PE and CE to enable VRF-based routes learning. PE and CE only learn routes within the same VPN to enable VPNs segregation control.

IS-IS Definitions

- ES: End System refers to non-router devices, such as host.
- IS: Intermediate System refers to router devices, the basic unit sending routing information and generating routes in the IS-IS protocol.
- ES-IS: End System-to-Intermediate System, an OSI protocol that defines how end systems (ES) and intermediate systems (IS) learn about each other.

- Domain: routing domain. In one routing domain, a group of ISs will exchange routing information through the same routing protocol.
- Area: a routing sub-domain. One routing domain can be divided into multiple areas.
- CSNP: Complete sequence number PDU, sent by DIS every 10 seconds on the broadcast network to synchronize link state.
- PSNP: Partial sequence number PDU, sent on the point-to-point link to acknowledge receipt of an LSP or on the broadcast network to request an LSP.
- ENPA: attached subnet point that provides subnet services.
- CLNP: Connectionless Network Protocol, an IP-alike OSI protocol to transmit data and error messages in the network layer.
- CNLS: Connectionless Network Service is the solution to unreliable connection which doesn't need the circuit to be established before data transmission.
- DIS: Designated Intermediate System, which is similar to the DR in OSPF. It floods LSPs to other devices on the LAN. Unlike OSPF, DIS forms adjacencies with other devices which also form adjacencies between each other.
- Hello: This packet is used to establish and maintain adjacencies.
- LSP: Link-state PDU, which is similar to the LSA in OSPF, but LSP doesn't rely on TCP/IP protocol information. There are different LSPs for different routes, such as L1 LSP and L2 LSP.
- NSEL: NSAP selector, sometimes also called SEL. It identifies a network service user, and is similar to the TCP/UDP port for upper-layer service in the IP protocol. In IS-IS, SEL is usually set to 00 to imply the routing device.
- NSAP: Network Service Access Point is the complete address for CLNS packets, including OSI address and high-level process, with structure containing area ID, System ID and SEL. A NSAP address with SEL being 00 implies the NET entity. It is similar to the combination of IP address and IP protocol number.
- SNPA: Sub-network Point of Attachment provides physical link and network layer services, and is similar to the MAC address in IP and DLCI, WAN and HDLC in FR.
- L1 router: The router inside an area. It only accepts relevant information from the local area. In order to reach other areas, a default route to the closest L2 must be saved in L1.
- L2 router: the trunk router between different areas. L1 cannot be directly connected with L2.
- L1/L2 router: The boundary router used to connected L1 router and L2 router, containing the databases of both L1 router and L2 routers. It is similar to the ABR in OSPF.
- Pseudonode: The identifier of broadcast subnet of LAN. Pseudonode makes broadcast media a virtual routing device, while every router acts as its interface. DIS manages the adjacency between router and pseudonode.
- NET: network entity title, a part of OSI address describing the area and system ID.
- Circuit: Circuit is the term for interface in IS-IS. NSAP and NET represent the entire device, while circuit represents the interface. For a point-to-point interface, the circuit ID is 1 byte long. For example, the circuit ID is 0x00 in HDLC; in a broadcast network such as LAN, the circuit ID is generally 7 bytes long combining the System ID, such as 1921.6800.0001.01.

To learn more details about IS-IS, please refer to ISO 10589 and RFC 1195.

IS-IS configuration task list

IS-IS configuration must be performed consistently on devices. When no configuration is performed, devices adopt the default setting and packets sent and received are not authenticated. The interface does not belong to any IS-IS process. Configuration on different devices should be consistent.

The following tasks must be performed to configure IS-IS. While others are optional according to actual application, IS-IS must be enabled.

- Enabling IS-IS
- Configuring IS-IS Hello packets
- Configuring IS-IS LSP packets
- Configuring IS-IS SNP packets
- Configuring IS-IS level type
- Configuring IS-IS authentication
- Configuring IS-IS GR (optional)
- Configuring other IS-IS parameters

The default configurations of IS-IS are given below:

Function	Default setting
Network interface	Interface metric: 10 Advertised Hello interval: 10 seconds Advertised CSNP interval: 10 seconds Minimal interval for LSP transmission: 33 milliseconds LSP retransmission interval: 5 seconds Hello multiplier number: 3 Priority for routing node election: 64 Circuit type: Level-1-2 Authentication password: none
System type	Level-1-2
Default route	Level-1 default route: enabled Level-2 default route: disabled.
LSP authentication password	NA
IS-IS GR	IS-IS GR Restarter: Disabled IS-IS GR Helper: Enabled
Summary-address	Undefined
Overload flag bit	Undefined
LSP checksum error	Enabled
Adjacency change logging	Disabled
LSP refresh interval	900 seconds
LSP lifetime	1200 seconds

Enabling IS-IS

Unlike other routing protocols, you need to first create an IS-IS routing process and specify the interfaces on which IS-IS shall be enabled.

Creating IS-IS Routing Process

Command	Function
Ruijie(config)# **router isis** [*tag*]	Starts IS-IS routing process, with tag being the name of IS-IS process.
Ruijie(config-router)# net areaAddress. SystemId.00	Configures the NET address of IS-IS.

- Create IS-IS route process:
- To run IS-IS routing protocol, first create IS-IS routing process in global configuration mode; you can also add "Tag" behind "router isis". This Tag refers to the name of IS-IS routing process. You can also choose not to configure the name of IS-IS routing process. You can configure different IS-IS routing processes by adding different Tags.
- Configure IS-IS protocol's system ID and area address:
- System ID is the only identifier of IS in an autonomous system. Therefore, System ID must be unique in the entire autonomous system. In IS-IS, each area can have one or multiple area addresses, and generally only one area address is needed. Area repartition can be done by configuring multiple area addresses. When configuring multiple area addresses for one IS, the System ID must be identical.

Example:

```
Ruijie(config-router)# net 49.0001.0000.0000.0001.00
```

In the above configuration command, the area address is 49.0001 and System ID is 0000.0000.0001.Dots in the numbers are for your convenience only.


Caution

Level-1 IS routing nodes in the same area must be configured with the same area address. Currently, the core routing table will not be sensitive to the IS-IS process generating the routing table.


Caution

By default, CPU protection is enabled on the switch. For packets corresponding to each destination group address of IS-IS (AllISSystems, AllL1ISSystems, AllL2ISSystems), there will be default limit in number when sent to the CPU. For example, the default limit is 400pps. If there are many adjacencies or if Hello packets are sent at short intervals, the IS-IS packets received by the switch may exceed the default limit, leading to the continual oscillation of adjacencies. In such a case, the limit for IS-IS packets must be raised by configuring such global commands of **cpu-protect type isis-is pps, cpu-protect type isis-l1is pps and cpu-protect type isis-l2is pps**.

Configuring IS-IS Protocol on the Interface

After global IS-IS protocol is enabled, you need to configure IS-IS protocol on the interface.

Use the following command to configure IS-IS protocol on the interface.

Command	**Function**

Ruijie(config-if)# ip router isis [tag]	Enables IPv4 IS-IS on the specified interface, with "tag" being the name of IS-IS process.
Ruijie(config-if)# **ipv6 router isis** [*tag*]	Enables IPv6 IS-IS on the specified interface, with "tag" being the name of IS-IS process.


Caution When configuring IP address, the IP address must be in the same network segment as the IP address of adjacent interface.


Caution If the IP address is not in the same network segment as the IP address of adjacent interface, the adjacency cannot be established.


Caution If the interface needs to join the specified IS-IS process, the Tag name of this IS-IS process must be added after "ip router isis".


Caution By configuring the no ip routing command in global configuration mode, IS-IS will disable IPv4 routing function on all interfaces, namely "no ip router isis [tag]" will be executed automatically on all interfaces, while other IS-IS configurations will remain unchanged.


Caution When you configure the IPv6 address, the local link address will be configured by default


Caution If the IPv6 address or the IPv6 address of the adjacent interface does not have the local link address, the adjacency cannot be established.


Caution If you want to add the interface to the designated IS-IS process, attach the Tag of this IS-IS process to the end of **ipv6 router isis.**


Caution If the **no ipv6 unicast-routing** command is executed in global configuration mode, IS-IS will disable IPv6 routing on all interfaces. Namely, the **no ipv6 router isis** [*tag*] command is executed automatically on all interfaces while other IS-IS configurations remain unchanged.


Caution In order to avoid routing blackholes on the network where IPv4 and IPv6 coexist, if protocols supported by two devices or interfaces are not the same, adjacency will not be set up. In this case, please check

whether the network topology has any problem. If there is no problem with the network topology and there are no routing blackholes, configure different instances to perform IPv4 and IPv6 routes learning.

Configuring IS-IS Hello Packets

Configuring the Advertised Hello Interval

IS-IS will periodically send Hello packets on the interface, while routing deviceswill discover and maintain adjacencies through the reception and sending of Hello packets. Complete the following configuration in interface configuration mode to set the Hello packet broadcast interval:

Command	Function
Ruijie(config-if)**#isis hello-interval** { **interval** | **minimal** } [**level-1** | **level-2**]	Configures the interval for sending Hello packets on the interface, in the range of 1 to 65535 seconds.

Use the command to change the interval for sending Hello packets. DIS in broadcast network will send Hello packets at an interval which is three times shorter than non-DIS. If IS is elected as DIS on this interface, the interface will send Hello packets every 3.3 seconds by default.

If the key word minimal is used, then the holdtime in Hello packets will be set to 1, and hello interval will be calculated based on the hello-multiplier. For example, if hello-multiplier is configured to 3 and the isis hello-interval minimal command is configured at the same time, the value of hello-interval shall be 1s/3 (333ms).


Caution

By default, CPU protection is enabled on the switch. For packets corresponding to each destination group address of IS-IS (AllISSystems, AllL1ISSystems, AllL2ISSystems), there will be default limit in number when sent to the CPU. For example, the default limit is 400pps. If there are many adjacencies or if Hello packets are sent at short intervals, the IS-IS packets received by the switch may exceed the default limit, leading to the continual oscillation of adjacencies. In such a case, the limit for IS-IS packets must be raised by configuring such global commands of cpu-protect type isis-is pps, cpu-protect type isis-l1is pps and cpu-protect type isis-l2is pps.

Configuring Hello Multiplier Number

IS-IS will periodically send the Hello packet on the interface, and advertise the adjacency hold time of the IS device in the header of the Hello packet. Neighbors will update adjacencies based on the holdtime field in the Hello packet header. The holdtime value in the Hello packet header equals to the hello-interval value multiplies the hello-multiplier value.

Complete the following configuration in interface configuration mode to set the Hello packet holdtime multiplier:

Command	Function
Ruijie(config-if)**# isis hello-multiplier multiplier-number** [**level-1** | **level-2**]	Configures Hello multiplier number on the interface.

Use the command to change the holdtime multiplier of Hello packets and the holdtime. The holdtime of Hello packets can also be changed by changing hello-interval or changing both of them.

Configuring Hello packet failure number

IS-IS protocol maintains relationships with adjacent routers by sending and receiving Hello packets. When the local router fails to receive a specific number of Hello packets from peers continuously, adjacent routers will be considered failed. The default number is three. Complete the following configuration in interface configuration mode to set the failure number of Hello packets:

Command	Function
Ruijie(config-if)# **isis hello-multiplier** *multiplier-number* [**level-1** | **level-2**]	Sets the number of failure Hello packets on the interface.

Configuring IS-IS LSP

Configuring LSP Minimal Transmission Interval

Complete the following configuration to set the minimum interval for sending LSP packets continuously by IS-IS on the interface:

Command	Function
Ruijie(config-if)# **isis lsp-interval** *interval*	Configures the minimal interval (1-4294967295 milliseconds) for sending LSPs on the interface.

Configuring LSP Retransmission Interval

On a point-to-point link, if the local router fails to receive any reply after sending LSPs for a while, it will assume that the LSPs sent formerly are lost or discarded. To ensure the reliability the LSP sending, the local routing device will retransmit the same LSPs. Complete the following configuration in interface configuration mode to set the packets retransmission interval:

Command	Function
Ruijie(config-if)# **isis retransmit-interval** *interval*	Configures the interval (1-65535 seconds) for retransmit LSPs on the point-to-point link.

Configuring LSP Refresh Interval

To ensure that each network node can maintain the latest LSP, LSP will periodically refresh the current LSP, and such interval is called LSP refresh interval. With this mechanism, LSPs can remain synchronized in the entire area. Complete the following configuration in IS-IS protocol configuration mode to set the LSP refreshing frequency:

Command	Function
Ruijie(config-router)# **lsp-refresh-interval** *interval*	Configures LSP refresh interval (1-65535 seconds).

Caution The lsp-refresh-interval shall be less than the max-lsp-lifetime.

Configuring LSP Lifetime

In LSP, there is a field value called LSP lifetime. When the routing device generates LSP, it will set the maximal lifetime in the field for this LSP. When the LSP is received by another routing decvice, the lifetime will decrease gradually, and the old LSP will be replaced if a new LSP is received. If no refreshed LSP is received and the LSP lifetime has decreased to 0, it will still be kept in the link-state database for 60 seconds. If no refreshed LSP is received within the 60 seconds, this LSP will be deleted from LSDB. With this mechanism, LSPs can remain synchronized in the entire area. Complete the following configuration in IS-IS protocol configuration mode to set the lifetime of LSPs generated by the router:

Command	Function
Ruijie(config-router)**#max-lsp-lifetime value**	Configures LSP lifetime (1-65535 seconds).

Caution The max-lsp-lifetime must be greater than lsp-refresh-interval.

Configuring LSP fragments expansion

The LSP fragments expansion function is enabled by setting additional system ID and enabling fragments expansion . Execute the following commands in IS-IS routing process configuration mode:

Command	Function
Ruijie(config-router)# **lsp-fragment-extend** [**level-1 | level-2**] [**compatible rfc3786**]	Enables fragments extension.
Ruijie(config-router)**#virtual-system** *system-id*	Sets additional system ID.

Configuring IS-IS SNP

Configuring the Advertised CSNP Interval

Complete Sequence Number PDUs (CSNP) are packets sent by DIS in the broadcast network to maintain link-state database synchronization. CSNPs are also periodic broadcast packets. Complete the following configuration in interface configuration mode to set the CSNP packet broadcasting interval:

Command	Function

Ruijie(config-if)# **isis csnp-interval** *interval* [**level-1** | **level-2**]	Configures the interval (0-65535 seconds) for sending CSNP packets on the interface.

Configure this command to change the interval for sending CSNP packets. By default, DIS on the broadcast network will send CSNP packets every 10 seconds.

For P2P interface network, CSNP packets will only be sent when adjacency is just established; if the interface is set mesh-groups, you can set sending CSNP packets periodically.

If csnp-interval is set to 0, no CSNP will be sent.

If **mesh-group** is required on the IS-IS interface, you need to configure a non-zero interval for sending VSNP packets to synchronize LSP by using the **isis csnp-interval** command so as to ensure complete LSP synchronization among adjacencies in the network.

Configuring IS-IS Level Type

IS-IS protocol supports two-level hierarchy, so as to manage route selection and achieve expandable route selection. Every level only maintains the topology structure of local area.

You can execute "is-type" command in IS-IS router configuration mode to configure IS-IS Level, or execute "circuit-type" command in the interface configuration mode to configure IS-IS Level of this interface. The default is-type and circuit-type are Level-1-2. If these two commands are configured simultaneously, the corresponding interface will only send Level PDUs with is-type being same as circuit-type.

Configuring System Type

You can configure the level of existing routing devices, which can be divided into Level-1 router (intra-area routing device), Level-2 (inter-area routing device) and Level-1-2 router (both an intra-area routing device and an inter-area routing device). If is-type is configured to Level-1 or Level-2-only, the IS-IS process will only process data at this level. Complete the following configuration in IS-IS protocol configuration mode to set Level of the router:

Command	Function
Ruijie(config-router)# **is-type** { **level-1** | **level-1-2** | **level-2-only** }	Configures system type.

Configuring the Interface Circuit Type

You can configure the type of the interface circuit. Complete the following configuration in interface configuration mode to set the type of the interface circuit:

Command	Function
Ruijie(config-if)# **isis circuit-type** { **level-1** | **level-1-2** | **level-2-only** }	Configures the interface circuit type.

If the circuit-type of "Level-1" or "Level-2-only" is configured, then IS-IS will only send PDUs of the same level.

Configuring IS-IS Authentication

You can configure IS-IS authentication to improve the security of IS-IS network. You can configure authentication for IS-IS in the different level ranges, which include IS-IS interface, IS-IS area and IS-IS route domain.

The interface authentication functions during adjacency formation. If two IS-IS devices are configured with different interface authentication passwords, the adjacency won't be formed, thus avoiding unauthorized or unauthenticated IS-IS devices from joining an IS-IS network in which authentication is required. The interface authentication password is encapsulated in the Hello packets.

IS-IS domain authentication and routing domain authentication are used to authenticate LSP, CSNP and PSNP packets, so as to avoid unauthorized or unauthenticated routing information from entering IS-IS link-state database. The authentication password is encapsulated in the corresponding LSP, CSNP and PSNP packets.

Currently, the following two kinds of authentication methods are provided: plain text authentication and MD5 authentication. The approach of plain text authentication can only guarantee limited security as the password carried by packets can be seen directly. The approach of MD5 authentication will provide better security as the password carried by packets has been encrypted using MD5 algorithm.

Configuring Interface Authentication

Configuring interface plain-text authentication

You can configure plain-text authentication password for IS-IS interface. The authentication password will be encapsulated in Hello packets sent on the interface; when Hello packets are received, consistency of the password will be examined.

IS-IS interface authentication should be configured in interface configuration mode. You can use the following command to configure interface plain-text authentication:

Command	Function
Ruijie(config)# **interface** *interface-name* Ruijie(config-if)# **isis password** *password* [**send-only**] [**level-1** | **level-2**]	Configures plain-text authentication password for Hello packets transmitted on the interface. When the send-only is specified, the authentication password is only applicable to the sent Hello packets rather than the received Hello packets. When Level is not specified, the authentication password configured is by default applicable to every Level. When configuring this command, if "isis authentication mode" has been executed, this command won't be configured successfully. Both commands can be used to configure IS-IS interface authentication, but this command has a lower priority level. To configure this command, you need to delete "isis authentication mode" command first.

You can also use the following commands to configure plain-text authentication for IS-IS interface:

Command	Function
Ruijie(config-if)# **isis authentication mode text** [**level-1** | **level-2**]	Use this command to specify the mode of IS-IS interface authentication. When Level is not specified, the authentication mode configured is by default applicable to every Level. When configuring this command, if "isis password password [level-1|level-2]" has been executed, the said command will be overwritten by this command. Both commands can be used to configure IS-IS interface authentication, but this command has a higher priority level.
Ruijie(config-if)# **isis authentication key-chain name-of-chain** [**level-1** | **level-2**]	Configures the key chain used by IS-IS interface authentication. When Level is not specified, the key chain configured is by default applicable to every Level. This command must be configured together with "isis authentication mode" command in order to achieve IS-IS interface authentication. Neither of them can be omitted.
Ruijie(config-if)# **isis authentication send-only** [**level-1** | **level-2**]	(Optional) The IS-IS interface authentication can only apply to the packets sent. No authentication will be performed on packets received. When Level is not specified, the send-only authentication mode configured is by default applicable to every Level. This command can be used to avoid network oscillation caused by the failure in temporary authentication. Before deploying IS-IS authentication for the entire network, configure this command for all devices; after configuring the aforementioned two commands for all devices, execute "no isis authentication send-only" command to restore the authentication of packets received, so as to carry out smooth authentication deployment and avoid network oscillation.

Configuring interface encryption authentication

You can configure encryption authentication password for IS-IS interface. The authentication password will be encapsulated in Hello packets sent on the interface; when Hello packets are received, consistency of the password will be examined.

IS-IS interface authentication should be configured in interface configuration mode. You can use the following commands to configure interface encryption authentication:

Command	Function

Ruijie(config-if)# **isis authentication mode md5** [**level-1** | **level-2**]	Sets the IS-IS interface authentication mode. When Level is not specified, the set authentication mode applies to all Levels. If the isis password password [level-1 | level-2] command is previously configured, it will be covered by this command. The two commands can both configure IS-IS interface authentication. This command has a higher priority.
Ruijie(config-if)# **isis authentication key-chain** *name-of-chain* [**level-1** | **level-2**]	Sets key-chain used for IS-IS interface authentication. When Level is not specified, the set key-chain applies to all Levels. This command must be used together with the isis authentication mode command to authenticate IS-IS interface.
Ruijie(config-if)# **isis authentication send-only** [**level-1** | **level-2**]	(Optional) The IS-IS interface authentication can only apply to the packets sent. No authentication will be performed on packets received. When Level is not specified, the set authentication and password apply to all Levels. This command can be used to avoid network oscillation caused by the failure in temporary authentication during configuration of IS-IS authentication. Before deploying IS-IS authentication for the entire network, configure this command for all devices; after configuring the aforementioned two commands for all devices, use no isis authentication send-only command to restore the authentication of packets received, so as to carry out smooth authentication deployment and avoid network oscillation.

Configuring Area Authentication

Configuring area plain-text authentication

You can configure plain-text authentication password for IS-IS area. The authentication password will be encapsulated in LSP, CSNP and PSNP packets in the area (Level-1); when the packets are received, consistency of the password will be examined.

IS-IS area authentication must be configured in IS-IS process mode. You can use the following command to configure IS-IS area plain-text authentication:

Command	Function

Ruijie(config-router)# **area-password** *password* [**send-only**]	Configures area (Level-1) plain-text authentication password. When send-only is specified, the authentication password is only applicable to the sent packets rather than the received packets. When configuring this command, if "authentication mode" has been executed, this command won't be configured successfully. Both commands can be used to configure IS-IS area authentication, but this command has a lower priority level. To configure this command, you need to delete "authentication mode" command first.

You can also use the following commands to configure plain-text authentication for IS-IS area:

Command	**Function**
Ruijie(config-router)# **authentication mode text level-1**	Use this command to specify the mode of IS-IS area authentication. When configuring this command, if "area-password password" has been executed, the said command will be overwritten by this command. Both commands can be used to configure IS-IS area authentication, but this command has a higher priority level.
Ruijie(config-router)# **authentication key-chain** *name-of-chain* **level-1**	Configures the key chain used by IS-IS area authentication. This command must be configured together with "authentication mode" command in order to perform IS-IS area authentication. Neither of them can be omitted.
Ruijie(config-router)# **authentication send-only level-1**	(Optional) The IS-IS area authentication can only apply to the packets sent. No authentication will be performed on packets received. This command can be used to avoid network oscillation caused by the failure in temporary authentication. Before deploying IS-IS authentication for the entire area, configure this command for all devices; after configuring the aforementioned two commands for all devices, execute "no authentication send-only" command to restore the authentication of packets received, so as to carry out smooth authentication deployment and avoid network oscillation.

Configuring area encryption authentication

You can configure encryption authentication password for IS-IS area. The authentication password will be encapsulated in LSP, CSNP and PSNP packets in the area (Level-1); when the packets are received, consistency of the password will be examined.

IS-IS area authentication must be configured in IS-IS process mode. You can use the following commands to configure IS-IS area encryption authentication:

Command	Function
Ruijie(config-router)# **authentication mode md5 level-1**	Sets the IS-IS area authentication mode. If the area-password password command is previously configured, it will be covered by this command. The two commands can both configure IS-IS area authentication. This command has a higher priority.
Ruijie(config-router)# **authentication key-chain** *name-of-chain* **level-1**	Sets key-chain used for IS-IS area authentication. This command must be used together with the authentication mode command to authenticate IS-IS area authentication.
Ruijie(config-router)# **authentication send-only level-1**	(Optional) The IS-IS area authentication can only apply to packets sent. No authentication will be performed on packets received. This command can be used to avoid network oscillation caused by the failure in temporary authentication during configuration of IS-IS authentication. Before deploying IS-IS authentication for the entire area, configure this command for all devices; after configuring the aforementioned two commands for all devices, use no authentication send-only command to restore the authentication of packets received, so as to carry out smooth authentication deployment and avoid network oscillation.

Configuring the Routing Domain Authentication

Configuring routing domain plain-text authentication

You can configure plain-text authentication password for IS-IS routing domain. The authentication password will be encapsulated in LSP, CSNP and PSNP packets in Level-2; when the packets are received, consistency of the password will be examined.

IS-IS routing domain authentication must be configured in IS-IS process mode. You can use the following command to configure IS-IS routing domain plain-text authentication:

Command	Function
Ruijie(config-router)# domain-password password [send-only]	Configure routing domain (Level-2) plain-text authentication password. When send-only is specified, the authentication password is only applicable to the sent packets rather than the received packets. When configuring this command, if "authentication mode" has been executed, this command won't be configured successfully. Both commands can be used to configure IS-IS routing domain authentication, but this command has a lower priority level. To configure domain-password, you need to delete "authentication mode" command first.

You can also use the following commands to configure plain-text authentication for IS-IS routing domain:

Command	Function
Ruijie(config-router)# **authentication mode text level-2**	Use this command to specify the mode of IS-IS routing domain authentication. When configuring this command, if "domain-password password" has been executed, the said command will be overwritten by this command. Both commands can be used to configure IS-IS routing domain authentication, but this command has a higher priority level.
Ruijie(config-router)# **authentication key-chain** *name-of-chain* **level-2**	Configures the key chain used by IS-IS routing domain authentication. This command must be configured together with authentication mode command in order to achieve IS-IS routing domain authentication. Neither of them can be omitted.
Ruijie(config-router)# **authentication send-only level-2**	(Optional) The IS-IS routing domain authentication can only apply to the packets sent. Packets received will not be authenticated. This command can be used to avoid network oscillation caused by temporary authentication failure. Before deploying IS-IS authentication for the entire routing domain, configure this command for all devices; after configuring the aforementioned two commands for all devices, execute no authentication send-only command to restore the authentication of packets received, so as to carry out smooth authentication deployment and avoid network oscillation.

Configuring routing domain encryption authentication

You can configure encryption authentication password for IS-IS routing domain. The authentication password will be encapsulated in LSP, CSNP and PSNP packets in Level-2; when the packets are received, consistency of the password will be examined.

IS-IS routing domain authentication must be configured in IS-IS process mode. You can use the following commands to configure IS-IS routing domain encryption authentication:

Command	Function
Ruijie(config-router)# **authentication mode md5 level-2**	Sets the IS-IS routing domain authentication mode. If the domain-password password command is previously configured, it will be covered by this command. The two commands can both configure IS-IS routing domain authentication. This command has a higher priority.
Ruijie(config-router)# **authentication key-chain** *name-of-chain* **level-2**	Sets key-chain used for IS-IS routing domain authentication. This command must be used together with the authentication mode command to authenticate IS-IS routing domain authentication.
Ruijie(config-router)# **authentication send-only level-2**	(Optional) The IS-IS routing domain authentication can only apply to packets sent. No authentication will be performed on packets received. This command can be used to avoid network oscillation caused by the failure in temporary authentication during configuration of IS-IS authentication. Before deploying IS-IS authentication for the entire routing domain, configure this command for all devices; after configuring the aforementioned two commands for all devices, use no authentication send-only command to restore the authentication of packets received, so as to carry out smooth authentication deployment and avoid network oscillation.

Configuring IS-IS GR

IS-IS Graceful Restart (IS-IS GR) guarantees continuous data forwarding during the process of protocol restart. Currently, the high-end products of Ruijie can support IS-IS GR during main/standby switchover, so as to guarantee continuity of key services.

Operating Mechanism of IS-IS GR

- IS-IS GR Realization Standard

RFC5306: Restart Signaling for IS-IS

- RFC5306 operating mechanism

RFC5306 defines requirements, operating methods and issues to be noticed when executing GR; successful GR depends on two principles: 1) the network topology maintains stable; 2) the node maintains non-stop data forwarding during IS-IS protocol restart.

There are two roles in GR: Restarter and Helper. Accordingly, IS-IS GR can be functionally divided into IS-IS GR Restart Capability and IS-IS GR Help Capability. Devices with GR Restart Capability can send GR requests and proactively execute graceful restart, while devices with GR Help Capability can receive GR requests and help the neighbor to execute graceful restart. The process of GR starts with the sending of GR requests by Restarter. The neighbor devices will enter Help mode after receiving such GR requests and assist Restarter to rebuild link-state database while maintaining the adjacencies with Restarter. The main operating mechanism is shown below:

When proceeding with IS-IS GR, the device will advertise its neighbors to maintain their adjacencies, so that the other devices on the network will not perceive the network change. The topological relationships will remain unchanged, and the neighbors will not recalculate routes and update the forwarding table. On the other hand, the link-state database will be synchronized and restored under the aid of neighbors, so that routes and forwarding table remain unchanged after GR, ensuring continuity of data forwarding.

During graceful restart of Restarter, the following steps will be involved:

- GR Restarter advertises the GR Helpers of such restart

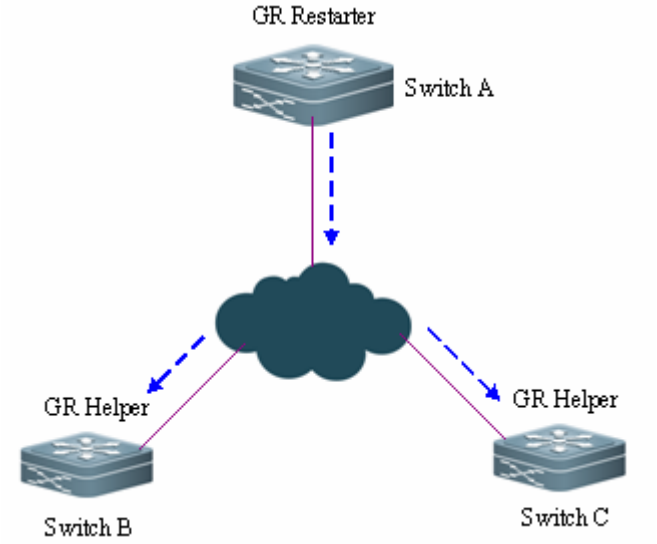


Figure 3 Restart of Restarter by advertising

As shown in Fig 3, Switch A is GR Restarter, Switch B and Switch C are GR Helpers of Switch A. Switch A sends GR requests to all its neighbors, as it needs to maintain the adjacencies during the process of GR. After receiving such requests, all neighbors will maintain the adjacencies with GR Restarter during the GR time (GR grace-period) advertised by the Restarter and send GR replies to Restarter.

- Restart of GR Restarter

As shown in Fig 4, when the GR Restarter proceeds with IS-IS restart, its IS-IS interface will undergo the process from Down to Up. Since the Helper is aware of the protocol restart state of Restarter, it will maintain its adjacency with GR Restarter and the routes acquired from GR Restarter during GR Time.

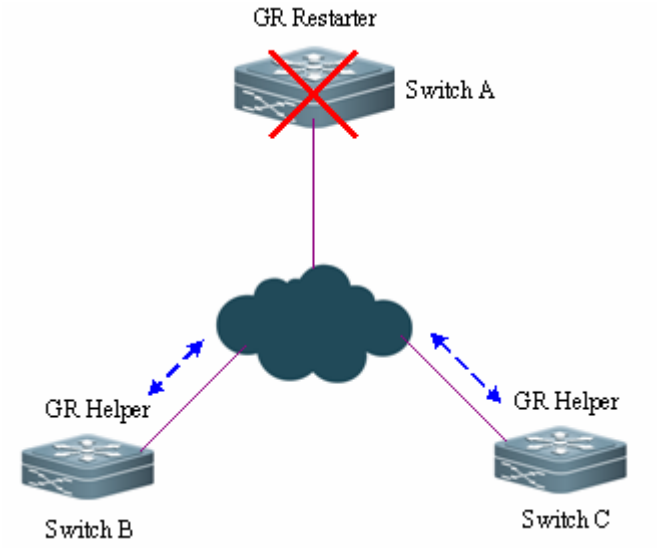


Figure 4 Restart of Restarter

- GR Restarter synchronizes with GR Helper and acquires the topology and routing information

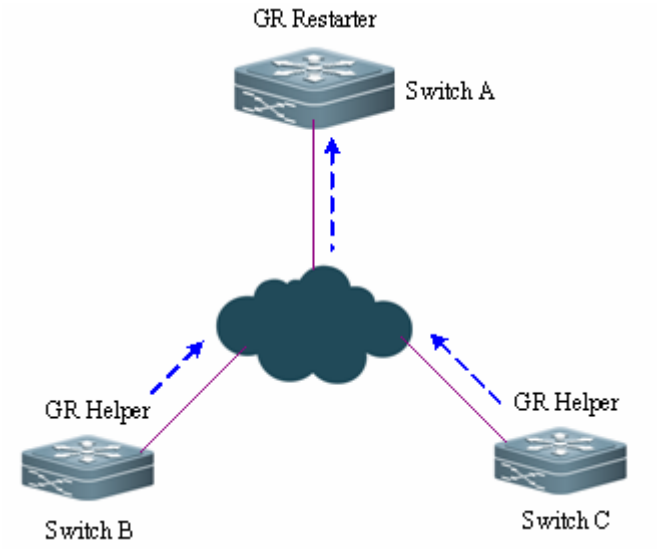


Figure 5 Database synchronization

As shown in Fig 5, after IS-IS protocol restart, GR Restarter will synchronize with GR Helper to acquire topology or routing information, and recalculate its own routing table accordingly. During this process, the forwarding table will not be updated by the routing table.

- GR Restarter completes database synchronization and graceful restart. All devices enter into IS-IS standard protocol interaction state.

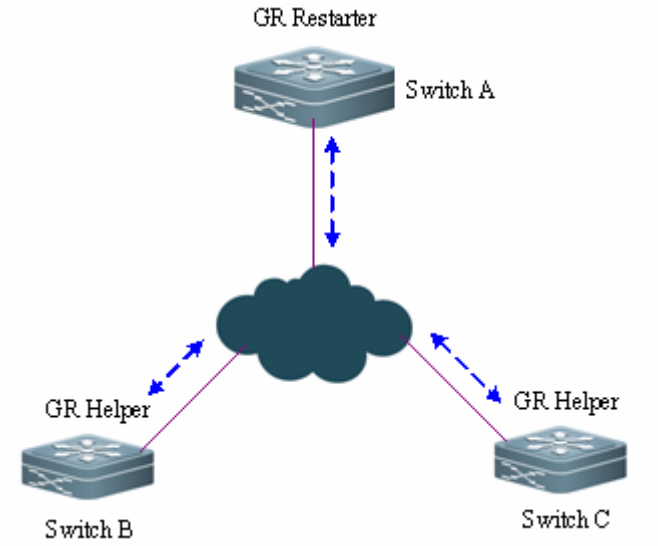


Figure 6 Completion of graceful restart

As shown in Fig 6, Restarter has completed data synchronization and all devices have entered into IS-IS standard protocol interaction state. By this time, the forwarding table will be updated by the routing table of Restarter and invalid entries will be deleted. Since the network maintains stable and Restarter has perfectly restored to the state before restart (completing graceful restart), its routing and forwarding tables will remain unchanged after the restart.

Use of IS-IS GR

GR of routing protocols is usually used to improve the system's reliability in the system that supports separation of the control panel and forwarding panel, thus realizing continued forwarding. IS-IS GR Restart capability depends on products.

When IS-IS GR Restarter capability is enabled, configure the IS-IS adjacency holdtime to no less than 40 seconds on devices with multiple management boards to ensure graceful restart of IS-IS triggered by switch of management boards. It can be achieved by configuring the isis hello-interval and isis hello-multiplier commands. If the holdtime value is less than 40 seconds, the holdtime value in the Hello packet header is set to 40 seconds by default.

The IS-IS GR Help capability only depends on software version. If the software supports IS-IS, the device is equipped with IS-IS GR Help capability.

Configuring IS-IS GR Restarter

To enable IS-IS graceful restart GR Restart capability, you must configure the graceful-restart command to enable graceful restart:

Command	Definition
Ruijie **# configure terminal**	Enters global configuration mode.
Ruijie (config)**# router isis**	Opens IS-IS and enters IS-IS configuration mode.
Ruijie(config-router)**# graceful-restart grace-period seconds**	(Optional) Configures the restart cycle GR Time (default value: 300 seconds).

Ruijie (config-router)**# end**	Returns to privileged mode.
Ruijie **# show isis graceful-restart**	Verifies the configuration.
Ruijie **# write**	(Optional) Save the configuration.

Configuring IS-IS GR Helper

IS-IS GR Help capability is enabled by default. You can also disable GR Help. The following example shows how to disable GR Help capability and re-enable it:

Command	Definition
Ruijie **# configure terminal**	Enters global configuration mode.
Ruijie (config)**# router isis**	Opens IS-IS and enters IS-IS configuration mode.
Ruijie(config-router)**# graceful-restart helper disable**	Disables IS-IS GR Restarter capability on the neighbor of Restarter. The capability is enabled by default.
Ruijie (config-router)**# no graceful-restart helper disable**	Re-enables IS-IS GR Help capability and restores it to the default action.
Ruijie (config-router)**# end**	Returns to privileged mode.
Ruijie **# show isis graceful-restart**	Verifies the configuration.
Ruijie **# write**	(Optional) Save the configuration.

Configuring Linkage between IS-IS and BFD

The IS-IS protocol detects neighbors through Hello packets. After BFD detection is enabled with IS-IS, BFD session is established for the UP neighbors to monitor the neighbor status, Once the BFD neighbor is DOWN, IS-IS performs immediate convergence. The convergence time is reduced to 1s from 30s(by default, IS-IS Hello packets sending interval is 10s on a point-to-point network, and the failure time of the neighbor device is three times of the interval, that is, 30s),

In normal cases, BFD send detecting packets to detect link state with intervals in milliseconds. When the link gets abnormal, for example, the link is disconnected, BFD can detect link anomaly quickly and inform IS-IS to delete neighbors and neighbors-reachable information in LSP packets. IS-IS performs routing calculation again to generate new a route, avoiding the abnormal link and achieving fast convergence, With the introduction of new technologies such as Multi-Service Transport Platform (MSTP), link is congestion-prone in peak periods of data communication. In congestion, BFD can detect link anomaly quickly and inform IS-IS to delete neighbors and neighbors-reachable information in LSP packets. Besides, BFD perform the link switch to avoid congestion. As the IS-IS neighbor detects that the interval to send Hello packets is 10s and the timeout period is 30s. When BFD detects anomaly, the router can receive IS-IS and establish IS-IS adjacency relation. The route restores to the congested link and performs BFD detection again. BFD repeats the process of detecting link anomaly and performing link switch, making the route switched to either the congested link or other links and causing congestion.
Anti-congestion is enabled to avoid routing congestion caused by link congestion. Thus in link congestion, the IS-IS neighbor remains but the neighbor-reachable information is deleted in LSP packets. The route is switched to the non-congested link. After the link restores to normal, or rather non-congested, the neighbor-reachable information in LSP packets is restored and the route is switched back, avoiding routing congestion.

When IS-IS enables anti- congestion, both the **bfd all-interfaces** [**anti-congestion**] and the **bfd up-dampening** commands must be configured on the interface. Configuring only one command may cause ineffective anti- congestion or other network anomalies.

Command	Definition
Ruijie(config-router)# **bfd all-interfaces** [**anti-congestion**]	Enables linkage between IS-IS and BFD on all interfaces.
Ruijie(config-if)# **isis bfd** [**disable** | **anti-congestion**]	Enables or disables linkage between IS-IS and BFD on the interface.


Note The BFD session needs to be set on the interface before configuring IS-IS with BFD.


Note When the interface is configured with the **bfd up-dampening** command, the **bfd all-interfaces** [**anti-congestion**] command must be enabled if IS-IS is used with BFD on the interface.


Note The **bfd all-interfaces** [**anti-congestion**] command must be configured together with the **bfd up-dampening** command on the interface.


Note IP routing may cause inconsistency between the specified interface and the actual outbound interface of BFD packets, therefore the BFD session cannot be established.


Note If the specified interface is not the actual inbound interface of BFD packets, the BFD session cannot be established.

Configuring IS-IS SNMP

By default, SNMP software can perform MIB on the first IS-IS instance displayed by the system. If you want to perfom MIB on another instance, specify it manually.

Execute the following command in IS-IS routing process configuration mode to bind the instance used for IS-IS MIB operation:

Command	Function
Ruijie(config-router)# **enable mib-binding**	Binds the current instance to perform MIB.

There are 18 types of IS-IS packets. Based on different features, they are divided into several sets and each set includes several types of IS-IS TRAP packets. Enable IS-IS TRAP globally in global configuration mode (with the **snmp-server enable traps isis** command), specify the host receiving TRAP packets, and use this command to specify the types of IS-IS TRAP packets allowed to be sent in IS-IS routing process configuration mode. Then IS-IS packets can be transmitted.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)#**snmp-server enable traps isis**	Enables IS-IS TRAP globally.
Ruijie(config)#**snmp-server host** 10.1.1.1	Configures global SNMP host and receives IS-IS TRAP packets.
Ruijie(config)#**router isis**	Enters IS-IS routing pricess configuration mode
Ruijie(config-router)# **enable traps all**	Allows all IS-IS TRAP packets to be sent to the host 10.1.1.1.

Configuring Other IS-IS Parameters

Configuring IS-IS Interface Metric

You can configure the interface metric, which must be configured in interface configuration mode as follows:

Command	Function
Ruijie(config-if)# **isis metric metric** [**level-1**| **level-2**]	Configures the metric for the interface. This value is only effective when metric-style includes narrow mode.
Ruijie(config-if)# **isis wide-metric metric** [**level-1** | **level-2**]	Configures the wide-metric for the interface. This value is only effective when metric-style includes wide mode.

Configuring the Priority Level of the Specified routing node

In the broadcast network, IS-IS needs to elect a designed routing node (DIS) among all routing nodes. The designated router will then create Pseudonode and generate Pseudonode LSP. In the broadcast network, the DIS is elected by priority, and the user can configure different priority values for different Levels. You can set different priority for different Levels. Complete the following configuration in interface configuration mode to set router priority for election:

Command	Function
Ruijie(config-if)# **isis priority value** [**level-1** | **level-2**]	Configures the priority for designated router election on the interface.

Caution The no isis priority command is used to restore the default priority no matter whether the parameter is followed. If you want to modify the configured priority, you can either use isis priority command with parameter specified to overwrite the configured command directly, or configure a new parameter after restoring the priority to the default value.

Configuring to Generate a Default Route

By default, L2 routers don't generate a default route. Execute the following command in IS-IS protocol configuration mode to generate a default route:

Command	Function
Ruijie(config-router)# **default-information originate** [*route-map map-name*]	Generates a Level-2 default route and publishes through LSP. If the route-map option is specified, the default route can be generated only when the condition in the route-map is matched.

Configuring Convergent Route

You can create a convergent route to represent a group of routes in the routing table. The process is called route convergence. One convergent route can include multiple routes in a Level. The interface metric of the convergent route is the smallest one of all routes. Complete the following configuration in IS-IS protocol configuration mode to set the route convergence:

Command	Function
Ruijie(config-router)#**summary-address ip-address net-mask** [**level-1** | **level-2** | **level-1-2**]	Sets convergent route.

Route convergence in IS-ISv6 protocol should be set in IS-ISv6 protocol configuration mode:

Command	Function
Ruijie(config-router)# **address-family ipv6 unicast** Ruijie(config-router-af)# **summary-prefix** *ipv6-prefix* / *prefix-length* [**level-1** | **level-2** | **level-1-2**]	Sets IS-IS IPv6 convergent route.

Configuring to Ignore LSP Authentication and Verification Errors

When local IS-IS receives LSP packet, the LSP packet needs to be verified and calculated. In addition, the calculation result is compared with the verification in the LSP packet. That is, the received LSP packet needs to be verified and authenticated. By default, if the calculation result is different from the verification in the LSP packet, the LSP packet is discarded and not processed. If you run the ignore-lsp- errors command to ignore the verification error, the LSP packet is processed normally even an error is verified. The configuration to ignore LSP authentication and errors must be performed in IS-IS protocol configuration mode:

Command	Function
Ruijie(config-router)#**ignore-lsp-errors**	Configures to Ignore LSP authentication and verification errors.

Configuring to Open Adjacent Event Output Switch

To log events when the IS-IS adjacency changes, you need to open the adjacent event output switch. Complete the following configuration in IS-IS protocol configuration mode to set the adjacent event output switch:

Command	Function
Ruijie(config-router)# **log-adjacency-changes**	Enable the logging of IS-IS adjacency change.

Configuring Route Redistribution

Route redistribution can redistribute one routing protocol's routing information to another routing protocol. Route redistribution must be configured in IS-IS configuration mode or IS-IS address-family ipv6 mode:


Caution

In case there are IS-IS Level-2 instances, all IS-IS Level-1 routes will by default be automatically redistributed into IS-IS Level-2 in these instances. Of course, you can also disable the redistribution from Level-1 into Level-2 by executing "no redistribute isis [tag] level-1 into level-2". You can also filter the redistributed Level-1 routes by executing "redistribute isis [tag] level-1 into level-2 {distribute-list access-list-name| route-map route-map-name}".


Caution

2. Configure no redistritbue {bgp | ospf <1-65535> | rip | connected | static} to disable protocol redistribution. If no redistribute is followed by any other parameter, it means that this parameter is restored to the default setting instead of disabling protocol redistribution. For example: no redistribute bgp will disable bgp redistribution, while no redistribute bgp route-map aa will disable route-map aa filtering during redistribution instead of disabling bgp redistribution.


Caution

3. In the old version software developed by some manufacturers, after configuring metric-type as external, the metric of redistributed route will be added by 64 during route calculation, and the route will be selected according to metric value. This has violated the protocol. In actual applications, the external route may have higher priority than the internal route. During the intercommunication with such manufacturers, if this problem exists, relevant configurations of devices can be adjusted (such as metric or metric-type) to ensure internal routes have higher priority than the external routes.

Monitoring and Maintaining IS-IS

View IS-IS's link status database and transmission and reception of various packets and calculation of SPF through the following configuration and operation to confirm maintenance of IS-IS route.

Command	Function
Ruijie# **show isis** [*tag*] **database** [*FLAGS* | *LEVEL* | *LSPID*]	Displays IS-IS link-state database.
Ruijie# **show isis** [*tag*] **neighbors** [**detail**]	Displays IS-IS neighbors.
Ruijie# **show isis** [*tag*] **virtual-neighbors**	Displays IS-IS neighbors in virtual system.
Ruijie# **show isis** [*tag*] **interface** [*interface-type interface-number*]	Displays IS-IS interface information.
Ruijie# **show isis** [*tag*] **topology** [**l1** | **l2** | **level-1** | **level-2**]	Displays IS-IS connection topology.
Ruijie# **show isis** [*tag*] **ipv6 topology** [**l1** | **l2** | **level-1** | **level-2**]	Displays IS-IS IPv6 unicast topology.
Ruijie# **show isis** [*tag*] **counter**	Displays various statistics of IS-IS.
Ruijie# **show isis** [*tag*] **hostname**	Displays the mapping relation between the device hostname and System ID.

Ruijie# **show isis** [*tag*] **mesh-groups**	Displays the mesh group configurations on each interface.
Ruijie# **show isis** [*tag*] **graceful-restart**	Displays IS-IS GR status.
Ruijie# **show isis** [*tag*] **protocol**	Displays the IS-IS protocol.

For detailed explanation of commands, please refer to *IS-IS Commands*.

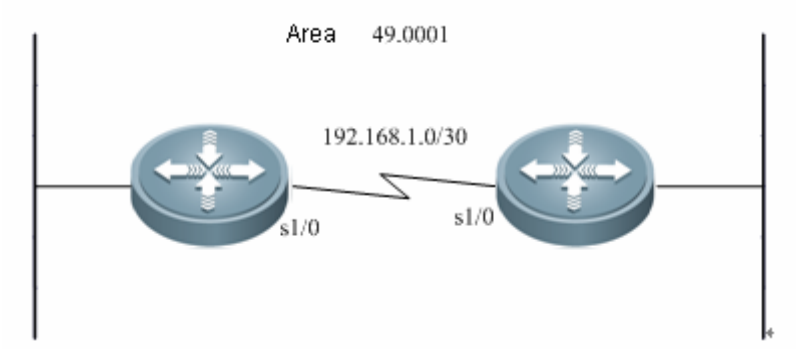
IS-IS Configuration Examples

IS-IS Point-to-Point Serial Link Configuration Example

- Requirement

The connection layout and IP address distribution are shown in Fig 7. A point-to-point network is configured between Device A and Device B.

Figure 7 IS-IS point-to-point serial link configuration



- Detailed configurations

Device A:

Configuring IS-IS routing protocol

```
Ruijie(config)# router isis
Ruijie(config-router)# net 49.0001.0000.0000.0001.00
```

Configuring the Ethernet interface

```
Ruijie(config)# interface GigabitEthernet 0/0
Ruijie(config-if)# ip address 10.1.1.1 255.255.255.0
Ruijie(config-if)# ip router isis
```

Device B:

Configuring IS-IS routing protocol

```
Ruijie(config)# router isis
Ruijie(config-router)# net 49.0001.0000.0000.0002.00
```

Configuring the Ethernet interface

```
Ruijie(config)# interface GigabitEthernet 0/0
Ruijie(config-if)# ip address 10.1.1.2 255.255.255.0
Ruijie(config-if)# ip router isis
```

Device C:

Configuring IS-IS routing protocol

```
Ruijie(config)# router isis
Ruijie(config-router)# net 49.0001.0000.0000.0003.00
```

Configuring the Ethernet port

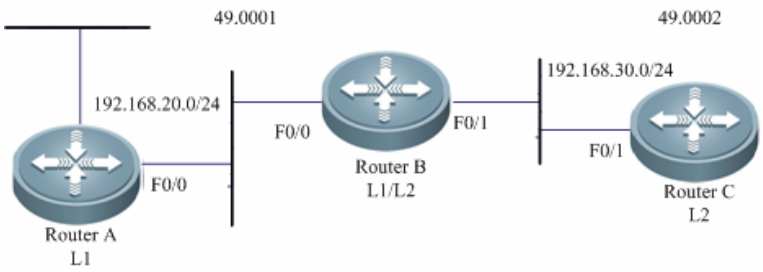
```
Ruijie(config)# interface GigabitEthernet 0/0
Ruijie(config-if)# ip address 10.1.1.3 255.255.255.0
Ruijie(config-if)# ip router isis
```

IS-IS Broadcast Multipoint Link Configuration Example

- Requirement

The connection layout and IP address distribution are shown in Fig 8. Device A, Device B and Device C are interconnected through Ethernet, running the IS-IS routing protocol. Device A is Level-1 node, Device B is Level1-2 node and Device C is Level-2 node. It is required that Hello packets between Device A and Device B, Level-1 LSP and SNP packets adopt plaintext authentication, Hello packets between Device B and Device C, Level-2 LSP and SNP packets adopt MD5 encryption authentication,

Figure 8 IS-IS broadcast multipoint link configuration



- Detailed configurations

Device A:

Configuring IS-IS routing protocol

```
Ruijie(config)# router isis
Ruijie(config-router)# net 49.0001.0000.0000.0001.00
```

Configuring Ethernet interface

```
Ruijie(config)# interface FastEthernet 0/0
Ruijie(config-if)# ip address 10.1.1.1 255.255.255.0
Ruijie(config-if)# ip router isis
```

Device B:

Configuring IS-IS routing protocol

```
Ruijie(config)# router isis
Ruijie(config-router)# net 49.0001.0000.0000.0002.00
```

Configuring Ethernet interface

```
Ruijie(config)# interface FastEthernet 0/0
Ruijie(config-if)# ip address 10.1.1.2 255.255.255.0
Ruijie(config-if)# ip router isis
```

Device C:

Configuring IS-IS routing protocol

```
Ruijie(config)# router isis
Ruijie(config-router)# net 49.0001.0000.0000.0003.00
```

Configuring Ethernet interface

```
Ruijie(config)# interface FastEthernet 0/0
Ruijie(config-if)# ip address 10.1.1.3 255.255.255.0
Ruijie(config-if)# ip router isis
```

IS-IS Authentication Configuration Example

- Requirement

Three devices are interconnected through Ethernet and run IS-IS routing protocol. The connection layout and IP address distribution are shown in Fig 9. Device A is a Level-1 router, Device B is a Level-1-2 router, and Device C is a Level-2 router. Hello packets exchanged between Device A and Device B shall be subject to plain-text authentication, and Level-1 LSP and SNP packets shall be subject to plain-text authentication. Hello packets exchanged between Device B and Device C shall be subject to MD5 encrypted authentication, and Level-2 LSP and SNP packets shall be subject to MD5 encrypted authentication.

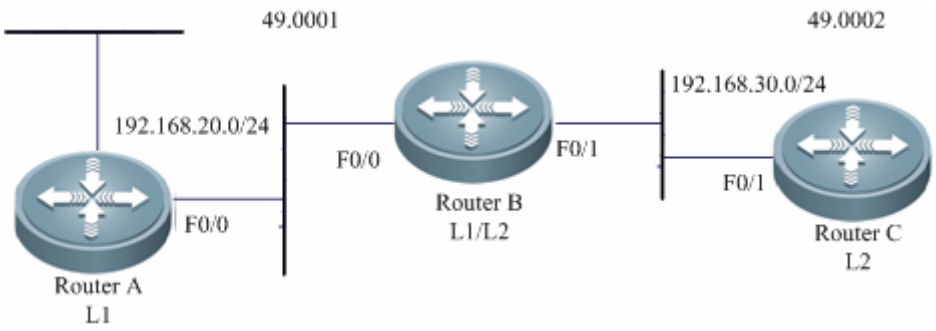


Figure 9 IS-IS authentication configuration

Detailed configurations

Device A:

Configuring IS-IS routing protocol

```
Ruijie(config)# router isis
Ruijie(config-router)# net 49.0001.0000.0000.0001.00
Ruijie(config-router)# is-type level-1
Ruijie(config-router)# area-password aa
```

Configuring Ethernet interface

```
Ruijie(config)# interface FastEthernet 0/0
Ruijie(config-if)# ip address 192.168.20.1 255.255.255.0
Ruijie(config-if)# ip router isis
Ruijie(config-if)# isis password cc
```

Device B:

Configuring the key chain used by IS-IS authentication:

```
Ruijie(config)# key chain kc1
Ruijie(config-keychain)# key 1
Ruijie(config-keychain-key)# key-string aa
Ruijie(config)# key chain kc2
Ruijie(config-keychain)# key 1
Ruijie(config-keychain-key)# key-string bb
Ruijie(config)# key chain kc3
Ruijie(config-keychain)# key 1
Ruijie(config-keychain-key)# key-string cc
```

Configuring IS-IS routing protocol

```
Ruijie(config)# router isis
Ruijie(config-router)# net 49.0001.0000.0000.0002.00
Ruijie(config-router)# authentication mode text level-1
Ruijie(config-router)# authentication key-chain kc1
Ruijie(config-router)# authentication mode md5 level-2
Ruijie(config-router)# authentication key-chain kc2
```

Configuring Ethernet interface

```
Ruijie(config)# interface FastEthernet 0/0
Ruijie(config-if)# ip address 192.168.20.2 255.255.255.0
Ruijie(config-if)# ip router isis
Ruijie(config-if)# isis authentication mode text
Ruijie(config-if)# isis authentication key-chain kc3
Ruijie(config)# interface FastEthernet 0/1
Ruijie(config-if)# ip address 192.168.30.2 255.255.255.0
Ruijie(config-if)# ip router isis
Ruijie(config-if)# isis authentication mode md5
Ruijie(config-if)# isis authentication key-chain kc3
```

Device C:

Configuring the key chain used by IS-IS authentication:

```
Ruijie(config)# key chain kc2
Ruijie(config-keychain)# key 1
Ruijie(config-keychain-key)# key-string bb
Ruijie(config)# key chain kc3
Ruijie(config-keychain)# key 1
Ruijie(config-keychain-key)# key-string cc
```

Configuring IS-IS routing protocol

```
Ruijie(config)# router isis
Ruijie(config-router)# net 49.0002.0000.0000.0002.00
Ruijie(config-router)# is-type level-2
Ruijie(config-router)# authentication mode md5 level-2
Ruijie(config-router)# authentication key-chain kc2
```

Configuring Ethernet interface

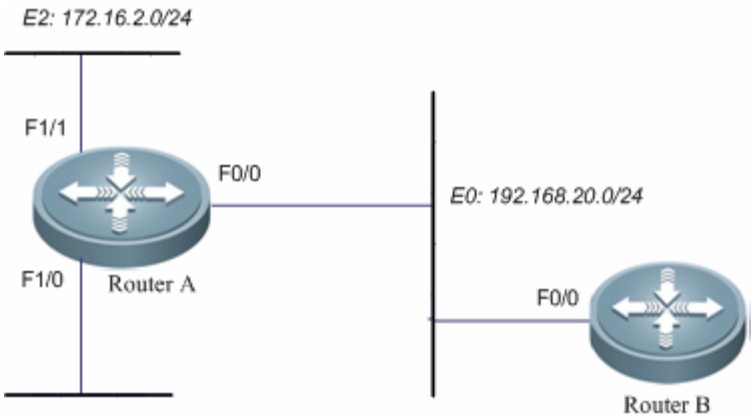
```
Ruijie(config)# interface FastEthernet 0/1
Ruijie(config-if)# ip address 192.168.30.3 255.255.255.0
Ruijie(config-if)# ip router isis
Ruijie(config-if)# isis authentication mode md5
Ruijie(config-if)# isis authentication key-chain kc3
```

IS-IS Route Summary

- Requirement

Two devices are connected through Ethernet. The IP address distribution and device layout are shown in Fig 10.

Figure 10 IS-IS route summary configuration



Requirement

1. Two devices run IS-IS route protocol.

2. Configure Router A, so that Router A only advertises the route of 172.16.0.0/22 instead of routes of 172.16.1.0/24 and 172.16.2.0/24.

- Detailed configurations

Device A:

Configuring IS-IS routing protocol

```
Ruijie(config)# router isis
Ruijie(config-router)# net 49.0001.0000.0000.0001.00
Ruijie(config-router)# summary-address 172.16.0.0/16 level-1-2
```

Configuring Ethernet interface

```
Ruijie(config)# interface FastEthernet 0/0
Ruijie(config-if)# ip address 192.168.20.1 255.255.255.0
Ruijie(config-if)# ip router isis
Ruijie(config)# interface FastEthernet 1/0
Ruijie(config-if)# ip address 172.16.1.1 255.255.255.0
Ruijie(config-if)# ip router isis
Ruijie(config)# interface FastEthernet 1/1
Ruijie(config-if)# ip address 172.16.2.1 255.255.255.0
Ruijie(config-if)# ip router isis
```

Device B:

Configuring IS-IS routing protocol

```
Ruijie(config)# router isis
Ruijie(config-router)# net 49.0001.0000.0000.0002.00
```

Configuring Ethernet interface

```
Ruijie(config)# interface FastEthernet 0/0
Ruijie(config-if)# ip address 192.168.20.2 255.255.255.0
Ruijie(config-if)# ip router isis
```

Execute show ip route on Device B to see only one summary address:

```
Ruijie(config)# show ip route
i L1   172.16.0.0/16 [115/20] via 192.168.20.1, FastEthernet0/0
```

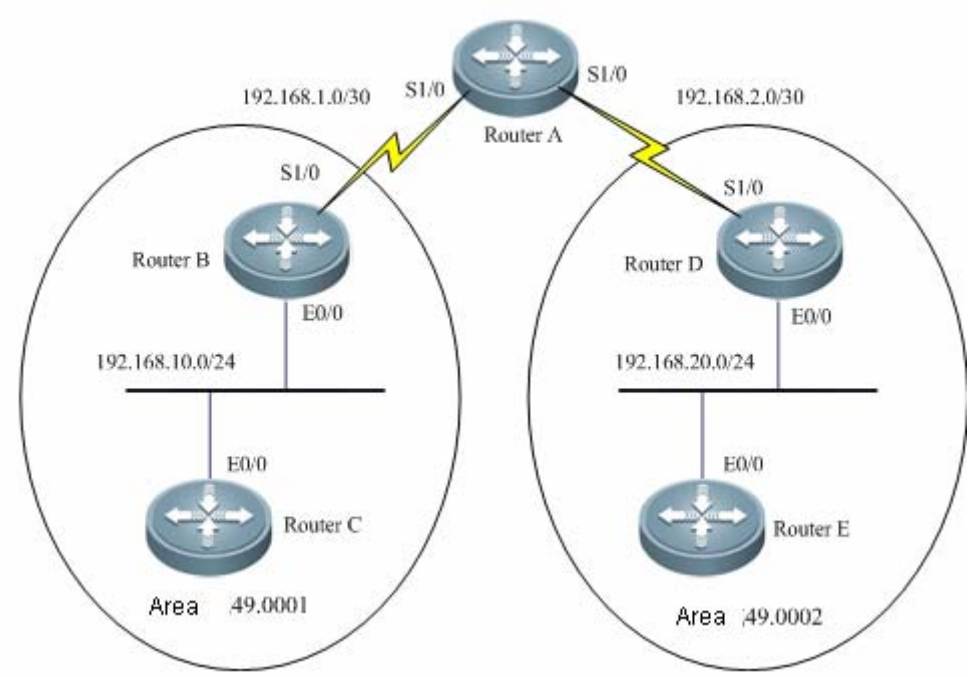
Caution If Level is no specified when summary-address is used, only Level-2 routes will be summarized by default.

IS-IS Level Configuration Example

- Requirement

See Fig 7 for allocation of IP addresses and connection of devices. P2P serial link connection is deployed between Device A and Device B and C respectively; Ethernet connection is deployed between Device B and Device C; Ethernet connection is deployed between Device D and Device E.

Figure 11 IS-IS level configuration



You need to configure IS-IS area route summary on Router A. Area route summary can only be configured on an area border device.

- Detailed configurations

Device A:

Configuring IS-IS routing protocol

```
Ruijie(config)# router isis
Ruijie(config-router)# net 50.0001.0000.0000.0001.00
```

```
Ruijie(config-router)# is-type level-2-only
```

Configuring serial link interface

```
Ruijie(config)# interface Serial 1/0
Ruijie(config-if)# ip address 192.168.1.1 255.255.255.252
Ruijie(config-if)# ip router isis
Ruijie(config)# interface Serial 1/1
Ruijie(config-if)# ip address 192.168.2.1 255.255.255.252
Ruijie(config-if)# ip router isis
```

Device B:

Configuring IS-IS routing protocol

```
Ruijie(config)# router isis
Ruijie(config-router)# net 49.0001.0000.0000.0002.00
```

Configuring Ethernet interface

```
Ruijie(config)# interface GigabitEthernet 0/0
Ruijie(config-if)# ip address 192.168.10.1 255.255.255.0
Ruijie(config-if)# ip router isis
```

Configuring serial link interface

```
Ruijie(config)# interface Serial 1/0
Ruijie(config-if)# ip address 192.168.1.2 255.255.255.252
Ruijie(config-if)# ip router isis
```

Device C:

Configuring IS-IS routing protocol

```
Ruijie(config)# router isis
Ruijie(config-router)# net 49.0001.0000.0000.0003.00
Ruijie(config-router)# is-type level-1
```

Configuring Ethernet interface

```
Ruijie(config)# interface GigabitEthernet 0/0
Ruijie(config-if)# ip address 192.168.10.2 255.255.255.0
Ruijie(config-if)# ip router isis
```

Device D:

Configuring IS-IS routing protocol

```
Ruijie(config)# router isis
Ruijie(config-router)# net 49.0002.0000.0000.0004.00
```

Configuring Ethernet interface

```
Ruijie(config)# interface GigabitEthernet 0/0
```

```
Ruijie(config-if)# ip address 192.168.20.1 255.255.255.0
Ruijie(config-if)# ip router isis
```

Configuring serial link interface

```
Ruijie(config)# interface Serial 1/0
Ruijie(config-if)# ip address 192.168.2.2 255.255.255.252
Ruijie(config-if)# ip router isis
```

Device E:

Configuring IS-IS routing protocol

```
Ruijie(config)# router isis
Ruijie(config-router)# net 49.0002.0000.0000.0005.00
Ruijie(config-router)# is-type level-1
```

Configuring Ethernet interface

```
Ruijie(config)# interface GigabitEthernet 0/0
Ruijie(config-if)# ip address 192.168.20.2 255.255.255.0
Ruijie(config-if)# ip router isis
```

IS-ISv6 Simplest Configuration

- Requirement

The connection layout and IPv6 address distribution are shown in Fig 12. Device A and Device B are interconnected through Ethernet.

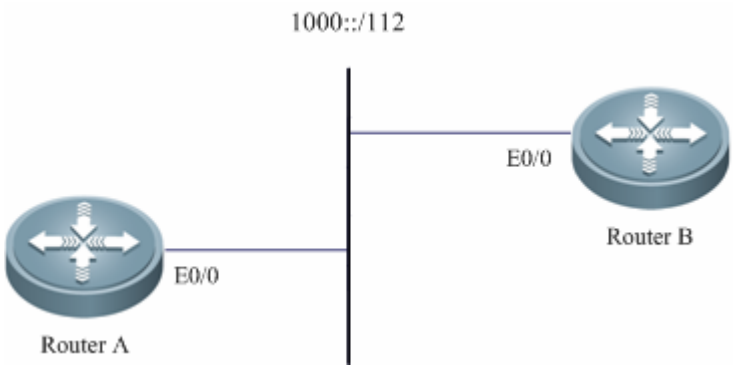


Figure 12 IS-ISv6 configuration

- Detailed configurations

Device A:

Configuring IS-IS routing protocol

```
Ruijie(config)# router isis
Ruijie(config-router)# net 49.0001.0000.0000.0001.00
```

Configuring Ethernet interface

```
Ruijie(config)# interface GigabitEthernet 0/0
Ruijie(config-if)# ipv6 address 1000 ::1/112
Ruijie(config-if)# ipv6 router isis
```

Device B:

Configuring IS-IS routing protocol

```
Ruijie(config)# router isis
Ruijie(config-router)# net 49.0001.0000.0000.0002.00
```

Configuring Ethernet interface

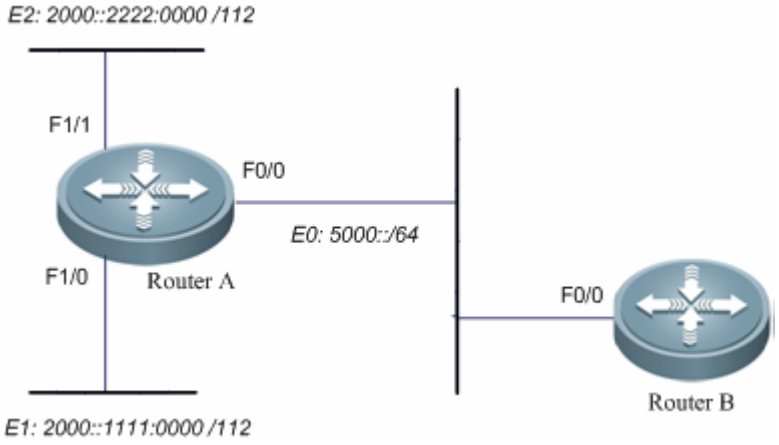
```
Ruijie(config)# interface GigabitEthernet 0/0
Ruijie(config-if)# ipv6 address 1000 ::2/112
Ruijie(config-if)# ipv6 router isis
```

IS-ISv6 Route Summary

- Requirement

Two devices are connected through Ethernet. See Fig 13 for allocation of IP addresses and connection of devices.

Figure 13 IS-ISv6 route summary configuration



Requirement

Two devices run IS-ISv6 route protocol.

Configure Router A, so that Router A only advertises the route of 2000::/96 instead of routes of 2000::1111:0/112 and 2000::2222::0/112.

Detailed configurations

Device A:

```
Configuring IS-IS routing protocol
Ruijie(config)# ipv6 unicast-routing
Ruijie(config)# router isis
Ruijie(config-router)# net 49.0001.0000.0000.0001.00
```

```
Ruijie(config-router)# address-family ipv6 unicast
Ruijie (config-router-af)# summary-prefix 2000::/96 level-1-2
Ruijie (config-router-af)# exit-address-family
Configuring Ethernet interface
Ruijie(config)# interface FastEthernet 0/0
Ruijie(config-if)# ipv6 address 5000::1/64
Ruijie(config-if)# ipv6 router isis
Ruijie(config)# interface FastEthernet 1/0
Ruijie(config-if)# ipv6 address 2000::1111:0001/112
Ruijie(config-if)# ipv6 router isis
Ruijie(config)# interface FastEthernet 1/1
Ruijie(config-if)# ipv6 address 2000::2222:0001/112
Ruijie(config-if)# ipv6 router isis
```

Device B:

```
Configuring IS-IS routing protocol
Ruijie(config)# ipv6 unicast-routing
Ruijie(config)# router isis
Ruijie(config-router)# net 49.0001.0000.0000.0002.00
Configuring Ethernet interface
Ruijie(config)# interface FastEthernet 0/0
Ruijie(config-if)# ipv6 address 5000::2/64
Ruijie(config-if)# ipv6 router isis
```

Execute "show ipv6 route" on Device B to see only one summary address:

```
Ruijie(config)# show ipv6 route
I1  2000::/96 [115/20]    via FE80::C800:1BFF:FEF8:1C, FastEthernet1/0
```

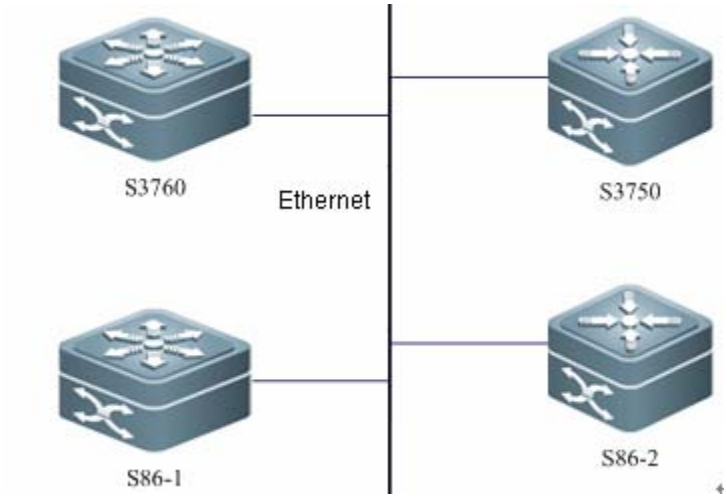
If Level is no specified when summary-prefix is used, only Level-2 routes will be summarized by default.

IS-IS GR Configuration Example

- Requirement

As shown in Fig 14, two S86 high-end switches have IS-IS GR Restart capability, and both devices have main and standby management boards to allow redundant backup at the control plane. S86-1 builds IS-IS adjacencies with S86-2, S3760 and S3750, and IS-IS GR Help capability is supported by all devices. The connection layout is shown below:

Figure 14 IS-IS GR configuration



In this topology, two S86 devices must be configured to allow non-stop data forwarding in order to enhance reliability of core devices. Therefore, IS-IS GR Restart capability must be enabled and GR time must be configured properly. In addition, S3750 is not allowed to participate in the Help process, and thus its IS-IS GR Help capability must be disabled. By default, IS-IS GR Help capability is supported by other devices, and no additional configuration is needed.

- Detailed configurations

S86-1:

```
Ruijie(config)# router isis
Ruijie(config-router)# graceful-restart
Ruijie(config-router)# graceful-restart grace-period 60
S86-2:
Ruijie(config)# router isis
Ruijie(config-router)# graceful-restart
Ruijie(config-router)# graceful-restart grace-period 80
S3750:
Ruijie(config)# router isis
Ruijie(config-router)# graceful-restart helper disable
```

Note Software that supports IS-IS GR capability enables IS-IS GR Help capability by default.

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Security Configuration

16. Configuring SDG
17. Configuring Anti-attack Features on Devices
18. Configuring RPL
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21. Configuring Web Authentication
22. Configuring 802.1X

Configuring ACLs

Overview

As part of Ruijie's security solution, an access control list (ACL) is used to provide a powerful traffic filtering function. Currently, Ruijie products support the following ACLs:

- Standard and extended IP ACLs
- MAC Extended ACLs
- Extended Expert ACLs
- IPv6 Extended ACLs

Depending on networks conditions, you can choose different ACLs to control data flows.

ACL Introduction

An ACL is also referred to as a firewall or packet filtering. ACLs permit or discard packets on interfaces of network devices by defining rules. According to application scopes, they can be divided into ACLs and QoS ACLs.

By filtering the data streams, you can restrict the communication data types in the network and restrict the users of the network and the device they can use. When data streams pass the switch, ACLs classify and filter them, that is, check the data streams input from the specified interface and determine whether to permit or deny them according to the matching conditions.

To sum up, the security ACL is used to control which data flow is allowed to pass through the network device. The QoS policy performs priority classification and processing for the data flow.

ACLs consist of a series of entries, known as Access Control Entry (ACE). Each entry has its matching condition and behavior.

ACL rules can be applied to the source addresses, destination addresses, upper layer protocols, time ranges or other information of data flows.

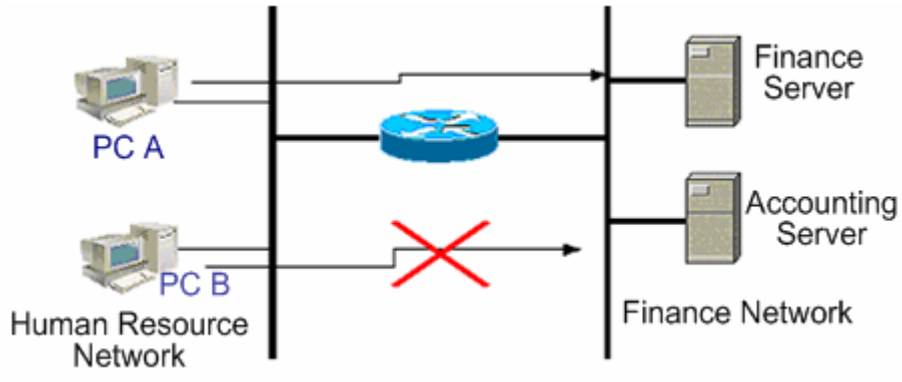
Why to Configure ACLs

There are many reasons why ACLs need to be configured. In most cases, ACLs are used to:

- Restrict route update: Control where the route update information is sent and received.
- Restrict network access: To ensure network security, provide users with access to desired services only (for example, if a user only needs webpage access and email services, other services such as Telnet are disabled), specify a time period in which access is permitted, or specify hosts which are allowed to access Internet.

In Figure 1, only host A is allowed to access Finance Network, while Host B is not.

Figure 1 Using ACLs to control network access



When to Configure Access Lists

Depending on your requirements, you can select the basic ACL or dynamic ACL. In general, the basic ACL can meet the security requirement. However, experienced hackers may use some software to forge source addresses and spoof the devices so as to gain access. Before the user can access the network, the dynamic ACL requires authentication so that the hackers are difficult to invade the network. So, in some sensitive areas the dynamic ACL can be used to ensure the network security.

Note

An inherent problem of all ACLs is spoofing, the behavior of providing spoofed source addresses to deceive switches. This cannot be avoided even you use the dynamic ACL. During the effective access period of an authenticated user, a hacker may use a spoofed user address and accesses the network. There are two methods to resolve the problem. One method is to set free time for a user to access the network as little as possible, making it hard for a hacker to attack the network. The other method is to use IPSEC to encrypt network data, ensuring that all the data entering switches is encrypted.

ACLs are usually configured in the following positions of network devices:

- Devices between the internal network and external network (such as the Internet)
- Devices at the border of two parts in a network
- Devices on the access control port

The execution of the ACL statements must follow the order in the table strictly. Starting from the first statement, once the header of a packet matches a conditional judge statement in the table, the following statements are ignored.

Input/Output ACL, Filtering Domain Template and Rule

When a device interface receives a message, the input ACL checks whether the message matches an ACE of the ACL input on the interface. When a device interface is ready to output a message, the output ACL checks whether the message matches an ACE of the ACL output on the interface.

When detailed filtering rules are formulated, all or some of the preceding eight items may be used. As long as the message matches one ACE, the ACL processes the message as the ACE defined (permit or deny). The ACE of an ACL identifies Ethernet messages according to some fields of Ethernet messages. The fields include the following:

Layer-2 fields:

- 48-bit source MAC address (all the 48 bits must be declared)
- 48-bit destination MAC address (all the 48 bits must be declared)
- 16-bit layer-2 type field

Layer 3 fields:

- Source IP address field (you can specify all the 32 bits of the IP address, or specify a type of streams of the defined subnet)
- Destination IP address field (you can specify all the 32 bits of the IP address, or specify a type of streams of the defined subnet)
- Protocol type fields

Layer-4 fields:

- You can specify one UDP source port, destination port, or both
- You can specify one UDP source port, destination port, or both

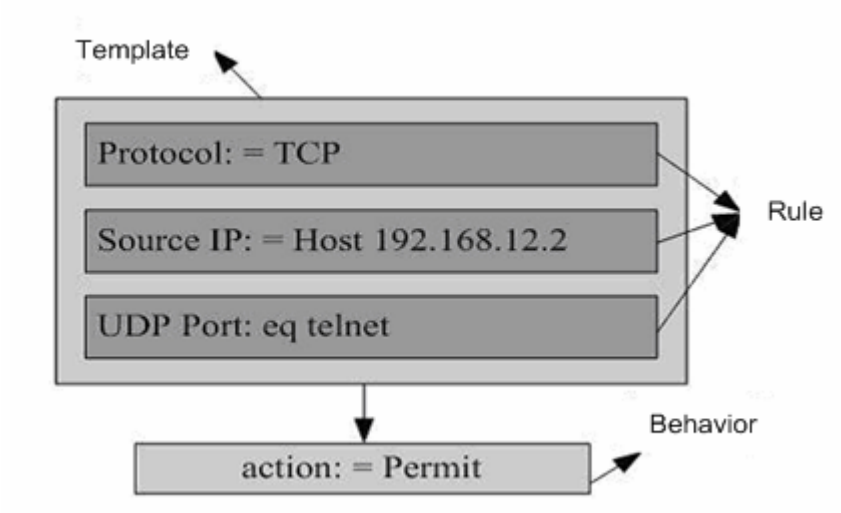
The filtering domain consists of the fields in the packets based on which the packets are identified and classified when you create an ACE. A filtering domain template is the definition formed by these fields. For example, when one ACE is generated, you want to identify and classify messages according to the destination IP field of a message. When another ACE is generated, you want to identify and classify messages according to the source IP address field of a message and the source port field of UDP. In this way, these two ACEs use different filtering domain templates.

Rules refer to the values of the ACE mask. For example, one ACE is:

```
permit tcp host 192.168.12.2 any eq telnet
```

In this ACE, the filtering domain template is a collection of the following fields: Source IP Address Fields, IP Protocol Fields and Destination TCP Port Fields. Corresponding values (rules) are respectively as follows: Source IP Address=Host 192.168.12.2; IP Protocol=TCP; TCP Destination Port=Telnet.

Figure 2 Analysis of the ACE: permit tcp host 192.168.12.2 any eq telnet



Note A filtering domain template can be the collection of L3 fields and L4 fields or the collection of multiple L2 fields. However, the filtering domain templates of a standard and extended ACL cannot be the collection of L2 and L3, L2 and 4, L2 and L3, or L4 fields. To use the combination of L2, L3 and L4 fields, it is possible to apply the Expert ACLs.

Caution 1. When associating SVI with the ACL at the outbound direction, you should note that:

Caution Standard IP ACL, extended IP ACL, MAC extended ACL and Expert ACL are supported. There are some limits on matching the destination IP address and the destination MAC address with an ACL. When you use the MAC extended ACL and Expert ACL to match the destination MAC addresses and then apply this ACL to the outbound direction of SVI, entries will be set, but will not take effect. If you need to match the destination IP address not in the subnet IP range of the associated SVI in the standard IP ACL, extended IP ACL or expert ACL, this ACL will not take effect. For example, the IP address of VLAN 1 is 192.168.64.1 and subnet mask of VLAN 1 is 255.255.255.0. Now you create an ACL with the ACE of **deny udp any 192.168.65.1 0.0.0.255 eq 255** and apply this ACL to the egress of VLAN 1. This ACL will not function for the destination IP address is not in the subnet IP range of VLAN 1. If the ACE is **deny udp any 192.168.64.1 0.0.0.255 eq 255**, this ACL will take effect.

Note When configuring and applying the Expert ACL to the outbound direction of the interface, failure occurs in controlling the non-IP packets transmitted on the interface by using the ACL Permit and Deny rules if some ACEs in the ACL contain L3 matching information (such as IP and L4 port).

Note When applying an ACL, the labeled MPLS packet matching does not take effect if an ACE in the ACL (including the IP ACL and Expert extended ACL) matches a non-L2 field (such as SIP and DIP).

Configuring IP Access List

To configure ACLs on a device, you must specify unique names or numbers for the ACLs of a protocol to uniquely identify each ACL within the protocol. The following table lists the protocols that can use numbers to specify ACLs and the number ranges of ACLs that can be used by each protocol.

Protocol	Number Range
Standard IP	1-99, 1300 - 1999
Extended IP	100-199, 2000 - 2699

Guide to Configuring IP ACLs

When you create an ACL, defined rules will be applied to all packets on a device. The device decides whether to forward or block a packet by judging whether the packet matches a rule.

Basic ACLs are classified into standard ACLs and extended ACLs. The typical rules defined in ACLs are as follows:

- Source address
- Destination address
- Upper layer protocol
- Time range

Standard IP ACLs (numbered from 1 to 99 and from 1300 to 1999) forward or block packets according to source addresses. Extended IP ACLs (numbered from 100 to 199 and from 2000 to 2699) use the above four combinations to forward or block packets. Other types of ACLs forward or block packets according to related codes.

A single ACL can use multiple separate ACL statements to define multiple rules. Where, all statements use the same number or name to bind these statements to the same ACL. However, the more the used statements are, the more difficult to read and understand an ACL.

Statement containing an implicit deny statement for all packets

The end of the ACL contains an implicit deny statement for all packets that it did not find a match for before reaching the end, as shown in the following example:

```
access-list 1 permit host 192.168.4.12
```

This ACL allows only the messages destined for host 192.168.4.12. This is because the ACL contains the following rule statement at the end: **access-list 1 deny any**

Here is another example:

```
access-list 1 deny host 192.168.4.12
```

If the ACL contains the only preceding statement, the messages from any host will be denied on the port.


Note

It is required to consider the routing update message when defining the ACL. Since the end of the ACL contains an implicit deny statement for all packets, this may cause all routing update messages blocked.

☑ If the inserted line cards do not include EA series, the ACEL associated with the outgoing direction of the AP port has no default deny ACE, which shall be configured manually as needed.

Order to Input Rule Sentences

Each added rule is appended to the ACL. If a statement is created, then you cannot delete it separately but delete the whole ACL. Therefore, the order of ACL statements is very important. When deciding whether to forward or block packets, a device compares packets and statements in order of statement creation time until It finds a matching statement.

If you have created a statement that allows all packets to pass, then the following statements will not be checked, as shown in the following example:

```
access-list 101 deny ip any any
access-list 101 permit tcp 192.168.12.0 0.0.0.255  eq  telnet any
```

Because the first rule statement denies all IP packets, the packets for accessing host 192.168.12.0/24 will be denied. Because the device discovers that the packets match the first rule statement, it will not check other rule statements.

Configuring IP ACLs

The configuration of the basic ACL includes the following steps:

- Define a basic ACL
- Apply the ACL to a specific interface.

There are two methods to configure a basic ACL.

Method 1: Run the following command in global configuration mode:

Command	Function
Ruijie(config)# **access-list id** {**deny** | **permit**} {**src** *src-wildcard* | **host src** | **any** | *interface idx*} [**time-range** *tm-rng-name*]	Defines an ACL .
Ruijie(config)# **interface** *interface*	Selects the interface to which the ACL is to be applied.
Ruijie(config-if)# ip access-group id { in | out } [unreflect]	Applies the ACL to the specific interface

Method 2: Run the following command in ACL configuration mode:

Command	Function
Ruijie(config)# **ip access-list** { **standard** | **extended** } { *id* | *name* }	Enters ACL configuration mode.
Ruijie (config-xxx-nacl)# [**sn**] { **permit** | **deny** } {**src** *src-wildcard* | **host src** | **any** } [**time-range** *tm-rng-name*]	Adds ACEs to the ACL. For details about the command, see command reference.
Ruijie(config-xxx-nacl)# **exit**	Exits ACL mode.
Ruijie(config)# **interface** *interface*	Selects the interface to which the ACL is to be applied.
Ruijie(config-if)# ip access-group *id* { in | out } [unreflect]	Applies the ACL to the specific interface.

Note

In method 1, an ACL can only be numbered. In method 2, an ACL can be numbered and named, and ACE priority can be specified if available. By default, the reflexive ACL is enabled on the IP ACL port. You can run the **unreflect** command to disable the reflexive ACL. (The operation principles of the reflexive ACL are described as follows:

a. The router automatically generates a temporary ACL according to the L3 and L4 information of the originating traffic in the internal network based on the principles. That is, the protocol is constant, while the source and destination IP addresses, and the source and destination ports are rigidly exchanged.

b. The router allows traffic to enter the internal network only when the L3 and L4 information of the returned traffic strictly matches the information in the temporary ACL previously created based on the outputting traffic.)

Displaying IP ACLs

To monitor ACLs, run the following command in privileged user mode:

Command	Function
Ruijie# **show access-lists** [*id* | *name*]	Queries the basic ACLs.

Configuring IPv6 Extended ACLs

Configuring IPv6 Extended ACLs

The configuration of an IPv6 ACL includes the following steps:

- Define an IPv6 ACL

- Apply the ACL to a specific interface (application particular case)

To configure a basic ACL, run the following command in ACL configuration mode:

Command	Function
Ruijie(config)# **ipv6 access-list** *name*	Enters ACL configuration mode.
Ruijie (config-ipv6-nacl)# [sn] **{permit | deny** } prot {*src-ipv6-prefix/prefix-len* | **host** *src-ipv6-addr* | **any**} {*dst-ipv6-pfix/pfix-len* | **any | host** *dst-ipv6-addr*} [**dscp** *dscp*] [**flow-label** *flow-labe*l] [**time-range** *tm-rng-name*]	Adds ACEs to the ACL. For details about the command, see command reference.
Ruijie(config-exp-nacl)# **exit**	Exits the access control list mode.
Ruijie(config)# **interface** *interface*	Selects the interface to which the ACL is to be applied.
Ruijie(config-if)# **ipv6 traffic-filter** *name* {**in** | **out**}	Applies the ACL to the specific interface.

Displaying Configuration of IPv6 Extended ACLs

To monitor ACLs, run the following command in privileged user mode:

Command	Function
show access-lists [*name*]	Queries the basic ACLs.

Configuring Extended Expert ACLs

To configure Expert extended ACLs on a device, you must specify unique names or numbers for the ACLs of a protocol to uniquely identify each ACL within the protocol. The following table lists the number range of the Expert ACLs.

Protocol	Number Range
Extended Expert ACL	2700-2899

Guide to Configuring Expert Extended ACLs

When you create an expert extended ACL, defined rules will be applied to all packets on a device. The device decides whether to forward or block a packet by judging whether the packet matches a rule.

The typical rules defined in Expert ACLs are as follows:

- All information in basic ACLs and MAC extended ACLs
- VLAN ID

Extended Expert ACLs (numbered from 2700 to 2899) are the syntheses of basic ACLs and MAC extended ACLs and can filter VLAN IDs.

A single expert ACL can use multiple separate ACL statements to define multiple rules. Where, all statements use the same number or name to bind these statements to the same ACL.

Configuring an Expert Extended ACL

The configuration of an expert ACL includes the following steps:

- Define an expert ACL
- Apply the ACL to a specific interface (application particular case)

There are two methods to configure an Expert ACL.

Method 1: Run the following command in global configuration mode:

Command	Function
Ruijie (config)# **access-list** *id* {**deny** | **permit**} [*prot* | {[*ethernet-type*] [**cos** *cos*]}] [**VID** *vid*] {**src** *src-wildcard* | **host** *src* | **interface** *idx*} {**host** *src-mac-addr* | **any**} {**dst** *dst-wildcard* | **host** *dst* | **any**}{**host** *dst-mac-addr* | **any**}] [**precedence** *precedence*] [**tos** *tos*] [**dscp** *dscp*] [**fragment**] [**time-range** *tm-rng-name*]	Defines an ACL. For details about the command, see command reference.
Ruijie(config)# **interface** *interface*	Selects the interface to which the ACL is to be applied.
Ruijie(config-if)# expert access-group *id* {in | out } [unreflect]	Applies the ACL to the specific interface.

Method 2: Run the following command in ACL configuration mode:

Command	Function
Ruijie(config)# **expert access-list extended** {*id*|*name*}	Enters ACL configuration mode.
Ruijie (config-exp-nacl)# [*sn*]{ **permit** | **deny** }[*prot* | {[*ethernet-type*] [**cos** *cos*]}] [**VID** *vid*] {**src** *src-wildcard* | **host** *src* | **interface** *idx*}{**host** *src-mac-addr* | **any**} {**dst** *dst-wildcard* | **host** *dst* | **any**} {**host** *dst-mac-addr* | **any**}][**precedence** *precedence*] [**tos** *tos*] [**dscp** *dscp*] [**fragment**] [**time-range** *tm-rng-name*]	Adds ACEs to the ACL. For details about the command, see command reference.
Ruijie(config-exp-nacl)# **exit**	Exit ACL mode.
Ruijie(config)# **interface** *interface*	Selects the interface to which the ACL is to be applied.
Ruijie(config-if)# **expert access-group** {*id*|*name*} {**in**|**out**} **[unreflect]**	Applies the ACL to the specific interface.

Note

In method 1, an ACL can only be numbered. In method 2, an ACL can be numbered and named, and ACE priority can be specified if available. In a version supporting ACE priority, method 2 can also specify the priorities of ACEs (using the [*sn*] option in a command).

☑ The router supports neither packet fragment filtering nor Expert ACLs.

Displaying Configuration of Expert Extended ACLs

To monitor ACLs, run the following command in privileged user mode:

Command	Function
show access-lists [*id* | *name*]	Queries the Expert ACLs.

Configuring MAC Extended ACLs

To configure MAC extended ACLs on a device, you must specify unique names or numbers for the ACLs of a protocol to uniquely identify each ACL within the protocol. The following table lists the range of the numbers that can be used to specify MAC ACLs.

Protocol	Number Range
MAC Extended Access List	700-799

Guide to Configuring MAC Extended ACLs

When a MAC ACL is created, the defined rules will be applied to all packets on a device. The device decides whether to forward or block a packet by judging whether the packet matches a rule.

The typical rules defined in MAC ACLs are as follows:

- Source MAC address
- Destination MAC address
- Ethernet protocol type
- Time-range

The MAC extended ACLs (numbered from 700 to 799) forward or block the packets based on the source and destination MAC addresses, and can also match Ethernet packets.

A single MAC ACL can use multiple separate ACL statements to define multiple rules. Where, all statements use the same number or name to bind these statements to the same ACL.

Configuring a MAC Extended ACL

The configuration of an MAC ACL includes the following steps:

- Define an MAC ACL
- Apply the ACL to a specific interface

There are two methods to configure an MAC ACL.

Method 1: Run the following command in global configuration mode:

Command	Function
Ruijie(config)# **access-list** id {**deny** | **permit**}{**any** | **host** *src-mac-addr*} {**any** | **host** dst-mac-addr} [*ethernet-type*] [**cos** *cos*]	Defines an ACL. For details about the command, see command reference.
Ruijie(config)# **interface** *interface*	Selects the interface to which the ACL is to be applied.
Ruijie(config-if)# **mac access-group** *id* { **in** | **out** }	Applies the ACL to the specific interface.

Method 2: Run the following command in ACL configuration mode:

Command	Function
Ruijie(config)# **mac access-list extended** {*id* | *name*}	Enters ACL configuration mode.

Ruijie (config-mac-nacl)# [sn] { **permit** | **deny** }{**any** | **host** *src-mac-addr*} {**any** | **host** *dst-mac-addr*} [*ethernet-type*] [**cos** *cos*]	Adds ACEs to the ACL. For details about the command, see command reference.
Ruijie(config-mac-nacl)# **exit** Ruijie(config)# **interface** *interface*	Exits ACL mode and selects the interface to which the ACL is to be applied.
Ruijie(config-if)# **mac access-group** {*id* | *name*} { **in** | **out**}	Applies the ACL to the specific interface.


Note

Method 1 only configures the numerical value ACL. Method 2 can configure the names and numerical value ACL, and specify the table entry priorities (in the devices that support ACE priorities).

☑ The route does not support MAC ACLs.

Displaying Configuration of MAC Extended ACLs

To monitor ACLs, run the following command in privileged EXEC mode:

Command	Function
show access-lists [*id* | *name*]	Queries the basic ACLs.

Other Related Configurations

Configuring ACEs by Priority

To embody the ACE priority, criteria is set up for each ACL so that ACEs in an ACL are arranged in a standard manner: using an ACE sequence number as the start point and making the sequence number grows at an increment:

- ACEs are arranged by sequence number in ascending order in the chain table.
- ACE arrangement starts from a sequence number. If no number is specified, it increases at an increment on the basis of the previous ACE number.
- To specify the sequence number of an ACE, insert the ACE and ensure that a new ACE can be inserted between two adjacent ACEs.
- The ACL specifies the start number and the increment.

The **ip access-list resequence** {*acl-id*| *acl-name*} *sn-start sn-inc* command is available. For details, see command reference.

Whenever the preceding command is run, the ACEs in the ACL will be sorted. For example, the ACEs in the ACL named **tst_acl** are numbered as follows:

In the beginning

```
ace1: 10
ace2: 20
ace3: 30
```

The ACEs are numbered as follows after “the **ip access-list resequence** *tst_acl 100 3*” command is run:

```
Ruijie(config)# ip access-list resequence tst_acl 100 3
ace1: 100
ace2: 103
ace3: 106
```

If you do not specify *sn-num* when adding ACE 4, ACE 4 is numbered as follows:

```
Ruijie(config-std-nacl)# permit …
ace1: 100
ace2: 103
ace3: 106
ace4: 109
```

If you set *seg-num* to **105** when adding ACE 5, ACE 5 is numbered as follows:

```
Ruijie(config-std-nacl)# 105 permit …
ace1: 100
ace2: 103
ace5: 105
ace3: 106
ace4: 109
```

The sequence number mechanism is designed to add ACEs by priority.

Delete ACEs

```
Ruijie(config-std-nacl)# no 106
ace1: 100
ace2: 103
ace5: 105
ace4: 109
```

It is also convenient to delete ACEs with a sequence number.

Configuring ACL Logging

When ACL Logging is enabled, if a packet matches a logging-enabled ACE and the matching speed reaches or even exceeds the configured logging threshold, the system generates a log within one logging interval to determine whether to permit or deny this packet.

Note This function applies only to standard and extended IP ACLs and is optional.

Default configuration

The ACL logging function is disabled by default.

ACL Options are configured as follows:

Configure the ACL logging speed threshold. This threshold means the maximum speed an ACE is matched. When it is exceeded, a log is generated.

Command	Function
Ruijie(config)#**ip access-list log-update threshold** *threshold-value*	Configures the ACL logging threshold.

Configure the ACL logging interval, in milliseconds.

Command	Function
Ruijie(config)#**ip ccess-list logging interval** *interval-value*	Configures the ACL logging interval.

Enable ACE logging so that packets matching an ACE can be counted.

Command	Function
Ruijie(config)# **ip access-list extended** { *id* | *name* }	Enters ACL configuration mode.
Ruijie(config-ext-nacl)# [sn] {**permit** | **deny**} **protocol** *source source-wildcard destination destination-wildcard* [**precedence** *precedence*] [**tos** *tos*] [**fragment**] [**range** *lower upper*] [**time-range** *time-range-name*] [**option** *option*] [**log**]	Adds ACEs to the ACL. For details about the command, see command reference.
Ruijie(config-exp-nacl)# **exit**	Exits ACL configuration mode and selects the interface to which the ACL is to be applied.

Configuration example:

- Configure the permission and password for enabling the ACL logging function.

```
Ruijie> enable
Ruijie#
```

- Enter global configuration mode.

```
Ruijie# configure terminal
Ruijie(config)#
```

- Configure the ACL logging threshold and interval.

```
Ruijie(config)# ip access-list log-update threshold 1
Ruijie(config)# ip access-list logging interval 1
```

- Enter ACL configuration mode and enable logging on the desired ACE.

```
Ruijie(config-ext-nacl)# permit ip 99.9.9.0 0.0.0.255 any log
```

- Add a deny ACE and enable the logging function on the ACE.

```
Ruijie(config-ext-nacl)# deny ip any any log
```

- end

```
Ruijie(config-ext-nacl)# end
```

- The following log will be generated when the ACL logging threshold is reached or exceeded:

```
*Feb 20 14:10:48.747: %SEC-6-IPACCESSLOGNP: list s1 permitted 0 99.9.9.2 -> 99.9.9.1, 1 packet
```

```
*Feb 20 14:11:37.171: %SEC-6-IPACCESSLOGNP: list s1 permitted 0 99.9.9.2 -> 99.9.9.1, 2 packets
*Feb 20 14:42:51.207: %SEC-6-IPACCESSLOGNP: list s1 denied 0 90.9.9.2 -> 99.9.9.1, 1 packet
```

In privileged configuration mode, run the following commands to configure a global security tunnel:

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)#security global access-group *1*	Configures a global security tunnel.

In privileged configuration mode, execute the following commands to set an exception port:

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)**#interface** *idx*	Enters interface configuration mode.
Ruijie(config-if)# security uplink enable	Sets the interface as an exceptional port..

In privileged configuration mode, run the following commands to configure a security tunnel on the interface:

Command	Function
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)**#interface** *idx*	Enters interface configuration mode.
Ruijie(config-if)# **security access-group** *1*	Configures a security tunnel on the interface.

The following example shows how to configure a security tunnel on a security port where IP/MAC binding is configured, so that IPX packets can pass:

Set port 4 as the security port and bind IP address and MAC address

```
Ruijie(config)#interface FastEthernet 0/4
Ruijie(config-if)#switchport port-security
Ruijie(config-if)#switchport port-security binding 0000.0000.0011 vlan 1 192.168.6.3
```

Only the packets whose source IP address is 192.168.6.3 and MAC address is 0000.0000.0011 can pass the device through port 4. To receive IPX packets, set a security tunnel as follows:

```
Ruijie#configure
Ruijie(config)#expert access-list extended safe_channel
Ruijie(config-exp-nacl)#permit ipx any any
Ruijie(config-exp-nacl)#exit
Ruijie(config)#security global access-group safe_channel
```

Or configure a security tunnel on the interface:

```
Ruijie#configure
Ruijie(config)#expert access-list extended safe_channel
Ruijie(config-exp-nacl)#permit ipx any any
Ruijie(config-exp-nacl)#exit
Ruijie(config)#interface FastEthernet 0/4
```

Ruijie(config-if)**#security access-group** *safe_channel*

IPX packets can pass through port 4 after a security channel is configured globally or on an interface.

Configuring ACL80

ACL 80 is also called the custom ACL, which is used to match the first 80 bytes of a packet. A packet consists of a series of byte flows. ACL 80 enables the user to filter packets according to the specified 16 bytes of the first 80 bytes in the packet.

Note The SMAC/DMAC/SIP/DIP/ETYPE field of the packets is not specified. In other words, a packet is filtered only when the specified 16 bytes match ACL 80 in addition to these fields.

For any 16-byte field, it is possible to compare or not the configured value by bits. In other words, it allows setting any bit of those 16 bytes as 0 or 1. There are two factors in filtering any byte: filtering rule and filter domain template. The bits of the both are one-to-one corresponding. The filtering rule specifies the value of the field to be filtered. The filter domain template specifies whether to filter the related fields in the filtering rule (“1” indicates matching the bit in the corresponding filtering rule, 0 for not). Therefore, when it is time to match a bit, it is required to set 1 for the corresponding bit in the filter domain template. If the filter domain template bit is set as 0, no match will be done no matter what the corresponding bit is in the filtering rule.

For example,

```
Ruijie(config)# expert access-list advanced name
Ruijie(config-exp-dacl)# permit 00d0f8123456 fffffffffff 0
Ruijie(config-exp-dacl)# deny 00d0f8654321 fffffffffff 6
```

The user custom ACL matches any byte of the first 80 bytes in the layer-2 data frames according to the user definitions, and then performs corresponding processing for the packets. To use ACL 80 correctly, it is necessary to have in-depth knowledge about the structure of layer-2 data frames. The following illustrates the first 64 bytes in a layer-2 data frame (each letter indicates a hexadecimal number, and each two letters indicate a byte).

AA AA AA AA AA AA BB BB BB BB BB BB CC CC DD DD

DD DD EE FF GG HH HH HH II II JJ KK LL LL MM MM

NN NN OO PP QQ QQ RR RR RR RR SS SS SS SS TT TT

UU UU VV VV VV VV WW WW WW WW XY ZZ aa aa bb bb

The following table lists the meanings and offset values of each letter:

Letter	Meaning	Offset	Letter	Meaning	Offset
A	Destination MAC	0	O	TTL field	34
B	Source MAC	6	P	Protocol ID	35
C	VLAN tag field	12	Q	IP checksum	36
D	Data frame length field	14	R	Source IP address	38
E	DSAP field	18	S	Destination IP address	42
F	SSAP field	19	T	TCP source port	46
G	Ctrl field	20	U	TCP destination port	48
H	Org Code field	21	V	Sequence number	50
I	Encapsulated data type	24	W	Confirmation field	54

J	IP version No.	26	XY	IP header length and reservation bits	58
K	TOS field	27	Z	Reservation bit and flags bit	59
L	IP packet length	28	a	Windows size field	60
M	ID	30	b	Others	62
N	Flags field	32			

As shown in the preceding table, the offset of each field is the offset in the SNAP+tag 802.3 data frame. In ACL 80, the user can use two parameters, the rule mask and offset, to abstract any byte from the first 80 bytes of the data frame, and then compare it with the user defined rule to filter the matched data frame for corresponding processing. The user defined rule can be some fixed attributes of the data. For example, the user wants to filter all the TCP packets by defining the rule as “06”, rule mask as “FF” and offset as 35. Here, the rule mask and offset work together to abstract the contents of the TCP protocol ID field in the received data frame, and compare it with the rule to filter all TCP packets.


Caution ACL 80 can be used to match Ethernet packets, 803.3 SNAP packets, and 802.311c packets. If the value for matching DSAP to the cnt1 field is set to AAAA03, it indicates to match the 803.3 SNAP packets. If the value is set to E0E003, it indicates to match the 803.311c packets. This field cannot be set to match Ethernet packets.


Caution ACL 80 only match only the 16 bytes of a packet. If the 16 bytes are used, no fields other than the 16 bytes can be matched. For example:

```
Ruijie(config)# expert access-list advanced name
Ruijie(config-exp-dacl)# permit 112233445566778899aabbccd deeff
ffffffffffffffffffffffffffffff 50
```

Add another ACE:

```
Ruijie(config-exp-dacl)#permit 112233445566778899aabbccd deeff
ffffffffffffffffffffffffffffff 54
```

The configuration will fail because the 16 bytes are used by the first ACE. To match the second ACE, you must delete the first ACE.

Configuring IP Options Filtering

IP Options filtering is used to match options in the IP packet header by option value (0–255) or option name. If the IP options in a packet match all bits defined in ACEs, the packet is deemed to match the ACL. Users can set any values for IP options to filter packets with specified IP options.


Note This feature applies only to named extended ACLs and is optional.

Configure IP Options filtering:

Command	Function
Ruijie(config)# **ip access-list extended** { *id* | *name* }	Enters ACL configuration mode.
Ruijie(config-ext-nacl)# [sn] {**permit** | **deny**} **protocol** *source source-wildcard destination destination-wildcard* [**precedence** *precedence*] [**tos** *tos*] [**fragment**] [**range** *lower upper*] [**time-range** *time-range-name*] [**option** *option*] [**log**]	Adds ACEs to the ACL. For details about the command, see command reference.
Ruijie(config-exp-nacl)# **exit**	Exits ACL configuration mode and selects the interface to which the ACL is to be applied.
Or	
Ruijie(config)# **interface** *interface*	Exits ACL configuration mode and selects the interface to which the ACL is to be applied.
Ruijie(config-if)# **ip access-group** {*id* | *name*} {**in** | **out**}	Applies the ACL to the specific interface.

Configuration example:

- Configure the permission and password for enabling the IP Option feature.

```
Ruijie> enable
Ruijie#
```

- Enter global configuration mode.

```
Ruijie# configure terminal
Ruijie(config)#
```

- Enter ACL configuration mode.

```
Ruijie(config)# ip access-list extended ip-options
Ruijie(config-ext-nacl)#
```

- Add ACEs.

```
Ruijie(config-ext-nacl)# permit ip any any option lsr
```

- Add deny ACEs.

```
Ruijie(config-ext-nacl)# deny ip any any option any-options
```

- end

```
Ruijie(config-ext-nacl)# end
```

- Display the configuration result.

```
Ruijie# show  access-list ip-options
ip access-lists extended ip-options
10 permit tcp any any option lsr
20 deny tcp any any option any-options
```

Configuring ACLs Based on the Time Range

You can make ACLs effective based on time, for example, ACLs take effect during certain periods in a week. For this purpose, you must first set a time range.

Time range implementation depends on the system clock. If you want to use this function, you must assure that the system has a reliable clock.

In privileged configuration mode, run the following commands:

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **time-range** *time-range-name*	Identifies a time range by using a meaningful display character string as its name
Ruijie(config-time-range)# **absolute** [**start time** *date*] **end time** *date*	Sets the absolute time range (optional). For details, see the time range configuration guide.
Ruijie(config-time-range)# **periodic day-of-the-week time to** [*day-of-the-week*] **time**	Sets the periodic time range (optional).
Ruijie# **show time-range**	Verifies the configuration.
Ruijie# **copy running-config startup-config**	Saves the configuration.
Ruijie(config)# **ip access-list extended** *101*	Enters ACL configuration mode.
Ruijie(config-ext-nacl)# **permit ip any any time-range** *time-range-name*	Configures a time range-based ACE.

Note

The length of the name should be 1-32 characters without any blank space.
You can set one absolute time range at most. The application based on time-ranges will be effective only in this time range.
You can set one or more intervals. If you have already set a running time range for **time-range**, the application takes effect at intervals in that time range.

The following example shows how to deny HTTP packets during the working hours in a week by using the time range-based ACLs:

```
Ruijie(config)# time-range no-http
Ruijie(config-time-range)# periodic weekdays 8:00 to 18:00
Ruijie(config)# end
Ruijie(config)# ip access-list extended limit-udp
Ruijie(config-ext-nacl)# deny tcp any any eq www time-range no-http
Ruijie(config-ext-nacl)# exit
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if)# ip access-group no-http in
Ruijie(config)# end
```

Example of time ranges:

```
Ruijie# show time-range
time-range entry: no-http(inactive)
```

```
periodic Weekdays 8:00 to 18:00
time-range entry: no-udp
periodic Tuesday 15:30 to 16:30
```

Configuring TCP Flag Filtering

The TCP Flag filtering feature provides a flexible mechanism. At present, TCP Flag filtering control supports the match-all option. Namely, when the TCP Flags in a received packet exactly match those defined in the ACE, the packet will be checked by the ACL rule. A user can define any combination of TCP Flags to filter some packets with specific TCP Flags.

For example,

```
permit tcp any any match-all rst
```

Allow the packets to pass if the TCP Flag is reset and other fields are set to 0.

Note This feature is optional when the protocol number is set to TCP in naming ACLs and numerical value ACLs. MAC extended and IP standard ACLs do not support this function.

To configure TCP Flag filtering, run the following commands:

Command	Function
Ruijie(config)# **ip access-list extended** { *id* | *name* }	Enters ACL configuration mode
Ruijie(config-ext-nacl)# [sn] {**permit** | **deny**} **tcp** source source-wildcard [operator port] destination destination-wildcard [operator port] [**match-all** flag-name][**precedence** precedence]	Adds ACEs to the ACL. For details about the command, see command reference.
Ruijie(config-exp-nacl)# **exit**	Exits ACL configuration mode and selects the interface to which the ACL is to be applied.
Or	
Ruijie(config)# **interface** *interface*	Exits ACL configuration mode and selects the interface to which the ACL is to be applied.
Ruijie(config-if)# **ip access-group** {*id* | *name*} {**in** | **out**}	Applies the ACL to the specific interface

The following example explains how to configure TCP Flag filtering.

- Configure the permission and password for enabling the TCP Flag filtering function.

```
Ruijie> enable
Ruijie#
```

- Enter global configuration mode.

```
Ruijie# configure terminal
Ruijie(config)#
```

- Enter ACL configuration mode.

```
Ruijie(config)# ip access-list extended test-tcp-flag
Ruijie(config-ext-nacl)#
```

- Add an ACE.

```
Ruijie(config-ext-nacl)# permit tcp any any match-all rst
Ruijie(config-ext-nacl)# permit tcp host 1.1.1.1 any established
```

- Add a deny ACE.

```
Ruijie(config-ext-nacl)# deny tcp any any match-all fin
```

- end

```
Ruijie(config-ext-nacl)# end
```

- Show

```
Ruijie# show access-list test-tcp-flag
ip access-lists extended test-tcp-flag
10 permit tcp any any match-all rst
20 deny tcp any any match-all fin
```

Configuring Comments

Comments on ACLs and ACEs are provided for easy query and understanding of ACL configuration.

Note Up to one ACL comment and 2048 ACE comments can be configured in one ACL.

Caution The length of each comment is 100 bytes.

☑ The ACE comment is supported on the router only.

In privileged configuration mode, run the following commands to configure an ACL comment:

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **ip access-list standard** *id*	Enters ACL configuration mode.
Ruijie(config-std-nacl)# **list-remark** *comment*	Comments the ACL.

You can also run the following commands to set an ACL comment:

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **access-list** *id* **list-remark** *comment*	Sets the ACL comment.

In privileged configuration mode, run the following commands to configure an ACE comment:

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **ip access-list standard** *id*	Enters ACL configuration mode.
Ruijie(config-std-nacl)# **remark** *comment*	Comment the ACE.

You can also run the following commands to set an ACE comment:

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **access-list** *id* **list-remark** *comment*	Sets the ACE comment.

The following example shows how to configure the ACL comment and the ACE comment:

```
Ruijie(config)#ip access-list standard 1
Ruijie(config-std-nacl)#remark ace_remark_permit_62_start
Ruijie(config-std-nacl)#permit 192.168.197.62 0.0.0.0
Ruijie(config-std-nacl)#remark ace_remark_permit_62_end
Ruijie(config-std-nacl)#list-remark acl_remark_foo
Ruijie(config-std-nacl)#end
Ruijie#write
Ruijie#show access-lists 1
ip access-list standard 1
 remark ace_remark_permit_62_start
 10 permit host 192.168.197.62
 remark ace_remark_permit_62_end
list-remark acl_remark_foo
Ruijie#
```

Configuring SVI Router ACLs

The ACLs applied to layer 3 interfaces are called Router ACLs, which apply only to the routing packets forwarded at layer 3.

To solve this problem, Ruijie switches are configured with a command for enabling SVI Router ACLs. After this function is enabled, security ACLs on SVIs apply only to layer 3 forwarding packets between VLANs.

Default Configuration

By default, SVI Router ACLs are disabled. SVI ACLs apply to both inter-VLAN layer 3 packets and intra-VLAN bridge-forwarded packets.

Configuring SVI Router ACLs

Command	Function
Ruijie**# configure terminal**	Enters global configuration mode.
Ruijie**# [*no*] svi router-acls enable**	Enables/Disables the SVI Router ACLs.

☑ This function is only supported on SS3000E, S5750, S8600 and S12000 series routers.

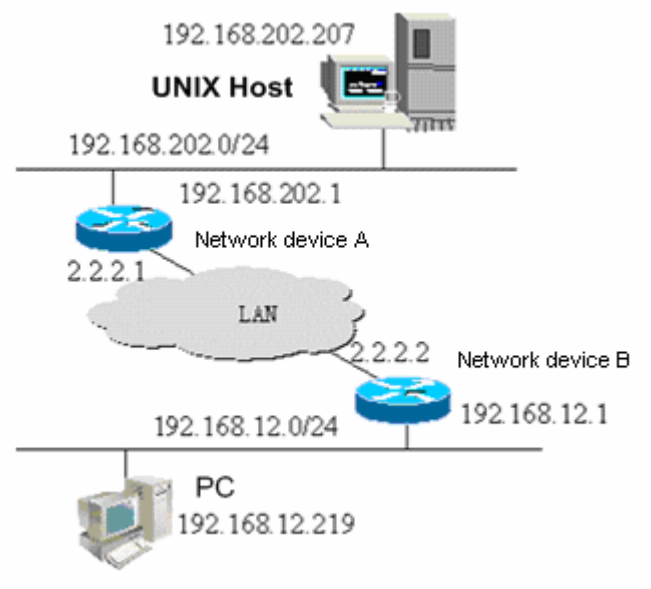
Configuration Examples

IP ACL Example

Configuration requirements:

There are two network devices A and B, as shown in Figure 1-3:

Figure 3 Basic ACL



It is required to implement the following security functions by configuring ACLs on device B.

Hosts on the 192.168.12.0/24 network segment can telnet the remote Unix host only in working hours and these host cannot ping the Unix server.

Device B is forbidden to access any services of hosts on the 192.168.202.0/24 network segment.

Note This example shows a simplified topology of the banking system. Namely, only access from hosts on the LAN in a branch or outlet to the central host is allowed.

Equipment Configuration

Device B configuration:

```
Ruijie(config)# interface GigabitEthernet 0/1
Ruijie(config-if)# ip address 192.168.12.1 255.255.255.0
Ruijie(config-if)# exit
Ruijie(config)# interface GigabitEthernet 0/2
Ruijie(config-if)# ip address 2.2.2.2 255.255.255.0
Ruijie(config-if)# ip access-group 101 in
Ruijie(config-if)# ip access-group 101 out
```

According to requirements, configure an extended ACL numbered 101

```
access-list 101 permit tcp 192.168.12.0 0.0.0.255 any eq telnet time-range check
Ruijie(config)# access-list 101 deny icmp 192.168.12.0 0.0.0.255 any
Ruijie(config)# access-list 101 deny ip 2.2.2.0 0.0.0.255 any
Ruijie(config)# access-list 101 deny ip any any
```

Configure the time range

```
Ruijie(config)# time-range check
Ruijie(config-time-range)# periodic weekdays 8:30 to 17:30
```

Note For ACL 101, the last rule statement ”access-list 101 deny ip any any” is not needed, because the end of the ACL contains an implicit deny statement for all packets.

Device A configuration:

```
Ruijie(config)# hostname Ruijie
Ruijie(config)# interface GigabitEthernet 0/1
Ruijie(config-if)# ip address 192.168.202.1 255.255.255.0
Ruijie(config)# interface GigabitEthernet 0/2
Ruijie(config-if)# ip address 2.2.2.1 255.255.255.0
```

IPv6 Extended ACL Configuration Example

It is required to implement the following security functions by configuring ACLs:

- The host whose IP address is 192.168.4.12 can access the gigabit 0/1 interface of a device.
- It cannot access other interfaces.

```
Ruijie> enable
Ruijie# config terminal
Ruijie(config)# ipv6 access-list v6-list
Ruijie(config-ipv6-nacl)# permit ipv6 ::192:68:4:12/24 any
Ruijie(config-ipv6-nacl)# deny ipv6 any any
Ruijie(config-ipv6-nacl)# exit
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if)# ipv6 traffic-filter v6-list in
Ruijie(config-if)# end
Ruijie# show access-lists
ipv6 access-list extended v6-list
petmit ipv6 ::192.168.4.12 any
deny any any
```

☑ An ACL cannot match all the preceding areas. Besides, the IPv6 ACL does not apply to packet fragments. Besides, when **sip** and **dip** of a packet match an ACL, **type code** or source and destination ports of ICMP is ignored.

Expert Extended ACL Configuration Example

It is required to implement the following security functions by configuring Expert ACLs:

- The host 0013.2049.8272 in VLAN 20 can access the gigabit 0/1 interface of a device.
- It cannot access other interfaces.

```
Ruijie> enable
```

```
Ruijie# config terminal
Ruijie(config)# expert access-list Expert extended-list
Ruijie(config-exp-nacl)# permit ip vid 20 any host 0013.2049.8272 any any
Ruijie(config-exp-nacl)# deny any any any any
Ruijie(config-exp-nacl)# exit
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if)# expert access-group expert-list in
Ruijie(config-if)# end
Ruijie# show access-lists
expert access-list Expert extended-list
permit ip vid 20 any host 0013.2049.8272 any any
deny any any any any
```

MAC Extended ACL Configuration Example

It is required to implement the following security functions by configuring MAC ACLs:

- The host 0013.2049.8272 using the IPX protocol cannot access the gigabit 0/1 interface of a device.
- It can access other interfaces.

```
Ruijie> enable
Ruijie# configure terminal
Ruijie(config)# mac access-list extended mac-list
Ruijie(config-mac-nacl)# deny host 0013.2049.8272 any ipx
Ruijie(config-mac-nacl)# permit any any
Ruijie(config-mac-nacl)# exit
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if)# mac access-group mac-list in
Ruijie(config-if)# end
Ruijie# show access-lists
mac access-list extended mac-list
deny host 0013.2049.8272 any ipx
permit any any
```

Note The ”permit any any” statement is required because the end of an ACL contains an implicit deny statement for all packets.

Configuring Unidirectional TCP Connections

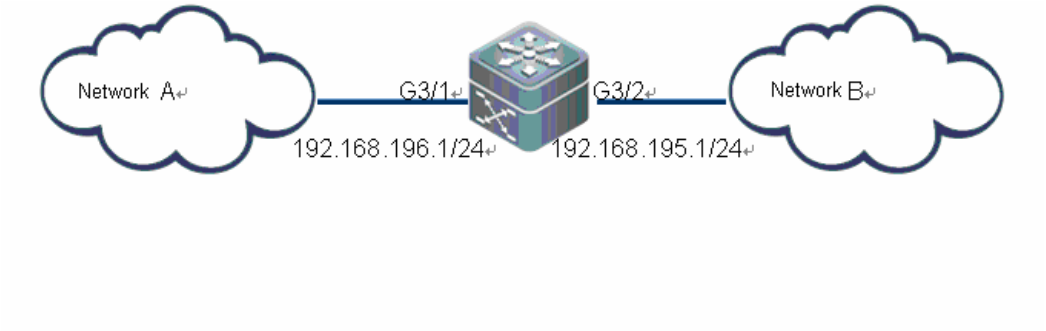
A unidirectional TCP connection can be established by configuring TCP Flag filtering.

Configuration Requirements

For the security of network A, the hosts in network A are allowed to originate the TCP connection request to the hosts in network B. However, the hosts of network B are not allowed to originate the TCP communication requests to network A.

Topology

Figure 4 Configuring a unidirectional TCP connection



As shown in the preceding figure, two networks are connected through an intermediate device. Network A connects to the G3/1 port of the device and network B connects to the G3/2 port of the device.

Analysis

By filtering the packets of TCP connection request originated by network B on the G3/2 port of the device, you can block the TCP connection request from hosts in network B to network A. According to the analysis of TCP connection, the SYN of the flag field in the TCP header of the initial TCP request packet is reset and the ACK is set to 0. Therefore, to enable network A to access network B, configure the **Match-all** option of the extended ACL to set the SYN of the TCP header to 1 and ACK to 0 on the inbound direction of the G3/2 port.

Configuration Steps

1) Define an ACL.

Enter global configuration mode

```
Ruijie# configure terminal
```

Create extended ACL 101 in configuration mode

```
Ruijie(config)# ip access-list extended 101
```

Deny the packets whose SYN is 1 and permit packets whose SYN is 0 (including ACK).

```
Ruijie(config-ext-nacl)# deny tcp any any match-all SYN
```

Permit other IP packets.

```
Ruijie(config-ext-nacl)# permit ip any any
```

2) Apply the ACL to the interface.

Exit ACL configuration mode.

```
Ruijie(config-ext-nacl)# exit
```

Enter the G3/2 port to which the ACL is applied.

```
Ruijie(config)# interface gigabitEthernet 3/2
```

Apply ACL 101 to the inbound direction of the G3/2 port for packet filtering.

```
Ruijie(config-if)# ip access-group 101 in
```

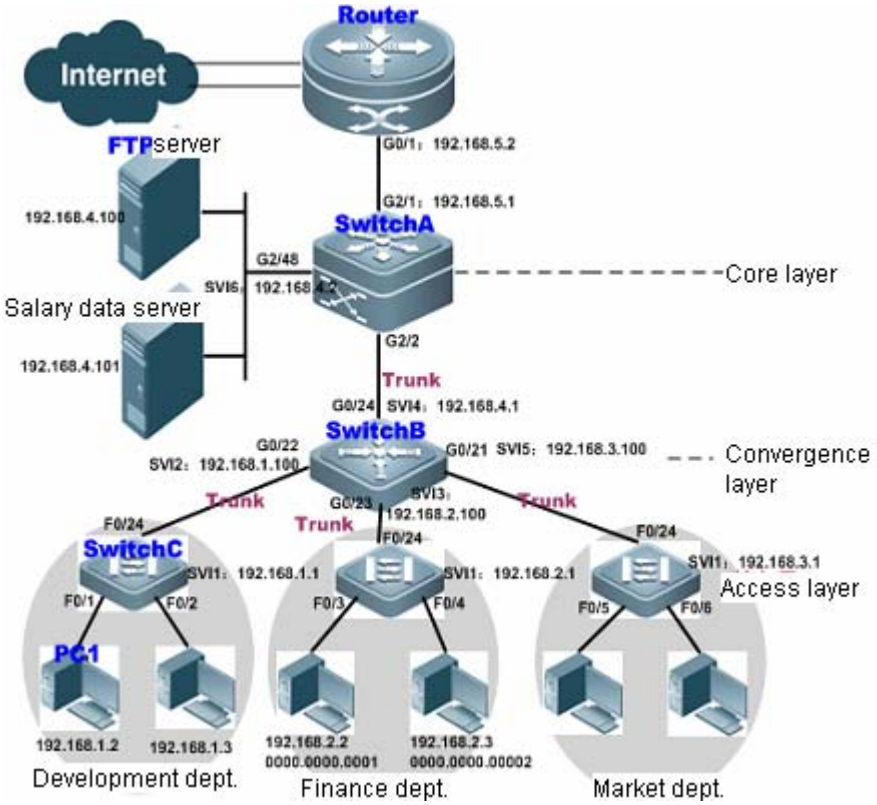
3) Display the configuration of ACL.

In privileged EXEC mode, use the **Show** command to display related ACL configuration.

```
Ruijie# show access-lists 101
ip access-list extended 101
 10 deny tcp any any match-all syn
 20 permit ip any any
```

Typical Application of Intranet ACL

Networking Diagram



The preceding diagram shows the typical topology of an Intranet:

The access switch (Switch C) connecting PCs of respective departments is connected to the convergence switch through Gigabit optical cable (trunk mode).

The convergence switch (Switch B) assigns one VLAN for each department and is connected to the core switch through 10G optical fiber cable (trunk mode).

The core switch (Switch A) is connected with multiple servers, such as FTP, HTTP server and etc, and is connected to Internet through firewall.

Application Requirements

The ACL application in this network has the following requirements:

Ports that are susceptible to viruses must be disabled to guarantee Intranet security.

Only the internal PCs can access the servers.

Only PCs within a department can access each other.

R&D personnel are forbidden to use Instant messaging software such as QQ and MSN in working hours (namely from 09:00 to 18:00).

Notes

- The viruses can be avoided by configuring extended ACLs on the router-connecting port (G2/1) of core switch (Switch A) to filter packets destined for relevant ports.
- As for the requirement that internal PCs can access the servers while external PCs are not allowed to access these servers, IP extended ACLs can be defined and applied to ports (G2/2, SVI2) of the core switch (Switch A) that connect with the convergence switch and server.
- As for the requirement that specific departments cannot access each other, IP extended ACLs can be applied to G0/22 and G0/23 of Switch B).
- Configuring time & IP based extended ACL can prevent R&D departments from suing QQ/MSN and other IM application during a specific period (applying time & IP based extended ACL to SVI2 of Switch B).

Configuration Steps

- Configure the core switch: Switch A

Step 1: Define the virus-blocking ACL "Virus_Defence".

Note

The worm viruses on the network will create a TFTP server on the local port of "udp/69" in order to transmit the binary virus program to other infected systems. While selecting the destination IP address, the worms will generally select the IP address of subnet to which the infected system belongs, and then randomly select the attack target on Internet as per certain algorithm. Once the connection is established, the worms will send attack data to TCP ports (135, 445, 593, 1025, 5554, 9995, and 9996), UDP ports (136, 445, 593, 1433, and 1434) and UDP/TCP ports (135, 137, 138, and 139) of targets. If the attack is successful, TCP/4444 port of target system will be used as the backdoor port. After that, worms will connect to this port and send **tftp** command in order to transmit virus file to the target system and run the file. The infected server will send substantive invalid data packets to the network, thus wasting network bandwidth and even causing failure of network devices and the network. In such a case, the extended ACL can be used to filter data packets destined for these ports.

```
A#configure terminal
A(config)#ip access-list extended Virus_Defence
```

! Deny packets destined for internal and external TCP ports which may have been used by viruses.

```
A(config-ext-nacl)#deny tcp any any eq 135
A(config-ext-nacl)#deny tcp any eq 135 any
A(config-ext-nacl)#deny tcp any any eq 136
A(config-ext-nacl)#deny tcp any eq 136 any
```

```
A(config-ext-nacl)#deny tcp any any eq 137
A(config-ext-nacl)#deny tcp any eq 137 any
```

…….! The configuration on other ports is similar.

```
A(config-ext-nacl)#deny tcp any any eq 9996
A(config-ext-nacl)#deny tcp any eq 9996 any
```

! Deny packets destined for internal and external UDP ports which may have been used by viruses.

```
A(config-ext-nacl)#deny udp any any eq 69
A(config-ext-nacl)#deny udp any eq 69 any
A(config-ext-nacl)#deny udp any any eq 135
A(config-ext-nacl)#deny udp any eq 135 any
A(config-ext-nacl)#deny udp any any eq 137
A(config-ext-nacl)#deny udp any eq 137 any
```

! The configuration on other ports is similar.

```
A(config-ext-nacl)#deny udp any any eq 1434
A(config-ext-nacl)#deny udp any eq 1434 any
```

! Deny ICMP packets.

```
A(config-ext-nacl)#deny icmp any any
```

! Permit all other IP packets.

```
A(config-ext-nacl)#permit ip any any
A(config-ext-nacl)#exit
```

Step 2: Apply the ACL *Virus_Defence* to the router-connecting interface of the core device.

```
A(config)#interface gigabitEthernet 2/1
A(config-if)#no switchport
A(config-if)#ip address 192.168.5.1 255.255.255.0
```

! Apply the ACL *Virus_Defence* in the inbound direction of G2/1 to deny virus infected packets from an external network.

```
A(config-if)#ip access-group Virus_Defence in
A(config-if)#exit
```

Step 3: Define the ACL *access_server* that permits only Intranet PCs to access the server.

```
A(config)#ip access-list extended access_server
```

! Permit only specified Intranet PCs to access the server (IP address: 192.168.4.100).

```
A(config-ext-nacl)#permit ip 192.168.2.0 0.0.0.255 host 192.168.4.100
A(config-ext-nacl)#permit ip 192.168.1.0 0.0.0.255 host 192.168.4.100
A(config-ext-nacl)#permit ip 192.168.3.0 0.0.0.255 host 192.168.4.100
A(config-ext-nacl)#deny ip any any
```

Step 4: Apply the ACL *access_server* to the interface connecting with convergence device and server.

```
A(config)#interface gigabitEthernet 2/2
A(config-if)#switch mode trunk
```

! Apply the ACL to the inbound direction of the convergence switch.

```
A(config-if)#ip access-group access_server in
A(config-if)#exit
```

! Create a VLAN.

```
A(config)#vlan 2
A(config-vlan)#exit
A(config)#interface gigabitEthernet 2/48
```

! The server-connecting interface of G2/48 belongs to VLAN 2.

```
A(config-if)#switch access vlan 2
A(config-if)#exit
```

! Apply the ACL to the inbound direction of the server-connecting interface.

```
A(config)#interface vlan 2
A(config-if-VLAN 2)# ip access-group access_server in
A(config-if-VLAN 2)# ip address 192.168.4.2 255.255.255.0
A(config-ext-nacl)#end
```

- Configure the convergence switch: SwitchB

Step 1: Create VLAN 2, VLAN 3, and VLAN 4.

```
B#configure terminal
```

! Create VLAN 2, VLAN 3, and VLAN 4.

```
B(config)#vlan range 2-4
B(config-vlan-range)#exit
```

Step 2: Define ACLs.

! Define the IP extended ACLs vlan_access1 and vlan_access2.

```
B(config)#ip access-list extended vlan_access1
```

! Prohibit PCs of the finance department and market department from accessing PCs of the R&D department.

```
B(config-ext-nacl)#deny ip 192.168.2.0 0.0.0.255 192.168.1.0 0.0.0.255
B(config-ext-nacl)#deny ip 192.168.3.0 0.0.0.255 192.168.1.0 0.0.0.255
B(config-ext-nacl)#permit ip any any
B(config)#ip access-list extended vlan_access2
```

! Prohibit PCs of the R&D department and market department from accessing PCs of the finance department.

```
B(config-ext-nacl)#deny ip 192.168.1.0 0.0.0.255 192.168.2.0 0.0.0.255
B(config-ext-nacl)#deny ip 192.168.3.0 0.0.0.255 192.168.2.0 0.0.0.255
B(config-ext-nacl)#permit ip any any
B(config-ext-nacl)#exit
```

Step 3: Apply ACLs *vlan_access1* and *vlan-access2* to the corresponding interfaces.

! Configure G0/22 as a trunk port and apply *vlan_access1* to this port.

```
B(config)#interface GigabitEthernet 0/22
B(config-if)#switchport mode trunk
B(config-if)#ip access-group vlan_access1 in
```

! Configure G0/23 as a trunk port and apply *vlan_access2* to this port.

```
B(config)# interface GigabitEthernet 0/23
B(config-if)# switchport mode trunk
B(config-if)# ip access-group vlan_access2 in
```

! Configure G0/24 as a trunk port.

```
B(config)#interface GigabitEthernet 0/24
B(config-if)#switchport mode trunk
```

! Configure the IP address of SVI 2.

```
B(config)#interface vlan 2
B(config-if)#ip address 192.168.1.100 255.255.255.0
```

! Configure the IP address of SVI 3.

```
B(config)#interface vlan 3
B(config-if)#ip address 192.168.2.100 255.255.255.0
```

! Configure the IP address of SVI 4.

```
B(config)#interface vlan 4
B(config-if)#ip address 192.168.4.1 255.255.255.0
```

Step 4: Define time range.

! Define the time range that starts from 09:00 to 18:00 in weekdays.

```
B#configure terminal
B(config)#time-range worktime
B(config-time-range)#periodic weekdays 9:00 to 18:00
```

Step 5: Define the traffic rule of R&D department.

```
B#configure terminal
```

! Create the extended ACL *yanfa* in configuration mode.

```
B(config)#ip access-list extended yanfa
```

! Prohibit all IM applications such as QQ and MSN on hosts of R&D department from 09:00 to 18:00 in weekdays.

```
B(config-ext-nacl)#deny tcp 192.168.1.0 0.0.0.255 eq 8000 any time-range worktime
B(config-ext-nacl)#deny tcp 192.168.1.0 0.0.0.255 eq 8001 any time-range worktime
B(config-ext-nacl)#deny tcp 192.168.1.0 0.0.0.255 eq 443 any time-range worktime
B(config-ext-nacl)#deny tcp 192.168.1.0 0.0.0.255 eq 1863 any time-range worktime
```

```
B(config-ext-nacl)#deny tcp 192.168.1.0 0.0.0.255 eq 4000 any time-range worktime
B(config-ext-nacl)#deny udp 192.168.1.0 0.0.0.255 eq 8000 any time-range worktime
B(config-ext-nacl)#deny udp 192.168.1.0 0.0.0.255 eq 1429 any time-range worktime
B(config-ext-nacl)#deny udp 192.168.1.0 0.0.0.255 eq 6000 any time-range worktime
B(config-ext-nacl)#deny udp 192.168.1.0 0.0.0.255 eq 6001 any time-range worktime
B(config-ext-nacl)#deny udp 192.168.1.0 0.0.0.255 eq 6002 any time-range worktime
B(config-ext-nacl)#deny udp 192.168.1.0 0.0.0.255 eq 6003 any time-range worktime
B(config-ext-nacl)#deny udp 192.168.1.0 0.0.0.255 eq 6004 any time-range worktime
```

! Permit all other IP traffic.

```
B(config-ext-nacl)#permit ip any any
```

! Apply the ACL to the inbound direction of SVI 2.

```
B(config)#interface vlan 2
B(config-if)#ip access-group yanfa in
```

Verification

Step 1: Verify whether ACEs are correct. The key is that whether the priorities of ACEs are correct and whether ACEs are effective.

```
SwitchA#show access-lists
ip access-list extended Virus_Defence
 10 deny tcp any any eq 135
 20 deny tcp any eq 135 any
 30 deny tcp any eq 4444 any
 40 deny tcp any any eq 5554
 50 deny tcp any eq 5554 any
 60 deny tcp any any eq 9995
 70 deny tcp any eq 9995 any
 80 deny tcp any any eq 9996
 90 deny tcp any eq 9996 any
 100 deny udp any any eq tftp
 110 deny udp any eq tftp any
 120 deny udp any any eq 135
 130 deny udp any eq 135 any
 140 deny udp any any eq netbios-ns
 150 deny udp any eq netbios-ns any
 160 deny udp any any eq netbios-dgm
 170 deny udp any eq netbios-dgm any
 180 deny udp any any eq netbios-ss
 190 deny udp any eq netbios-ss any
 200 deny udp any any eq 445
 210 deny udp any eq 445 any
 220 deny udp any any eq 593
 230 deny udp any eq 593 any
 240 deny udp any any eq 1433
```

```
 250 deny udp any eq 1433 any
 260 deny udp any any eq 1434
 270 deny udp any eq 1434 any
 280 deny tcp any any eq 136
 290 deny tcp any eq 136 any
 300 deny tcp any any eq 137
 310 deny tcp any eq 137 any
 320 deny tcp any any eq 138
 330 deny tcp any eq 138 any
 340 deny tcp any any eq 139
 350 deny tcp any eq 139 any
 360 deny tcp any any eq 445
 370 deny tcp any eq 445 any
 380 deny tcp any any eq 593
 390 deny tcp any eq 593 any
 400 deny tcp any eq 1025 any
 410 deny tcp any any eq 4444
420 deny icmp any any
 430 permit tcp any any
 440 permit udp any any
 450 permit ip any any

ip access-list extended access_server
 10 permit ip 192.168.2.0 0.0.0.255 host 192.168.4.100
 20 permit ip 192.168.1.0 0.0.0.255 host 192.168.4.100
 30 permit ip 192.168.3.0 0.0.0.255 host 192.168.4.100
 40 deny ip any any
SwitchB#show access-lists
ip access-list extended vlan_access1
 10 deny ip 192.168.2.0 0.0.0.255 192.168.1.0 0.0.0.255
 20 deny ip 192.168.3.0 0.0.0.255 192.168.1.0 0.0.0.255
 30 permit ip any any

ip access-list extended vlan_access2
 10 deny ip 192.168.1.0 0.0.0.255 192.168.2.0 0.0.0.255
 20 deny ip 192.168.3.0 0.0.0.255 192.168.2.0 0.0.0.255
 30 permit ip any any

ip access-list extended yanfa
 10 deny tcp 192.168.1.0 0.0.0.255 eq 8000 any time-range worktime (active)
 20 deny tcp 192.168.1.0 0.0.0.255 eq 8001 any time-range worktime (active)
 30 deny tcp 192.168.1.0 0.0.0.255 eq 443 any time-range worktime (active)
 40 deny tcp 192.168.1.0 0.0.0.255 eq 1863 any time-range worktime (active)
 50 deny tcp 192.168.1.0 0.0.0.255 eq 4000 any time-range worktime (active)
 60 deny udp 192.168.1.0 0.0.0.255 eq 8000 any time-range worktime (active)
```

```
 70 deny udp 192.168.1.0 0.0.0.255 eq 1429 any time-range worktime (active)
 80 deny udp 192.168.1.0 0.0.0.255 eq 6000 any time-range worktime (active)
 90 deny udp 192.168.1.0 0.0.0.255 eq 6001 any time-range worktime (active)
 100 deny udp 192.168.1.0 0.0.0.255 eq 6002 any time-range worktime (active)
 110 deny udp 192.168.1.0 0.0.0.255 eq 6003 any time-range worktime (active)
 120 deny udp 192.168.1.0 0.0.0.255 eq 6004 any time-range worktime (active)
```

Step 2: Verify whether ACL configuration is complete. The key is that whether the correct ACL has been applied to the specified interface.

Device A configuration:

```
A#show run
interface GigabitEthernet 2/1
 no switchport
 no ip proxy-arp
 ip access-group Virus_Defence in
 ip address 192.168.5.1 255.255.255.0
!
interface GigabitEthernet 2/2
 switchport mode trunk
 ip access-group access_server in
!
interface VLAN 2
 no ip proxy-arp
 ip access-group access_server in
 ip address 192.168.4.2 255.255.255.0
```

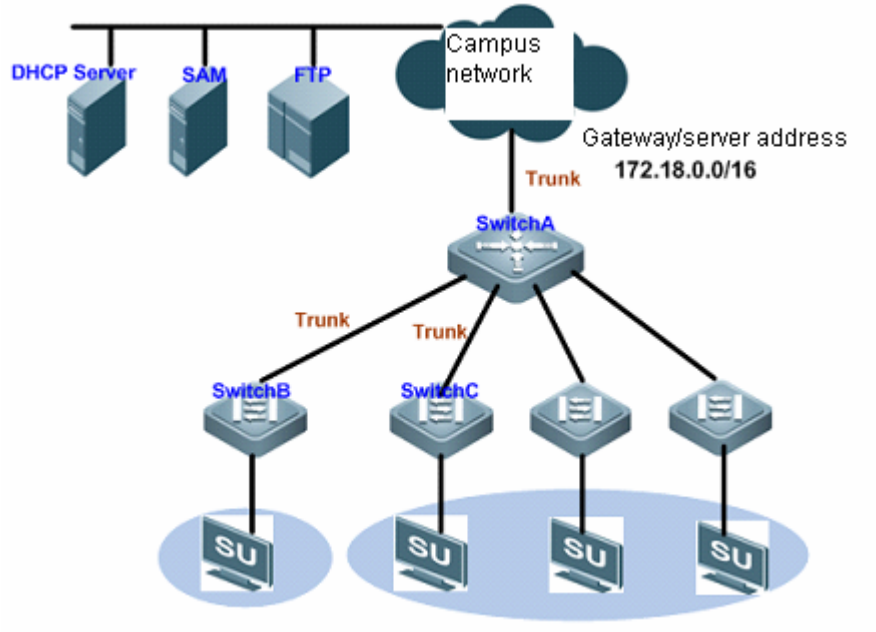
Device B configuration:

```
B#show run
!
interface GigabitEthernet 0/22
 switchport mode trunk
 ip access-group vlan_access1 in
!
interface GigabitEthernet 0/23
 switchport mode trunk
 ip access-group vlan_access2 in
!
interface VLAN 2
 no ip proxy-arp
 ip access-group yanfa in
 ip address 192.168.1.100 255.255.255.0
```

Application of expert ACL & ACL 80

Networking Diagram

Figure 5 Application topology diagram of the expert ACL&ACL 80



The preceding figure shows the simplified topology of a campus network:

Switch A is the convergence device assigning one VLAN for each faculty and is connected to the campus network through 10G optical cable (trunk mode).

Switch B and Switch C are access devices connecting PCs of respective faculties, and are connected to the convergence switch through Gigabit optical cable (trunk mode).

SU client must be installed on each PC so that a PC can access Internet after being authenticated.

Application Requirements

SU software is not embedded in Windows. You must download and install SU client on the PC. However, the PC cannot download software before 802.1x authentication. To solve this problem, the following requirements must be met:

- IP packets and ARP packets accessing the segment address of gateway/server (172.18.0.0/16) are allowed to pass through without authentication, so that the user PC can download software from the specified server or access gateway before authentication.
- DHCP packets (UDP port number being 67/68) are allowed to pass through without authentication, so that the user PC can acquire the IP address in order to proceed with authentication.

Notes

Configure ACL80 or expert ACL on the access device (Switch B/Switch C) and combine the feature of secure tunnel to permit certain packets without authentication.

In this case, ACL 80 is configured on Switch B and expert ACLs are configured on Switch C.

Configuration Steps

■ Device B configuration

Note ACL 80 allows the user to define 16 bytes out of the first 80 bytes of packets to perform per-bit matching and filtering. The user-defined string will be compared with the string extracted from packet (1 means match and 0 means mismatch), so as to determine further action.

Step 1: Configure the customized ACL.

```
B#configure terminal
```

! Create a customized ACL named "tongdao"

```
B(config)#expert access-list advanced tongdao
```

! Permit all ARP packets (protocol number being 0806, offset being 24) with source IP address(the offset in the source IP of ARP packets is 40) falling within the network segment of 172.18.0.0 (hexadecimal value being ac12)

```
B(config-exp-dacl)#permit 0806 ffff 24 ac12 ffff 40
```

! Permit all IP packets (protocol number being 0800, offset being 24) with source IP (the offset in the source IP of IP packets is 38) falling within the network segment of 172.18.0.0 (hexadecimal value being ac12)

```
B(config-exp-dacl)#permit 0800 ffff 24 ac12 ffff 38
```

! Permit DHCP packets with UDP port being 67 (Bootstrap Protocol Server) and 68 (Bootstrap Protocol Client) (offset in protocol number being 35; hexadecimal value of 11 to indicate UDP; offset in port being 46; hexadecimal value of 43/44 corresponding to 67 and 68).

```
B(config-exp-dacl)# permit 11 ff 35 00440043 ffffffff 46
B(config-exp-dacl)#exit
```

Step 2: Globally configure the ACL for secure tunnel application.

! Configure ACL "tongdao" for secure tunnel application

```
B(config)# security global access-group tongdao
```

■ Device C configuration:

Step 1: Configure an expert ACL.

```
C#configure terminal
```

! In configuration mode, create an expert ACL named "tongdao1"

```
C(config)#expert access-list extended tongdao1
```

! Permit all IP packets with source IP falling within the network segment of 172.18.0.0

```
C(config-exp-dacl)#permit ip 172.18.0.0 0.0.255.255 any any any
```

! Permit all packets with UDP port number being 67 (Bootstrap Protocol Server) and 68 (Bootstrap Protocol Client)

```
C(config-exp-dacl)# permit udp any any eq bootpc any any eq bootps
```

```
C(config-exp-dacl)#exit
```

Step 2: Globally configure the ACL for secure tunnel application.

! Configure ACL "tongdao1" for secure tunnel application

```
C(config)# security global access-group tongdao1
```

Verifications

Step 1: Verify whether ACEs are correct. The key is that whether the priorities of ACEs are correct and whether ACEs are effective.

```
B# show access-lists
expert access-list advanced tongdao
 10 permit 0806 FFFF 24 AC12 FFFF 40
 20 permit 0800 FFFF 24 AC12 FFFF 38
 30 permit 11 FF 35 00440043 FFFFFFFF 46
C# show access-lists
expert access-list extended tongdao1
 10 permit ip 172.18.0.0 0.0.255.255 any any any
 20 permit udp any any eq bootpc any any eq bootps
```

Run the preceding command to verify whether the corresponding ACEs are correct.

Step 2: Verify whether ACL configuration is complete. The key is that whether the correct ACL has been applied in global configuration mode:

```
B#show run
!
expert access-list advanced tongdao
!
security global access-group tongdao
!
!
C#show run
!
expert access-list advanced tongdao1
!
security global access-group tongdao1
!
```

☑ ACL configuration for different line cards:

The following description applies only to versions later than RGOS10.3.

This principle is also appropriate for hot pluggable line cards, which prompts the users to reset line cards.

If ACL out is implemented on the egress, then IP extended ACL and expert ACL will not support port matching. Besides, expert ACL only supports IP packet matching, not other L2 packets, IPV6 does not support flow_label, DSCP and fragment matching.

If ACL out is processed in the original way, then associating ACL out with SVIs has lots of restrictions:

- Changes the priority of in and out direction; the ACL used in the outbound direction is higher than that used in the inbound direction.
- When you apply an ACL to the outbound direction of an SVI, there is no **deny any any** option by default. But there is **deny any any** option in other ACLs.
- Associating ACL with SVI in Out direction can support IP standard, IP extended, MAC extended, ACL application of expert extended ACLs.
- There are some restrictions for matching destination ip and destination mac in ACL when associating ACL with SVI in the outbound direction. If you want to match destination MAC in MAC extended and expert ACL and apply the ACL in the outbound direction of SVI, the entry will be set and not take effect.
- The set ACL will not take effect if you want to match destination IP address, which is not within the subnet IP range of associated SVI, in IP standard, IP extended and expert ACL. For example, the address of VLAN 1 is 192.168.64.1 255.255.255.0. And now, if you create an IP extended ACL with ACE deny udp any 192.168.65.1 0.0.0.255 eq 255, it will not take effect when applying this ACL to the egress of VLAN 1, for the destination IP address is not within the subnet IP range of VLAN 1; but it will take effect if the ACE is deny udp any 192.168.64.1 0.0.0.255 eq 255, for the destination IP address is up to specification.
- The priority of the ACL associated with an SVI in the outbound direction has the highest priority.
- ACL out does not support user-defined acl type.

Configuring the Firewall

Understanding IP-MAC Binding

Overview

IP-MAC binding refers to that the IP address and MAC address of a host are bound on the router or firewall it directly connects to, so that an IP address can be used only by the host with the matching MAC address. This function is designed to prevent IP address spoofing. To deploy this function, two prerequisites must be met:

4) The MAC address is unique and genuine.
5) IP-MAC binding applies only to hosts that are directly connected to a router or firewall.

Furthermore, a host interface may be configured with multiple IP addresses, thus allowing multiple IP addresses to be bound to the same MAC address.

Configuring IP-MAC Binding

Enabling or Disabling the IP-MAC Binding Function

IP-MAC binding is disabled by default. To use this function, configure binding rules by using the **ipmacbind** command in global configuration mode. IP-MAC binding function will be disabled if all IP/MAC binding rules are deleted.

Configuring IP-MAC Binding

The IP address of a host can be bound to its MAC address by using the **ipmacbind** command to prevent the IP address from being counterfeited by other hosts. Rebind the bound IP address if it already exists. Multiple IP addresses can be bound to the same MAC address. For example:

```
Ruijie(config)# ipmacbind 192.168.52.69 032a.33ac.3f11 log
```

The preceding command binds the IP address 192.168.52.69 to the network card with MAC address 032a.33ac.3.3f11. Here, **log** indicates that the log function regarding IP-MAC binding is enabled. Besides, you can specify the format of any IP address and any MACaddress. For example:

Ruijie(config)**# ipmacbind any any log**

Meanwhile, the IP-MAC binding entries on a LAN can be detected and exported from the ARP table dynamically by using the **ipmacbind auto** command.

```
Ruijie(config)# ipmacbind auto
```

You can configure an IP-MAC binding rule list as well as the rules in the list and apply the list to the interface. Besides, you can specify the default processing of packets not matching the IP-MAC binding rule on the current interface. For example:

```
Ruijie(config)# ipmacbind list number
Ruijie(config-ipmac-bind)#ipmacbind ip mac [log]
```

```
Ruijie(config-if-GigabitEthernet 0/0)# ipmacbind list number [ default action {permit | deny [ log ]} ]
```

Configure the IP MAC binding rule list and the corresponding rules in the list, apply the list to the corresponding interface at the same time, and configure the default rule operation on the current interface.

```
Ruijie(config)# ipmacbind list number
Ruijie(config-ipmac-bind)#ipmacbind ip mac [log]
Ruijie(config-if-GigabitEthernet 0/0)# ipmacbind list number [ default action {permit | deny [ log ]} ]
```

The **no** form of the **Ipmacbind** command is used to delete IP-MAC binding entries. If an IP address is specified in this command, the IP address is deleted from an IP-MAC binding entry. Besides, you can use the **clear ipmacbind** command to delete the IP-MAC binding entries dynamically exported from the ARP table or all IP-MAC binding entries. For example:

```
Ruijie# clear ipmacbind dynamic
```

The preceding command clears all IP-MAC binding entries dynamically exported from the ARP table by using the **ipmacbind auto** command.

```
Ruijie# clear ipmacbind all
```

The preceding command clears all IP-MAC binding entries including the information of the rule list.

By default, packets without IP MAC address binding rule are permitted to pass. Use the ipmacbind default action command to deny packets without IP MAC address.

```
Ruijie(config)#ipmacbind default action deny
```

Rule description:

The IPMAC binding rule operation only permits or denies two situations. By default, the rule is permit, and the matching rule combinations and the results are as follows:

Deny:

IP Address	MAC Address	Result
False	Correct	Deny
Correct	False	Deny
False	False	Deny
Correct	Correct	Permit

Permit:

IP Address	MAC Address	Result
Correct	False	Deny
Correct	Correct	Permit
False	Correct	Permit
False	False	Permit

Viewing IP-MAC Binding Information

Run the **show ipmacbind** command to view records or statistics on current IP-MAC binding.

```
Ruijie# show ipmacbind table
Totol number of IPMAC-Bind rule: 2
IPMAC-Bind global rule:
No    Type        IP Address      MAC Address     Log
1     <static>    any           00d0.0011.0012   off

IPMAC-Bind list 1 rule:
No     Type        IP Address      MAC Address     Log
1   <static>    192.168.2.2     00d0.0011.0011   off
```

To view all IP-MAC binding entries and the IP-MAC binding rule information:

```
Ruijie# show ipmacbind statistic
IPMAC-Bind global dropped 0 packets
IPMAC-Bind list 1 dropped 0 packets
```

To view the IP MAC function and the number of invalid packets intercepted by the IP MAC binding rule list;

```
Ruijie# show ipmacbind hash
IPMAC-Bind global:
In MAC hash-list 211:
   1: ip-any, mac-00d0.0011.0012
IPMAC-Bind list 1:
In IP hash-list 616:
1: ip-192.168.2.2, mac-00d0.0011.0011
```

To view the IP-MAC binding rule and the hash table corresponding to IP-MAC binding rule list:

Understanding URL Filtering

Overview

URL filtering is an extension of packet filtering, achieving in-depth access control. It is a means of content filtering and restricts intranet users from accessing certain illegal websites.

The process of URL filtering is as follows:

1) The firewall resolves the HTTP request from a client to obtain the requested URL;
2) The firewall uses the predefined URL filtering rules to match the requested URL;
3) If a match is detected, the firewall determines whether to permit or reject the access based on the matching result.
4) If no match is detected, the firewall sends the URL request to a third-party content filtering server (such as Websense or N2H2) and meanwhile suspends the HTTP session until a response is returned from the server. Then the firewall determines whether to permit or reject the HTTP request based on the response. All requests shall be denied and an alarm is reported if the server is unavailable.

Currently, only local URL filtering is supported. The linkage with a third-party content filtering server will be realized in future.

Configuring URL Filtering

URL filtering rules are configured as follows:

5) Specify the URLs to be filtered and add these URLs to a filtering category.
6) Configure filtering rules and add the filtering category to the rules.
7) Apply these rules to interfaces.

It should be noticed that you need to specify an ACL before applying the rules to the interfaces for advertising the URL filtering range.

Registering URLs

To filter a URL, use a URL-related command in global configuration mode to register the URL and the filtering category the URL belongs to. To delete a registered URL, run the **no url** command.

It should be noticed that a URL always begins with a stop (.) in all cases.

For example:

```
Ruijie(config)# ip urlfilter rule test .sina.com.cn
Ruijie(config)# ip urlfilter rule test .*sina.com.cn
Ruijie(config)# ip urlfilter rule test .sina*
Ruijie(config)# ip urlfilter rule test .*sina*
```

In the example, the asterisk (*) is used as the wildcard. The wildcard can be placed only at the end of a URL or after the first stop in a URL.

These URL formats are explained as follows:

- .sina.com.cn represents URLs such as www.sina.com.cn, blog.sina.com.cn, and new.sina.com.cn, instead of Ruijie.blog.sina.com.cn, sports.news.sina.com.cn, and the like.
- .*sina.com.cn represents all URLs ended with "sina.com.cn".
- .sina* represents all URLs in which the first stop is followed by "sina". For example, blog.sina.com.cn matches this rule but Ruijie.blog.sina.com.cn does not.
- *sina* represents all URLs containing "sina" such as Ruijie.blog.sina.com.cn, blog.sina.com.cn, and www.adfsina.com.

Configuring URL Filtering Rules

Filtering rules should be configured after the URL category is configured.

URL filtering rules are configured in global configuration mode.

```
Ruijie(config)# ip urlfilter category 1 test
```

The preceding command is to create a filtering rule numbered 1. Then, the predefined filtering category can be added to this rule. Each rule can accommodate 15 categories. That is, other predefined categories can also be added to this rule. For example:

- Ruijie(config)# ip urlfilter category 1 test1
- Ruijie(config)# ip urlfilter category 1 test2
- Ruijie(config)# ip urlfilter category 1 test3

It should be noticed that Ruijie products allow a category to be added to different rules.

```
Ruijie(config)# ip urlfilter category 1 test
Ruijie(config)# ip urlfilter category 2 test
Ruijie(config)# ip urlfilter category 3 test
```

Applying Rules to Interfaces

After the preceding configuration is complete, you need to apply these rules to interfaces.

Before applying rules to interfaces, remember configuring an ACL rule in configuration mode.

The following example shows how to create a URL that filters all IP addresses and allows access to the URLs defined in rule 1. In this example, logs are recorded when access is denied.

```
Ruijie(config)# access-list 1 permit any
Ruijie(config)# interface gigabitEthernet 0/0
Ruijie(config-if)# ip urlfilter exclusive-domain 1 1 permit in log
```

Now, URL filtering rule configuration is complete.

Viewing Configuration Information and Statistical Information of the URL Filtering Module

Configuration Information

Suppose that some URL filtering rules have been configured. The following describes how to query, configure, and delete these rules,

show ip urlfilter config address

Run the preceding command in configuration mode.

```
Ruijie(config)# show ip urlfilter config address
================[Url without wildcard]===================
cls_name          cls-id           url-address
==========================================================
test1              2               .tianya.cn
----------------------------------------------------------
test2              3               .sohu.com
----------------------------------------------------------
test1              1               .sina.com.cn
----------------------------------------------------------
test1              2               .mop.com
=================[Url no-wildcard end]====================
===================[Url with pre-wildcard]================
cls_name          cls-id           url-address
```

```
============================================================
test1              2               .*hong.com
------------------------------------------------------------
test2              3               .*263.net
------------------------------------------------------------
test1              2               .*163.com
==================[Url pre-wildcard end]==================
==================[Url with post-wildcard]=================
cls_name          cls-id           url-address
============================================================
test2              3               .taob*
------------------------------------------------------------
test1              2               .google.com*
------------------------------------------------------------
test2              3               .ebay*
------------------------------------------------------------
test1              2               .baid*
==================[Url post-wildcard end]==================
==================[Url with all-wildcard]==================
cls_name          cls-id           url-address
============================================================
test2              3               .*huawei*
------------------------------------------------------------
test1              2               .*cisco*
==================[Url all-wildcard end]===================
=================[Relative CLI Command]====================
ip urlfilter rule test1 .tianya.cn
ip urlfilter rule test2 .sohu.com
ip urlfilter rule test .sina.com.cn
ip urlfilter rule test1 .mop.com
ip urlfilter rule test1 .*hong.com
ip urlfilter rule test2 .*263.net
ip urlfilter rule test1 .*163.com
ip urlfilter rule test2 .taob*
ip urlfilter rule test1 .google.com*
ip urlfilter rule test2 .ebay*
ip urlfilter rule test1 .baid*
ip urlfilter rule test2 .*huawei*
ip urlfilter rule test1 .*cisco*
==========[Relative CLI Command To Del the Rules ]==========
no ip urlfilter rule test1 .tianya.cn
no ip urlfilter rule test2 .sohu.com
no ip urlfilter rule test .sina.com.cn
no ip urlfilter rule test1 .mop.com
no ip urlfilter rule test1 .*hong.com
```

```
no ip urlfilter rule test2 .*263.net
no ip urlfilter rule test1 .*163.com
no ip urlfilter rule test2 .taob*
no ip urlfilter rule test1 .google.com*
no ip urlfilter rule test2 .ebay*
no ip urlfilter rule test1 .baid*
no ip urlfilter rule test2 .*huawei*
no ip urlfilter rule test1 .*cisco*
```

Firstly, classify the addresses into four categories: addresses without a wildcard, addresses preceded by a wildcard, addresses followed by a wildcard and addresses with one wildcard at the beginning and one wildcard at the end. And we print out the classified addresses under the same category in a continuous manner.

Secondly, record all the commands you use to configure these addresses. As a result, even a green hand will be able to view the configuration process.

Lastly, provide you a cookie that shows you the commands for deleting configuration, so that you no longer need to run **show run** to query the command for deleting a configuration but copy the desired command and paste it in the CLI.

show ip urlfilter config rule

The **show** command shows the addresses that have been configured in the current system. Now let's learn the configured rules.

```
Ruijie(config)# show ip urlfilter config rule
=================[ Ip UrlFilter Rule configure ]=================
Id     Attribute         Details
------------------------------------------------------------------------------==-------------
--------
1      contain-class:     test
ref-interface:gigabitEthernet 0/0 gigabitEthernet 0/1
------------------------------------------------------------------------------==-------------
---------
2      contain-class:     test1
ref-interface:     gigabitEthernet 0/0
gigabitEthernet 0/1
gigabitEthernet 0/2
------------------------------------------------------------------------------------------------
----------
3      contain-class:     test2
ref-interface:     gigabitEthernet 0/2
================================================================
================[Relative CLI Command]=======================
ip urlfilter category 1 test
ip urlfilter category 2 test1
ip urlfilter category 3 test2
=========[Relative CLI Command To Del the Rules ]===============
no ip urlfilter category 1 test
```

```
no ip urlfilter category 2 test1
no ip urlfilter category 3 test2
Using this command, you can view the address categories included in a rule and the interface to which rules apply. Then you can determine the interface from which the desired information can be obtained.
```

show ip urlfilter config setting

Query information about gigabitEthernet 0/0.

```
Ruijie(config-if)# show ip urlfilter config setting
========[ Url Filter Rules On gigabitEthernet 0/0 ]==============
Rules On Input
================================================================
Id   Acl   Action   Class-name     Url-address
-------------------------------------------------------------------------------------------
--------
1    1    permit   test          .sina.com.cn
-------------------------------------------------------------------------------------------
--------
2    12    permit   test1           .tianya.cn
                                  .mop.com
                                  .*hong.com
                                  .*163.com
                                  .google.com*
                                  .baid*
                                  .*cisco*
-------------------------------------------------------------------------------------------
--------
3    12    block    test2          .sohu.com
                                  .*263.net
                                  .taob*
                                  .ebay*
                                  .*huawei*
-------------------------------------------------------------------------------------------
-------
2    13    permit   test1           .tianya.cn
                                  .mop.com
                                  .*hong.com
                                  .*163.com
                                  .google.com*
                                  .baid*
                                  .*cisco*
-------------------------------------------------------------------------------------------
--------
3    13    block    test2          .sohu.com
                                  .*263.net
```

```
                                .taob*
                                .ebay*
                                .*huawei*
=========================================================
Relative CLI Command
=========================================================
ip urlfilter exclusive-domain 1 1 permit in log
ip urlfilter exclusive-domain 2 12 permit in
ip urlfilter exclusive-domain 3 12 block in
ip urlfilter exclusive-domain 2 13 permit in
ip urlfilter exclusive-domain 3 13 block in
-------------------------------------------------------------------------------------------
--------
Relative CLI Command to Del Rules
-------------------------------------------------------------------------------------------
--------
no ip urlfilter exclusive-domain 1 1 permit in log
no ip urlfilter exclusive-domain 2 12 permit in
no ip urlfilter exclusive-domain 3 12 block in
no ip urlfilter exclusive-domain 2 13 permit in
no ip urlfilter exclusive-domain 3 13 block in
======[ Url Filter Rules On gigabitEthernet 0/0 End]=======
```

In the command output, you can view rule IDs, effective scope of rules (ACL numbers), conform-action, inclusive categories, and URLs in these categories.

Statistical Information

Statistical information is also what administrators care much for.

```
Ruijie(config)# show ip urlfilter statistics
url filter statistics
=============================================
the rule 1
       Total requests allowed: 0
       Total requests blocked: 0
the rule 2
       Total requests allowed: 0
       Total requests blocked: 0
the rule 3
       Total requests allowed: 0
       Total requests blocked: 0
```

Problems Encountered in Use of this Function

By now, you have seen that URL filtering function configuration is very flexible. But flexible things are always hard to command. Next, let's together have a look at some matters that require your attention.

One URL can only belong to one address category at one time.

Just as you have seen, one URL can only belong to one rule at one time according to our rules.

Only one rule applies to one interface.

Perhaps you have noticed that we provide only one action for each rule in regard to the rules for interfaces, i.e., the action we take when the website to access to matches our rules. What about the mismatch? Take opposite action, of course.

Different URLs have different priorities in the matching process.

Rules' priorities are arranged as follows in descending order:

- Rules without a wildcard.
- Rules with a wildcard at the beginning.
- Rules with a wildcard at the end
- Rules with one wildcard at the beginning and the other at the end.

Once matched by a rule with high priority, an address will not be matched by following rules.

```
ip urlfilter rule test .sina.com.cn
ip urlfilter rule test1 .*.*

ip urlfilter category 0 test
ip urlfilter category 1 test1
!
!
ip access-list standard 1
10 permit any

interface gigabitEthernet 0/0
ip urlfilter exclusive-domain 1 1  block in log
ip ref
ip address 130.130.130.1 255.255.255.0
duplex auto
speed auto
!
interface gigabitEthernet 0/1
ip ref
ip address 192.168.52.141 255.255.255.0
duplex auto
speed auto

ip route  0.0.0.0 0.0.0.0  192.168.52.1
```

What is the function of this rule?

He has only configured two rules: one is for filtering .sina.com.cn, and the other is for filtering all websites with the character "." What did he do next? He added the two categories to the two rules, and apply the rule that filters all websites with the character "." to the ingress. It seems that he really wants to disable Internet access.

Well, guess whether the current rule can filter all websites or not? The answer is: of course not.

Take it easy. I will answer your question.

In order to save time and space, I will directly tell you that those websites with .sina.com.cn will not be filtered. Why?

Let's analyze the process of searching, matching and filtering.

First of all, the website that users visit will match in the rule without wildcard. If they access www.sina.com.cn or news.sina.com.cn, the website will match the rule. Notice that once matched by any rule, the URL a user visits will no longer match following rules. This shall be emphasized. Then, as for our filtering program, the visited website falls into the category of "test" instead of "test 1".

When the category is found out, the filtering begins. Our filtering program on the interface will search in its own rule. When it finds that the category "test" is not included in its own rule, it will adopt the processing mode opposite to what is defined in its own rule to deal with this website. Since the guy defined the rule action is ‘block”, the action taken for the category "test" that is not in his rule will surely be "permit".

Now, let's have another look from the very beginning before we come to the conclusion why this guy has not filtered all rules. It is because he has not noticed the priority problem of website matching. Though the rule .*.* can match all addresses, .sina.com.cn that has a higher priority will match in a better way.

Therefore, we can say that it is very important to configure rule priority.

Notice should be given to the website with lower level domain name(s) and URL redirection.

When we verified our own products, our filter device was always disabled for some websites. Later, we kept track of the visits to these websites. The result was really surprising. Let's see the example of www.google.com.

Careful users may have found that when they access Google in China, they use www.google.com, but they come to see www.google.cn in the address bar of browser when the webpage is opened. This is called redirection.

However, under a real environment, the access process is more complicated. (Take our environment here for example).

First, we resolve the domain name of Google in DNS. Then, we will access the website of 210.70.14.147. Next, we will visit www.google.cn.

If you want to deal with such websites, you need to add the IP address and google.cn into the rule.

Then, you can use tailored functions as you wish.

Understanding Network Ingress Filtering

Overview

A lot of DoS/DDoS attacks are carried out with forged source IP addresses. NIF (Network Ingress Filtering, RFC 2827) is aimed to defend against such attacks, or limit the scope and lower the risk of being attacked. It will check up whether the source IP address claimed by the data packet entering a network meets the network prefix advertised by route. If not, filter it. Such filtering mechanism implemented on the router at the network ingress will be very effective to prevent IP spoofing attacks. However, it will take no effect on the IP spoofing attacks with legitimate IP address prefix at all.

Configuring NIF

Enabling or Disabling Network Ingress Filtering

NIF is disabled by default. To use this function, run the **ip ingress -filter** command in interface mode. For example:

```
Ruijie(config-if)# ip ingress-filter log
```

The preceding command enables the NIF function on the interface and the log function of NIF at the same time.

The **no** form of **ip ingress-filter** disables the NIF function on the interface. For example:

```
Ruijie(config-if)# no ip ingress-filter log
```

The preceding command disables the NIF function on the interface.

Viewing Network Ingress Filtering Information

Run the **show ip ingress-filter** command to view current IP/MAC binding records or statistical information, e.g.,.

```
Ruijie(config)# show ip ingress-filter
Firewall Network-ingress-filter is enable, blocked 0 flowsInterface FastEthernet 1/0: log is on, blocked 0 flows
```

Through the preceding command, you can view whether the NIF function is enabled and how much unauthorized information has been blocked.

Understanding TCP SYN Proxy

Overview

SYN proxy is an effective way to guard against SYN Flood attacks. SYN flood attacks occur at the stage of three-way handshakes of TCP. Attackers send a large number of TCP SYN packets to victims, who then open a lot of TCP links and respond attackers by sending TCP SYN ACK. However, attackers do not send TCP ACK packets to complete three-way handshakes. In this case, thus victims' queues are filled with semi-connections and new connections cannot be established until these semi-connections time out. The basic process of TCP SYN proxy is that three-way handshakes between router/firewall proxy service terminal and client terminal are completed first, if the connection is legal, then connection with the service terminal will be established.

Configuring TCP SYN Proxy

Enabling or Disabling TCP SYN Proxy Function

TCP SYN proxy function is disabled by default. Before enabling this function, configure ACL rules to specify the streams to which TCP SYN proxy applies, e.g.,.

```
Ruijie(config)# access-list 100 permit ip 192.168.52.0 0.0.0.255 any
```

Then, run the **ip tcp-intercept list in|out** command in interface configuration mode to apply TCP SYN proxy to the streams that pass through the interface and match the ACL rules, e.g.,.

```
Ruijie(config)# interface gigabitEthernet 0/0
Ruijie(config-if)# ip tcp-intercept list 100 in log
```

The preceding command indicates that TCP SYN proxy is applied to the inbound streams of gigabit0/0 complying with ACL 100 and the log function of TCP SYN proxy is enabled.

Use the **no** form of the **ip tcp-intercept list in|out** command to disable this function, e.g., .

```
Ruijie(config)# interface gigabitEthernet 0/0
Ruijie(config-if)# no ip tcp-intercept list 100 in log
```

Viewing TCP SYN Proxy Information

Use the **show ip tcp-intercept** command to view current TCP SYN proxy records or statistical information, e.g., .

```
Ruijie(config-if)# show ip tcp-intercept
Intercepting new connections using access-list 100 at gigabitEthernet 0/0 in
20 incomplete, 1320 established connections (total 1340)
```

Through the preceding command, you can see that TCP SYN proxy has been enabled on gigabit 0/0 interface. In addition, 20 invalid TCP streams unfinished and 1,320 normal TCP streams have been monitored.

Understanding Special Protocol

Overview

Such protocols as FTP, MMS, H.323, etc have separate command control channels and data channels. And the data channels are port numbers, etc randomly specified through the control channels by both channels. If control channel port access is only allowed by configuring ACL and other packet filtering rules on network equipments, and provided that no special means is available for processing, data channels will be completely blocked. Therefore, a special way is needed to establish some temporary pass and access mechanisms for the data channels of these protocols.

Configuring a Special Protocol

Users need to configure rules in configuration mode, where they specify a name that consists of character strings and is easy to remember for a special protocol to access, e.g., .

You can add FTP to the rule library named "abc", to which the MMS protocol can also be added. These two protocols do not overlay or conflict with each other.

In the same way, a rule library named "123" may be defined.

```
Ruijie(config)# ip inspect name abc ftp
Ruijie(config)# ip inspect name abc mms
Ruijie(config)# ip inspect name 123 mms
Ruijie(config)# ip inspect name 123 h323

Ruijie(config)# show ip inspect all
Inspection Rule Configuration
Inspection name abc
```

```
ftp
mms
Inspection name 123
mms
h323
```

Then, users need to enter the specified interface and add this rule. For example:

```
Ruijie(config)# interface gigabitEthernet 0/0
Ruijie(config-if)# ip inspect abc in
Ruijie(config)# show ip inspect all
Inspection Rule Configuration
Inspection name abc
ftp
mms
Inspection name 123
mms
h323

Interface Configurationn
Interface gigabitEthernet 0/0
Inbound inspection rule is abc
ftp
mms
```

It should be noticed that one interface can only be applied with one special protocol rule library. If added with another, the newly added rule shall replace the original one. For example:

```
Ruijie(config)# interface gigabitEthernet 0/0
Ruijie(config-if)# ip inspect abc in
Ruijie(config)# show ip inspect all
Inspection Rule Configuration
Inspection name abc
ftp
mms
Inspection name 123
mms
h323
Interface Configurationn
Interface gigabitEthernet 0/0
Inbound inspection rule is abc
ftp
mms
Ruijie(config)# interface gigabitEthernet 0/0
Ruijie(config-if)# ip inspect 123 in
Ruijie(config)# show ip inspect all
Inspection Rule Configuration
```

```
Inspection name abc
ftp
mms
Inspection name 123
mms
h323
Interface Configurationn
Interface gigabitEthernet 0/0
Inbound inspection rule is 123
mms
h323
```

Understanding TCP Sequence Number Tracking

Overview

The purpose of TCP sequence number check is to guard against intrusion such as TCP session hijacking. It determines whether a data packet is valid by recording and tracking send sequence numbers, acknowledgement sequence numbers, and receive windows of both sides of a TCP connection.

Configuring TCP Sequence Number Tracking

Enabling or Disabling the TCP Sequence Number Tracking Function

The TCP sequence number tracking function is disabled by default. To enable this function, run the **ip inspect** command in interface configuration mode; or you may use **no** form of this command to disable the function.

Configuring TCP Sequence Number Tracking Rules

The TCP sequence number tracking function configuration basically agrees with the special protocol with the difference existing in that TCP protocol is added to **ip inspect name** rule library, e.g., .

```
Ruijie(config)# ip inspect name abc tcp
```

The preceding command indicates that TCP is added to the detection rule named "abc".

Then, it is still necessary to apply the configured ip inspect name detection rule to the interface, e.g., .

```
Ruijie(config)# interface gigabitEthernet 0/0
Ruijie(config-if)# ip inspect abc in
```

The preceding command applies the detection rule named "abc" in the inbound direction of gigabit 0/0 interface.

Understanding Session Limit

Overview

This function is mainly designed to prevent flow flood attacks generated at certain IP address or IP network segment by limiting the speed of session establishment and total number of concurrent sessions.

Configuring a Session Limit

Before configuring the session limit function, users need to configure an ACL rule first to define the scope of the session limit function, e.g., .

If users want to limit all sessions through ports whose sources and destination IP addresses are specified in the limit function, configure the following ACL first.

```
access-list 1 permit any
```

Then configure the rule in interface mode.

For example, now users want to configure a rule under gigabit 0/0 interface, and the rule takes effect in the inbound direction of this interface, the limit scope shall be ACL-defined scope, the speed of session establishment shall be 100 per second and concurrent sessions shall be 100,000 in total. Sessions that meet such requirements shall be allowed while others are blocked and the blocked session will be recorded in a log.

```
Ruijie(config)# in gi 0/0
Ruijie(config-if)# session-limit access-group 1 rate 100 concurrent 100000 in log
```

Use the **no** form of this command to delete configuration.

Viewing Session Limit Information

show session-limit config

```
Ruijie(config-if)# show session-limit config
============[ Show gigabitEthernet 0/0's config]==============
Input
session-limit access-group 1 rate 12 concurrent 123 in log
session-limit access-group 12 rate 20 concurrent 100 in log
session-limit access-group 13 rate 20 concurrent 100 in log
session-limit access-group 14 rate 20 concurrent 100 in log
-------------------------------------------------------------------------------------
-----------------
 Output
session-limit access-group 1 rate 12 concurrent 123 out log
===========[ Show gigabitEthernet 0/0's config end]=============
```

show session-limit del-rule

With this function, you may find the commands used to view and delete configuration.

```
Ruijie(config-if)# show session-limit del-rule
```

```
======[ Show Cmd to del the rule on the gigabitEthernet 0/0 ]=====
Input
no session-limit access-group 1 rate 12 concurrent 123
in log
no session-limit access-group 12 rate 20 concurrent 100
in log
no session-limit access-group 13 rate 20 concurrent 100
in log
no session-limit access-group 14 rate 20 concurrent 100
in log
-------------------------------------------------------------------------------------
-----------------
Output
no session-limit access-group 1 rate 12 concurrent 123
out log
==[ Show Cmd to del the rule on the gigabitEthernet 0/0's end ]=
```

show session-limit statistics

```
Ruijie(config-if)# show session-limit statistics
=========[ Show gigabitEthernet 0/0's Statistics ]========
Input
matches access-group  : 1
[Configure]:  new_session_rate : 12 , concurren : 123
[Statistics]:  conformed 2247 sessions, blocked 0 sessions
matches access-group  : 12
[Configure]:  new_session_rate : 20 , concurren : 100
[Statistics]:  conformed 0 sessions, blocked 0 sessions
matches access-group  : 13
[Configure]:  new_session_rate : 20 , concurren : 100
[Statistics]:  conformed 0 sessions, blocked 0 sessions
matches access-group  : 14
[Configure]:  new_session_rate : 20 , concurren : 100
[Statistics]:  conformed 0 sessions, blocked 0 sessions
-------------------------------------------------------------------------------------
-----------------
Output
matches access-group  : 1
[Configure]:  new_session_rate : 12 , concurren : 123
[Statistics]:  conformed 0 sessions, blocked 0 sessions
=========[ Show gigabitEthernet 0/0's Statistics End ]=======
```

Understanding Flow Management

Overview

The purpose of flow management is to prevent some users or applications from occupying excessive resources (e.g., bandwidth). Besides, flow limit is a simple and direct way to guard against ICMP flood and UDP flood attacks when other means of defense are void.

Configuring Flow Management

During flow management configuration, ACLs are used to control bandwidth quota of users, maximum number of concurrent connections, and number of new connections. Bandwidth is classified into uplink bandwidth and downlink bandwidth. If same bandwidth is specified on the uplink and downlink, the system automatically changes the keyword to **both**. The number of concurrent connections and speed of connection establishment are optional and can be left unspecified.

To configure this function, run the **ip rate-control** command in interface configuration mode.

You can use the **no** form of this command to disable this function.

It should be noticed that the command is effective only on the outbound interface.

Understanding Others

Enabling Session Log

At the end of a session, some information of the session, including source IP address, destination IP address, protocol, port, bytes sent and received, session duration, may need to be sent to the log server for future analysis. The session log function is disabled by default. To enable this function, run the **ip session log-on** command.

Sometimes a large number of session logs may be generated. In this case, some session logs may be lost due to limits on network transmission and processing capability of the log server.

Confiuguring Session Timeout

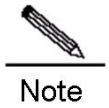
One session that remains inactive in a certain time will be considered completed. This period of time is called the timeout time of a session. Session timeout varies with session statuses. The system has different timeout settings for sessions in different statuses, which does not need to be changed in normal conditions. If you want to change timeout settings, run the **ip session timeout** command.

Configuring Abnormal Session Status Restriction

As for some abnormal session status, it is conducive to security enhancement to control the number of the packets sent from the source terminal. Generally, an appropriate threshold of different abnormal session status has been configured by the system and needs no change. When a change is needed, run the **ip session threshold** command.

Enabling Strict Status Tracking

Strict status tracking applies to TCP connection establishment and ICMP error packets. It interrupts connections in case of abnormal TCP connection (e.g., non-SYN packet) and reception of unreachable ICMP packets. Misreport may occur, therefore, strict status tracking is disabled by default. To enable this function, run the **ip session track-state-strictly** command. It is recommended that you enable this function when there is a high security requirement for better attack defense capability and disable it in internal networks or private networks to protect key services.


Note

When running the **ip session track-state-strictly** command to start the FW module for strict status tracking, the system will interrupt established TCP connections in order to trigger stream creation for effective tracking of the status. As a result, some established TCP services like telnet, ftp, etc will be interrupted when the command is used. Be cautious when using this command.

Enabling ICMP Reverse Flow Check

When ICMP reverse flow check is disabled, only the life time of ICMP reverse flows will be refreshed and flows are deleted and re-established by themselves in case of a ping failure. When the function is enabled, life time of both forward and reverse flows will be refreshed. This function is disabled by default. If there is a routing imbalance, packets are sent only in one direction and packets may be lost in a ping test. In this case, you can enable this function to avoid packet loss.

Configuring Connection Filtering

Invalid IP packets affect the transmission of normal packets. To prevent communication or attacks that hinge on invalid packets, you can enable connection filtering.

Before enabling this function, you need to know characteristics of invalid packets such as the source IP address, destination IP address, protocol, and port and then configure an ACL rule to define the range of forbidden packets. Finally, you can run the **ip session filter** *acl_id* command.

This function takes effect globally. It checks and filters forward and reverse flows, and discards packets that meet the filter rule without creating flow entries on the platform.

The connection filtering function is not disabled or displayed by default.

Network Security Protocol (IPSec)

Overview of IPSec

Purposes of Encryption

Data transmitted on a network without any protection measures is vulnerable to various kinds of attacks. When the data passes a device, any one who accesses this device can read, tamper or forge the data. For example, the protocol analyzer (such as sniffer) can be used to read packets and obtain confidential information. Inside an organization, the malicious users can tamper packets and perform destructive activities by interfering, reducing or blocking network traffic. Hence, it is extremely important to encrypt private, confidential and emergent data when it is transmitted.

Ruijie Networks products support the IPSec and IKE protocols, ensuring that the data is transmitted securely in a network without any protection measures.

- The IPSec protocol is an open standard framework developed by IETF. It works in the network layer to provide encryption and authentication for the traffic between the devices that provide the IPSec protocol services. IPSec can protect all or part of the data above the IP layer. It provides the following optional security services: data confidentiality, data integrity, data origin authentication, and anti-replay. These functions prevent the data from being monitored, tampered and forged when being transmitted over the network.
- IKE is a key management protocol standard that should be used with IPSec. IKE works in the UDP layer to provide secure key exchange and management mechanism. Since IPSec can be used independently, IKE will make IPSec more flexible and easy to configure, strengthening the security.

Supported Standards

Ruijie Networks products implement the following encryption standards:

- IPSec: It specifies a set of security architectures and provides data confidentiality, integrity and data authentication services between IPSec entities. It can protect one or more data streams between hosts, between subnets, and between security gateways.
- AH: It provides the data authentication service and the anti-replay service.
- ESP: It provides the data encryption service, the optional data authentication service, and the anti-replay capability.
- DES: It is an encryption algorithm that uses a 64-bit key to encrypt the packet (there are 56 significant bits).
- 3DES: It is an encryption algorithm that uses a 192-bit key to encrypt packets (there are 168 significant bits).
- AES: It is a sub-key, 128-bit data input algorithm, key length is 128. As the next generation data encryption standard, AES boasts high security, high performance, high efficiency, easy-to-use and flexibility
- NULL: It is the null encryption algorithm that encapsulates, instead of encrypts, packets.
- MD5-HMAC: (Message Digest 5) It is a HASH algorithm used to verify packets and prevent them from being modified.
- SHA-HMAC: (secure HASH algorithm) It is a HASH algorithm used to verify packets and prevent them from being modified.

- IKE: This protocol implements the Oakley and Skeme key exchange protocols within the ISAKMP (Internet Security Association and Key Management Protocol) framework. It performs IPSec end-point authentication, IPSec parameter negotiation and key exchange.
- ISAKMP: It defines the format and parameters of the payload in data exchange, and the key negotiation mode.
- Diffie-Hellman: It is a public key encryption protocol that allows both parties involved in the exchange to establish shared secrecy on an insecure channel.

Terms

Anti-replay: It is a security service that allows recipients to deny outdated packets or packet copies to avoid being attacked. It is a security association that is used for IKE negotiation and provides the authentication service.

Note The manually created security association does not support the anti-replay function. Only the security associations that pass IKE negotiation support anti-replay.

Data authentication: It includes the following two concepts:

- Data integrity: Check whether the data has been modified.
- Data origin authentication: Check whether the data is really sent by the declared sender.

Data confidentiality: It protects the data from being snooped.

Data stream: It refers to the specific communication data that has a source address/mask, destination address/mask, the next protocol field of IP, and source and destination port IDs. The protocol and port fields can be specified using "any". All the traffic of a certain association that meets the above conditions is called a data stream. A data stream may represent a TCP connection between two hosts, or all the traffic between two subnets.

Peer: It refers to the device involved in IPSec or other devices.

Security Association (SA): It refers to a logical connection that provides the security service for a specific data stream. This security service has such parameters as specific security protocol, security algorithm, key, and data stream description. There are two types of security association: IPSec and IKE. The IPSec SA provides the IPSec protection function for data and allows users to establish a connection either manually or through IKE negotiation. The IKE SA is used to protect the negotiation data of IKE.

Security Parameter Index (SPI): SPI is a 32-bit integer, which is combined with a destination IP address and a security protocol type to form the unique ID of a SA. When a SA is established by using IKE, the SPI value of each SA is a pseudo-random inherited digit. If IKE is not used, specify an SPI value for each SA.

Security association lifetime: It refers to the validity period of a SA. The manually established security association has no lifetime, that is, it can be used permanently until a user deletes it manually. The lifetime of the SA established through IKE negotiated is negotiated with the remote IKE entity. The SA will be deleted once its lifetime expires, and IKE will negotiate about a new SA.

Transform set: The transform set describes the security suite that consists of a security protocol (AH or ESP) and an algorithm. For example, a transform set defines use of the ESP protocol and the DES encryption algorithm.

Crypto map entry: The crypto map entry associates the transform set with the data stream, and describes the peer address, and parameters necessary for communication. It fully describes the contents necessary for IPSec communication with the remote peer. An IPSec SA can be established only by using the crypto map entry.

At present, IPSec can be used to send IP packets in unicast manner only. Because the IPSec workgroup has not released the group key, now IPSec does not support IP packet multicast or broadcast.

If a device uses NAT, the static NAT should be configured, so that IPSec can work normally. NAT must be performed before IPSec encapsulation of the device, that is, IPSec should use the IP address of the public network.

IPSec Configuration

Overview of IPSec Working Process

IPSec provides a secure channel for two IPSec peers, such as two devices. You can define which sensitive data streams should be protected. These data streams will be transmitted along the secure channels. Moreover, you can define parameters to protect these sensitive packets by specifying parameters for these channels. When IPSec detects such a sensitive packet, it will establish a secure channel, through which this packet is sent to the remote peer.

The sensitive data streams can be defined by configuring the access list. Describe the sensitive data streams to be protected on the basis of the source/destination address, protocol and port in the access list. After configuring the access lists, use a crypto map set to apply these access lists to the interface, so that the interface protects the specific incoming and outgoing data streams.

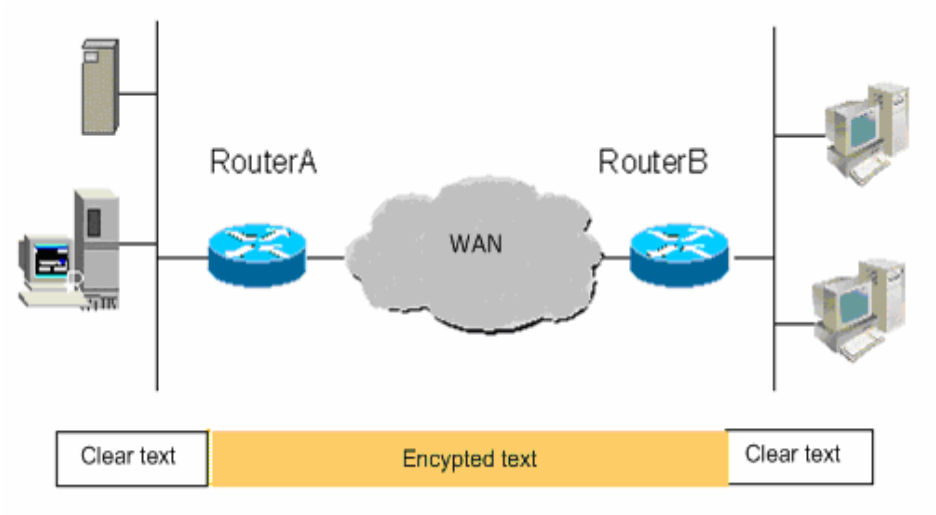
One crypto map set can have multiple entries, each of which corresponds to a different access list. The device finds the entry that matches the current traffic by sequence (the device tries to match the packet with the access list specified by the entry). When a packet matches a permit entry in the specific access list, if the crypto map entry is labeled as ipsec-manual, IPSec is triggered directly to process the data stream securely; if the crypto map entry is labeled as ipsec-isakmp, when an IPSec SA has been established, IPSec protection is provided to the data directly, otherwise IKE negotiation will be triggered automatically to create an IPSec SA. If the user does not configure IPSec or IKE parameters properly, it will be impossible to establish a SA, and the packets will be discarded.

Once a SA is established, the outgoing packet will be encrypted by IPSec and authentication information is filled in before it is sent to the peer. This packet is an incoming packet of the peer, which finds the related SA, and decrypts, authenticates and restores the packet.

The crypto map entry also specifies a transform set that defines the combination of the algorithm and protocol mode used by IPSec. Two IPSec peers must finally use the same transform set in order to communicate effectively.

The following figure shows an example of implementing IPSec protection between subnets:

Figure 6 Implementation of IPSec protection between subnets



IPSec Configuration Tasks

The ultimate purpose of IPSec configuration task is to establish an IPSec SA. An IPSec SA can be established manually or through negotiation by IKE. Manual configuration does not need IKE, but requires more parameters to be specified and has lower level of security. To establish a SA through IKE negotiation, you need to configure the IKE parameters besides configuring the IPSec parameters, so it has a higher level of security.

IPSec configuration tasks include:

- **Configure the default lifetime (optional)**: This is an optional step. You can use this command to modify the default lifetime value of the system. If there is no special description, IKE will use this lifetime value for negotiation, so that the lifetime of IPSec is not longer than the default lifetime.
- **Create an encryption access list**: An encryption access list determines the data streams to be protected. IPSec needs to rely on the encryption access list to filter incoming/outgoing packets. It provides IPSec protection for the matched outgoing data, and checks the validity of the matched incoming packets.
- **Define a transform set**: A transform set describes how to protect data streams. The transform set is a combination of the specific security protocol and algorithm. It specifies an algorithm, a security protocol, and a data encapsulation mode. To specify the degree of and requirements for protection of the data, the user must define an appropriate transform set here in advance.
- **Create a crypto map entry**: To create a crypto map entry, associate the predefined access list with the transform set, and define the key and the peer address to form a complete IPSec scheme description.
- **Configure a multicast policy:** Disable IPSec encapsulation of multicast and broadcast packets.
- **Apply a crypto map entry to an interface**: This action activates IPSec scheme defining. It applies a crypto map entry to an interface to make the crypto map set start working on the interface.
- **Create a Profile crypto map entry:** Define IPSec encryption policies of dynamic multipoint VPN (DMVPN).
- **Apply a Profile crypto map entry to a tunnel interface**: Activate the IPSec functions of DMVPN.
- **Configure extended authentication mode:** This action is used for extended authentication.
- **Configure IPSec packet filter:** Decapsulated packets are no longer filtered.
- **Configure IPSec MIB:** It sends IPSec monitoring information to the SNMP server. This function is disabled by default and needs to be enabled using a command.
-

- **Monitor and maintain IPSec**: Monitor and maintain IPSec, view and adjust the IPSec parameters, and judge whether IPSec works normally.

Note IKE uses UDP port 500. The IPSec ESP and AH protocols are numbered 50 and 51 respectively. If access list (firewall) filtering data has been configured on the device, then before configuring IPSec, please make sure the traffic for protocols 50 and 51 and UDP port 500 on the interface used by IPSec is not blocked. If possible, add a statement to the access list to explicitly allow the traffic.

Configuring Default Lifetime

To configure the default lifetime, run the following command in global configuration mode or privileged user configuration mode:

Command	Function
Ruijie(config)# **crypto ipsec security-association lifetime seconds** *seconds*	Changes the global lifetime limit of IPSec SA. This command will cause the SA timeout after the specified seconds elapse.
Ruijie(config)# **crypto ipsec security-association lifetime kilobytes** *kilobytes*	Changes the global traffic lifetime of IPSec SA. This command will cause the SA timeout after the transmitted traffic (in KBs) protected by IPSec using this SA reaches a specified value.
Ruijie# **clear crypto sa** or Ruijie# **clear crypto sa peer** {*ip-address* | *peer-name*} or Ruijie# **clear crypto sa map** *map-name*	Clears an existing SA. This will immediately interrupt all the existing SAs. The subsequent SAs will use a new lifetime. Otherwise, all the existing SAs will expire on the basis of the original lifetime.

Note Use the **clear crypto sa** command without parameters to clear the entire SA database. This will also clear the active encryption processes. You can use such keywords as peer and map to clear only one subnet from the SA database. For detailed information, refer to the command reference for **clear crypto sa**.

The default lifetime of the system is 1-hour communication (3600 seconds) or 4,608,000KB traffic (continuous communication for 1 hour at the rate of 10 MBit/s). If the user accepts the default value, skip this step. This default lifetime is used if there is no special description in the crypto map entry. When negotiating the lifetime of IPSec, IKE uses the smaller value of those of the local end and the peer. When the lifetime of the IPSec SA expires, IKE will negotiate again and replace a new set of parameters and key for IPSec to make it start working again.

The SA (and the related key) is timeout on the basis of the lifetime that expires earliest: Use the seconds (specified by the keyword seconds) or the kilobytes of transmitted traffic (specified by the keyword kilobytes). The manually established SA (established by the crypto map entry identified as ipsec-manual) has no lifetime limit.

In order to make sure that a new SA is available when the original SA expires, the new SA must be negotiated before the original SA expires. When there are 30 seconds left before the lifetime expires, or when there are 256 Kbytes left before

the traffic that passes this channel reaches the lifetime (determined by the peer that reaches the lifetime first), a new SA is negotiated.

If no traffic takes this channel throughout the lifetime of a SA, this SA will be released but negotiation of a new SA will not be underway when the lifetime elapses. In this case, a new SA will be negotiated only when IPSec finds another packet that should be protected.

DF bit Override Function of IPSec Tunnel

The DF bit override function allows users to specify whether the device is reset, is set to 1, or copies the encapsulated header.

The DF bit on the IP header determines whether the device can fragment the packet. Value 1 indicates that this packet cannot be fragmented, and value 0 indicates that the packet can be fragmented. This function in IPsec tunnel mode allows the device to control whether the DF bit of the packet IP header encapsulated by IPSec is determined by the DF bit value of the original IP header. Only tunnel mode supports this feature.

To configure the DF bit value for all the interfaces, run the following command in global configuration mode:

Command	Function
Ruijie(config)# **crypto ipsec df-bit** [**clear** | **set** | **copy**]	Sets the DF bit of the IP external header for all the interfaces in tunnel mode.

In the following example, the device is configured to clear the DF bit globally, and copy the DF bit on FastEthernet0/0. This way, all the interfaces other than FastEthernet0/0 allow packets larger than the MTU size to be sent (in fragments), while FastEthernet0/0 must determine whether to allow the device to fragment the packet according to the DF bit in the original IP header.

```
crypto isakmp policy 1
hash md5
authentication pre-share
crypto isakmp key 0 DELaware address 192.168.10.66
crypto isakmp key 0 Key-What-Key address 192.168.11.19
!
!
crypto ipsec transform-set BearMama ah-md5-hmac esp-des
crypto ipsec df-bit clear
!
!
crypto map armadillo 1 ipsec-isakmp
set peer 192.168.10.66
set transform-set BearMama
match address 101
!
crypto map basilisk 1 ipsec-isakmp
set peer 192.168.11.19
set transform-set BearMama
match address 102
```

```
!
!
interface FastEthernet0/0
ip address 192.168.10.38 255.255.255.0
ip broadcast-address 0.0.0.0
crypto map armadillo
crypto ipsec df-bit copy
!
interface FastEthernet0/1
ip address 192.168.11.75 255.255.255.0
ip broadcast-address 0.0.0.0
crypto map basilisk
!
```

Creating Encryption Access Lists

The encryption access list is used to define which data streams should be encrypted, and which should not be encrypted. For example, you can create an encryption access list to protect all the IP traffic between Subnet A (192.168.202.0/24) and Subnet B (192.168.12.0/24) (access list 120), or the IP traffic between Host A and Host B (access list 101):

```
access-list 120 permit ip 192.168.12.0 0.0.0.255 192.168.202.0 0.0.0.255
access-list 101 permit ip host 2.2.2.2 host 2.2.2.1
```

The encryption access list specified by the IPSec crypto map entry has the following four major functions:

- Filter the outbound traffic that is encrypted by using IPSec (permit = protect).
- When starting to negotiate an IPSec SA, indicate which data streams are protected by the new SA (indicated by a single permit entry).
- Process the inbound traffic, so as to filter and discard those traffic that should have been protected by IPSec.
- When handling the IKE negotiation initiated by the IPSec peer, determine whether to accept the IPSec SA request that represents the requested data stream (only the crypto map entry ipsec-isakmp should be negotiated). You must make sure that the access lists of peers at both ends match. It is recommended that the access lists of peers at both ends are consistent.

To configure the encryption access list, run the following command in global configuration mode:

Command	Function
Ruijie(config)# **access-list** *access-list-number* {**deny** | **permit**} *protocol source source-wildcard destination destination-wildcard* [**log**] Or: Ruijie(config)# **ipv6 access-list** ipv6-acl-name Ruijie(config-ipv6-acl)# **{deny | permit}** *protocol source source-wildcard destination destination-wildcard*	Describes the data stream in terms of its source/destination address and its wildcard, communication protocol and communication port. If the keyword **permit** is used, the policy described in the related crypto map entry will provide encryption protection for all the IP traffics that meet the specified conditions. The keyword **deny** can be used to prevent the traffic from being encrypted by the specific crypto map entry.
Ruijie(config-exp-nacl)# **exit**	Exits ACL configuration mode.

If the keyword **permit** is used, the policy described in the related crypto map entry will provide encryption protection for all the IP traffic that meets the specified conditions. The keyword **deny** can be used to prevent the traffic from being encrypted by the specific crypto map entry.

Note

It is recommended that you define a mirrored encryption access list on the remote peer for each encryption access list defined on the local peer. Otherwise, some data is not protected or the SA cannot be established. Since the ACL has priority, the inclusion relation of ACEs should be noted during the configuration. In case of conflict, the ACE having a higher priority takes effect.

The keyword **any** should be used with great care because it will discard lots of broadcast information and make the device unable to work normally. The encryption access list is not specially designed for and used by IPSec. IPSec uses the extended IP access list, so the value of **access-list-number** ranges from 100 to 199]. If no port is defined, this encryption access list can be used for the data stream in either the inbound direction or the outbound direction.

For example, when you want to protect the IP traffic between Subnet A (192.168.12.0/24) and Subnet B (192.168.10.0/24), the following access list should be defined for the device:

```
access-list 101 permit ip 192.168.12.0 0.0.0.255 192.168.10.0 0.0.0.255
```

For example, if you want to protect the TCP traffic between Subnet A (192.168.12.0/24) and Host C (202.101.11.3), the following access list should be defined for the device:

```
access-list 120 permit tcp 192.168.12.0 0.0.0.255 202.101.11.3 0.0.0.0
```

If port filtering is defined, the destination address in the encryption access list provides the service for this port.

For example, if you need to protect the Telnet traffic between Host D (1.1.1.1) and Host E (2.2.2.2) that provides the Telnet service, define as follows on the device:

```
access-list 133 permit tcp 1.1.1.1 0.0.0.0 2.2.2.2 0.0.0.0 eq telnet
```

Caution

In terms of permit ipv6 any any encryption access list, Ruijie devices are not compatiable with Cisco devices. Because Cisco devices will encrypted “neighbor request packet” and “neighbor advertisement packet” (Similar to ARP packets of IPv4), the IPSec data communication between two non-direct devices failed. To avoid the preceding issue, Ruijie devices will not encrypt “neighbor request packet” and “neighbor advertisement packet”.

Defining Transform Set

Transform set is a combination of the specific security protocol and algorithm. During negotiation of the IPSec SA, the peer must use the same specific transform set to protect the specific data stream.

Because there is no anti-replay negotiation process between peers for the manually established SA, the same transform set must be specified for the two peers. Change to the definition of the transform set will apply to negotiation of the subsequently established SA, instead of the existing SA. If you want these new settings to take effect immediately, use the **clear crypto sa** command to clear all or part of the SA database.

To define a transform set, run the following command in global configuration mode:

Command	Function
Ruijie(config)# **crypto ipsec transform-set transform-set-name** *transform1* [*transform2* [*transform3*]]	The transform parameter is an algorithm supported by the system. Algorithms can be combined according to a certain rule.
Ruijie(cfg-crypto-trans)# **mode** {**tunnel** | **transport**} (Optional)	Changes the mode associated with the transform set. Mode setting is useful only for the communication where both the source and the destination addresses and those of the IPSec peer, while not useful for other communications (all other communications are performed in the tunnel mode).
exit	Exits crypto transform configuration mode.
Ruijie# **clear crypto sa** or Ruijie# **clear crypto sa peer** {*ip-address* | *peer-name*} or Ruijie# **clear crypto sa map** *map-name*	Clears the existing SAs, so as to make sure that any change to the transform set applies to the subsequently established SAs (the manually established SAs will be reestablished immediately)

Present below are all the transform sets supported by the system:

transform1 [transform2]	Description
ah-md5-hmac	AH protocol and MD5 HMAC algorithm
ah-sha-hmac	AH protocol and SHA HMAC algorithm
esp-des	ESP protocol and DES encryption algorithm
esp-3des	ESP protocol and 3DES encryption algorithm
esp-aes-128	ESP protocol and aes encryption algorithm with key length being 128.
esp-aes-192	ESP protocol and aes encryption algorithm with key length being 192.
esp-aes-256	ESP protocol and aes encryption algorithm with key length being 256.
ah-md5-hmac esp-des	The AH protocol is located outside, and the MD5 HMAC authentication algorithm is used. The ESP protocol is located inside, and the DES encryption algorithm is used
ah-sha-hmac esp-des	The AH protocol is located outside, and the SHA HMAC authentication algorithm is used. The ESP protocol is located inside, and the DES encryption algorithm is used
ah-md5-hmac esp-des esp-md5-hmac	The AH protocol is located outside, and the MD5 HMAC authentication algorithm is used. The ESP protocol is located inside, and the DES encryption algorithm and the MD5 HMAC authentication algorithm are used

transform1 [transform2]	Description
ah-md5-hmac esp-null esp-md5-hmac	The AH protocol is located outside, and the MD5 HMAC authentication algorithm is used. The ESP protocol is located inside, and the null encryption algorithm and the MD5 HMAC authentication algorithm are used
ah-md5-hmac esp-des esp-sha-hmac	The AH protocol is located outside, and the MD5 HMAC authentication algorithm is used. The ESP protocol is located inside, and the DES encryption algorithm and the SHA HMAC authentication algorithm are used
ah-md5-hmac esp-null esp-sha-hmac	The AH protocol is located outside, and the MD5 HMAC authentication algorithm is used. The ESP protocol is located inside, and the null encryption algorithm and the SHA HMAC authentication algorithm are used
ah-sha-hmac esp-des esp-md5-hmac	The AH protocol is located outside, and the SHA HMAC authentication algorithm is used. The ESP protocol is located inside, and the DES encryption algorithm and the MD5 HMAC authentication algorithm are used
ah-sha-hmac esp-null esp-md5-hmac	The AH protocol is located outside, and the SHA HMAC authentication algorithm is used. The ESP protocol is located inside, and the null encryption algorithm and the MD5 HMAC authentication algorithm are used
ah-sha-hmac esp-des esp-sha-hmac	The AH protocol is located outside, and the SHA HMAC authentication algorithm is used. The ESP protocol is located inside, and the DES encryption algorithm and the SHA HMAC authentication algorithm are used
ah-sha-hmac esp-null sp-sha-hmac	The AH protocol is located outside, and the SHA HMAC authentication algorithm is used. The ESP protocol is located inside, and the null encryption algorithm and the SHA HMAC authentication algorithm are used
esp-des esp-md5-hmac	For the ESP protocol, the DES encryption algorithm and the MD5 HMAC authentication algorithm are used.
esp-null esp-md5-hmac	For the ESP protocol, the null encryption algorithm and the MD5 HMAC authentication algorithm are used.
esp-des esp-sha-hmac	For the ESP protocol, the DES encryption algorithm and the SHA HMAC authentication algorithm are used.
esp-null esp-sha-hmac	For the ESP protocol, the null encryption algorithm and the SHA HMAC authentication algorithm are used.
esp-3des	ESP protocol and 3DES encryption algorithm
esp-3des esp-sha	For the ESP protocol, the 3DES encryption algorithm and the SHA HMAC authentication algorithm are used.
esp-3des esp-md5	For the ESP protocol, the 3DES encryption algorithm and the MD5 HMAC authentication algorithm are used.

transform1 [transform2]	Description
ah-md5-hmac esp-des	The AH protocol is located outside, and the MD5 HMAC authentication algorithm is used. The ESP protocol is located inside, and the 3DES encryption algorithm is used
ah-sha-hmac esp-des	The AH protocol is located outside, and the SHA HMAC authentication algorithm is used. The ESP protocol is located inside, and the 3DES encryption algorithm is used
ah-md5-hmac esp-3des esp-sha	The AH protocol is located outside, and the MD5 HMAC authentication algorithm is used. The ESP protocol is located inside, and the 3DES encryption algorithm and the SHA HMAC authentication algorithm are used
ah-sha-hmac esp-3des esp-sha	The AH protocol is located outside, and the SHA HMAC authentication algorithm is used. The ESP protocol is located inside, and the 3DES encryption algorithm and the SHA HMAC authentication algorithm are used
ah-md5-hmac esp-3des esp-md5	The AH protocol is located outside, and the MD5 HMAC authentication algorithm is used. The ESP protocol is located inside, and the 3DES encryption algorithm and the MD5 HMAC authentication algorithm are used
ah-sha-hmac esp-3des esp-md5	The AH protocol is located outside, and the SHA HMAC authentication algorithm is used. The ESP protocol is located inside, and the 3DES encryption algorithm and the MD5 HMAC authentication algorithm are used

Note Generally, the combination esp-des (without data authentication) will satisfy your requirement. If you want to verify data, you can choose esp-des esp-md5-hmac or esp-des esp-sha-hmac.

Configuring IPSec MIB

IPSec MIB management involves statistics of data streams and encrypted/decrypted data packets and it may affect performance of IPSec data communication in some certain. Therefore, the MIB statistical function is disabled by default. To access the MIB node of IPSec, you need to enable the IPSec MIB function using the CLI command.

Command	Function
Ruijie(config)**# crypto mib enable**	Configures IPSec MIB statistics function.

Configuring Multicast Policies

If an ACL covers multicast and broadcast addresses, IPSec encapsulation will be applied to packets related to these addresses. To skip IPSec encapsulation, run the following command:

Command	Function
Ruijie(config)**#crypto ipsec multcast disable**	Disables encapsulation of multicast and broadcast packets.

Creating Crypto Map Entry

The crypto map entry can be configured in the following aspects:

- Which traffic should be protected by IPSec: Associate the configured encryption ACL.
- Where the traffic protected by IPSec will be sent to: Which is the remote IPSec peer.
- Local address used for IPSec communication: Apply the crypto map set to the interface. IPSec uses the address of the communication interface as the address of the local peer.
- Which IPSec security policies should be applied to traffic: Choose from the list that consists of one or more transform sets.
- Lifetime of the SA.
- Whether the SA is established manually or through IKE negotiation.

The crypto map entries that have the same crypto map name (but with different map sequence numbers) constitute a crypto map set. Apply the crypto map set to the interface, so that all the IP traffic that passes this interface is judged according to the crypto map set applied to the interface. If a crypto map entry finds an outbound IP channel that should be protected, and the crypto map specifies use of IKE, the SA will be negotiated with the remote peer according to the parameters in this crypto map entry. If the crypto map entry specifies use of the manually established SA, then a SA must have been established during configuration. The data is encrypted for transmission once the SA is established successfully either manually or through IKE negotiation. If negotiation of SA fails, the data is discarded.

The policy described in the crypto map entry will be used during negotiation of SA. To carry out IPSec smoothly between two IPSec peers, the crypto map entries of the two peers must include mutually compatible configuration statements. When two peers try to establish a SA, both of them must have at least one crypto map entry that is compatible with the crypto map entry of the remote peer and at least meets the following conditions:

- The crypto map entry must include a compatible encryption access list (such as mirrored map access list).
- The crypto map entries at both sides must identify the address of the peer (unless the peer is using a dynamic crypto map).
- The crypto map entries must have at least one identical transform set.

Only one crypto map set is applied to a single interface. The crypto map set contains IPSec/IKE or combination of IPSec/manual entry. If you create multiple crypto map entries for a given interface, you have to use the *seq- num* parameter of the map entry to sort these map entries again. The smaller the value of *seq-num*, the higher the priority.

Multiple crypto map entries must be created for a single interface if one of the following situations exists.

- If different data streams on this interface will be processed by different IPSec peers.
- If you want to apply different IPSec securities to different types of traffic (destined for the same or different peers). For example, you want that the traffic among the subnets in a group is authenticated, while the traffic among other subnets is both authenticated and encrypted. In this case, different types of traffic should be defined in two different access lists, and a separate crypto map entry must be created for each encryption access list.

Creating a SA manually

To create a SA manually, run the following commands in global configuration mode at the beginning:

Command	Function
Ruijie(config)# **crypto map** *map-name seq-num* **ipsec-manual**	Specifies the crypto map entry to be created or modified. When using this command, you will enter crypto map configuration mode.
Ruijie(config-crypto-map)# **match address** *access-list-id* *or* Ruijie(config-crypto-map)# **match ipv6** *ipv6-acl-name*	Specifies an access list for the crypto map list. This access list determines which traffic should be protected by IPSec, and which traffic should not be protected by the IPSec security defined in this crypto map entry.
Ruijie(config-crypto-map)# **match vrf** *vrf-name*	Specifies the crypto map list a VRF that are associated with the access list. Only when the packets under the VRF matching the access list can they be protected by IPSec.
Ruijie(config-crypto-map)# **set peer** {*hostname* | *ip-address*}	Specifies a remote IPSec peer. The traffic protected by IPSec will be sent to this peer. If IKE is not used, only one peer can be configured.
Ruijie(config-crypto-map)# **set transform-set** *transform-set-name*	Specifies which transform set to use. This transform set must be the same as the one specified in the corresponding crypto map entry of the remote peer. (If IKE is not used, only one transform set can be specified.)
Ruijie(config-crypto-map)# **set vrf** *vrf-name*	Specifies the VRF that are associated with tunnel.
Ruijie(config-crypto-map)# **set session-key inbound ah** *spi hex-key-data* or Ruijie(config-crypto-map)# **set session-key outbound ah** *spi hex-key-data*	If the specified transform set includes the AH protocol, you should use this command to set the AH Security Parameter Indexes (SPIs) and passwords for the protected outbound and inbound traffic. Here, the local inbound SPI, protocol and key must be the same as the outbound SPI, protocol and key of the remote peer, and vice versa.
Ruijie(config-crypto-map)# **set session-key inbound esp** *spi* **cipher** *hex-key-data* [**authenticator** *hex-key-data*] or Ruijie(config-crypto-map)# **set session-key outbound esp** *spi* **cipher** *hex-key-data* [**authenticator** *hex-key-data*]	If the specified transform set includes the ESP protocol, you should use this command to set the ESP security parameter indexes and passwords for the protected outbound and inbound traffics. If the transform set includes the ESP encryption algorithm, the encryption key must be provided. If the transform set includes the ESP authentication algorithm, the authentication key must be provided. Here, the local inbound SPI, protocol and key must be the same as the outbound SPI, protocol and key of the remote peer, and vice versa.
Ruijie(config-crypto-map)# **set mtu** *length*	Sets the side of a fragment in tunnel mode.
Ruijie(config-crypto-map)# **exit**	Exits the crypto map configuration mode and return to the global configuration mode.

Repeat the preceding steps to create other necessary crypto map entries.

The following shows a configuration example:

Local peer (router A) configuration:

Define a transform set named myset

```
crypto ipsec transform-set myset esp-des
```

Define a manual map set named mymap

```
crypto map mymap 3 ipsec-manual
 set peer 2.2.2.2
 set session-key inbound esp 301 cipher abcdef1234567890
 set session-key outbound esp 300 cipher abcdef1234567890
 set transform-set myset
 match address 101
!
access-list 101 permit ip 192.168.12.0 0.0.0.255 192.168.202.0 0.0.0.255
```

Remote peer (router B) configuration:

Define a transform set named myset

```
crypto ipsec transform-set myset  esp-des
```

Define a manual map set named mymap

```
crypto map mymap 3 ipsec-manual
 set peer 2.2.2.1
 set session-key inbound esp 300 cipher abcdef1234567890
 set session-key outbound esp 301 cipher abcdef1234567890
 set transform-set myset
 match address 101
 !
access-list 101 permit ip 192.168.202.0 0.0.0.255 192.168.12.0 0.0.0.255
```

Caution

The keyword **hex-key-data** is a hexadecimal number. The length of **hex-key-data** following the keyword cipher in the configuration command in the sixth step and the length of **hex-key-data** in the configuration command in the fifth step are determined by the encryption algorithm in use (at present, IPSec supports the DES, 3DES and AES encryption algorithms). The length of **hex-key-data** following the keyword authenticator in the configuration command in the sixth step is determined by the data authentication algorithms (including the SHA and MD5 algorithms) in use. In the above example, the encryption algorithm DES is used, and the length of 64 bits is required, so its value is set to abcdef1234567890 (equivalent to 0xabcdef1234567890). Because no data authentication algorithm is used in the above example, the key following authenticator is not configured. You can configure it simply by entering a string that contains digits from 1 to 9 and/or letters from a to f. It is unnecessary to identify it by 0x.

Table:

Name of Algorithm	Length of Key (bits)	Length of Entered Hexadecimal String (bytes)	Configuration Example
Des	64	8	Example: set session-key inbound esp 300 cipher abcdef1234567890
3Des	192	24	set session-key inbound esp 300 cipher abcdef1234567890 abcdef1234567890 abcdef1234567890
aes	128	16	set session-key inbound esp 300 cipher abcdef1234567890abcdef1234567890
Md5	128	16	Example: set session-key inbound esp 302 cipher abcdef1234567890 authenticator abcdef1234567890abcdef1234567890
Sha	160	20	Example: set session-key inbound esp 302 cipher abcdef1234567890 authenticator abcdef1234567890abcdef1234567890abcd

Caution Generally, a full length of key should be configured. If the key is not complete, the device may append "0" (low security), or may not append "0" (this will cause negotiation of SA failed).

Use of the manual SA is the result prearranged by the local device and IPSec peer administrators. They may want to first use the manual SA for debugging, and then use the IKE-based SA or the remote peer does not support IKE.

Configuring Anti-Replay Window

The anti-replay window is the basic attack protection feature of IPSec. By default, when hash (MD5, SHA, etc) authentication mode is configured, the anti-reply feature will be enabled, yet you can still disable this feature through the following command:

Command	Function
Ruijie(config)**#crypto ipsec security-association replay disable**	Disables the anti-replay window.

Caution Since QoS will divert traffic into different queues, thus leading to the disorder of packet transmission, and if IPSec enables anti-replay window in such a context, IPSec will drop all packets exceeding the window. Therefore, you can disable the anti-replay window to avoid packet loss, but it will also increase the possibility of being attacked.

Configuring Data Security Check

Data security check is the basic attack protection feature of IPSec. The criteria for attack judging is: if the packet which ought to be in encrypted text is received in plain text, such packet is considered unsafe and will be dropped. Under certain circumstances, data security check is not mandatory and can be disabled through the following command.

Command	Function
Ruijie(config)**#crypto ipsec optional**	Disables IPSEC data security check.

Caution Data security check will result in significant resource overhead, and disabling this feature can save CPU resources. In the model of l2tp over ipsec, l2tp can force to enable IPSec, and thus only IPSec-encrypted packets are allowed. This feature can be used according to actual needs.

Configuring to use IKE to create a crypto map entry for the SA

To configure to use IKE to create a crypto map entry for the SA, run the following commands in global configuration mode in the beginning:

Command	Function
Ruijie(config)# **crypto map** *map-name seq-num* **ipsec-isakmp**	Specifies the crypto map entry to be created or modified. When using this command, you will enter crypto map configuration mode.
Ruijie(config-crypto-map)# **match address** *access-list-id* or Ruijie(config-crypto-map)# **match ipv6** *ipv6-acl-name*	Specifies an access list for the crypto map list. This access list determines which traffic should be protected by IPSec, and which traffic should not be protected by the IPSec security defined in this crypto map entry.
Ruijie(config-crypto-map)# **match vrf** *vrf-name*	Specifies the crypto map list a VRF that are associated with the access list. Only when the packets under the VRF matching the access list can they be protected by IPSec.
Ruijie(config-crypto-map)# **set peer** {*hostname* | *ip-address*}	Specifies a remote IPSec peer. The traffic protected by IPSec will be sent to this peer. You can configure multiple peers.
Ruijie(config-crypto-map)# **set local** *ip-address*	Sets the IP address for local negotiation. If no IP address is specified, the primary address of the interface is used.
Ruijie(config-crypto-map)# **set transform-set** *transform-set-name1* [*transform-set-name2…transform-set-name6*]	Specifies which transform set to use. List the transform set by priority (high priority first).
Ruijie(config-crypto-map)# **set security-association lifetime seconds** *seconds* or Ruijie(config-crypto-map)# **set security-association lifetime kilobytes** *kilobytes*	(Optional) Specifies a SA lifetime for the crypto map entry.
Ruijie(config-crypto-map)# **set security-association idle-time** *seconds*	(Optional) Specify the idle time timeout for the crypto map entry.
Ruijie(config-crypto-map)# **set exchange-mode** *main* | *aggressive*	Sets which mode is used to initiate negotiation using this static entry.

Command	Function
Ruijie(config-crypto-map)# **set pfs** *group1* | *group2*	Specifies the Diffie-Hellman group identification.
Ruijie(config-crypto-map)# **set mtu** *length*	Sets the fragment size in tunnel mode.
Ruijie(config-crypto-map)# **set vrf** *vrf-name*	Specifies the VRF that are associated with tunnel.
Ruijie(config-crypto-map)#**username** *name* **password {0|7}** *pass*	Configures the username and password used for extended authentication.
Ruijie(config-crypto-map)#**reverse-route** [**remote-peer** *ip-address*] [*distance*] [**tag** *tagvalue*] [**track** *trackvalue*] [**bfd**] [**weight** weightvalue]	Configures Ipv4 reverse routing
Ruijie(config-crypto-map)# **reverse-ipv6-route** [**remote-peer** *ip-address*] [*distance*] [**bfd**] [**weight** weightvalue]	Configures Ipv6 reverse routing
Ruijie(config-crypto-map)# **exit**	Exits crypto map configuration mode and returns to global configuration mode.

Repeat the preceding steps to create other necessary crypto map entries.

The following example shows how to configure to establish a SA using IKE:

Local peer (router A) configuration:

Define a transform set named myset

```
crypto ipsec transform-set myset esp-des
```

Define a map set named mymap that establishes a SA using IKE

```
crypto map mymap 3 ipsec-isakmp
 set peer 2.2.2.2
 set transform-set myset
 match address 101
!
access-list 101 permit ip 192.168.12.0 0.0.0.255 192.168.202.0 0.0.0.255
```

Remote peer (router B) configuration:

Define a transform set named myset

```
crypto ipsec transform-set myset  esp-des
```

Define a map set named mymap that establishes a SA using IKE

```
crypto map mymap 3 ipsec-isakmp
 set peer 2.2.2.1
 set transform-set myset
 match address 101
 !
access-list 101 permit ip 192.168.202.0 0.0.0.255 192.168.12.0 0.0.0.255
```

Note RGOS supports both the manual SA and the IKE-established SA. The two modes of establishing SAs can also be added to the same crypto map set.

Caution Use IKE to establish a SA because IKE will negotiate again and use a new key when the lifetime expires, ensuring data security. However, because the content encrypted by using the DES encryption algorithm may be cracked maliciously within a certain time, the key must be modified regularly if the SA is established manually.

Creating a dynamic crypto map

The dynamic crypto map (IKE is needed) requires less configuration. If the IP address of the remote peer is unknown during configuration, the dynamic crypto map function must be used. For example, a mobile subscriber is dynamically assigned an IP address. First, the mobile subscriber uses something other than the IP address, such as the domain name, for the local IKE authentication. Once the authentication is complete, the SA request that meets the dynamic crypto map can be processed, and this dynamic crypto map can accept requests that meet the local policy.

Understanding dynamic crypto map

Only IKE can use the dynamic crypto map. The dynamic crypto map entry acts as a policy template. The missing parameters can be obtained dynamically (IPSec negotiation) to meet requirement of the remote peer. It allows the remote peer and the device to exchange IPSec traffic even if the crypto map of the device does not fully satisfy the requirement of the remote peer.

The dynamic crypto map is used for the remote peer to initiate IPSec negotiation, not for the device to initiate new IPSec negotiation with the remote peer.

The dynamic crypto map set is referred to as a part of the crypto map. Any crypto map entry that refers to the dynamic map is the crypto map entry with the lowest priority in the crypto map set (namely it has the largest sequence number). This way, other crypto map entries will be evaluated first. The dynamic crypto map entry is checked when all the static crypto map entries do not match.

If the device accepts the request from the peer, it will create a new IPSec SA, and install a temporary crypto map entry, which is filled in with the negotiation result. At this point, the device uses a temporary crypto map entry as if it uses a normal crypto map entry. Once the SA expires, the temporary crypto map entry will be deleted.

For the static and dynamic crypto maps, if the incoming traffic not protected meets one permit statement in the access list, the traffic will be discarded because it is not protected by IPSec.

For the static crypto map entry, if the outgoing traffic meets the permit statement in the access list, and the corresponding SA has not been established, the device will initiate SA negotiation with the remote peer. For the dynamic crypto map entry, if a SA does not exist, the traffic is discarded directly (because the dynamic crypto map is not used to initiate a new SA negotiation).

Caution The **any** keyword should be used carefully in the **permit** entry in the dynamic crypto map. Because **permit** may cover multicast and broadcast, **deny** must be used to exclude the broadcast and multicast traffic, and other traffic that is not protected by IPSec must also be excluded.

The dynamic crypto map entries are grouped into a set like the normal crypto map entries. A set contains crypto map entries that are grouped together using the same crypto map name but have different sequence numbers.

To create a dynamic crypto map entry, use the following commands in global configuration mode:

Command	Function
Ruijie(config)# **crypto dynamic-map** *dynamic-map-name dynamic-seq-num*	Creates a crypto map entry
Ruijie(config-crypto-map)# **set transform-set** *transform-set-name1* [*transform-set-name2...transform-set-name6*]	Specifies which transform set to use. List the transform set by priority (high priority first).
Ruijie(config-crypto-map)# **match address** *access-list-id* or Ruijie(config-crypto-map)# **match ipv6** *ipv6-acl-name*	(Optional) Specifies an access list for the crypto map list. This access list determines which traffic should be protected by IPSec, and which traffic should not be protected by the IPSec security defined in this crypto map entry. Note: Although the access list is optional to the dynamic crypto map, it is strongly recommended to configure it. If it is configured, the data stream ID suggested by the peer must match a permit entry in the crypto map access list. If it is not configured, the device accepts any data stream ID suggested by the peer.
Ruijie(config-crypto-map)# **match vrf** *vrf-name*	Specifies the crypto map list a VRF that are associated with the access list. Only when the packets under the VRF matching the access list can they be protected by IPSec.
Ruijie(config-crypto-map)# **set peer** {*hostname* | *ip-address*}	(Optional) Specifies a remote IPSec peer. You can configure multiple peers. This configuration is rare in the dynamic crypto map entry. The dynamic crypto map is often used when information about the peer is unknown.
Ruijie(config-crypto-map)# **set local** *ip-address*	Sets the IP address of the local peer. If no IP address is specified, the primary address of the interface is used.

Ruijie(config-crypto-map)# **set security-association lifetime seconds** *seconds* or Ruijie(config-crypto-map)# **set security-association lifetime kilobytes** *kilobytes*	(Optional) Specifies a SA lifetime for the crypto map entry.
Ruijie(config-crypto-map)# **set mtu** *length*	Sets the fragment size in tunnel mode.
Ruijie(config-crypto-map)# **set vrf** *vrf-name*	Specifies the VRF that are associated with tunnel.
Ruijie(config-crypto-map)#**username** *name* **password** *pass*	Configures the username and password used for extended authentication.
Ruijie(config-crypto-map)# **exit**	Exits crypto map configuration mode and returns to the global configuration mode.

- **Adding a dynamic crypto map set to the normal (static) crypto map set**

You can add one or more crypto map sets to a static crypto map set through reference of the crypto map entry to the dynamic map set. The crypto map entry that refers to the dynamic crypto map should be set as the entry with the lowest priority in the crypto map set.

To add a dynamic crypto map set to a static crypto map set, run the following command in global configuration mode:

Command	Function
Ruijie (config)# **crypto map** *map-name seq-num* **ipsec-isakmp dynamic** *dynamic-map-name*	Adds a dynamic crypto map set to a static crypto map set

Applying Crypto Map Entry to an Interface

To apply a crypto map set to an interface, run the following command in interface configuration mode:

Command	Function
Ruijie(config-if)# **crypto map** *map-name*	Applies a crypto map set to an interface.

A crypto map set should be configured for every interface that the IPSec traffic will pass. The device uses this crypto map set to judge all the traffic that passes this interface and apply a specific policy to filter the traffic.

Note Only one crypto map set can be applied to an interface at one time, while the crypt map set can be applied to multiple interfaces at one time. When the IPSec traffic that passes this interface is processed, the IP address of this interface will be used as the address of the local device.

Creating Profile Crypto Map Entries

To create Profile crypto map entries for using IKE to establish SAs, run the following commands in global configuration mode in the beginning:

Command	Function

Command	Function
Ruijie(config)# **crypto map** *map-name seq-num* **ipsec-isakmp**	Specifies the Profile crypto map entry to be created or modified. When using this command, you will enter crypto map configuration mode.
Ruijie(config-crypto-map)# **match address** *access-list-id*	Specifies an access list for the crypto map list. This access list defines which communications are protected by the IPSec and which are not.
Ruijie(config-crypto-map)# **set peer** {*hostname* |*ip-address*} [*trustpoint1* [*trustpoint2*]]	Specifies remote IPSec peer. Communications protected by the IPSec are forwarding to this peer. Several peers can be configured.
Ruijie(config-crypto-map)# **set local** *ip-address*	Sets the IP address of the negotiation. Use the primary IP address of the interface if it is not otherwise configured.
Ruijie(config-crypto-map)# **set transform-set** *transform-set-name1* [*transform-set-name2…transform-set-name6*]	Specifies the transform set and lists the transform sets according to certain priority (set with higher priorities prevail).
Ruijie(config-crypto-map)# **set security-association lifetime seconds** *seconds*	
Or: Ruijie(config-crypto-map)# **set security-association lifetime kilobytes** *kilobytes*	
Ruijie(config-crypto-map)# **set exchange-mode** *main* | *aggressive*	Sets the mode to initiate negotiations by this static entry.
Ruijie(config-crypto-map)# **set pfs** *group1* | *group2*	Specifies the Diffie-Hellman group mark.
Ruijie(config-crypto-map)# **set mtu** *length*	Sets the length of pre-fragment in tunnel mode.

Repeat the preceding steps to create other necessary crypto map entries.

The following example shows how to configure to establish a SA using IKE:

Local peer (router A) configuration:

Define a transform set named myset

```
crypto ipsec transform-set myset esp-des
```

Define a map set named *profile-name* that establishes a SA using IKE.

```
crypto ipsec profile profile-name
set transform-set myset
```

Remote peer (router B) configuration:

Define a transform set named myset.

```
crypto ipsec transform-set myset  esp-des
```

Define a map set named *profile-name* that establishes a SA using IKE

```
crypto ipsec profile profile-name
set transform-set myset
```

Note

For the IPV6, IPSEC-IPV4, or IPSEC-IPV6 tunnels, the **match any** command must be configured in the map set *profile-name*. In addition, **Profile map** in this command can apply only to IPIP and IPv6 tunnels.
The dhcp over ipsec configuration takes effect only on the crypto map entry with the smallest value of *seq-num*.

Applying Profile Crypto Map Entries to a Tunnel Interface

To apply a Profile crypto map set to a tunnel interface, run the following command in interface configuration mode:

Command	Function
Ruijie(config-if-Tunnel 1)# **tunnel protection ipsec profile** *profile-name*	Applies a crypto map set to a tunnel interface.

A crypto map set must be configured for every interface IPSec traffic passes through. Then the device can use the crypto map set to decrypt all packets through these interfaces.

Note

Profile crypto map entries can apply only to a tunnel interface. An attempt to apply a Profile crypto map entry to a non-tunnel interface may fail. In addition, only GRE, IPIP, and IPv6 tunnels are supported. If the **match any** command is configured in an entry, the entry applies only to IPIP and IPv6 tunnels.

Configuring Extended Authentication

Extended authentication uses AAA authentication items to verify the identities of users. To configure this function, run the following command in configuration mode:

Command	Function
Ruijie(config)# **crypto map** *map-name* **client authentication list** *aaa-name*	Uses AAA authentication to verify identities of users.

Configuring IPSec Packet Filtering

This function determines whether decrypted original IPSec packets need to be filtered. To configure this function, run the following command in configuration mode:

Command	Function
Ruijie(config)**# crypto ipsec no-filter**	Decrypted packets are not filtered.

Monitoring and Maintaining IPSec

Some changes to the configuration only take effect when subsequent SAs are negotiated. If you want the new settings to take effect immediately, you must delete existing SAs, so that they will be established again using the new settings. The

manually established SAs must be deleted and established again. Otherwise, changes will never take effect. If the device is processing the IPSec traffic, you may just want to clear the content that may be affected by the configuration change from the SA database (that is, only delete the SAs established by a given crypto map set). All the contents are only cleared from the SA database when the configuration is changed significantly, or the amount of the IPSec traffic that the device is processing is very small.

To delete and initiate the IPSec SA again, run the following commands in global configuration mode:

Command	Function
Ruijie# **clear crypto sa**	Clears the entire SA database. This will also delete all the active security threads.
Ruijie# **clear crypto sa peer** {*ip-address* | *peer-name*}	Clears the SAs with specific peer addresses.
Ruijie# **clear crypto sa map** *map-name*	Clears the SAs of a specific crypto map set.
Ruijie# **clear crypto sa spi** *destionation-address* {ah | esp} *spi*	Clears the SAs with the specified destination address, protocol, or SPI.

To view configuration information of IPSec, run the following command in normal user mode:

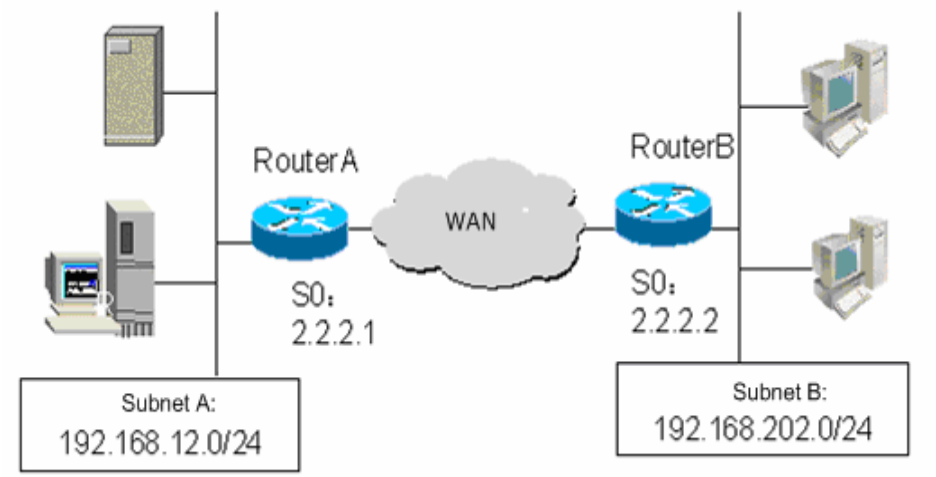
Command	Function
Ruijie# **show crypto ipsec transform-set**	Views configuration of a transform set.
Ruijie# **show crypto map** [*map-name*]	Views configuration of all or the specified crypto maps.
Ruijie# **show crypto ipsec sa**	Views information about the IPSec SA.
Ruijie# **show crypto dynamic-map** [*tag map-name*]	Views information about the dynamic crypto map.
Ruijie# **debug crypto ipsec**	Displays debug messages about the IPSec event.

IPSec Configuration Example

Configuration requirements

As shown in Figure 7, in order to protect the IP traffic from Subnet A (192.168.12.0/24) to Subnet B (192.168.202.0/24), use the Ethernet interface (192.168.12.1) of Router A and the Ethernet interface (192.168.202.1) of Router B as the security gateways at both ends, using the channel mode and the protection mode ESP-DES-SHA (the encryption and authentication services are available).

Figure 7 IPSec configuration example



Router configuration

In order to protect the IP traffic between hosts in two subnets, you can use the manually established SA or the IKE-established SA. Because Router A and Router B have similar configurations, the following only shows the configuration of the manually established SA for Router A. For the configuration of the IKE-established SA, refer to the typical case in the "IKE Configuration Guide" chapter .

Configuration of Router A:

Use an access list to define the traffic to be protected

```
access-list 101 permit ip 192.168.12.0 0.0.0.255 192.168.202.0 0.0.0.255
```

Define a transform set:

```
crypto ipsec transform-set myset esp-des esp-sha-hmac
```

The crypto map associates the IPSec access list with the transform set, and specifies the destination of the protected traffic

```
crypto map mymap 10 ipsec-manual
    match address 101
    set transform-set myset
    set session-key inbound esp 301 cipher 0123456789abcdef authenticator
00001111222233334444555566667777788889999
set session-key outbound esp 300 cipher 0123456789abcdef authenticator
55556666777788889999000011112222333344444
    set peer 2.2.2.2
!
interface Fastethernet 0
  ip address 192.168.12.1 255.255.255.0
```

Apply the crypto map to the interface

```
interface Serial 0
ip address 2.2.2.1
crypto map mymap
!
```

```
ip route 0.0.0.0 0.0.0.0 2.2.2.2
```

IKE Configuration

IKE Working Process

IKE is a key management protocol standard that is used with the IPSec standard. IPSec is an IP security function that provides robust authentication and IP packet encryption. IPSec can be configured without using IKE. However, IKE enhances the IPSec function by providing additional functions and flexibility and making it easier to configure the IPSec standard. IKE is a hybrid protocol that implements the Oakley key exchange and the Skeme key exchange (ISAKMP, Oakley and Skeme are security protocols implemented by IKE) within the Internet Security Association and Key Management Protocol (ISAKMP) framework.

IPSec must be configured (depending on IPSec of IKE) and applied to the interface before IKE can work. When an outgoing packet that meets requirements is detected on the interface, IPSec will trigger IKE to negotiate with the peer IKE. They establish a secure channel between the peers to transmit various supported IPSec parameters. Finally, a consistent SA is established at both ends to enable IPSec at both ends to work. If there are data that meets requirements to be transmitted when the lifetime of the IPSec SA expires over time, IKEs at both ends will start to negotiate IPSec again, and so on.

IKE can be used to eliminate the need to manually specify all the IPSec parameters and keys in the crypto map tables for the two parties in communication. It allows you to specify the lifetime of the IPSec SA. IKE makes IPSec change the key regularly and thus strengthen the security. IKE enables IPSec to provide the anti-replay service.

IKE Configuration Task

IKE configuration tasks including:

Enabling or Disabling IKE: make sure IKE is working.

Ensuring Compatibility between Access List and IKE: if an access list (firewall) is configured on the device, you must make sure that the UDP packets of IKE are not prohibited.

Creating IKE Policies: specify parameters in each IKE policy.

Selecting Working Mode: There are two working modes-main mode (default) and aggressive mode. (note: aggressive mode is also called violent mode).

Configuring Local Identity: specifiy local indeidentity for IKE negotiation.

Setting Automatic Mode Recognition: specify whether the IKE negotiation responder automatically accept the negotiation in aggressive mode.

Configuring Digital Certificate: a digital certificate for IKE authentication.

Configuring Pre-shared Key: the pre-shared key is shared by the two peers participating in IKE negotiation.

Configuring DPD Detection: two mechanisms are used to implement DPD-- on-demand and periodic.

Configuring NAT Traversal Timeout: the UDC header is added to solve the NAT traversal problem. Use the keepalive packets to maintain the UDP linkage and to avoid the NAT connection timeout.

Exlude Ruijie vendor information: Ruijie vendor information is often delivered during IKE negotiation. If incompatibility is found in vendor informationIKE Session limit, exlude Ruijie vendor information

IKE SESSION LIMIT: set a limit on the number of IKE sessions. .

Ruijie Networks' IKE session mode: except for Digital signature authentication, switch all IKE negotiation within the network to Ruijie Networks' IKE session mode.

Extended Authentication Timeout: configure extended authentication timeout,

Configure domain authentication: confgure extended domain authentication to associate IPSEC tunnel with VRF.

Configure cisco's compatible extended authentication: configure this command on devices that negotiate with cisco's devices.

Exclude designated IP addresses from extended Digital signature authentication.

IKE Maintenance (optional): maintain IKE, make sure IKE is working, chech parameters.

Enabling or Disabling IKE

IKE is enabled by default. If you do not want to use IKE with IPSec together, you can disable it with a command. However, only the manual IPSec SA can work.

To disable or enable IKE, run the following command in global configuration mode:

Command	Function
Ruijie(config)# **no crypto isakmp enable**	Disables the IKE function.
Ruijie(config)# **crypto isakmp enable**	Enables the IKE function.

If IKE is disabled, subsequent configuration will not take effect.

Caution

Disabling IKE will result in:

- During IPSec communication, the encryption key never changes, and you need to modify your key regularly.
- The anti-replay service is unavailable.
- You must establish all the SAs manually.

Ensuring Compatibility between Access List and IKE

IKE is an application running on the basis of UDP that transmits packets in the UDP format through port 500. If an access list (firewall) is configured on the device, and UDP packets are prohibited, IKE negotiation will fail. Therefore, you must make sure that the UDP packets of IKE are not prohibited.

Creating IKE Policies

Both parties participating in IKE negotiation must have at least one set of consistent IKE policies. This is mandatory for successful IKE negotiation. You must create multiple policies with priorities on each peer, so as to make sure at least one policy matches the policy of the remote peer.

Define the following five parameters in each IKE policy:

Parameter	Keyword	Value Range	Default Value
Encryption algorithm	Des	56-bit DES-CBC	56-bit DES-CBC
	3des	168-bit DES-CBC	
	aes	128-bit AES-CBC	
HASH algorithm	Sha	SHA-1 (HMAC variant)	SHA-1 (HMAC variant)
	md5	MD5 (HMAC variant)	
Authentication method	pre-share	Pre-shared key	Digital signature authentication
	rsa-sig	Digital signature authentication	
	digital-email	Digital envelope authentication	
Diffie-Hellman group ID	1	768-bit Diffie-Hellman group	768-bit Diffie-Hellman group
	2	1024-bit Diffie-Hellman group	
	5	3072-bit Diffie-Hellman group	
	14	2048-bit Diffie-Hellman group	
	15	3072-bit Diffie-Hellman group	
	16	4096-bit Diffie-Hellman group	
	17	6144-bit Diffie-Hellman group	
	18	8192-bit Diffie-Hellman group	
Lifetime of IKE SA	Void	1 minute to 1 day (in seconds)	1 day (86400 seconds)

When IKE negotiation starts, IKE tries to find a consistent policy on the two peers. The initiator of negotiation sends all the policies to the remote responder. The responder searches, by priority, the policies that match with the local policies in the policies received from the remote peer.

If both peers participating in negotiation have the same encryption, HASH, authentication and Diffie-Hellman parameters, and the lifetime specified by the policy of the remote peer is smaller than or equal to the lifetime specified by the compared policy, then they match (if no lifetime is specified, the shorter lifetime specified by the policy of the remote peer is used). If no acceptable matching policy is found, IKE refuses to negotiate and IPSec is not established. If a matching policy is found, IKE negotiates and establishes the IPSec SA.

You can select a value of each parameter by making a tradeoff between security and performance:

- Encryption algorithms: At present, 56-bit DES-CBC, 168-bit 3DES-CBC, and 128-bit AES-CBC are supported.
- Hash algorithms: SHA-1 and MD5. MD5 has less digest and is often considered a little faster than SHA-1. Attacks on MD5 are proved to be successful in one way, but extremely difficult. However, the HMAC variant (MD5) used by IKE can block this attack.

- Authentication method: Currently RGOS supports pre-shared key method and digital certificate authentication. To authenticate with the pre-shared key method, you need to configure a correct pre-shared key. To authenticate using a digital certificate, you need to configure a correct certificate for both parties (refer to the section regarding certificate configuration).
- There are two options for the Diffie-Hellman group ID: 768-bit or 1024-bit Diffie-Hellman. 1024-bit Diffie-Hellman is more difficult to crack, but occupies more CPU resources.
- The lifetime of the IKE SA, different from that of the IPSec SA, refers to the validity period of IKE negotiation. It can be set to any value. The following is a general rule: The shorter the lifetime (to a critical point), the securer the IKE negotiation is. If a longer lifetime is used, however, negotiation of IPSec SA will be faster.

You can create multiple IKE policies, each of which corresponds to a different combination of parameters. A unique priority (1-10000, where 1 represents the highest priority) should be assigned to each created policy.

You can configure multiple policies on each peer. However, you must make sure that one of these policies has exactly the same encryption, HASH, authentication and Diffie-Hellman parameters as the remote peer (they can have different lifetimes). If no policy is configured, the device uses the default policy, which is set to have the lowest priority and includes the default value of each parameter.

To configure a policy, run the following commands in global configuration mode in the beginning:

Command	Function
Ruijie(config)# **crypto isakmp policy priority**	Identifies the policy to be created. Each policy is uniquely identified by the priority.
Ruijie(config-isakmp)# **encryption des | 3des | aes-128 | aes-192 | aes-256**	Specifies an encryption algorithm.
Ruijie(config-isakmp)# **hash {sha | md5}**	Specifies a HASH algorithm.
Ruijie(config-isakmp)# **authentication {pre-share | rsa-sig }**	Specifies an authentication method.
Ruijie(config-isakmp)# **group {1 | 2| 5}**	Specifies a Diffie-Hellman group ID.
Ruijie(config-isakmp)# **lifetime** *seconds*	Specifies the lifetime of IKE SA.
Ruijie(config-isakmp)# **exit**	Returns to global configuration mode.

If no value is specified for parameters, the default values are used.

To view the configured IKE policy, run the following command in privileged user mode:

Command	Function
Ruijie**# show crypto isakmp policy**	Shows all the existing IKE policies.

Note The configuration does not include the default policy and the default values of configured policies. To view these settings, use the **show crypto isakmp policy** command.

Selecting Working Mode

There are two working modes: main mode (default) and aggressive mode.

A working mode should be configured for the initiator. To do so, run the following commands at the crypto map entry where IKE is configured to establish a SA:

Command	Function
Ruijie(config)# **crypto map** *map-name seq-num* **ipsec-isakmp**	Specifies the crypto map entry to be created or modified. When using this command, you will enter crypto map configuration mode.
Ruijie(config-crypto-map)# **set exchange-mode {main | aggressive}**	Selects a working mode of IKE negotiation. The main mode is used by default.

By default, the responder negotiates in main mode. To use the aggressive mode, run the following command in global configuration mode.

Command	Function
Ruijie(config)**# crypto ipsec-isakmp mode-detect**	Negotiates in the mode used by the initiator.

To view the working mode of IKE, run the following command in privileged user mode:

Command	Function
Ruijie**# show crypto isakmp sa**	Browses all the current IKE SAs.

Configuring Local Identity

When selecting a working mode, you set the mode (main or aggressive mode) in which the initiator initiates the first negotiation message. If the main mode is selected, this configuration will not affect negotiation. If the aggressive mode is selected, this configuration specifies the identity type in the first negotiation message of the initiator, which directly affects negotiation in aggressive mode. Currently, you can set three forms: 1. Local address; 2. Domain name; 3. User name@domain name. You can set as necessary.

Command	Function
Ruijie(config)# **self-identity address** | **fqdn** | **user-fqdn** *identity* | dn	Specifies the form of the negotiation identity in aggressive mode. Address: The primary IP address of the local interface through which negotiation is initiated. Fqdn: Specifies the domain name form for the local identity. User-fqdn: Specifies the user name@domain name form for the local identity. Dn: DN value of the certificate

Setting Automatic Mode Recognition

The device, as the center, needs to accept dial-in in multiple modes (main mode and aggressive mode). The device needs to respond to the two different types of initiation and negotiate. Therefore, this command is mainly used in this working environment. Configuration of this command for the initiator has no influence.

Command	Function

Ruijie(config)**# crypto isakmp mode-detect**	Specifies that the responder negotiates by using automatic recognition.

Configuring Digital Certificate

By default, IKE authenticates by using a digital certificate. A digital certificate must be configured if this method is used. Refer to the "Digital Certificate Configuration" chapter.

Configuring Pre-shared Key

The pre-shared key is shared by the two peers participating in IKE negotiation. Therefore, each pre-shared key corresponds to a pair of IKE peers. On a given peer, you should specify a key that is the same as those of multiple pre-shared remote peers. For the purpose of security, you should configure different keys for different peer pairs.

To configure a pre-shared key, run the following commands in global configuration mode:

Command	Function
Router(config)**# ip host** *hostname address*	If hostname is used to identify the remote peer, specify the IP address corresponding to this hostname.
Ruijie(config)**# crypto isakmp key 0|7** *keystring* { **hostname** *peer-hostname* | **address** *peer-address* } [**no-xauth**]	Specifies a pre-shared key that is used with the remote IKE peer. Number 0 indicates the plain text is used. Number 7 indicates the cipher text is used.
Router(config)**# crypto isakmp key 0|7** *keystring* **address** *peer-address* [*mask*] [**no-xauth**]	Specifies a pre-shared key used for the IKE peer of a certain network segment. Both *peer-address* and *mask* are 0.0.0.0. 0.0.0.0 is the default pre-shared key.

You must configure the same pre-shared key on each pair of peers.

Note

1. Like Cisco devices, versions later than RGOS 8.31 use the digital signature authentication in the IKE policy by default. If the pre-shared key is needed, IKE policy configuration must be added. See the following example:

```
crypto isakmp policy 1
 authentication pre-share
!
```

Earlier versions of RGOS only support authentication using the pre-shared key.

2. If the hostname of a remote IKE negotiation peer has been registered on DNS, the second step mentioned above can be omitted.

3. On Cisco devices, if the peer uses the hostname to identify the pre-shared key, the initiator will initiate negotiation in aggressive mode.

4. After the extended authentication command **crypto map** *map-name* **client authentication list** *aaa-name*

is configured, use the command **no-xauth** to disable the extended authentication for devices with designated address.

Configuring DPD Detection

Currently, two mechanisms are used to implement DPD: 1. on-demand. This mechanism sends packets when a tunnel is idle in a time longer than what is configured. This will trigger sending of a DPD message. 2. periodic. This mechanism actively sends a DPD message when the idle time of the tunnel exceeds the configured time. The maximum number of retransmission times is 5. (For DPD configuration in earlier versions, refer to the version 8.2 configuration guide)

To configure DPD detection, run the the following commands:

Command	Function
Router(config)# **crypto isakmp keepalive** *seconds*	seconds - Idle time of the tunnel The default retransmission interval is 5 seconds, and the on-demand mechanism is used
Router(config)# **crypto isakmp keepalive** *seconds retries*	seconds - Idle time of the tunnel retries – Retransmission interval The on-demand mechanism is used by default.
Router(config)# **crypto isakmp keepalive** *seconds retries* **on-demand**	seconds - Idle time of the tunnel retries - Retransmission interval on-demand - The on-demand mechanism
Router(config)# **crypto isakmp keepalive** *seconds* **periodic**	seconds - Idle time of the tunnel periodic - periodic mechanism The default Retransmission interval is 5 seconds.
Router(config)# **crypto isakmp keepalive** *seconds retries* **periodic**	seconds - Idle time of the tunnel retries - Retransmission interval periodic - periodic mechanism

Configuring NAT Traversal Timeout

As the RFC3947 and IPSEC NAT-t are supported, the UDC header is added to solve the NAT traversal problem. To avoid the NAT connection timeout, the keepalive mode shall be used to send packets. The default time is 5 minutes.

Command	Function
Router(config)# **crypto isakmp nat keepalive** *seconds*	Seconds: the interval of sending the packets in keepalive mode. The default interval is 5 minutes.

Excluding Ruijie Vendor Information

Ruijie vendor information is often delivered during IKE negotiation. If incompatibility is found in vendor information, run the following command:

Command	Function
Router(config)# **crypto isakmp vendorid disable**	Excludes the vendor id information.

Configuring IKE Session Limit

To set a limit on the number of IKE sessions, run the following command:

Command	Function
Router(config)# **crypto isakmp session limit number**	Sets a limit on the number of IKE sessions.

Configuring Ruijie IKE Negotiation Mode

To switch all IKE negotiation (except for Digital signature authentication) within the network to Ruijie Networks' IKE session mode, run the following command:

Command	Function
Router(config)# **crypto isakmp rg-sm1**	Switches all IKE negotiation (except for Digital signature authentication) within the network to Ruijie Networks' IKE session mode

Configuring Extended Authentication Timeout

To configure extended authentication timeout, run the following command:

Command	Function
Router(config)# **crypto isakmp xauth timeout** *seconds*	Configures the timeout time of extended authentication, with the value ranging from 5 to 90 seconds.

Configuring AAA Server Response Timeout

To configure AAA server response timeout, run the following command:

Command	Function
Router(config)# **crypto isakmp xauth timeout** *seconds*	Configures the timeout time of waiting AAA server response, with the value ranging from 5 to 10000 seconds.

Configuring Client Policy Delivery

When both Key ID authentication and extended authentication are used on a client, run the following commands in configuration mode to configure client policy delivery:

Command	Function
Ruijie(config)# **crypto isakmp client configuration group** name	Creates or modifies a client configuration delivery entry. When using this command, you will enter client policy delivery configuration mode.
Router(config-isakmp-group)# **key 0|7** *keystring*	Configures the shared key used for Key ID authentication. This configuration takes effect only in aggressive mode.

Router(config-isakmp-group)# **dns** pri-dns sec-dns	Configures the DNS from which a policy is delivered to a client.
Router(config-isakmp-group)# **netmask** mask	Configures the subnet mask from which a policy is delivered to a client.
Router(config-isakmp-group)# **pool** pool-name	Configures the address pool from which an IP address is selected for delivering a policy to a client.
Router(config-isakmp-group)# **network center** *net-addr/prefix*	(optional) open for the networks under the client's server. Only tht packeks forwarding to these networks can pass over the IPSec tunnel. Currently, the maximum unmber of these nuetworks is 5.

Configuring domain authentication

To enable domain authentication:

Command	Function
Router(config)# **crypto isakmp authorize** [**split**]	enables domain authentication:

To configure domain-delimiter:

Command	Function
Router(config)# **crypto isakmp domain-delimiter** *keyword* [**prefix| suffix**]	Specifies domain-delimiter； by default, the **suffix** is domain.

To specify domain-name ,

Command	Function
Router(config-isakmp-group)# **domain** *domain-name* [**vrf**] *vrf-name*	Specifies the domain-name and associates domain-name with vrf-name

Configuring cisco's compatible extended authentication:

To adopt cisco's compatible extended authentication for IKE negotiation. Run the following commands in configuration mode:

Command	Function
Router(config)# **crypto isakmp xauth cisco_comp**	Adopts Cisco's compatible extended authentication.

Note After configured the command **crypto map** *map-name* **client authentication list** *aaa-name* on a crypto map, all clients need to be authenticated. However, some client with designated IP address do not need extended authentication. To exclude these designated IP addresses from extended Digital Signature Authentication, run the commend mentioned in the above table.

Configuring IP address pool

Use the following commands to issue an IP address for a XAUTH client:

Command	Function
Router(config)# **crypto isakmp ippool** *pool-name*	Creates an address pool
Ruijie(config-isakmp-ippool)#**address** *low-ip high-ip*	Configures the range of the IP address pool.

TRACK Correlation

In a scenario where there is a backup linkage or multiple linkage, the IPSec is used to monitor the status of primary linkage. When the primary linkage is up, the IPSec channel in the backup linkage will be removed so as to clear the reverse routing. And then the normal data forwarding is guranteed.Currently, TRACK and DLDP are used to monitor primary linkage. Refer to the corresponding files for the configuration of TRACK and DLDP.

Command	Function
Ruijie(config)#**crypto isakmp link-redundency backup** *backup_interface* **track** *track_id*	Monitors *track id* via the TRACK protocol. The *backup_interface* will be removed after *track id* is up.
Ruijie(config)#**crypto isakmp link-redundency backup** *backup_interface* **dldp** *master_interface*	Monitors *master_interface* via the TRACK protocol. The *backup_interface* will be removed after the primary linkage is up.

IKE Maintenance

Clear an IKE connection

To clear an IKE connection, run the following commands in privileged user mode:

Command	Function
Ruijie# **show crypto isakmp sa**	Shows the existing IKE connections, and note down the connection ID of the connection you want to clear.
Ruijie# **clear crypto isakmp** [*connection-id*]	Clears an IKE connection. When connection-id is not used, all IKE connections are cleared.
Directly execute: Ruijie# **clear crypto isakmp**	Clears all the local IKE connections.

IKE diagnosis

To obtain the IKE diagnostics information, run the following commands in privileged user mode:

Command	Function
Ruijie# **show crypto isakmp policy**	Shows all the IKE policy parameters.
Ruijie# **show crypto isakmp sa**	Shows all the current IKE SAs.
	Shows IKE address pool
Ruijie# **debug crypto isakmp**	Shows debug messages about the IKE event.
	Shows debug message about the IKE address pool event.

IKE Configuration Example

The following shows an IKE configuration example:

```
crypto isakmp enable
crypto isakmp policy 4
    group 1
    encryption 3des
crypto isakmp policy 5
   authen pre-share
   group 2
   lifetime 1000
crypto isakmp policy 6
   authen rsa-sig
   group 1
   lifetime 1000
For details, run the following command in privileged user mode:
Ruijie # show crypto isakmp policy
Protection suite of priority 4
encryption algorithm:  3DES - Data Encryption Standard (56 bit keys).
   hash algorithm:        Secure Hash Standard
   authentication method: Rsa-Sig
   Diffie-Hellman group:  #1 (1024 bit)
   lifetime:              1000 seconds
Protection suite of priority 5
   encryption algorithm:  DES - Data Encryption Standard (56 bit keys).
   hash algorithm:        Secure Hash Standard
   authentication method: Pre-shared key
   Diffie-Hellman group:  #2 (1024 bit)
   lifetime:              1000 seconds
Protection suite of priority 6
   encryption algorithm:  DES - Data Encryption Standard (56 bit keys).
   hash algorithm:        Secure Hash Standard
   authentication method: Rsa-Sig
   Diffie-Hellman group:  #1 (768 bit)
   lifetime:              1000 seconds
Default protection suite
   encryption algorithm:  DES - Data Encryption Standard (56 bit keys).
   hash algorithm:        Secure Hash Standard
   authentication method: Rsa-Sig
   Diffie-Hellman group:  #1 (768 bit)
   lifetime:              86400 seconds
```

Typical Application Cases

Statically Configuring Tunnels

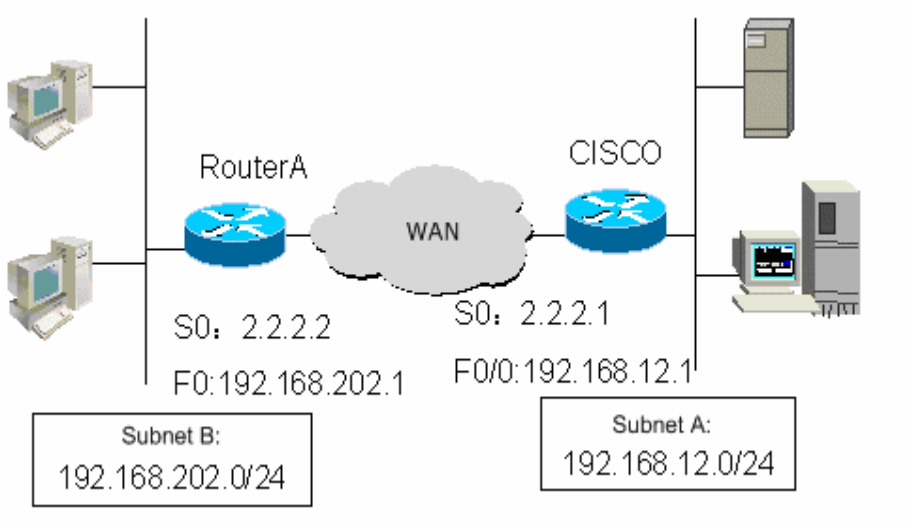
Analysis

In this case, the IP traffic between two subnets is protected by using a Cisco device connected to Subnet A as the gateway at one side, and using a Ruijie device connected to Subnet B as the gateway at the other side. The following requirements should be met:

- The 3DES algorithm is used in phase 1.
- The tunnel mode is used.
- The protection method is ESP-DES-MD5 (the encryption and authentication services are available).

In the following application, a Cisco device is used as the center, and Ruijie devices are used as remote branches. See Figure 8:

Figure 8 Typical IPSec application



Router configuration

This section describes how to manually establish a SA and establish a SA using IKE for Ruijie router, namely Router A. Meanwhile, it also provides configurations of Cisco devices for your reference in actual work.

8) Configuration for establishing a SA using IKE

Configuration of Router A:

```
!
hostname "RouterA"
```

Enable IKE

```
crypto isakmp enable
crypto isakmp policy 1
authentication pre-share
encryption 3des
!
```

Configure a pre-shared key and a transform set

```
crypto isakmp key 0 preword address 2.2.2.1
crypto ipsec transform-set myset  esp-des esp-md5-hmac
```

Define a crypto map set

```
crypto map mymap 5 ipsec-isakmp
 set peer 2.2.2.1
 set transform-set myset
 match address 101
!
interface FastEthernet0
 ip address 192.168.202.1 255.255.255.0
```

Apply the crypto map to the interface

```
interface Serial0
 ip address 2.2.2.2 255.255.255.0
 encapsulation ppp
 crypto map mymap
!
ip route 0.0.0.0 0.0.0.0 Serial0
```

Define an encryption access list to protect the IP traffic between the subnet 192.168.202.0/24 and the subnet 192.168.12.0/24

```
access-list 101 permit ip 192.168.202.0 0.0.0.255 192.168.12.0 0.0.0.255
!
end
```

Configuration of Cisco device:

```
!
hostname Cisco
```

Define an IKE policy, using the pre-shared key for authentication, and using the default values for other parameters

```
crypto isakmp policy 1
 authentication pre-share
encryption 3des
```

Configure a pre-shared key

```
crypto isakmp key 0 preword address 2.2.2.2
```

Define a transform set

```
crypto ipsec transform-set myset esp-des esp-md5-hmac
```

Define a crypto map

```
crypto map mymap 5 ipsec-isakmp
 set peer 2.2.2.2
```

```
 set transform-set myset
 match address 101
!
interface FastEthernet0/0
 ip address 192.168.12.1 255.255.255.0
```

Apply the crypto map to the interface

```
interface Serial0
 ip address 2.2.2.1 255.255.255.0
 encapsulation ppp
 crypto map mymap
!
ip route 192.168.202.0 255.255.255.0 Serial0
```

Define an encryption access list to protect the IP traffic between the subnet 192.168.12.0/24 and the subnet 192.168.202.0/24

```
access-list 101 permit ip 192.168.12.0 0.0.0.255 192.168.202.0 0.0.0.255
!
end
```

Configuration for establishing a SA manually

Configuration of Router A:

```
!
hostname "RouterA"
```

Define a transform set

```
crypto ipsec transform-set myset  esp-des esp-md5-hmac
```

Define a crypto map set

```
crypto map mymap 5 ipsec-manual
 set peer 2.2.2.1
 set session-key inbound esp 300 cipher abcdef1234567890
 authenticator abcdef1234567890abcdef1234567890  //This is the same configuration statement
as the previous line
 set session-key outbound esp 301 cipher abcdef1234567890
 authenticator abcdef1234567890abcdef1234567890  //This is the same configuration statement
as the previous line
 set transform-set myset
 match address 101
!
interface FastEthernet0
 ip address 192.168.202.1 255.255.255.0
```

Apply the crypto map to the interface

```
interface Serial0
 ip address 2.2.2.2 255.255.255.0
 encapsulation ppp
 crypto map mymap
!
ip route 0.0.0.0 0.0.0.0 Serial0
```

Define an encryption access list to protect the IP traffic between the subnet 192.168.202.0/24 and the subnet 192.168.12.0/24

```
access-list 101 permit ip 192.168.202.0 0.0.0.255 192.168.12.0 0.0.0.255
!
end
```

Configuration of Cisco device:

```
!
hostname Cisco
```

Define a transform set

```
crypto ipsec transform-set myset esp-des esp-md5-hmac
```

Define a crypto map

```
crypto map mymap 5 ipsec-manual
 set peer 2.2.2.2
 set session-key inbound esp 301 cipher abcdef1234567890
 authenticator abcdef1234567890abcdef1234567890  //This is the same configuration statement
as the previous line
 set session-key outbound esp 300 cipher abcdef1234567890
 authenticator abcdef1234567890abcdef1234567890  //This is the same configuration statement
as the previous line
 set transform-set myset
 match address 101
!
interface FastEthernet0/0
 ip address 192.168.12.1 255.255.255.0
# Apply the crypto map to the interface
interface Serial0
 ip address 2.2.2.1 255.255.255.0
 encapsulation ppp
 crypto map mymap
!
ip route 192.168.202.0 255.255.255.0 Serial0
```

Define an encryption access list to protect the IP traffic between the subnet 192.168.12.0/24 and the subnet 192.168.202.0/24

```
access-list 101 permit ip 192.168.12.0 0.0.0.255 192.168.202.0 0.0.0.255
```

```
!
end
```

Monitoring and debugging

9) Monitoring and debugging the IKE-based SA

On any host in Subnet B, send a packet to Subnet A. IKE negotiation is triggered and finally an IPSec SA is established successfully.

Turn on the debugging switches of IKE and IPSec:

```
RouterA# debug  crypto ipsec
IPSEC debugging is on
RouterA# debug  crypto isakmp
ISAKMP debugging is on
```

You can see the following debugging information during negotiation:

```
Get acquire: 192.168.202.0/0.0.0.255 -> 192.168.12.0/0.0.0.255 , prot 0, port 0/0
Acqurire negotiate with 2.2.2.1
(36) Beginning Quick Mode exchange, M-ID of 4445127
(36) sending packet to 2.2.2.1 (I) QM_SI1_WR1
ipsec_output:423, get item acclist 101
ipsec_output:429, match  3
(36) received packet from 2.2.2.1 (I) QM_SI1_WR1
payload format: <Hdr>,<hash> <sa> <nonce> <id>
(36) processing SA payload. message ID = 4445127
(36) Creating IPSec SAs.
    inbound SA has spi 4445127
    protocol esp, DES_CBC
    auth MD5
    outbound SA has spi 275385850
    protocol esp, DES_CBC
    auth MD5
    lifetime of 3600 seconds, soft 3570 seconds
    lifetime of 4608000 kilobytes, soft 256 kilobytes
ipsec_output:423, get item acclist 101
ipsec_output:429, match  3
(36) sending packet to 2.2.2.1 (I) QM_IDLE
(36) Phase_2 negotiate complete!
```

In order to view and confirm whether the SAs of IKE and IPSec have been established, use the following command:

```
RouterA# show crypto isakmp sa
destination    source         state                conn-id
lifetime(second)
 2.2.2.1       2.2.2.2        QM_IDLE               36
5013
```

The preceding information shows that an IKE SA has been established successfully

```
RouterA# show crypto ipsec sa
Interface: Serial0
Crypto map tag:mymap, local addr  2.2.2.2  //The current crypto map set is named mymap that
uses the local address 2.2.2.2
    media mtu 1500
    local  ident (addr/mask/prot/port): (192.168.202.0/0.0.0.255/0/0))
    remote  ident (addr/mask/prot/port): (192.168.12.0/0.0.0.255/0/0))
PERMIT                 //Protect the traffic between 192.168.202.0/24 and 192.168.12.0/24
current_peer: 2.2.2.1      //The address of the remote peer is 2.2.2.1
    #pkts encaps: 3, #pkts encrypt: 3, #pkts digest 3
    #pkts decaps: 3, #pkts decrypt: 3, #pkts verify 3
    #send errors 0, #recv errors 0
//Statistical data in turn: number of encapsulation packets, number of encryption packets,
number of digest packets, number of de-capsulation packets, number of decryption packets, number
of verification packets, send errors, and receive errors.
    inbound esp sas:                   //Security association for the inbound packet
processing, with the protocol ESP
            spi:0x43D3C7 (4445127)         //The SPI value is 4445127
        transform: esp-des esp-md5-hmac    //The transform set is esp-des-md5
            in use settings={Tunnel,}      //Tunnel mode
sa timing: remaining key lifetime (k/sec): (4607999/3578)
//There are 4607999 kbytes/3578 seconds left before expiry of the SA
            IV size: 8 bytes               //The IV vector length is 8
            Replay detection support:Y     //Anti-replay processing

    outbound esp sas:                      //Security association for the outbound packet
processing, with the protocol ESP
            spi:0x106A0DFA (275385850)     //The SPI value is 275385850
        transform: esp-des esp-md5-hmac    //The transform set is esp-des-md5
            in use settings={Tunnel,}      //Tunnel mode
sa timing: remaining key lifetime (k/sec): (4607999/3577)
//There are 4607999 kbytes/3577 seconds left before expiry of the SA
            IV size: 8 bytes               //The IV vector length is 8
            Replay detection support:Y     //Anti-replay processing
```

The preceding statistical data shows that IPSec has been established and some packets are protected.

Monitoring and debugging the manually established SA

Because the manually established SA exists from the beginning, you needn't negotiate it and cannot view its debugging information. You can only view some statistical data:

```
RouterA# show crypto ipsec sa
Interface: Serial0
```

```
Crypto map tag:mymap, local addr  2.2.2.2  //The current crypto map set is named mymap that
uses the local address 2.2.2.2
    media mtu 1500
    local  ident (addr/mask/prot/port): (192.168.202.0/0.0.0.255/0/0))
    remote  ident (addr/mask/prot/port): (192.168.12.0/0.0.0.255/0/0))
PERMIT                                //Protect the traffic between 192.168.202.0/24 and
192.168.12.0/24
current_peer: 2.2.2.1                    //The address of the remote peer is 2.2.2.1
    #pkts encaps: 8, #pkts encrypt: 8, #pkts digest 8
    #pkts decaps: 8, #pkts decrypt: 8, #pkts verify 8
    #send errors 0, #recv errors 0
//Statistical data in turn: number of encapsulation packets, number of encrypted packets, number
of digest packets, number of decapsulated packets, number of decryption packets, number of
verification packets, send errors, and receive errors.
inbound esp sas:                      //Security association for the inbound packet
processing, with the protocol ESP
spi: 0x12C (300)              //The SPI value is 300
transform: esp-des esp-md5-hmac    //The transform set is esp-des-md5
in use settings={Tunnel,}      //Tunnel mode
no sa timing                              //Expired
IV size: 8 bytes              //The IV vector length is 8
Replay detection support:N     //No anti-replay processing

outbound esp sas:                 //Security association for the outbound packet processing,
with the protocol ESP
spi: 0x12D (301)              //The SPI value is 301
transform: esp-des esp-md5-hmac    //The transform set is esp-des-md5
in use settings={Tunnel,}      //Tunnel mode
no sa timing                              //Expired
IV size: 8 bytes           //The IV vector length is 8
Replay detection support:N      //No anti-replay processing
```

The preceding statistical data shows that IPSec has been established and some packets are protected.

Dynamically Configuring Tunnels

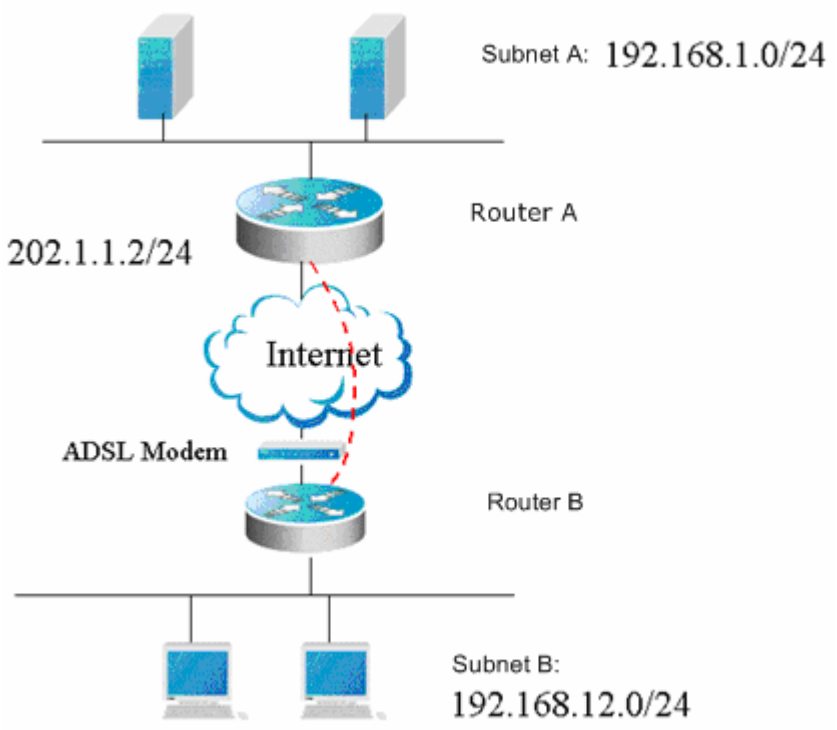
Case analysis

In this case, the IP traffic between two subnets is protected by using Ruijie Router A connected to Subnet A as the gateway at one side, and using Ruijie Router B connected to Subnet B as the branch gateway at the other side, as shown in Figure-4. The following requirements should be met:

- The tunnel mode is used.
- The protection method is ESP-DES-MD5 (the encryption and authentication services are available).
- The IP address of the WAN interface of Router A is fixed: 202.1.1.2/24. The router is connected to the Internet through a dedicated line.

- Router B is connected to the Internet through ADSL using the PPPOE protocol. Its IP address is allocated by the ISP dynamically.
- Use IKE to establish the SA.
- Use the pre-shared key.

Figure 9 IPSec typical case



Router configuration

This section provides configuration for establishing a SA between Ruijie routers, namely Router B and Router A.

Configuration of Router B:

```
!
hostname "RouterB"
```

Enable IKE

```
crypto isakmp enable
```

Configure a pre-shared key and a transform set

```
crypto isakmp policy 1
 authentication pre-share
crypto isakmp key 0 preword address 202.1.1.2
crypto ipsec transform-set myset  esp-des esp-md5-hmac
```

Define a crypto map set

```
crypto map mymap 5 ipsec-isakmp
 set peer 202.1.1.2
 set transform-set myset
```

```
 match address 101
!
interface FastEthernet0
 ip address 192.168.12.1 255.255.255.0
interface FastEthernet1
 no ip addrsss
 pppoe enable
 pppoe-client 1 dial-pool-number 1 dial-on-demand
```

Apply the crypto map to the interface

```
interface Dialer0
  mtu 1488
ip address negotiate
  encapsulation ppp
  ppp pap sent-username xxx password xxx
  crypto map mymap
dialer idle-timeout 2400
  dialer pool 1
  dialer-group 1
!
dialer-list protocol ip permit
ip route 0.0.0.0 0.0.0.0 Dialer0 permanent
```

Define an encryption access list to protect the IP traffic between the subnet 192.168.12.0/24 and the subnet 192.168.1.0/24

```
access-list 101 permit ip 192.168.12.0 0.0.0.255 192.168.1.0 0.0.0.255
!
end
```

Configuration of Router A:

```
!
hostname “RouterA”
```

Define an IKE policy, using the pre-shared key for authentication, and using the default values for other parameters

```
crypto isakmp policy 1
 authentication pre-share
```

Configure the default pre-shared key. Because the IP address of the remote end is dynamic, you couldn't know in advance it is necessary to configure the default pre-shared key

```
crypto isakmp key 0 preword address 0.0.0.0 0.0.0.0
```

Define a transform set

```
crypto ipsec transform-set myset esp-des esp-md5-hmac
```

Define a dynamic crypto map

```
crypto dynamic-map dymymap 5
 set transform-set myset
 match address 101
!
```

Add a dynamic crypto map set to a static crypto map set

```
crypto map mymap 10 ipsec-isakmp dynamic  dymymap
!
interface FastEthernet0/0
 ip address 192.168.1.1 255.255.255.0
```

Apply the crypto map to the interface

```
interface Serial0
 ip address 202.1.1.2 255.255.255.0
 encapsulation ppp
 crypto map mymap
!
ip route 0.0.0.0 0.0.0.0  Serial0
```

Define an encryption access list to protect the IP traffic between the subnet 192.168.1.0/24 and the subnet 192.168.12.0/24

```
access-list 101 permit ip 192.168.1.0 0.0.0.255 192.168.12.0 0.0.0.255
!
end
```

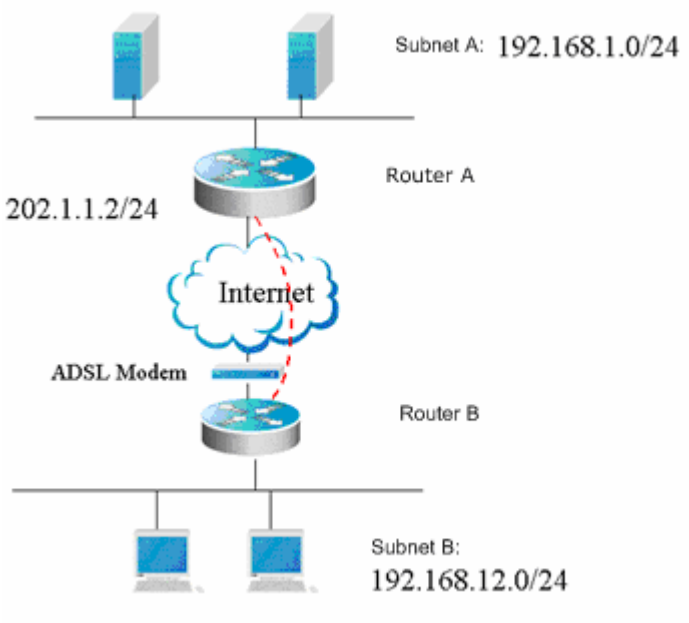
Initiating Negotiation with the Domain Name

Case analysis

In this case, the IP traffic between two subnets is protected by using Ruijie Router A connected to Subnet A as the gateway at one side, and using Ruijie Router B connected to Subnet B as the branch gateway at the other side. The following requirements should be met:

- The tunnel mode is used.
- The protection method is ESP-DES-MD5 (the encryption and authentication services are available).
- The IP address of the WAN interface of Router A is always 202.1.1.2/24. The router is connected to the Internet through a dedicated line.
- Router B is connected to the Internet through ADSL using the PPPOE protocol. Its IP address is allocated by ISP dynamically.
- Use the pre-shared key, and specify the pre-shared key for the central router using the host name.
- Use IKE to establish the SA.

Figure 10



Router configuration

This section describes how to establish a SA between Ruijie routers, namely Router B and Router A.

Configuration of Router B:

```
!
hostname "RouterB"
```

Enable IKE

```
crypto isakmp enable
```

Configure the local identity

```
self-identity fqdn www.google.com
```

Configure a pre-shared key and a transform set

```
crypto isakmp key 0 preword address 202.1.1.2
crypto ipsec transform-set myset  esp-des esp-md5-hmac
```

Define a crypto map set

```
crypto map mymap 5 ipsec-isakmp
 set peer 202.1.1.2
 set exchange-mode aggressive
 set transform-set myset
 match address 101
!
interface FastEthernet0
 ip address 192.168.12.1 255.255.255.0
interface FastEthernet1
 no ip addrsss
```

```
 pppoe enable
 pppoe-client 1 dial-pool-number 1 dial-on-demand
```

Apply the crypto map to the interface

```
interface Dialer0
  mtu 1488
ip address negotiate
  encapsulation ppp
  ppp pap sent-username xxx password xxx
  crypto map mymap
dialer idle-timeout 2400
  dialer pool 1
  dialer-group 1
!
dialer-list protocol ip permit
ip route 0.0.0.0 0.0.0.0 Dialer0 permanent
```

Define an encryption access list to protect the IP traffic between the subnet 192.168.12.0/24 and the subnet 192.168.1.0/24

```
access-list 101 permit ip 192.168.12.0 0.0.0.255 192.168.1.0 0.0.0.255
!
end
```

Configuration of Router A:

```
!
hostname “RouterA”
```

Define an IKE policy, using the pre-shared key for authentication, and using the default values for other parameters

```
crypto isakmp policy 1
 authentication pre-share
```

Configure a default pre-shared key. Because the IP address of the remote end is dynamic, the pre-shared key is found by specifying the hostname

```
crypto isakmp key 0 preword hostname www.google.com
```

Configure automatic recognition for the center

```
crypto isakmp mode-detect
```

Define a transform set

```
crypto ipsec transform-set myset esp-des esp-md5-hmac
```

Define a dynamic crypto map

```
crypto dynamic-map dymymap 5
 set transform-set myset
```

```
 match address 101
!
```

Add a dynamic crypto map set to a static crypto map set

```
crypto map mymap 10 ipsec-isakmp dynamic  dymymap
!
interface FastEthernet0/0
 ip address 192.168.1.1 255.255.255.0
```

Apply the crypto map to the interface

```
interface Serial0
 ip address 202.1.1.2 255.255.255.0
 encapsulation ppp
 crypto map mymap
!
ip route 0.0.0.0 0.0.0.0  Serial0
```

Define an encryption access list to protect the IP traffic between the subnet 192.168.1.0/24 and the subnet 192.168.12.0/24

```
access-list 101 permit ip 192.168.1.0 0.0.0.255 192.168.12.0 0.0.0.255
!
End
```

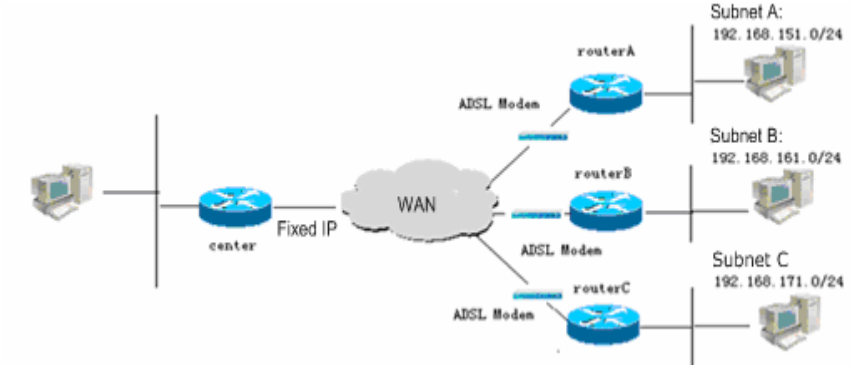
Dynamically Configuring to Use Certificate Negotiation

Case analysis

Configure a dynamic crypto map set for the center. The IKE negotiation policy uses the digital signature for authentication. The branch is connected to the center through L2TP. L2TP will trigger IKE negotiation. The IPSec tunnel must be established successfully before the L2TP tunnel can be established. L2TP is used to run OSPF, so that both the center and the branch can learn their own subnet routes. The following requirements should be met:

- The tunnel mode is used.
- The protection method is ESP-DES (the encryption service is available).
- The IP address of the WAN interface of the center is always 63.23.12.212/29. The center is connected to the Internet through a dedicated line.
- The branch router is connected to the Internet through ADSL using the PPPOE protocol. Its IP address is allocated by the ISP dynamically.
- The central router is configured with IKE negotiation policies and uses the certificate for authentication.

Figure 11



Configuration of Center:

```
hostname center
!
!
route-map static-ospf permit 10
 match ip address 1
!
access-list 1 permit 0.0.0.0 255.255.255.0
!
vpdn enable
!
vpdn-group 1
! Default L2TP VPDN group
 accept-dialin
  protocol l2tp
  virtual-template 1
 l2tp tunnel force_ipsec
source-ip 63.23.12.212
!
username RGOS password 0 RGOS
!
```

Configure the certificate and root certificate for the local router

```
crypto pki certificate chain
 certificate ca 56AE073C10A17E8C45AE8D3F15523357
 3082032E 308202D8 A0030201 02021056 AE073C10 A17E8C45 AE8D3F15 52335730
 0D06092A 864886F7 0D010105 05003081 AC312130 1F06092A 864886F7 0D010901
 16126469 6E676A73 40737461 722D6E65 742E636E 310B3009 06035504 06130243
 4E310F30 0D060355 04081306 46754A69 616E310F 300D0603 55040713 0646755A
 686F7531 20301E06 0355040A 13175265 6769616E 74204E65 74776F72 6B20436F
 2E204C74 64311D30 1B060355 040B1314 52657365 61726368 20417061 72746D65
 6E742035 31173015 06035504 03130E43 41207465 73742073 65727665 72301E17
 0D303530 32323530 38343630 325A170D 30373033 30313032 33363233 5A3081AC
 3121301F 06092A86 4886F70D 01090116 1264696E 676A7340 73746172 2D6E6574
 2E636E31 0B300906 03550406 1302434E 310F300D 06035504 08130646 754A6961
```

```
6E310F30 0D060355 04071306 46755A68 6F753120 301E0603 55040A13 17526567
69616E74 204E6574 776F726B 20436F2E 204C7464 311D301B 06035504 0B131452
65736561 72636820 41706172 746D656E 74203531 17301506 03550403 130E4341
20746573 74207365 72766572 305C300D 06092A86 4886F70D 01010105 00034B00
30480241 00D91F1A C60EF951 924CDC96 4D4443FA DABE53F2 DDF513B6 34B5A6A1
9FFD57A1 6C6F7AF4 A113C159 3D0C4C3E 8E62DE76 D8A24CF2 2CF8DA82 AA17D3E8
CC80C295 8F020301 0001A381 D33081D0 300B0603 551D0F04 04030201 C6300F06
03551D13 0101FF04 05300301 01FF301D 0603551D 0E041604 14724384 1C2B0345
2D8258F5 844377F5 21AA4B2C 21307F06 03551D1F 04783076 3038A036 A0348632
68747470 3A2F2F7A 6A2D726F 75746572 2F436572 74456E72 6F6C6C2F 43412532
30746573 74253230 73657276 65722E63 726C303A A038A036 86346669 6C653A2F
2F5C5C7A 6A2D726F 75746572 5C436572 74456E72 6F6C6C5C 43412532 30746573
74253230 73657276 65722E63 726C3010 06092B06 01040182 37150104 03020101
300D0609 2A864886 F70D0101 05050003 41007F2E 7D1676B5 560EDD1E D80B4205
3B39A742 B8E06813 786E9992 2E4C5860 AB4AF193 63A34170 50BD756A AEA7086A
7A9FC2AC D1D8A3A0 CC6779D0 76CE7D1A 7F4C
quit
!
certificate 1FFC97F0000100000029
308204B3 3082045D A0030201 02020A1F FC97F000 01000000 29300D06 092A8648
86F70D01 01050500 3081AC31 21301F06 092A8648 86F70D01 09011612 64696E67
6A734073 7461722D 6E65742E 636E310B 30090603 55040613 02434E31 0F300D06
03550408 13064675 4A69616E 310F300D 06035504 07130646 755A686F 75312030
1E060355 040A1317 52656769 616E7420 4E657477 6F726B20 436F2E20 4C746431
1D301B06 0355040B 13145265 73656172 63682041 70617274 6D656E74 20353117
30150603 55040313 0E434120 74657374 20736572 76657230 1E170D30 35303332
31303632 3335395A 170D3036 30333231 30363333 35395A30 81A63122 30200609
2A864886 F70D0109 0116137A 68616F6A 756E4073 7461722D 6E65742E 636E310B
30090603 55040613 02434E31 0F300D06 03550408 13064675 4A69616E 310F300D
06035504 07130646 755A686F 75312030 1E060355 040A1317 52656769 616E7420
4E657477 6F726B20 436F2E20 4C746431 1D301B06 0355040B 13145265 73656172
63682041 70617274 6D656E74 20353110 300E0603 55040313 077A6861 6F6A756E
305C300D 06092A86 4886F70D 01010105 00034B00 30480241 00BB70FF 351D18F5
7735FE4F C890AF42 8E8744BA D946C4B8 61F046DF 614E4A37 D8A3BA80 7003D7E1
BC5394F3 58DDE033 4ABA82D1 AEAD4C10 3135C2AE BB58FA2F 75020301 0001A382
02633082 025F300E 0603551D 0F0101FF 04040302 06C03013 0603551D 25040C30
0A06082B 06010505 08020230 1D060355 1D0E0416 0414420E 87E0F7C1 B744AFE3
2C1EFD64 E03E2144 844C3081 E8060355 1D230481 E03081DD 80147243 841C2B03
452D8258 F5844377 F521AA4B 2C21A181 B2A481AF 3081AC31 21301F06 092A8648
86F70D01 09011612 64696E67 6A734073 7461722D 6E65742E 636E310B 30090603
55040613 02434E31 0F300D06 03550408 13064675 4A69616E 310F300D 06035504
07130646 755A686F 75312030 1E060355 040A1317 52656769 616E7420 4E657477
6F726B20 436F2E20 4C746431 1D301B06 0355040B 13145265 73656172 63682041
70617274 6D656E74 20353117 30150603 55040313 0E434120 74657374 20736572
76657282 1056AE07 3C10A17E 8C45AE8D 3F155233 57307F06 03551D1F 04783076
```

```
 3038A036 A0348632 68747470 3A2F2F7A 6A2D726F 75746572 2F436572 74456E72
 6F6C6C2F 43412532 30746573 74253230 73657276 65722E63 726C303A A038A036
 86346669 6C653A2F 2F5C5C7A 6A2D726F 75746572 5C436572 74456E72 6F6C6C5C
 43412532 30746573 74253230 73657276 65722E63 726C3081 AC06082B 06010505
 07010104 819F3081 9C304B06 082B0601 05050730 02863F68 7474703A 2F2F7A6A
 2D726F75 7465722F 43657274 456E726F 6C6C2F7A 6A2D726F 75746572 5F434125
 32307465 73742532 30736572 76657228 31292E63 7274304D 06082B06 01050507
 30028641 66696C65 3A2F2F5C 5C7A6A2D 726F7574 65725C43 65727445 6E726F6C
 6C5C7A6A 2D726F75 7465725F 43412532 30746573 74253230 73657276 65722831
 292E6372 74300D06 092A8648 86F70D01 01050500 034100AF 173B4A23 E95C8042
 ED4F2F97 0D869C1E 715800E6 F64F505F 1A6F291C 4B8C95C8 2FE04F9C CA81778F
 07A2DE20 C9640A8B DD36BCC0 359C26BB D5A5E434 B5F46B
 quit
 !
!
```

The IKE negotiation uses a certificate for authentication by default

```
!
```

Configure a transform set

```
crypto ipsec transform-set myset  esp-des
```

Configure a dynamic crypto map set

```
crypto dynamic-map dy 1
 set transform-set myset
!
!
crypto map mymap 1 ipsec-isakmp dynamic dy
!
interface FastEthernet 0/0
 ip address 63.23.12.212 255.255.255.248
 crypto map mymap
 duplex auto
 speed auto
!
interface FastEthernet 0/1
 ip address 192.168.216.1 255.255.255.0
 ip address 192.168.217.1 255.255.255.0 secondary
 ip address 192.168.218.1 255.255.255.0 secondary
 ip address 192.168.219.1 255.255.255.0 secondary
 duplex auto
 speed auto
!
interface Null 0
!
```

```
interface Virtual-Template 1
 mtu 1400
 ip ospf mtu-ignore
 ip unnumbered FastEthernet 0/1
 ip mtu 1360
!
!
router ospf
 redistribute static subnets route-map static-ospf
 network 192.168.216.0 0.0.0.255 area 0.0.0.0
 network 192.168.217.0 0.0.0.255 area 0.0.0.0
 network 192.168.218.0 0.0.0.255 area 0.0.0.0
 network 192.168.219.0 0.0.0.255 area 0.0.0.0
!
line con 0
 exec-timeout 0 0
line aux 0
 disconnect-character 240
line vty 0 4
 exec-timeout 0 0
 privilege level 15
 no login
!
!
end
```

Configuration of router A:

```
hostname routerA
!
# Configure an access list
access-list 101 permit ip interface dialer 0 host 63.23.12.212
access-list 177 deny icmp any any unreachable
access-list 177 permit ip any any
dialer-list 1 protocol ip permit
!
l2tp-class l2x
 hostname rg36_1
!
pseudowire-class pw
 encapsulation l2tpv2
 protocol l2tpv2 l2x
 ip local interface dialer 0
!
!
```

Configure the certificate and root certificate for the local router

```
crypto pki certificate chain
 certificate ca 56AE073C10A17E8C45AE8D3F15523357
 3082032E 308202D8 A0030201 02021056 AE073C10 A17E8C45 AE8D3F15 52335730
 0D06092A 864886F7 0D010105 05003081 AC312130 1F06092A 864886F7 0D010901
 16126469 6E676A73 40737461 722D6E65 742E636E 310B3009 06035504 06130243
 4E310F30 0D060355 04081306 46754A69 616E310F 300D0603 55040713 0646755A
 686F7531 20301E06 0355040A 13175265 6769616E 74204E65 74776F72 6B20436F
 2E204C74 64311D30 1B060355 040B1314 52657365 61726368 20417061 72746D65
 6E742035 31173015 06035504 03130E43 41207465 73742073 65727665 72301E17
 0D303530 32323530 38343630 325A170D 30373033 30313032 33363233 5A3081AC
 3121301F 06092A86 4886F70D 01090116 1264696E 676A7340 73746172 2D6E6574
 2E636E31 0B300906 03550406 1302434E 310F300D 06035504 08130646 754A6961
 6E310F30 0D060355 04071306 46755A68 6F753120 301E0603 55040A13 17526567
 69616E74 204E6574 776F726B 20436F2E 204C7464 311D301B 06035504 0B131452
 65736561 72636820 41706172 746D656E 74203531 17301506 03550403 130E4341
 20746573 74207365 72766572 305C300D 06092A86 4886F70D 01010105 00034B00
 30480241 00D91F1A C60EF951 924CDC96 4D4443FA DABE53F2 DDF513B6 34B5A6A1
 9FFD57A1 6C6F7AF4 A113C159 3D0C4C3E 8E62DE76 D8A24CF2 2CF8DA82 AA17D3E8
 CC80C295 8F020301 0001A381 D33081D0 300B0603 551D0F04 04030201 C6300F06
 03551D13 0101FF04 05300301 01FF301D 0603551D 0E041604 14724384 1C2B0345
 2D8258F5 844377F5 21AA4B2C 21307F06 03551D1F 04783076 3038A036 A0348632
 68747470 3A2F2F7A 6A2D726F 75746572 2F436572 74456E72 6F6C6C2F 43412532
 30746573 74253230 73657276 65722E63 726C303A A038A036 86346669 6C653A2F
 2F5C5C7A 6A2D726F 75746572 5C436572 74456E72 6F6C6C5C 43412532 30746573
 74253230 73657276 65722E63 726C3010 06092B06 01040182 37150104 03020101
 300D0609 2A864886 F70D0101 05050003 41007F2E 7D1676B5 560EDD1E D80B4205
 3B39A742 B8E06813 786E9992 2E4C5860 AB4AF193 63A34170 50BD756A AEA7086A
 7A9FC2AC D1D8A3A0 CC6779D0 76CE7D1A 7F4C
 quit
 !
 certificate 11F7C51700010000003E
 308204B1 3082045B A0030201 02020A11 F7C51700 01000000 3E300D06 092A8648
 86F70D01 01050500 3081AC31 21301F06 092A8648 86F70D01 09011612 64696E67
 6A734073 7461722D 6E65742E 636E310B 30090603 55040613 02434E31 0F300D06
 03550408 13064675 4A69616E 310F300D 06035504 07130646 755A686F 75312030
 1E060355 040A1317 52656769 616E7420 4E657477 6F726B20 436F2E20 4C746431
 1D301B06 0355040B 13145265 73656172 63682041 70617274 6D656E74 20353117
 30150603 55040313 0E434120 74657374 20736572 76657230 1E170D30 35303431
 32303932 3935335A 170D3036 30343132 30393339 35335A30 81A43121 301F0609
 2A864886 F70D0109 01161264 696E676A 73407374 61722D6E 65742E63 6E310B30
 09060355 04061302 434E310F 300D0603 55040813 0646754A 69616E31 0F300D06
 03550407 13064675 5A686F75 3120301E 06035504 0A131752 65676961 6E74204E
 6574776F 726B2043 6F2E204C 7464311D 301B0603 55040B13 14526573 65617263
 68204170 6172746D 656E7420 35310F30 0D060355 04031306 64696E67 6A73305C
```

```
 300D0609 2A864886 F70D0101 01050003 4B003048 024100CD 2C3B2981 FF9BF7E6
 F9DFFCF9 495FE6AA 6691FD76 BB5EBEC3 5A1E48F8 8B75DD68 9E79AC5A 36C0B4F4
 AA959323 49EEEB7F 24B546B8 74421F17 401033AE EC3F4102 03010001 A3820263
 3082025F 300E0603 551D0F01 01FF0404 030204F0 30130603 551D2504 0C300A06
 082B0601 05050802 02301D06 03551D0E 04160414 216567F3 E72263B2 4990E14D
 ECC22471 1596A71F 3081E806 03551D23 0481E030 81DD8014 7243841C 2B03452D
 8258F584 4377F521 AA4B2C21 A181B2A4 81AF3081 AC312130 1F06092A 864886F7
 0D010901 16126469 6E676A73 40737461 722D6E65 742E636E 310B3009 06035504
 06130243 4E310F30 0D060355 04081306 46754A69 616E310F 300D0603 55040713
 0646755A 686F7531 20301E06 0355040A 13175265 6769616E 74204E65 74776F72
 6B20436F 2E204C74 64311D30 1B060355 040B1314 52657365 61726368 20417061
 72746D65 6E742035 31173015 06035504 03130E43 41207465 73742073 65727665
 72821056 AE073C10 A17E8C45 AE8D3F15 52335730 7F060355 1D1F0478 30763038
 A036A034 86326874 74703A2F 2F7A6A2D 726F7574 65722F43 65727445 6E726F6C
 6C2F4341 25323074 65737425 32307365 72766572 2E63726C 303AA038 A0368634
 66696C65 3A2F2F5C 5C7A6A2D 726F7574 65725C43 65727445 6E726F6C 6C5C4341
 25323074 65737425 32307365 72766572 2E63726C 3081AC06 082B0601 05050701
 0104819F 30819C30 4B06082B 06010505 07300286 3F687474 703A2F2F 7A6A2D72
 6F757465 722F4365 7274456E 726F6C6C 2F7A6A2D 726F7574 65725F43 41253230
 74657374 25323073 65727665 72283129 2E637274 304D0608 2B060105 05073002
 86416669 6C653A2F 2F5C5C7A 6A2D726F 75746572 5C436572 74456E72 6F6C6C5C
 7A6A2D72 6F757465 725F4341 25323074 65737425 32307365 72766572 2831292E
 63727430 0D06092A 864886F7 0D010105 05000341 00148479 89448BB7 E6D3A7A7
 34376464 C8D857C2 D9075263 9E278FC3 2D6C5041 036B66C7 F59ADCA5 39C9F824
 A40A4C57 05373965 66671538 921FF39C B95C90F4 3F
 quit
!
crypto pki revocation-check none
!
```

Configure that DPD is triggered periodically

```
crypto isakmp keepalive 20 periodic
```

Configure a transform set

```
crypto ipsec transform-set myset  esp-des
```

Configure a crypto map set

```
crypto map mymap 1 ipsec-isakmp
 set peer 63.23.12.212
 set transform-set myset
 match address 101
!
!
!
interface FastEthernet 0/0
```

```
pppoe enable
  pppoe-client dial-pool-number 1 no-ddr
  duplex auto
  speed auto
!
interface FastEthernet 0/1
 ip address 192.168.161.1 255.255.255.0
 duplex auto
 speed auto
!
interface dialer 0
 mtu 1488
 encapsulation PPP
 ppp chap hostname abcd@163.com
 ppp chap password 0 123456
 ppp pap sent-username abcd@163.com password 0 123456
 ip access-group 177 in
 ip address negotiate
 crypto map mymap
 dialer pool 1
 dialer idle-timeout 1200
 dialer-group 1
 bandwidth 2048
!
interface Null 0
!
interface Virtual-ppp 1
 pseudowire 63.23.12.212 20 encapsulation l2tpv2 pw-class pw
 mtu 1400
 ppp pap sent-username RGOS password 0 RGOS
 ip ospf mtu-ignore
 no ip route-cache policy
 ip unnumbered FastEthernet 0/1
 ip mtu 1360
!
!
router ospf
 network 192.168.161.0 0.0.0.255 area 0.0.0.0
!
ip route 0.0.0.0 0.0.0.0 dialer 0
!
!
line con 0
line aux 0
line vty 0 4
```

```
 exec-timeout 0 0
 privilege level 15
 no login
!
!
end
```

For configurations of Router B and Router C, refer to the configuration of Router A.

Caution

Because the private key of a device is confidential information that does not exist in the system configuration file, when you copy and paste the preceding configuration information to the device console or use the **copy tft flash** command to copy this configuration file to the device configuration file **config.txt**, the preceding certificate-related configurations cannot be performed. To configure a certificate, you must run the **crypto pki import pem terminal** command to import a certificate. This example only shows the configurations that are visible to you.

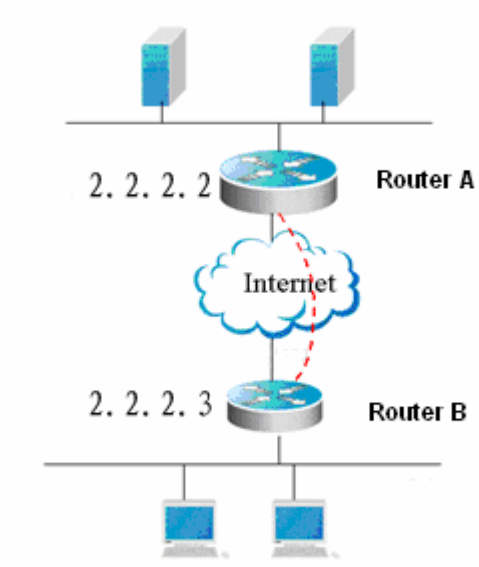
Reverse Route Injection

Analysis

In this case, the IP traffic between two subnets is protected by using the Router A as the central gateway at one side, and using Router B as the branch gateway at the other side, as shown in Figure 5. The following requirements should be met:

- The 3DES algorithm is used in phase 1.
- The tunnel mode is used.
- The protection method is ESP-3des (the encryption and authentication services are available).

Figure 12



Router configuration

10) Router A

```
ip host peerhost 2.2.2.2
ip access-list extended 110
10 permit ip host 2.2.2.3 host 2.2.2.2
crypto isakmp policy 1
authentication pre-share
!
!
crypto isakmp key 7 01334b46391e033004 address 0.0.0.0 0.0.0.0
crypto ipsec transform-set myset  esp-3des
crypto dynamic-map dymap 100
set transform-set myset
reverse-route
match address 111
!
!
crypto map mymap 7 ipsec-isakmp dynamic dymap
interface GigabitEthernet 1/0/0
 ip ref
ip address 2.2.2.3 255.255.255.0
crypto map mymap
duplex auto
speed auto
end
```

11) Router B

```
ip access-list extended 110
10 permit ip host 2.2.2.2 host 2.2.2.3
crypto isakmp policy 1
authentication pre-share
crypto isakmp key 7 0424100330052a1b15 address 0.0.0.0 0.0.0.0
crypto ipsec transform-set myset  esp-3des
crypto map mymap 10 ipsec-isakmp
set peer 2.2.2.3
set transform-set myset
match address 110
interface FastEthernet 0/0
ip address 2.2.2.2 255.255.255.0
crypto map mymap
duplex auto
speed auto
!
interface FastEthernet 0/1
ip address 200.1.1.10 255.255.255.0
duplex auto
speed auto
end
```

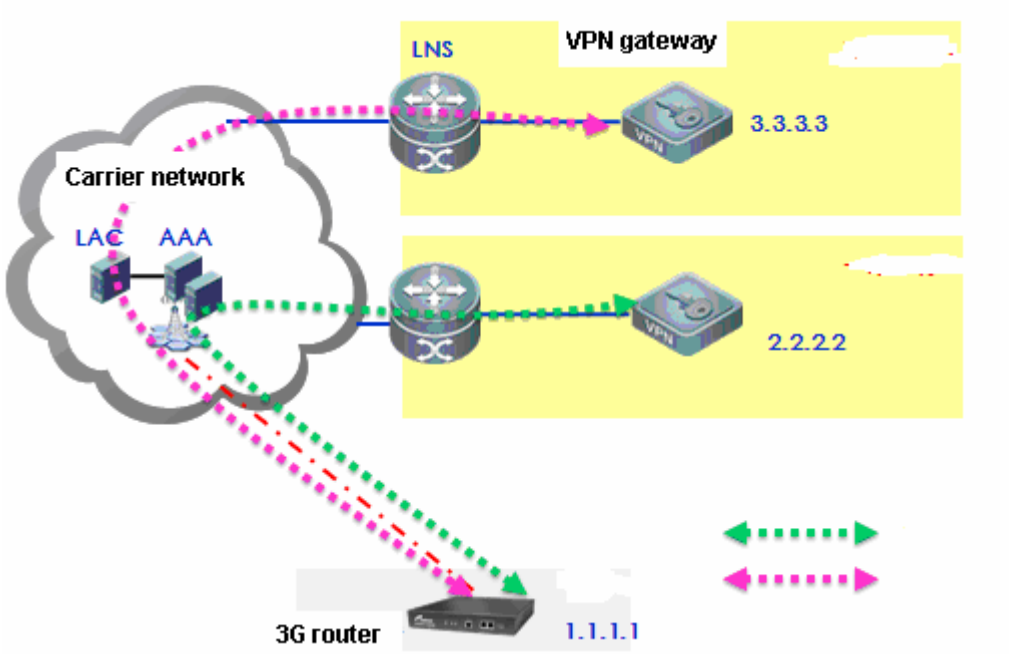
Mutual Backup of Multiple Peers

Analysis

In this case, there are multiple servers and each server uses a different certificate chain. The access device is configured with multiple peers and certificate chains. While the convergence device has the same configuration as that in the other case. As shown in the figure below, the following requirements should be met:

- Multiple VPN gateways are located in different places to provide access services.
- Every convergence router uses a different certificate chain.
- The access router changes according to the peer configuration.

Figure 13



Router configuration

12) Convergence router A

//Use the default policy.

```
!
crypto ipsec transform-set myset  esp-3des
crypto dynamic-map dymap 100
 set transform-set myset
 reverse-route
!
!
crypto map mymap 7 ipsec-isakmp dynamic dymap
interface GigabitEthernet 1/0/0
 ip ref
 ip address 2.2.2.3 255.255.255.0
```

```
 crypto map mymap
 duplex auto
 speed auto
end
```

13) Convergence router B whose configuration is the same as router A except the local address and certificate

//Use the default policy.

```
!
crypto ipsec transform-set myset  esp-3des
crypto dynamic-map dymap 100
 set transform-set myset
 reverse-route
!
!
crypto map mymap 7 ipsec-isakmp dynamic dymap
interface GigabitEthernet 1/0/0
 ip ref
 ip address 2.2.2.2 255.255.255.0
 crypto map mymap
 duplex auto
 speed auto
end
```

14) Access router A

```
ip access-list extended 110
 10 permit ip host 2.2.2.1 any
!
//Use the default policy: certificate-based authentication
crypto isakmp keepalive 10 2 periodic
//Use 3DES for encryption
crypto ipsec transform-set myset  esp-3des
!
crypto map mymap 7 ipsec-isakmp
set peer 2.2.2.2 //The default certificate chain is used if this parameter is not specified.
set peer 2.2.2.3 trustpoint backup
set transform-set myset
match address 100

interface GigabitEthernet 1/0/0
 ip ref
 ip address 2.2.2.1 255.255.255.0
 crypto map mymap
 duplex auto
 speed auto
end
```

Applying Profile crypto map entries in different tunnels

- Analysis

In this case, the IP traffic between two subnets is protected by using a Cisco device connected to Subnet A as the gateway at one side, and using a Ruijie device connected to Subnet B as the gateway at the other side. The following requirements should be met:

- The 3DES algorithm is used in phase 1
- The transmission mode is used.
- The protection method is ESP-DES-MD5 (the encryption and authentication services are available).

In the following application, a Cisco device is used as the center, and Ruijie devices are used as remote branches. See Figure 14.

Figure 14

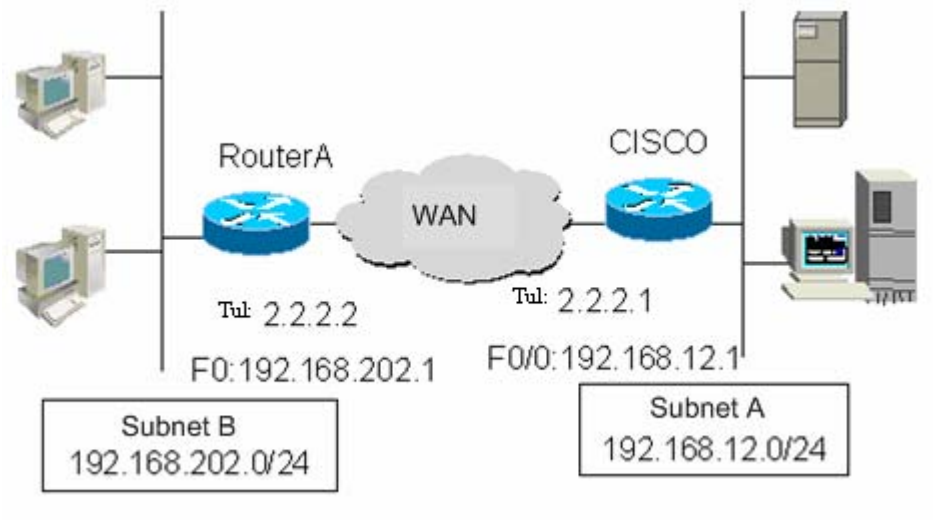
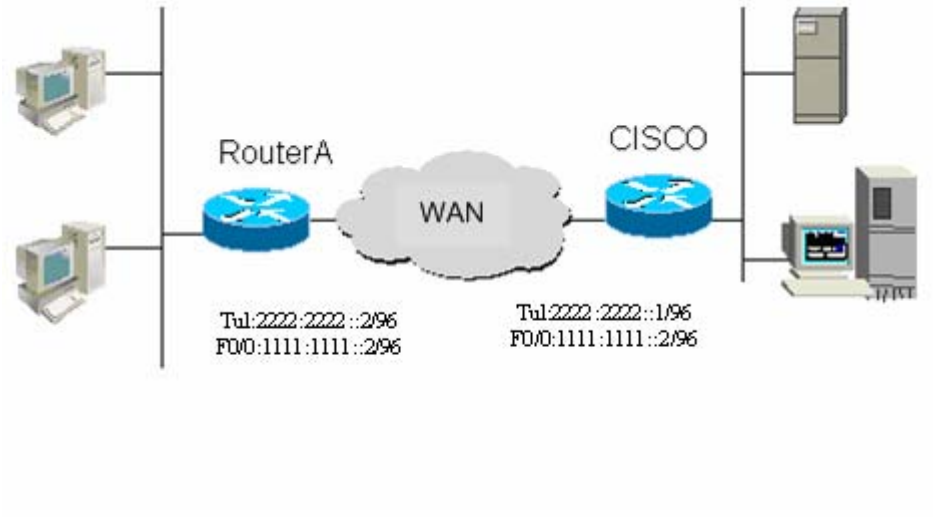


Figure 15



Applying the Profile map to a GRE tunnel

Configuration of Router A:

```
!
hostname "RouterA"
```

Enable IKE

```
crypto isakmp enable
crypto isakmp policy 1
authentication pre-share
encrytiong 3des
```

Configure a pre-shared key and a transform set

```
crypto isakmp key 0 123 address 192.168.12.1
crypto ipsec transform-set t1  esp-des esp-md5-hmac
mode transport
```

Define a crypto map set

```
crypto ipsec profile profi-map
set transform-set t1
!
interface FastEthernet0
ip address 192.168.202.1 255.255.255.0
# Apply the crypto map to a GRE tunnel interface
interface tunnel 1
tunnel source  192.168.202.1
tunnel destination 192.168.12.1
tunnel protection ipsec profile profile-map
ip address 2.2.2.2 255.255.255.0
!
ip route 0.0.0.0 0.0.0.0 tunnel 1
```

Configuration of Cisco device:

```
!
hostname Cisco
```

Define an IKE policy, using the pre-shared key for authentication, and using the default values for other parameters

```
crypto isakmp policy 1
authentication pre-share
encryption 3des
```

Configure the pre-shared key

```
crypto isakmp key 0 123 address 192.168.202.1
```

Define a transform set

```
crypto ipsec transform-set t1 esp-des esp-md5-hmac
```

```
mode transport
```

Define a crypto map

```
crypto ipsec profile profile-name
set transform-set t1
!
interface FastEthernet0/0
ip address 192.168.12.1 255.255.255.0
```

Apply the crypto map to the tunnel interface

```
interface tunnel 1
tunnel source  192.168.12.1
tunnel destination 192.168.202.1
tunnel protection ipsec profile profile-map
ip address 2.2.2.1 255.255.255.0
!
```

Applying the Profile map to an IPSEC-IPV4 tunnel

Configuration of Router A:

```
!
hostname "RouterA"
```

Enable IKE

```
crypto isakmp enable
crypto isakmp policy 1
authentication pre-share
encrytiong 3des
```

Configure a pre-shared key and a transform set

```
crypto isakmp key 0 123 address 192.168.12.1
crypto ipsec transform-set t1  esp-des esp-md5-hmac
mode transport
```

Define a crypto map set

```
crypto ipsec profile profi-map
set transform-set t1
match any
!
interface FastEthernet0
ip address 192.168.202.1 255.255.255.0
# Apply the crypto map to the tunnel interface
interface tunnel 1
  tunnel mode ipip
tunnel source  192.168.202.1
tunnel destination 192.168.12.1
```

```
tunnel protection ipsec profile profile-map
ip address 2.2.2.2 255.255.255.0
!
ip route 0.0.0.0 0.0.0.0 tunnel 1

Configuration of Cisco device:
!
hostname Cisco
```

Define an IKE policy, using the pre-shared key for authentication, and using the default values for other parameters

```
crypto isakmp policy 1
authentication pre-share
encryption 3des
```

Configure a pre-shared key

```
crypto isakmp key 0 123 address 192.168.202.1
```

Define a transform set

```
crypto ipsec transform-set t1 esp-des esp-md5-hmac
mode transport
```

Define a crypto map

```
crypto ipsec profile profile-name
set transform-set t1
!
interface FastEthernet0/0
ip address 192.168.12.1 255.255.255.0
```

Apply the crypto map to the tunnel interface

```
interface tunnel 1
tunnel mode ipsec ipv4
tunnel source  192.168.12.1
tunnel destination 192.168.202.1
tunnel protection ipsec profile profile-map
ip address 2.2.2.1 255.255.255.0
```

Applying the Profile map to an IPV6 tunnel

Configuration of Router A:

```
!
hostname "RouterA"
```

Enable IKE

```
crypto isakmp enable
crypto isakmp policy 1
authentication pre-share
```

```
encrytiong 3des
```

Configure a pre-shared key and a transform set

```
crypto isakmp key 0 123 ipv6  ::/0
crypto ipsec transform-set t1  esp-des esp-md5-hmac
mode transport
```

Define a crypto map set

```
crypto ipsec profile profi-map
set transform-set t1
match any
!
interface FastEthernet0
ipv6 address 1111:1111::2/96
# Apply the crypto map to the tunnel interface
interface tunnel 1
  tunnel mode ipv6
tunnel source  1111:1111::2
tunnel destination 1111:1111::1
tunnel protection ipsec profile profile-map
ipv6 address 2222:2222::2/96
!
ipv6 route ::/0 tunnel 1
```

Configuration of Cisco device:

```
!
hostname Cisco
```

Define an IKE policy, using the pre-shared key for authentication, and using the default values for other parameters

```
crypto isakmp policy 1
authentication pre-share
encryption 3des
# Configure a pre-shared key
crypto isakmp key 0 123 ipv6  ::/0
crypto ipsec transform-set t1  esp-des esp-md5-hmac
mode transport
```

Define a crypto map set

```
crypto ipsec profile profi-map
set transform-set t1
!
interface FastEthernet0
ipv6 address 1111:1111::1/96
# Apply the crypto map to the tunnel interface
```

```
interface tunnel 1
  tunnel mode ipv6
tunnel source  1111:1111::1
tunnel destination 1111:1111::2
tunnel protection ipsec profile profile-map
ipv6 address 2222:2222::1/96
```

Applying the Profile map to an IPIP tunnel when NAT is available

Configuration of Router A:

```
!
hostname "RouterA"
```

Enable IKE

```
crypto isakmp enable
crypto isakmp policy 1
authentication pre-share
encrytiong 3des
```

Configure a pre-shared key and a transform set

```
crypto isakmp key 0 123 address 192.168.12.1
crypto ipsec transform-set t1  esp-des esp-md5-hmac
mode transport
```

Define a crypto map set

```
crypto ipsec profile profi-map
set transform-set t1
!
interface FastEthernet0
ip address 192.168.202.1 255.255.255.0
```

Apply the crypto map to the GRE tunnel interface

```
interface tunnel 1
   tunnel mode ipip
tunnel source  192.168.202.1
tunnel destination 192.168.12.1
tunnel protection ipsec profile profile-map
ip address 2.2.2.2 255.255.255.0
!
ip route 0.0.0.0 0.0.0.0 tunnel 1
```

Configuration of the NAT device:

```
hostname "NAT"
```

#An ACL for NAT translation

```
ip access standard 1
10 permit any
!
```

#Connected to Router A

```
interface FastEthernet 0/0
ip address 192.168.202.2 255.255.255.0
ip nat inside
!
```

#Connected to Router B

```
interface FastEthernet0/1
ip add 192.168.12.2 255.255.255.0
ip nat outside
!
```

#NAT translation rule, translating the source IP address of packets through F0/0 into the IP address of F0/1

```
ip nat inside source list 1 interface fastEthernet 0/1
!
```

Configuration of Cisco device:

```
!
hostname Cisco
```

Define an IKE policy, using the pre-shared key for authentication, and using the default values for other parameters

```
crypto isakmp policy 1
authentication pre-share
encryption 3des
```

Configure a pre-shared key

```
crypto isakmp key 0 123 address 192.168.202.1
```

Define a transform set

```
crypto ipsec transform-set t1 esp-des esp-md5-hmac
mode transport
```

Define a crypto map

```
crypto ipsec profile profile-name
set transform-set t1
!
interface FastEthernet0/0
ip address 192.168.12.1 255.255.255.0
```

Apply the crypto map to the tunnel interface

```
interface tunnel 1
   tunnel mode ipip
tunnel source  192.168.12.1
tunnel destination 192.168.12.2
tunnel protection ipsec profile profile-map
ip address 2.2.2.1 255.255.255.0
!
```

Applying the Profle map to an IPSEC-Ipv4 tunnel when NAT is available

Configuration of Router A:

```
!
hostname "RouterA"
```

Enable IKE

```
crypto isakmp enable
crypto isakmp policy 1
authentication pre-share
encrytiong 3des
```

Configure a pre-shared key and a transform set

```
crypto isakmp key 0 123 address 192.168.12.1
crypto ipsec transform-set t1  esp-des esp-md5-hmac
mode transport
```

Define a crypto map set

```
crypto ipsec profile profi-map
set transform-set t1
match any
!
interface FastEthernet0
ip address 192.168.202.1 255.255.255.0
```

Apply the crypto map to the GRE tunnel interface

```
interface tunnel 1
   tunnel mode ipip
tunnel source  192.168.202.1
tunnel destination 192.168.12.1
tunnel protection ipsec profile profile-map
ip address 2.2.2.2 255.255.255.0
!
ip route 0.0.0.0 0.0.0.0 tunnel 1
```

Configuration of the NAT device:

```
hostname "NAT"
```

#An ACL for NAT translation

```
ip access standard 1
10 permit any
!
```

#Connected to Router A

```
interface FastEthernet 0/0
ip address 192.168.202.2 255.255.255.0
ip nat inside
!
```

#Connected to Router B

```
interface FastEthernet0/1
ip add 192.168.12.2 255.255.255.0
ip nat outside
!
```

#NAT translation rule, translating the source IP address of packets through F0/0 into the IP address of F0/1

```
ip nat inside source list 1 interface fastEthernet 0/1
!
```

Configuration of Cisco device:

```
!
hostname Cisco
```

Define an IKE policy, using the pre-shared key as the authentication method, and using the default values for other parameters

```
crypto isakmp policy 1
authentication pre-share
encryption 3des
```

Configure a pre-shared key

```
crypto isakmp key 0 123 address 192.168.202.1
```

Define a transform set

```
crypto ipsec transform-set t1 esp-des esp-md5-hmac
mode transport
```

Define a crypto map

```
crypto ipsec profile profile-name
set transform-set t1
!
```

```
interface FastEthernet0/0
ip address 192.168.12.1 255.255.255.0
```

Apply the crypto map to the tunnel interface

```
interface tunnel 1
tunnel mode ipsec ipv4
tunnel source  192.168.12.1
tunnel destination 192.168.12.2
tunnel protection ipsec profile profile-map
ip address 2.2.2.1 255.255.255.0
!
```

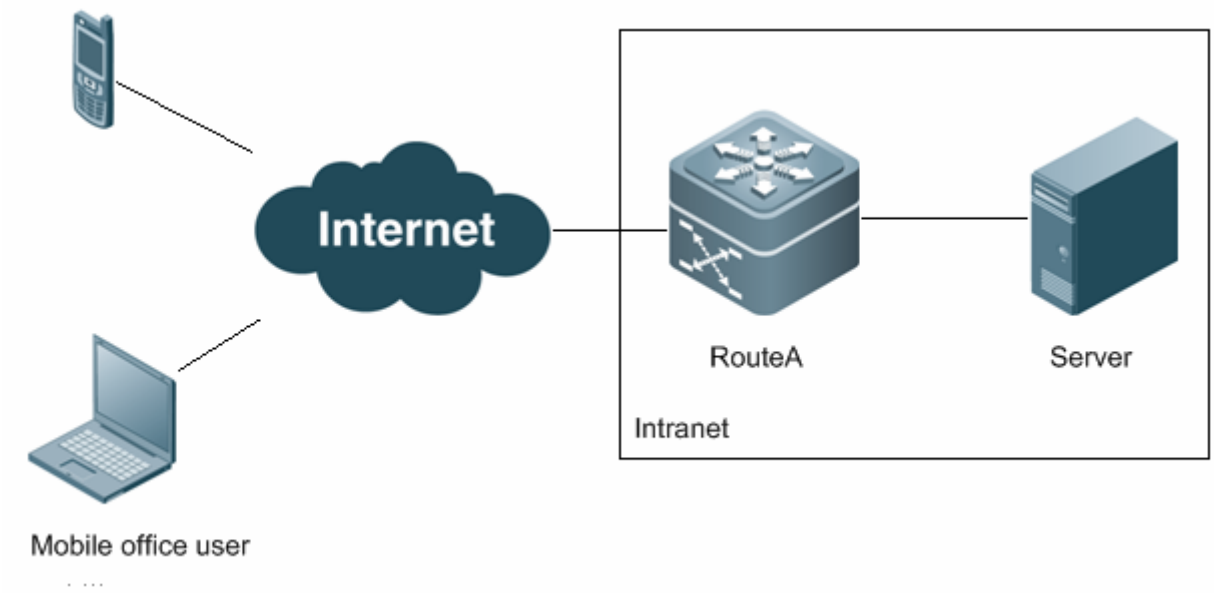
Extended authentication

- Analysis

In this case, a mobile office user wants to establish an IPSec connection with Route A through Internet for access to intranet resources, as shown in Figure 9. The following requirements should be met:

- Authentication is required.
- IPSec policies are dynamically downloaded to clients.

Figure 16



Configuration of Route A:

Configure AAA authentication

```
aaa new-model
```

Configure local authentication

```
aaa authentication login lab-remote-access local
```

Configure the username and password for authentication

```
username ruijie password 0 ruijie
```

Configure an IKE policy

```
crypto isakmp policy 10
 encr 3des
 authentication pre-share
 group 2
```

Configure an IKE address pool

```
crypto isakmp ippool Remote-Pool
 address 172.16.1.200 172.16.1.250
```

Configure a policy to be delivered to clients

```
crypto isakmp client configuration group test
key VPNKEY
dns 220.170.0.18
pool Remote-Pool
network center 192.168.52.0/24
```

Configure a transform set

```
crypto ipsec transform-set VPNTRANSFORM esp-3des esp-sha-hmac
```

Define a dynamic crypto map set

```
crypto dynamic-map Dynamic-Map 10
set transform-set VPNTRANSFORM
reverse-route
```

Use AAA authentication

```
crypto map ClientMap client authentication list lab-remote-access
```

Add a dynamic crypto map set to the static crypto map set

```
crypto map ClientMap 65535 ipsec-isakmp dynamic Dynamic-Map
```

Apply the crypto map to the interface

```
interface FastEthernet0/0
ip address 61.168.202.1 255.255.255.0
crypto map ClientMap
!
interface FastEthernet0/1
ip address 192.168.202.1 255.255.255.0
```

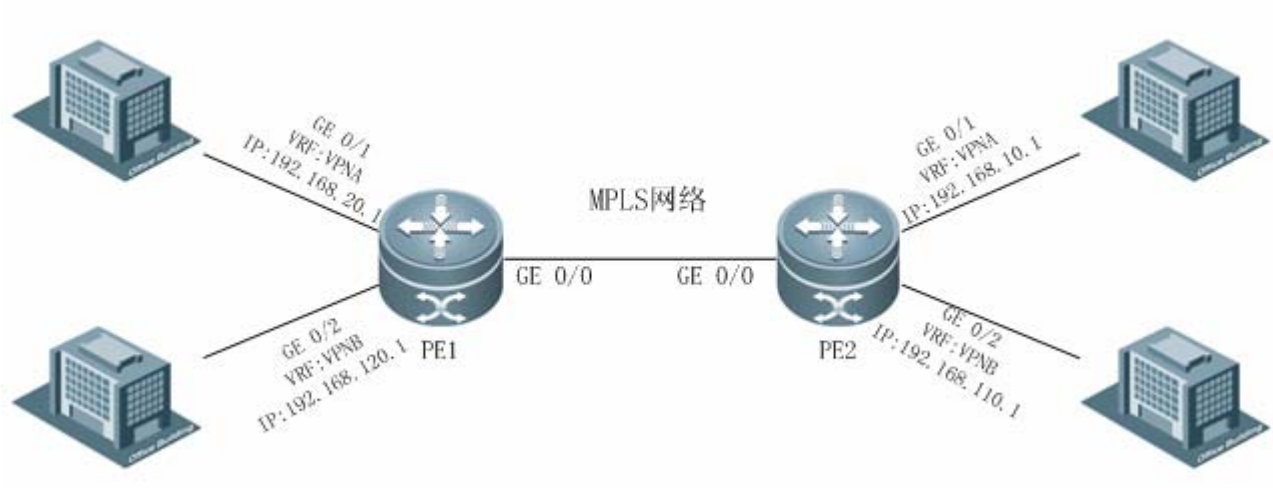
IPSEC OVER MPLS

Analysis

MPLS on E-government extranet connects networks of official organs. To enhance MPLS networking security, encryption protection is adopted for network communication data. The following requirements should be met:

The data transferring on MPLS networks must be encrypted by IPSec.

To make sure the IPSEC encryotion do not interfere with data transferring on MPLS networks, adopt IPSEC OVER MPLS.



PE1：

configure VRF

```
ip vrf VPNA
 rd 1:100
 route-target both 1:100
!
ip vrf VPNB
 rd 1:200
 route-target both 1:200
```

configure MPLS network

```
mpls ip
interface Loopback 0
 ip address 172.168.0.1 255.255.255.255
router bgp 1
 bgp log-neighbor-changes
 neighbor 172.168.0.2 remote-as 1
 neighbor 172.168.0.2 update-source Loopback 0
 !
 address-family ipv4
  neighbor 172.168.0.2 activate
 exit-address-family
 !
 address-family vpnv4 unicast
  neighbor 172.168.0.2 activate
  neighbor 172.168.0.2 send-community extended
```

```
 exit-address-family
 !
 address-family ipv4 vrf VPNA
  maximum-prefix 10000
  redistribute connected
  neighbor 172.168.10.2 remote-as 65002
  neighbor 172.168.10.2 activate
 exit-address-family
 !
 address-family ipv4 vrf VPNB
  maximum-prefix 10000
  redistribute connected
  neighbor 172.168.10.2 remote-as 65002
  neighbor 172.168.10.2 activate
 exit-address-family
!
!
router ospf 10
 network 172.168.0.1 0.0.0.0 area 0
 network 172.168.10.0 0.0.0.255 area 0
 network 192.168.20.0 0.0.0.255 area 0
 network 192.168.120.0 0.0.0.255 area 0!
!
mpls router ldp
 ldp router-id interface Loopback 0 force
```

configure IPSEC

```
ip access-list extended 110
 10 permit ip 192.168.20.0 0.0.0.255 192.168.10.0 0.0.0.255
!
!
ip access-list extended 111
 10 permit ip 192.168.120.0 0.0.0.255 192.168.110.0 0.0.0.255
!
crypto isakmp policy 1
 encryption 3des
 authentication pre-share
!
crypto ipsec transform-set myset esp-3des esp-sha-hmac
!
crypto map mymap1 1 ipsec-isakmp
 set local 192.168.20.2
 set peer 192.168.10.2
 set transform-set myset
 match vrf VPNA
```

```
 match address 110
!
crypto map mymap1 2 ipsec-isakmp
 set local 192.168.120.2
 set peer 192.168.110.2
 set transform-set myset
 match vrf VPNB
 match address 111
!
interface GigabitEthernet 0/0
 ip address 172.168.10.1 255.255.255.0
 label-switching
 mpls ip
 crypto map mymap
 duplex auto
 speed auto
!
interface GigabitEthernet 0/1
 ip vrf forwarding VPNA
 ip address 192.168.20.2 255.255.255.0
duplex auto
 speed auto
!
interface GigabitEthernet 0/1
 ip vrf forwarding VPNB
 ip address 192.168.120.2 255.255.255.0
duplex auto
 speed auto
```

PE2：

configure VRF

```
ip vrf VPNA
 rd 1:100
 route-target both 1:100
!
ip vrf VPNB
 rd 1:200
 route-target both 1:200
```

configure MPLS network

```
mpls ip
!
router bgp 1
 bgp log-neighbor-changes
```

```
 neighbor 172.168.0.1 remote-as 1
 neighbor 172.168.0.1 update-source Loopback 0
 !
 address-family ipv4
  neighbor 172.168.0.1 activate
 exit-address-family
 !
 address-family vpnv4 unicast
  neighbor 172.168.0.1 activate
  neighbor 172.168.0.1 send-community extended
 exit-address-family
 !
 address-family ipv4 vrf VPNA
  maximum-prefix 10000
  redistribute connected
  neighbor 172.168.10.1 remote-as 65002
  neighbor 172.168.10.1 activate
 exit-address-family
 !
 address-family ipv4 vrf VPNB
  maximum-prefix 10000
  redistribute connected
  neighbor 172.168.10.1 remote-as 65002
  neighbor 172.168.10.1 activate
 exit-address-family
!
!
!
!
router ospf 10
 network 172.168.0.2 0.0.0.0 area 0
 network 172.168.10.0 0.0.0.255 area 0
 network 192.168.10.0 0.0.0.255 area 0
 network 192.168.110.0 0.0.0.255 area 0
!
!
!
!
mpls router ldp
 ldp router-id interface Loopback 0 force
```

configure IPSEC

```
crypto isakmp policy 1
 encryption 3des
 authentication pre-share
```

```
!
!
crypto isakmp key 7 021211644c536854774c address 0.0.0.0 0.0.0.0
crypto ipsec transform-set myset esp-3des esp-sha-hmac
!
crypto dynamic-map dy 1
 set transform-set myset
 reverse-route
!
crypto map mymap 1 ipsec-isakmp dynamic dy
!
interface GigabitEthernet 0/0
 ip address 172.168.10.1 255.255.255.0
 label-switching
 mpls ip
 crypto map mymap
 duplex auto
 speed auto
!
interface GigabitEthernet 0/1
 ip vrf forwarding VPNA
 ip address 192.168.10.2 255.255.255.0
duplex auto
 speed auto
!
interface GigabitEthernet 0/1
 ip vrf forwarding VPNB
 ip address 192.168.110.2 255.255.255.0
duplex auto
 speed auto
```

Configuring VPDN

Overview of VPDN

RGOS supports two types of VPDN tunnels: L2TP and PPTP.

Layer Two Tunneling Protocol (L2TP);

Point-to-Point Tunneling Protocol (PPTP).

These two types of VPDN tunneling protocols have their own history. For their configuration and usage, see the following sections. PPTP is commonly used in the Microsoft Windows series products, while L2TP is commonly used in the network devices from such vendors as Cisco. As an industry standard, L2TP is supported by Windows 2000/XP.

Caution In this chapter, a router refers to the generic route and security gateway unless specially specified.

Configuring PPTP

Overview of PPTP

Point-to-Point-Tunneling Protocol (PPTP) is a network technology that supports multi-protocol VPN. With the PPTP protocol, remote users can dial in the local ISP through Microsoft Windows NT® Workstation, Windows® 95, Windows® 98, Windows® 2000 and other systems with the PPP function enabled, so as to connect and access the corporate network over the Internet securely. Its standard description document is RFC 2637, which is proposed jointly by Microsoft and several industry leading communication device developers. Now it has been recommended to Internet Engineering Task Force(IETF).

The PPTP protocol transmits PPP packets through the tunnel in the IP network. Although it does not modify the PPP protocol in any way, it defines a new PPP packet carrier. By defining the client-server architecture, PPTP divides the functions of the network access server (NAS) and has them implemented by PPTP network server (PNS) and PPTP access concentrator (PAC). The PNS is designed to run on general operating systems. Based on the TCP/IP network, it only requires IP interfaces. The PAC typically has one or more PSTNs, ISDNs or other PPP-enabled physical interfaces.

RGOS now can be used as the PNS, that is, it accepts the PPTP tunnel initiated by the remote client. In this case, the router accepts connection requests from the remote PPTP client and negotiates with the client to establish tunnels.

Note Now the PNS is only supported on the R26, R36, SecVPN, and RSR series routers but not on the NBR1000.

Configuring the PPTP Server

Configuration Tasks

Configuring a Local Address Pool (Optional)

In order to accept the PPTP connection initiated by the remote client, the PNS must allocate an IP address to the remote client if no IP address is set for it to use internal VPN. Generally, an idle IP address in a specified address pool is allocated to the client. RGOS provides the following commands to configure the local address pool.

Command	Function
Ruijie(config)# **ip local pool** *poolname first-ip* [*last-ip*]	Creates a local address pool.
Ruijie(config)# **no ip local pool** *poolname*	Deletes a specified address pool.

poolname is the name of the local address pool to be created, *first-ip* and *last-ip* are the first and last address in the address range set for the local address pool, respectively.

Configuring User Information (Optional)

To authenticate the remote client that tries to access the local PNS, run the following command.

Command	Function
Ruijie(config)# **username** *user-name* **password** *password*	Configures the user information.
Ruijie(config)# **no username** *user-name*	Deletes the specified user.

user-name is the name of the user who is allowed to dial in, and *password* is the password of the user. The router maintains a local database that contains the user names and passwords.

Configuring VPDN Globally

Enabling/Disabling the VPDN Function

If the user requires the router to accept the PPTP access by the remote client and establish a PPTP tunnel, the VPDN function must be enabled on the router. To enable or disable the VPDN function, run the following command:

Command	Function
Ruijie(config)# **vpdn enable**	Enables the VPDN function.
Ruijie(config)# **no vpdn enable**	Disables the VPDN function.

Note that if the VPDN function is disabled, all the existing PPTP tunnels and sessions are retained, but new PPTP tunnels and sessions cannot be created.

Setting Source Address of VPDN

RGOS offers the following commands for users to set the (local) source address of the VPDN function. After the source address of VPDN is set, the destination address of the tunnel set for the remote client must match it before a PPTP tunnel can be established properly.

Command	Function
Ruijie(config)# **vpdn source-ip** *ip-address*	Sets the source address of VPDN.
Ruijie(config)# **no vpdn source-ip** *ip-address*	Cancels the set source address of VPDN.

By default, the system does not check whether the destination address in the received tunnel establishment request is a specific value.

Setting Maximum Number of VPDN Sessions

To set the maximum number of sessions allowed by the VPDN server, run the following command. Once specified, the access requests that exceed the maximum value will be denied.

Command	Function
Ruijie(config)# **vpdn session-limit sessions**	Sets the maximum number of VPDN sessions.

Ruijie(config)# **no vpdn session-limit**	Restores the maximum number of VPDN sessions to the default value.

By default, the maximum number of sessions is one configured with this command.

Setting Domain Resolution

RGOS offers the following commands for users to set the domain resolution in VPDN domain authentication. With this command configured, the domain type can be identified.

Command	Function
Ruijie(config)# **vpdn domain-delimiter** @/%#-\	Sets the domain delimiter: prefix and suffix.
Ruijie(config)# **no vpdn domain-delimiter**	Cancels the VPDN domain authentication option.

By default, the system does not resolve the domain field.

Enabling Domain Authentication

RGOS offers the following commands for users to set the VPDN domain authentication function.

Command	Function
Ruijie(config)# **vpdn authorize domain split**	Enables the domain authentication, and enables the domain split.
Ruijie(config)# **no vpdn authorize domain**	Disables the domain authentication.

By default, the system does not enable the domain authentication.

Setting VPDN Rate Limiting

RGOS offers the following commands for users to limit the rate of creating VPDN sessions, namely, to limit the number of VPDN tunnels allowed to be created at one time.

Command	Function
Ruijie(config)# **vpdn limit_rate** *rate_num*	Enables rate limiting. The *rate_num* parameter indicates the number of tunnels allowed to be created, ranging from 5 to 100.
Ruijie(config)# **no vpdn limit_rate**	Disables rate limiting.

By default, the system does not enable rate limiting.

Configuring a Virtual-Template Interface

Setting a Virtual-Template Interface

To set the virtual-template interface, run the following commands.

Command	Function
Ruijie(config)# **interface virtual-template** *number*	Creates a specified virtual -template interface.
Ruijie(config)# **no interface virtual-template** *number*	Deletes the specified virtual- template interface.

number is the sequence number of the specified virtual-template interface. The created virtual-template will act as the configuration profile of the virtual-access interface that binds and carries PPTP sessions.

Configuring VPDN Group

Setting VPDN Group

To set a VPDN group, run the followng commands:

Command	Function
Ruijie(config)# **vpdn-group** *name*	Configures a VPDN group.
Ruijie(config)# **no vpdn-group** *name*	Deletes a VPDN group.

name is the name of the VPDN group. Users can access the VPDN group to establish a tunnel.

Setting Tunneling Mode

To set the tunneling mode, run the following commands:

Command	Function
Ruijie (config-vpdn)# **accept-dialin**	Permits the remote client's access.
Ruijie (config-vpdn)# **no accept-dialin**	Denies the remote client's access.

If a user wants the local router to perform the PNS function, the user must allow the remote client to dial in.

Setting Tunneling Protocol

To set the tunneling protocol, run the following commands.

Command	Function
Ruijie(config-vpdn-acc-in)# **protocol** {**any** | **l2tp** | **pptp**}	Sets the tunneling protocol.
Ruijie(config-vpdn-acc-in)# **no protocol**	Cancels the set tunneling protocol.

The tunneling mode must be set before the tunneling protocol is set. To make the local router perform the PNS function, the user must run the **protocol pptp** or **protocol any** command.

Setting Virtual Template to Be Used

To set a virtual template used by a VPDN group, run the following commands.

Command	Function
Ruijie(config-vpdn-acc-in)# **virtual-template** *number*	Sets a virtual template to be used.
Ruijie(config-vpdn-acc-in)# **no virtual-template**	Cancels the virtual template in use.

The tunneling mode must be set first before a virtual template used by a VPDN group is set.

Setting the Name of the Remote Peer

If the name of the remote client has been set, this VPDN group is effective only for the remote client that matches the host name. If not, this VPDN group will become the default VPDN group of the system, and can provide the VPDN service for any remote client. If the name of remote client is not configured for any VPDN group, the system will use the first found VPDN group that matches conditions to accept access from a remote dial-in user.

Command	Function
Ruijie(config-vpdn)# **terminate-from hostname** *name*	Sets the name of the remote host.
Ruijie(config-vpdn)# **no terminate-from**	Cancels the set name of the remote host.

name indicates the name of the remote host.

Setting Local Name

To set the local name, run the following commands. This name will be sent to the remote peer as a record property.

Command	Function
Ruijie(config-vpdn)# **local name** *name*	Sets the local name.
Ruijie(config-vpdn)# **no local** *name*	Cancels the set local name.

name indicates the local name. By default, RGOS uses the name of the router as the local name and sends it to the remote host of the tunnel.

Setting Source Address of VPDN group

To set the source address of a VPDN group, run the following commands. Only when the destination address in the tunnel establishment request sent by the remote client matches it, will the corresponding VPDN group apply.

Command	Function
Ruijie(config-vpdn)# **source-ip** *src-ip*	Sets the source address of a VPDN group.
Ruijie(config-vpdn)# **no source-ip**	Cancels the set source address of a VPDN group.

Setting PPTP Flow Control Parameters

To set the PPTP flow control parameters, run the following commands. In general application, the default value of this parameter can be used.

Command	Function
Ruijie(config-vpdn)# **pptp flow-control receive-window winsize**	Sets the size of the receive window of the PPTP session. The value range is 1 to 64
Ruijie(config-vpdn)# **no pptp flow-control receive-window**	Cancels the set size of the receive window of the PPTP session and restores to the default value. PAC is 16, and PNS is 64
Ruijie(config-vpdn)# **pptp flow-control** *static-rtt interval*	Sets the static reference time of waiting for ACK on receiving/sending PPTP session packets. The value range is 100 to 5000 (in milliseconds).

Command	Function
Ruijie(config-vpdn)# **no pptp flow-control**	Cancels the set static reference time of waiting for ACK on receiving/sending PPTP session packets, and restore to the default value 1500 milliseconds.

winsize is the size of the receive window of the PPTP session, and *interval* is the static reference time of waiting for an ACK message.

Setting PPTP Tunnel Parameters

To set the PPTP tunnel parameters, run the following commands. In general application, the default value of this parameter can be used.

Command	Function
Ruijie(config-vpdn)# **pptp tunnel echo** *interval*	Sets the time interval at which the PPTP tunnel actively sends echo messages. The value range is 0 to 1000 (in seconds).
Ruijie(config-vpdn)# **no pptp tunnel echo**	Cancels the set interval of sending PPTP echo messages, and restore to the default value 60 seconds.

interval is the time interval at which the PPTP tunnel actively sends ECHO messages. Value **0** indicates that the tunnel does not actively send ECHO messages. The values other than **0** indicates that the tunnel actively sends ECHO messages to detect the tunnel status after it does not receive any valid packet from the remote end of the tunnel within this time interval.

Setting the Supported Domain Name

To set the domain name, run the following commands. After the domain authentication is enabled, this command will take effect. Only the domain matching the content of this command can be identified. If the domain does not match the content of this command, another VPDN group will be used for matching. If no matched group is found, the authentication will fail.

Command	Function
Ruijie(config-vpdn)# **domain** *domain-name* **vrf** *vrf-name*	Sets the authentication domain name and the corresponding VRF instance.
Ruijie(config-vpdn)# **no pool**	Removes the domain setting.

domain-name is the name of a domain, and *vrf-name* is the name of a VRF instance.

Binding a Domain Name to an Address Pool

To bind a domain name to an address pool, run the following command in vpdn-domain configuration mode. The domain name is verified during the process of VPDN tunnel negotiation to obtain the address pool binding information configured with this command. After the PPP negotiation is successful, the specified address pool will be used to assign an address to the peer end of the tunnel. By default, the address is assigned by the address pool configured in the virtual-template interface.

Command	Function
Ruijie(config-vpdn)# **domain** *domain-name* **vrf** *vrf-name* Ruijie(config-vpdn-domain)# **pool** *pool-name*	Sets the address pool bound to the authentication domain name.

Ruijie(config-vpdn)# **no domain** *domain-name*	Removes address pool binding.

domain-name is the name of a domain, *vrf-name* is the name of a VRF instannce and *pool-name* is the name of an address pool.

Setting the DNS Negotiation Address for Binding PPP to the Domain Name

To set the DNS negotiation address of PPP through domain name matching, run the following command in vpdn-domain configuration mode. By default, the DNS address of PPP configured in the virtual-template interface is used for negotiation.

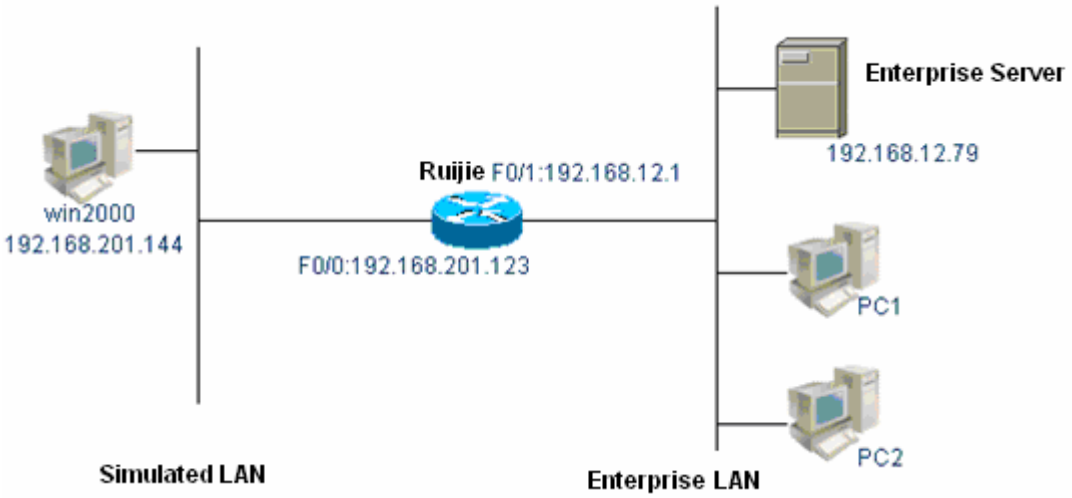
Command	Function
Ruijie(config-vpdn)# **domain** *domain-name* **vrf** *vrf-name* Ruijie(config-vpdn-domain)#**dns** *A.B.C.D A.B.C.D*	Sets the DNS negotiation address of PPP bound to the authentication domain name.
Ruijie(config-vpdn)# **no dns**	Removes DNS binding.

domain-name is the name of a domain, *vrf-name* is the name of a VRF instance and *A.B.C.D* is the address of the DNS.

Configuration Examples

The network topology in this example is shown in the following figure. The Ruijie router is used as the gateway of the corporate LAN, and the PPTP protocol is used to provide the VPDN dial-in service. Use a Windows 2000 PC as the VPDN remote client to create a PPTP tunnel to the router and access the server in the corporate LAN. To reduce testing complexity, use Ethernet to simulate the IP WAN between the remote client and R3660. The IP addresses are configured as shown in the following diagram.

Figure 17 Using a router as the PNS



The configurations of R3660 and Windows 2000 PC are respectively described as follows:

15) Configuration of R3660:

```
Ruijie# show running-config
Building configuration...
Current configuration : 1053 bytes
```

```
!
enable password 1
!
vpdn enable
!
vpdn-group pptp
! Default PPTP VPDN group
accept-dialin
protocol pptp
virtual-template 1
!
username pc password 0 1111
!
ip local pool pptp 1.1.1.2 1.1.1.254
interface FastEthernet 0/0
ip address 192.168.201.123 255.255.255.0
duplex auto
speed auto
!
interface FastEthernet 0/1
ip address 192.168.12.1 255.255.255.0
duplex auto
speed auto
!
interface Virtual-Template 1
ppp authentication pap
ip unnumbered FastEthernet 0/1
peer default ip address pool pptp
!
ip route 0.0.0.0 0.0.0.0 FastEthernet0/0
!
line con 0
session-timeout 0
escape-character 29
line aux 0
session-timeout 0
escape-character 29
password 1
line vty 0
login
terminal-type ANSI
escape-character 29
line vty 1 4
login
escape-character 29
```

```
!
!
end
Ruijie#
```

16) Configuration of the Windows 2000 PC:

```
F:\>ver
Microsoft Windows 2000 [Version 5.00.2195]
F:\>ipconfig /all
Windows 2000 IP Configuration
  Host Name . . . . . . . . . . . . : topding
  Primary DNS Suffix . . . . . . . :
  Node Type . . . . . . . . . . . . : Hybrid
  IP Routing Enabled. . . . . . . . : Yes
  WINS Proxy Enabled. . . . . . . . : No
Ethernet adapter local connection:
  Connection-specific DNS Suffix . :
  Description . . . . . . . . . . . : STAR 901 Family Fast Ethernet
r (ACPI)
  Physical Address. . . . . . . . . : 00-D0-F8-00-68-E5
  DHCP Enabled. . . . . . . . . . . : No
  IP Address. . . . . . . . . . . . : 192.168.201.144
  Subnet Mask . . . . . . . . . . . : 255.255.255.0
  Default Gateway . . . . . . . . . : 192.168.201.123
  DNS Servers . . . . . . . . . . . : 202.101.143.141
  Primary WINS Server . . . . . . . : 192.168.9.7
F:\>route print
===========================================================
Interface List
0x1 ........................... MS TCP Loopback interface
0x2 ...00 d0 f8 00 68 e5 ...... PCI Bus Master Adapter
===========================================================Active Routes:
Network Destination Netmask Gateway  Interface Metric
  0.0.0.0    0.0.0.0 192.168.201.123 192.168.201.144   1
  127.0.0.0   255.0.0.0  127.0.0.1  127.0.0.1    1
192.168.201.0  255.255.255.0 192.168.201.144 192.168.201.144  1
192.168.201.144  255.255.255.255  127.0.0.1  127.0.0.1    1
192.168.201.255  255.255.255.255 192.168.201.144 192.168.201.144  1
224.0.0.0     224.0.0.0 192.168.201.144 192.168.201.144   1
255.255.255.255  255.255.255.255 192.168.201.144 192.168.201.144  1
Default Gateway:  192.168.201.123
===========================================================
Persistent Routes:
None
```

Double-click **Network and Dial-up Connections** on the Windows 2000 PC to create a network connection. Select **Connect to a private network through the Internet** for **Network connection type**, select **Do not dial initial**

connection for **Public network**, and fill in the destination address 192.168.201.123. Name this connection as Vpdnconnect. On the page for setting the properties of Vpdnconnect, use PPTP as the VPDN server type, and define the PAP authentication and optional encryption in the security settings. After you click **Dial**, enter the user name **PC** and password **1111** configured in the router.

Upon completion of configuration, the Windows 2000 PC can access the server, for exmaple, the server with the IP address as 192.168.12.79, in the corporate intranet after dialing in the router, as shown below:

```
F:\>ipconfig /all
Windows 2000 IP Configuration
  Host Name . . . . . . . . . . . . : testpc
  Primary DNS Suffix . . . . . . . :
  Node Type . . . . . . . . . . . . : Hybrid
  IP Routing Enabled. . . . . . . . : Yes
  WINS Proxy Enabled. . . . . . . . : No
Ethernet adapter local connection:
  Connection-specific DNS Suffix . :
  Description . . . . . . . . . . . : STAR 901 Family Fast Ethernet Adapte
r (ACPI)
  Physical Address. . . . . . . . . : 00-D0-F8-00-68-E5
  DHCP Enabled. . . . . . . . . . . : No
  IP Address. . . . . . . . . . . . : 192.168.201.144
  Subnet Mask . . . . . . . . . . . : 255.255.255.0
  Default Gateway . . . . . . . . . :
  DNS Servers . . . . . . . . . . . : 202.101.143.141
  Primary WINS Server . . . . . . . : 192.168.9.7
PPP adapter vpn_RGOS:
  Connection-specific DNS Suffix . :
  Description . . . . . . . . . . . : WAN (PPP/SLIP) Interface
  Physical Address. . . . . . . . . : 00-53-45-00-00-00
  DHCP Enabled. . . . . . . . . . . : No
  IP Address. . . . . . . . . . . . : 1.1.1.4
  Subnet Mask . . . . . . . . . . . : 255.255.255.255
  Default Gateway . . . . . . . . . : 192.168.12.1
  DNS Servers . . . . . . . . . . . :
F:\>
F:\>route print
===========================================================================
Interface List
0x1 ........................... MS TCP Loopback interface
0x2 ...00 d0 f8 00 68 e5 ...... PCI Bus Master Adapter
0x30000004 ...00 53 45 00 00 00 ...... WAN (PPP/SLIP) Interface
===========================================================================
Active Routes:
Network Destination  Netmask   Gateway  Interface Metric
   0.0.0.0   0.0.0.0  192.168.12.1   1.1.1.4  1
```

```
  1.1.1.4 255.255.255.255  127.0.0.1  127.0.0.1  1
 1.255.255.255 255.255.255.255  1.1.1.4  1.1.1.4  1
  127.0.0.0  255.0.0.0  127.0.0.1  127.0.0.1  1
 192.168.201.0 255.255.255.0 192.168.201.144 192.168.201.144  1
 192.168.201.123 255.255.255.255 192.168.201.144 192.168.201.144  1
 192.168.201.144 255.255.255.255  127.0.0.1  127.0.0.1  1
 192.168.201.200 255.255.255.255 192.168.201.100 192.168.201.144  1
 192.168.201.255 255.255.255.255 192.168.201.144 192.168.201.144  1
  224.0.0.0  224.0.0.0  1.1.1.4   1.1.1.4  1
  224.0.0.0  224.0.0.0 192.168.201.144 192.168.201.144  1
 255.255.255.255 255.255.255.255 192.168.201.144 192.168.201.144 1
Default Gateway:  192.168.12.1
===========================================================================
Persistent Routes:
 None
F:\>
F:\>ping 192.168.12.1
Pinging 192.168.12.1 with 32 bytes of data:
Reply from 192.168.12.1: bytes=32 time<10ms TTL=255
Reply from 192.168.12.1: bytes=32 time<10ms TTL=255
Reply from 192.168.12.1: bytes=32 time<10ms TTL=255
Reply from 192.168.12.1: bytes=32 time<10ms TTL=255
Ping statistics for 192.168.12.1:
 Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
 Minimum = 0ms, Maximum = 0ms, Average = 0ms
F:\>ping 192.168.12.79
Pinging 192.168.12.79 with 32 bytes of data:
Reply from 192.168.12.79: bytes=32 time=10ms TTL=127
Reply from 192.168.12.79: bytes=32 time<10ms TTL=127
Reply from 192.168.12.79: bytes=32 time<10ms TTL=127
Reply from 192.168.12.79: bytes=32 time<10ms TTL=127
Ping statistics for 192.168.12.79:
 Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
 Minimum = 0ms, Maximum = 10ms, Average = 2ms
```

The routing information on the router is shown below:

```
Ruijie#sh ip route
Codes: C - connected, S - static, R - RIP
  O - OSPF, IA - OSPF inter area
  E1 - OSPF external type 1, E2 - OSPF external type 2
Gateway of last resort is 0.0.0.0 to network 0.0.0.0
  1.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C  1.1.1.0/24 is directly connected, Virtual-Access1
```

```
C  1.1.1.4/32 is directly connected, Virtual-Access1
C 192.168.12.0/24 is directly connected, FastEthernet0/1
C 192.168.201.0/24 is directly connected, FastEthernet0/0
S* 0.0.0.0/0 is directly connected, FastEthernet0/0
Ruijie#
```

Note that in order to enable remote VPDN users to access the intranet servers, routes to these users must be configured on the servers. Generally, you can simply set the default gateway of these servers to the internal gateway address of the router, which is 192.168.12.1 in this example.

Monitoring and Maintaining PPTP

Monitoring PPTP

To query the information about currently created tunnels and remote dial-in users, run the **show vpdn** command.

Command	Function
Ruijie# **show vpdn tunnel**	Displays information about all the existing VPDN tunnels.
Ruijie# **show vpdn session**	Displays information about all the existing VPDN sessions.
Ruijie# **show vpdn**	Displays information about all the existing VPDN tunnels and sessions.

In the configuration example, the following information can be viewed:

```
Ruijie# sh vpdn
%No active L2TP tunnels
PPTP Tunnel and Session Information Total tunnels 1 sessions 1
LocID Remote Name  State  Remote Address Port Sessions
1      estbed  192.168.201.144 1436 1
LocID RemID TunID Intf Username  State  Last Chg
1  49152 1  Vi1  pc   connected 00:31:33
Ruijie#
```

Information about the L2TP and PPTP tunnels and sessions are displayed by category. The tunnel type and statistical values are displayed first, and all the tunnel and session information is displayed later . Statistical values of the tunnels and sessions: Total tunnels 1 sessions 1. The tunnel information includes tunnel ID (LocID), remote host name (Remote Name), tunnel state (State), IP address of the remote host (Remote Address), TCP port number of the PPTP tunnel (Port), number of sessions in this tunnel (Sessions). The session information about the local call ID (LocID), remote call ID (RemID), the ID of the tunnel to which this session belongs (TunID), name of the Virtual-Access interface used by this session (Intf), user name (Username), session state (State), and the time of last state change (Last Chg).

To view detailed tunnel information, run the **show vpdn tunnel pptp** *locid* command. In this example, the following information can be viewed:

```
R3660# show vpdn tunnel pptp 1
PPTP tunnel id 1 is up, remote id is 0, 1 active session
Tunnel state is estbed
Remote tunnel name is
Internet Address 192.168.201.144, port 1436
Local tunnel name is
Internet Address 192.168.201.123
```

The command output contains the tunnel status, name of the peer user, peer IP address, local host name, and local IP address.

Maintaining PPTP

RGOS provides the **clear vpdn** command to clear the specified tunnel and all its sessions.

Command	Function
Ruijie**# clear vpdn tunnel** [[**l2tp** | **pptp**] [*remote name*]]	Clears all the tunnels or the tunnel of the specified type and with the specified remote host name, and all their or its sessions.

remote name is the remote host name for which the tunnel should be cleared. In the configuration example, if **clear vpdn tunnel pptp** or **clear vpdn tunnel** is used after a tunnel is created, the session and the tunnel will be cleared. The command output is as follows:

```
Ruijie# show vpdn
%No active L2TP tunnels
%No active PPTP tunnels
```

During network debugging, you can run the **debug vpdn** command to track the establishment process of PPTP tunnels and sessions. In addition, the debugging information obtained by using the **debug ppp** command is extremely important for tracking call failures. For details, refer to description of the PPP protocol.

Command	Function
Ruijie**# debug vpdn** { **error** | **event** | **packet** }	Displays the debugging information during creation and use of the VPDN tunnel and session on the configuration terminal. **Error** indicates error information, **Event** indicates a general event, and **Packet** indicates the content in the control packet.

Note The debugging information may vary slightly with the RGOS software version.

During creation of PPTP tunnels and sessions, the **debug vpdn event** command outputs the following information:

```
VPDN: Pptp recv start-control-connection-request from host 192.168.200.114
PPTP: New tunnel socket id =9
VPDN: Pptp get tunnel info for 192.168.200.114 ok!
VPDN: Pptp send start-control-connection-reply, ok
VPDN: Pptp tunnel id 0 state change: idle --> estbed
PPTP: Add send-echo-request timer, interval = 60
```

```
VPDN: Pptp tunnel id 0 recv outgoing-call-request!
Pptp: Tunnel to 192.168.200.114 get config para. from vpdn-group pptp!
VPDN: Must process using ACCEPT_DIALIN parameters
Pptp: Session va0 get config para. from vpdn-group pptp!
VPDN: Pptp session va0 state change: idle --> connected
PPTP: Receive outcall request,process ok!assign local call id = 1
VPDN: Pptp tunnel id 0 send out-call reply
%LINK CHANGED: Interface virtual-access 0, changed state to up
VPDN: Pptp tunnel to 192.168.200.114 peer callid 1 recv set-linkinfo
VPDN: Pptp tunnel to 192.168.200.114 peer callid 1 recv set-linkinfo
%LINE PROTOCOL CHANGE: Interface virtual-access 0, changed state to UP
```

During creation of PPTP tunnels and tunnels, the **debug vpdn packet** command outputs the following information:

```
PPTP: I Start-Control-Connection-Request len 156 Magic Cookie 0x1A2B3C4D
   Protocol Version 0x100
   Framing Type 0x1
   Bearer Type 0x1
   Maximum Channels 0x0
   Firmware Revision 0x893
   Host Name:
   Vendor String: Microsoft Windows NT
PPTP: O Start-Control-Connection-Reply len 156 Magic Cookie 0x1A2B3C4D
   Protocol Version 0x100
   Framing Type 0x2
   Bearer Type 0x3
   Maximum Channels 0x0
   Firmware Revision 0x100
   Host Name: Dingjs
   Vendor String: Ret-Giant Network Operating System
PPTP: I Outgoing-Call-Request len 168 Magic Cookie 0x1A2B3C4D
   Call Id 0x4000
   Call Serial Number 0x96A5
   Min BPS 0x12C
   Max BPS 0x5F5E100
   Bearer Type 0x3
   Framing Type 0x3
   Rec Window Size 0x40
   Proc Delay 0x0
   Phone Number Length 0x0
   Phone Number:
   Subaddress:
PPTP: O Outgoing-Call-Reply len 32 Magic Cookie 0x1A2B3C4D
   Call Id 0x1
   Peer Call Id 0x4000
   Result Code 0x1
```

```
   Error Code 0x0
   Cause Code 0x0
   Connect Speed 0xFA00
   Rec Window Size 0x10
   Physical Channel Id 0x0
PPTP: I Set-Link-Info len 24 Magic Cookie 0x1A2B3C4D
   Peer Call Id 0x1
   Send ACCM 0xFFFFFFFF
   Recv ACCM 0xFFFFFFFF
%UPDOWN: Interface Virtual-Access1, changed state to up
Vi1 VPDN PROCESS Into tunnel: Sending 54 byte pak
Vi1 VPDN PROCESS Into tunnel: Sending 64 byte pak
Vi1 VPDN PROCESS Into tunnel: Sending 50 byte pak
PPTP: I Set-Link-Info len 24 Magic Cookie 0x1A2B3C4D
   Peer Call Id 0x1
   Send ACCM 0xFFFFFFFF
   Recv ACCM 0xFFFFFFFF
Vi1 VPDN PROCESS Into tunnel: Sending 45 byte pak
Vi1 VPDN PROCESS Into tunnel: Sending 46 byte pak
Vi1 VPDN PROCESS Into tunnel: Sending 187 byte pak
Vi1 VPDN PROCESS Into tunnel: Sending 56 byte pak
Vi1 VPDN PROCESS Into tunnel: Sending 64 byte pak
Vi1 VPDN PROCESS Into tunnel: Sending 50 byte pak
Vi1 VPDN PROCESS Into tunnel: Sending 50 byte pak
Vi1 VPDN PROCESS Into tunnel: Sending 52 byte pak
```

If the physical connection with the client is interrupted, output of the **debug vpdn error** command is as follows:

```
VPDN: PPTP session Virtual-Access1 wait pak ack timeout(wait seq=37, ack=36), de
crease send window to half of current = 33!
VPDN: PPTP session Virtual-Access1 adjust ATO to 220 ms!
VPDN: PPTP session Virtual-Access1 wait pak ack timeout(wait seq=38, ack=36), de
crease send window to half of current = 16!
VPDN: PPTP session Virtual-Access1 adjust ATO to 280 ms!
VPDN: PPTP session Virtual-Access1 wait pak ack timeout(wait seq=39, ack=36), de
crease send window to half of current = 8!
VPDN: PPTP session Virtual-Access1 adjust ATO to 400 ms!
VPDN: Pptp EGRE encap fail, err=-4!
VPDN: PPTP session Virtual-Access1 wait pak ack timeout(wait seq=40, ack=36), de
crease send window to half of current = 4!
VPDN: PPTP session Virtual-Access1 adjust ATO to 640 ms!
```

FAQs

The following gives an FAQ about VPDN access over PPTP.

Suppose a PPTP dial-up connection is created on a Windows 2000 PC.

When setting the properties of the new dial-up connection, set **Security measure options** to **Advanced (user-defined setting) (D)**, set **Data encryption** to **Optional encryption (connect even if no encryption available)** on the **Setting** tab page, and allow PAP, CHAP and MS-CHAP authentication according to the authentication type configured in virtual-template that RGOS uses for PPTP dial-in. Additionally, **VPN server type** on the **Network** tab page is set to **Automatic**. After this setting, the Windows 2000 PC will try to create an L2TP tunnel before it creates a PPTP tunnel. This takes a long time. Therefore, you can set **VPN server type** to **Point-to-Point Tunneling Protocol (PPTP)**. As a result, a PPTP tunnel is directly created without an attempt to creating an L2TP tunnel.

When the RGOS router is located behind other firewalls, the TCP port 1723 of the firewall must be enabled.

Configuring L2TP

Overview

The Layer 2 Tunnel Protocol (L2TP), as specified in RFC 2661, is a standard tunneling protocol that Internet Engineering Task Force (IETF) proposes by combining two existing tunneling protocols, namely, Cisco Layer 2 Forwarding (L2F) protocol and Microsoft Point-to-Point Tunneling Protocol (PPTP).

L2TP, an extension of the Point-to-Point Protocol (PPP), implements user authentication and data transmission using PPP. Different from PPTP, L2TP uses UDP as the transmission protocol for control and data messages.

L2TP is also an important and effective way to implement VPN. VPN allows network users to access the enterprise intranet more conveniently and securely, no matter whether the users access the network in dial-up mode or in other modes.

RGOS supports L2TP tunnels in two modes.

- L2TP tunnel initiated by the local client: In this mode, the router acts as the L2TP client and actively initiates negotiation with the L2TP server to establish a tunnel.
- L2TP tunnel initiated by the remote client: In this mode, the router accepts a connection request from the remote L2TP client and negotiates with it to establish a tunnel.


Note

Both modes are supported on the R26, R36, and SecVPN platforms, but the NBR platform supports only L2TP tunnel initiated by the local client.

Initiation by the Local Client

Configuration Task List

- Creating and configuring an L2TP-class interface (optional)
- Creating and configuring a pseudowire-class interface (optional)
- Creating and configuring a virtual-ppp interface (mandatory)

Creating and Configuring an L2TP-class Interface

This is an optional step for establishing an L2TP tunnel initiated by the local client. In this step, you can set the parameters for the L2TP control connection. The operations of configuring an L2TP-class interface include:

- Setting an L2TP-class unit
- Setting time for the L2TP control connection
- Setting authentication for the L2TP control connection
- Setting maintenance and update for the L2TP control connection

Setting an L2TP-class Unit

Use the following commands to set an L2TP-class unit for setting parameters for the L2TP control connection.

Command	Function
Ruijie(config)# **l2tp-class** *l2tp-class-name*	Configures or creates an L2TP-class interface of the specified name.
Ruijie(config)# **no l2tp-class** *l2tp-class-name*	Deletes an L2TP-class interface of the specified name.

l2TP-class-name is the name of the created or set L2TP-class unit. The L2TP-class interface created here can be referenced by the pseudowire-class interface by name.

Setting Time for the L2TP Control Connection

Use the following commands to set time for the L2TP control connection.

Command	Function
Ruijie(config-l2tp-class)# **receive-window** *size*	Sets the size of the receiving window of the control connection.
Ruijie(config-l2tp-class)# **no receive-window**	Restores the default size of the receiving window of the control connection.
Ruijie(config-l2tp-class)# **retransmit** {**initial** {**retries** *initial-retries* | **timeout** {**max** | **min**} *initial-timeout*} | **retries** *retries* | **timeout** {**max** | **min**} *timeout*}	Sets retransmission of the control connection.
Ruijie(config-l2tp-class)# **no retransmit** { **initial** {**retries** | **timeout** {**max** | **min**} }| **retries** | **timeout** {**max** | **min**} }	Restores default retransmission setting of the control connection.
Ruijie(config-l2tp-class)# **timeout setup** *seconds*	Sets the timeout period for establishing a control connection.
Ruijie(config-l2tp-class)# **no timeout setup**	Restores the default timeout period for establishing a control connection.

size is the size of the receiving window, and the default value is 8.

initial-retries is the number of SCCRQ retransmission times, and the default value is 2.

initial-timeout is the interval of SCCRQ retransmission. The default minimum interval is 1 second, and the default maximum interval is 8 seconds.

retries is the number of retransmission times of control messages, and the default value is 5.

timeout is the interval of control message retransmission. The default minimum interval is 1 second, and the default maximum interval is 8 seconds.

seconds is the upper limit of time for establishing a control connection (tunnel), and the default value is 120 seconds.

Setting Authentication for the L2TP Control Connection

Use the following commands to set authentication for the L2TP control connection (tunnel).

Command	Function
Ruijie(config-l2tp-class)# **authentication**	Enables authentication.
Ruijie(config-l2tp-class)# **no authentication**	Disables authentication.
Ruijie(config-l2tp-class)# **no hostname**	Uses the default local host name.
Ruijie(config-l2tp-class)# **hostname** *host-name*	Sets the local host name corresponding to this control connection.
Ruijie(config-l2tp-class)# **password** *pass-words*	Sets the tunnel password.
Ruijie(config-l2tp-class)# **no password**	Cancels the tunnel password.

RGOS does not require tunnel authentication by default, but uses the name of the router as the local host name. If tunnel authentication is required, both ends must use the same tunnel password. *host-name* is the local host name set by users, and *pass-words* is the password used for tunnel authentication.

Setting Maintenance and Update for the L2TP Control Connection

Use the following commands to set maintenance and update for the control connection (tunnel).

Command	Function
Ruijie(config-l2tp-class)# **hello** *interval*	Sets the interval of sending Hello messages.
Ruijie(config-l2tp-class)# **no hello**	Restores the default interval of sending Hello messages.

Here, *interval* is the interval of sending Hello messages. Its default value is 60 seconds.

Creating and Configuring a Pseudowire-class Interface

This is an optional step for establishing an L2TP tunnel initiated by the local client. In this step, you can set L2TP data transmission parameters. The operations of setting a pseudowire-class interface include:

- Setting a pseudowire-class unit
- Setting the encapsulation mode for L2TP data transmission
- Setting IP parameters for L2TP data transmission
- Setting the L2TP control connection

Setting a Pseudowire-class Unit

Use the following commands to set a pseudowire-class unit for seting L2TP data transmission parameters.

Command	Function
Ruijie(config)# **pseudowire-class** *pseudowire-class-name*	Creates or configures a pseudowire-class interface of the specified name.
Ruijie(config)# **no pseudowire-class** *pseudowire-class-name*	Deletes the pseudowire-class interface of the specified name.

pseudowire-class-name is the name of the created or set pseudowire-class unit. Here, the created pseudowire-class interface can be referenced by the peudowire rule of the virtual-ppp interface by name.

Setting the Encapsulation Mode for L2TP Data Transmission

Use the following command to set the encapsulation mode for L2TP data transmission.

Command	Function
Ruijie (config-pw-class)# **encapsulation l2tpv2**	Sets the encapsulation mode for L2TP data transmission.

Note that once the encapsulation mode is set for data transmission in L2TP channels, it cannot be changed. If a user needs to set L2TP data transmission parameters on the peudowire-class interface, the user must first set the encapsulation mode for L2TP data transmission.

Setting IP Parameters for L2TP Data Transmission

Use the following commands to set IP parameters for L2TP data transmission.

Command	Function
Ruijie (config-pw-class)# **ip dfbit set**	Disables channel data fragmentation.
Ruijie (config-pw-class)# **no ip dfbit set**	Enables channel data fragmentation.
Ruijie (config-pw-class)# **ip ttl** *ttl-value*	Sets TTL for the IP header of the channel.
Ruijie (config-pw-class)# **no ip ttl**	Restores the default TTL.
Ruijie (config-pw-class)# **ip local interface** *interface-name*	Specifies the local interface (address) of the channel.
Ruijie(config-pw-class)# **no ip local interface** *interface-name*	Cancels the specified local interface (address) of the channel.

Setting IP parameters for L2TP data transmission actually means setting the IP header of the UDP data that carries L2TP. The system allows channel data fragmentation by default. The default TTL is 255, and the system will set the nearest local address (interface) in the route for it based on the specified peer address.

Setting the L2TP Control Connection

Use the following commands to set the L2TP control connection.

Command	Function
Ruijie(config-pw-class)# **protocol l2tpv2** [*l2tp-class-name*]	Sets the L2TP control connection parameter.
Ruijie(config-pw-class)# **no protocol**	Use the default control connection parameter.

Here, **l2tpv2** creates a control connection in compliance with the L2TP protocol specified in the RFC 2661. *l2TP-class-name* is set to an existing L2TP-class interface to limit the control connection parameter. If no L2TP-class interface is available, the default L2TP control connection parameter is used.

Creating and Configuring a Virtual-ppp Interface

This is a mandatory step for establishing an L2TP tunnel initiated by the local client. A specified L2TP session will be created in this step. The operations of setting a virtual-ppp interface include:

- Setting a virtual-ppp interface

- Setting the IP address
- Setting authentication
- Setting the pseudowire rule

For information about setting the IP address and authentication parameter, see related sections in the interface configuration guide.

Setting a Virtual-ppp Interface

Use the following commands to set a virtual-ppp interface for establishing an L2TP session.

Command	Function
Ruijie(config)# **interface virtual-ppp** *number*	Creates or configures a specified virtual-ppp interface.
Ruijie(config)# **no interface virtual-ppp** *number*	Deletes the specified virtual-ppp interface.

number is the name of the specified virtual-ppp interface. The created virtual-ppp interface will be used to create and bind an L2TP session.

Setting the Pseudowire Rule

Use the following commands to set the pseudowire rule on the virtual-ppp interface for establishing an L2TP session.

Command	Function
Ruijie (config-if)# **pseudowire** *peer-ip-address vcid* {**encapsulation l2tpv2** [**pw-class** *pw-class-name*] | **pw-class** *pw-class-name* }	Sets the pseudowire rule.
Ruijie (config-if)# **no pseudowire**	Deletes the pseudowire rule.

Once the pseudowire rule is set on a virtual-ppp interface, the virtual-ppp interface will automatically attempt to establish an L2TP session with the specified LNS. If a failure occurs, the virtual-ppp interface will attempt to establish an L2TP session 10 seconds later again. Here, *peer-ip-address* is the address of the remote LNS, *vcid* is the global ID, and *pw-class-name* is the name of the referenced pseudowire-class interface.

You can set an L2TP session with the specified LNS name when the DNS service is enabled. Our products support only the DNS client service, and the name of specified LNS must be registered on the DNS server.

Command	Function
Ruijie (config-if)# **pseudowire** *peer-ip-address vcid* {**encapsulation l2tpv2** [**pw-class** *pw-class-name*] | **pw-class** *pw-class-name* }	Sets the pseudowire rule.
Ruijie (config-if)# **no pseudowire**	Deletes the pseudowire rule.

Once the pseudowire rule is set on a virtual-ppp interface, the virtual-ppp interface will automatically attempt to establish an L2TP session with the specified LNS. If a failure occurs, the virtual-ppp interface will attempt to establish an L2TP session 10 seconds later again. Here, *peer-hostname* is the hostname of the remote LNS. Ruijie DNS will convert this hostname to a specific IP address (note that the hostname must be registered on the DNS server). *vcid* is the global ID, and *pw-class-name* is the name of the referenced pseudowire-class interface.

Setting the VRF Attribute

Use the following commands to set the VRF attribute on the virtual-ppp interface for establishing an L2TP session.

Command	Function
Ruijie(config-Virtual-ppp 1)# **vpdn vrf** *vrf-name*	Sets the name of the VRF to which L2TP tunnel packets belong.
Ruijie(config-Virtual-ppp 1)**#no vpdn vrf**	Deletes the VRF attribute configuration.

The command for setting the VRF attribute is generally used together with the **ip vrf forward** command of an interface. Once the VRF attribute is configured on the virtual-ppp interface, the encapsulated packets will be sent to the specified VRF. If the VRF of the interface is different from that of the tunnel, the VRF attribute of packets changes before and after encapsulation, implementing VRF spanning.

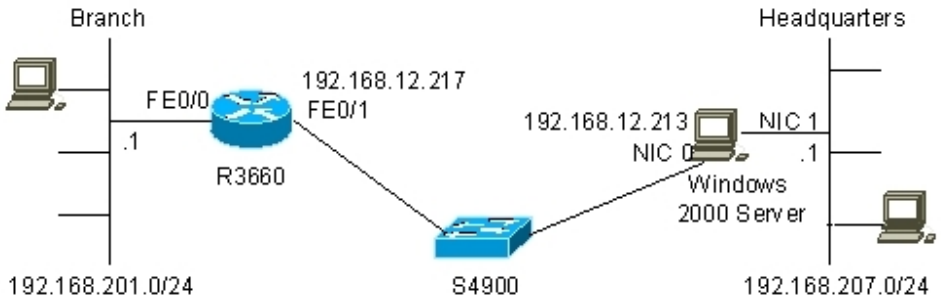
Configuration Examples

Two configuration examples are given below. In one configuration example, The Windows 2000 server is used as the remote L2TP server, and the tunnel authentication is not performed due to limitations of the Windows 2000 server. In the other configuration example, Cisco 2620 is used as the L2TP server, and tunnel authentication is performed.

Establishing a Tunnel with the Windows 2000 Server

Figure 18 shows the networking topology of the L2TP tunnel established by using Ruijie router and the Windows 2000 server.

Figure 18 Networking topology of the L2TP tunnel established by using the Windows 2000 server (LNS)



The configurations of the R3660 and Windows 2000 server are respectively described as follows:

17) R3660 configuration:

```
R3660# show running-config
Building configuration...
Current configuration : 868 bytes
!
hostname R3660
access-list 101 permit ip any 192.168.207.0 0.0.0.255
access-list 102 deny   ip any 192.168.207.0 0.0.0.255
access-list 102 permit ip any any
!
l2tp-class l2x
```

```
hostname branch
!
pseudowire-class pw
encapsulation l2tpv2
protocol l2tpv2 l2x
ip local interface FastEthernet 0/1
!
!
!
!
!
!
interface FastEthernet 0/0
ip address 192.168.201.1 255.255.255.0
ip nat inside
duplex auto
speed auto
!
interface FastEthernet 0/1
ip address 192.168.12.217 255.255.255.0
ip nat outside
duplex auto
speed auto
!
interface Null 0
!
interface Virtual-ppp 1
pseudowire 192.168.12.213 12 pw-class pw
ppp pap sent-username rgnos password 7 072C04211A01
ip mtu 1460
ip address negotiate
ip nat outside
!
ip nat inside source list 102 interface FastEthernet0/1 overload
ip nat inside source list 101 interface Virtual-PPP1 overload
ip route 0.0.0.0 0.0.0.0 FastEthernet 0/1 192.168.12.1
ip route 192.168.207.0 255.255.255.0 Virtual-ppp 1
!
line con 0
line aux 0
line vty 0 4
!
!
end
```

In this configuration, the intranet of the branch shares (using the NAT function) the L2TP tunnel that the interface virtual-ppp 1 establishes with the headquarters, to access the intranet of the headquarters. The intranet of the branch shares (using the NAT function) the WAN interface FastEthernet 0/1 to access the Internet. Distribution of such data streams is controlled by using the access control list (ACL).

18) Configuration of the Windows 2000 server:

```
Microsoft Windows 2000 [Version 5.00.2195]
(C) Copyright 1985-2000 Microsoft Corp.
C:\>ipconfig /all
Windows 2000 IP Configuration
       Host Name . . . . . . . . . . . . : BLIZZARD
       Primary DNS Suffix  . . . . . . . :
       Node Type . . . . . . . . . . . . : Broadcast
       IP Routing Enabled. . . . . . . . : Yes
       WINS Proxy Enabled. . . . . . . . : No
Ethernet adapter local connection 2:
       Connection-specific DNS Suffix  . :
       Description . . . . . . . . . . . : NE2000 Compatible
       Physical Address. . . . . . . . . : 00-10-88-01-A5-C3
       DHCP Enabled. . . . . . . . . . . : No
       IP Address. . . . . . . . . . . . : 192.168.12.213
       Subnet Mask . . . . . . . . . . . : 255.255.255.0
       Default Gateway . . . . . . . . . : 192.168.12.1
       DNS Servers . . . . . . . . . . . : 202.101.143.141
PPP adapter RAS Server (Dial In) Interface:
       Connection-specific DNS Suffix  . :
       Description . . . . . . . . . . . : WAN (PPP/SLIP) Interface
       Physical Address. . . . . . . . . : 00-53-45-00-00-00
       DHCP Enabled. . . . . . . . . . . : No
       IP Address. . . . . . . . . . . . : 192.168.103.2
       Subnet Mask . . . . . . . . . . . : 255.255.255.255
       Default Gateway . . . . . . . . . :
       DNS Servers . . . . . . . . . . . :
C:\>route print
===========================================================================
Interface List
0x1 ........................... MS TCP Loopback interface
0x1000002 ...00 53 45 00 00 00 ...... WAN (PPP/SLIP) Interface
0x1000003 ...00 10 88 01 a5 c3 ...... Novell 2000 Adapter.
===========================================================================
Active Routes:
Network Destination       Netmask         Gateway      Interface  Metric
         0.0.0.0         0.0.0.0     192.168.12.1  192.168.12.213     1
       127.0.0.0       255.0.0.0       127.0.0.1       127.0.0.1     1
    192.168.12.0   255.255.255.0   192.168.12.213   192.168.12.213     1
  192.168.12.213  255.255.255.255       127.0.0.1       127.0.0.1     1
```

```
  192.168.12.217  255.255.255.255   192.168.12.213  192.168.12.213     1
  192.168.12.255  255.255.255.255   192.168.12.213  192.168.12.213     1
   192.168.103.2  255.255.255.255        127.0.0.1       127.0.0.1     1
   192.168.103.6  255.255.255.255    192.168.103.2    192.168.103.2    1
       224.0.0.0        224.0.0.0   192.168.12.213   192.168.12.213    1
 255.255.255.255  255.255.255.255   192.168.12.213   192.168.12.213    1
Default Gateway:    192.168.12.1
===========================================================================
Persistent Routes:
  None
C:\>
```

Note that the routing and remote access function must be enabled on the Windows 2000 server to accept the remote VPDN access. Set the access control policies (including the ACL, authentication type, IP address allocation policies, and encryption method). Default values are used here. Then, in **Network and Dial-up Connections**, click **New connection** and **Accept incoming connections** to accept the access from the remote L2TP, and set which users' L2TP access requests are accepted.

Note

On Windows 2000/XP, L2TP is bound with IPSec/IKE, which undoubtedly increases the workload of network administrators, because most L2TP clients (such as network devices from Cisco and Quidway) do not bind L2TP to IPSec/IKE. Establishing an L2TP tunnel by using a Windows 2000/XP PC is also difficult due to such binding. Fortunately, network administrators can cancel the binding by modifying the registry on Windows 2000/XP. To do so, choose **Start** > **Run**, and then enter **regedit** to open the registry editor. Find the directory **HKEY_LOCAL_MACHINE/ SYSTEM / CurrentControlSet / Services / RasMan /Parameters**. Create a double-byte value named **ProhibitIpSec** and set it to **1**. Press **F5** to refresh the registry, and finally, restart the Windows 2000. Then, network administrators do not need to consider the complicated IPSec/IKE setting when using L2TP.

L2TP tunnels of Windows 2000/XP mentioned in this document are not bound with IPSec/IKE unless otherwise specified.

The following shows how the host "DENGL-NECBOOK" of the branch accesses the Internet and the intranet of the headquarters.

```
Microsoft Windows 2000 [Version 5.00.2195]
(C) Copyright 1985-2000 Microsoft Corp.
C:\WINNT\system32>ipconfig /all
Windows 2000 IP Configuration
       Host Name . . . . . . . . . . . . : DENGL-NECBOOK
       Primary DNS Suffix  . . . . . . . :
       Node Type . . . . . . . . . . . . : Hybrid
       IP Routing Enabled. . . . . . . . : No
       WINS Proxy Enabled. . . . . . . . : No
Ethernet adapter local connection:
       Connection-specific DNS Suffix  . :
       Description . . . . . .: Realtek RTL8139(A)-based PCI Fast Ethernet Adapter
```

```
      Physical Address. . . . . . . . . : 00-10-60-75-BD-7A
      DHCP Enabled. . . . . . . . . . . : No
      IP Address. . . . . . . . . . . . : 192.168.201.78
      Subnet Mask . . . . . . . . . . . : 255.255.255.0
      Default Gateway . . . . . . . . . : 192.168.201.1
      DNS Servers . . . . . . . . . . . : 202.101.143.141
                                          202.101.98.55
C:\WINNT\system32>route print
===========================================================================
Interface List
0x1 ........................... MS TCP Loopback interface
0x1000003 ...00 10 60 75 bd 7a ...... NDIS 5.0 driver
===========================================================================
Active Routes:
Network Destination       Netmask         Gateway      Interface  Metric
        0.0.0.0          0.0.0.0   192.168.201.1  192.168.201.78    1
      127.0.0.0        255.0.0.0       127.0.0.1        127.0.0.1   1
  192.168.201.64  255.255.255.192  192.168.201.78  192.168.201.78    1
  192.168.201.78  255.255.255.255       127.0.0.1        127.0.0.1   1
 192.168.201.255  255.255.255.255  192.168.201.78  192.168.201.78    1
       224.0.0.0        224.0.0.0  192.168.201.78  192.168.201.78   1
 255.255.255.255  255.255.255.255  192.168.201.78   192.168.201.78   1
Default Gateway:   192.168.201.1
===========================================================================
Persistent Routes:
  Network Address         Netmask  Gateway Address  Metric
     192.168.2.0   255.255.255.0     192.168.1.1      1
     192.168.9.0   255.255.255.0    192.168.12.1      1
     61.154.22.0   255.255.255.0    192.168.12.1      1
C:\WINNT\system32>ping 192.168.12.1
Pinging 192.168.12.1 with 32 bytes of data:
Reply from 192.168.12.1: bytes=32 time=50ms TTL=254
Reply from 192.168.12.1: bytes=32 time=20ms TTL=254
Reply from 192.168.12.1: bytes=32 time<10ms TTL=254
Reply from 192.168.12.1: bytes=32 time=60ms TTL=254
Ping statistics for 192.168.12.1:
   Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
   Minimum = 0ms, Maximum =  60ms, Average =  32ms
C:\WINNT\system32>ping 192.168.103.2
Pinging 192.168.103.2 with 32 bytes of data:
Reply from 192.168.103.2: bytes=32 time<10ms TTL=128
Reply from 192.168.103.2: bytes=32 time<10ms TTL=128
Reply from 192.168.103.2: bytes=32 time<10ms TTL=128
Reply from 192.168.103.2: bytes=32 time<10ms TTL=128
```

```
Ping statistics for 192.168.103.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum =  0ms, Average =  0ms
C:\WINNT\system32>
```

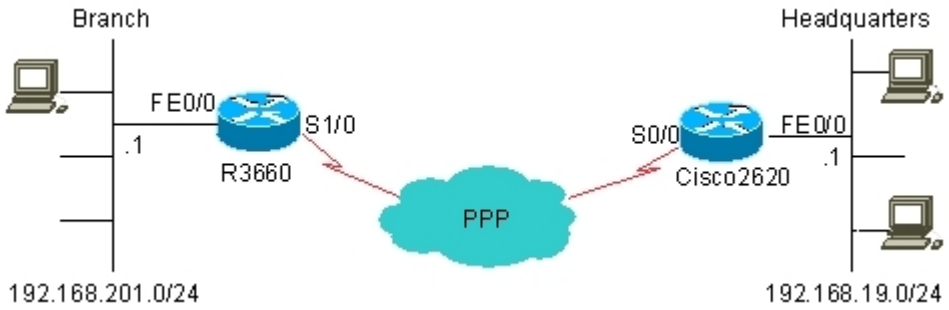
The preceding shows that the host "DENGL-NECBOOK" of the branch successfully accesses the Internet and the intranet of the headquarters. This host does not need VPDN configuration. Network administrators need to only allocate an intranet address (192.168.201.78 here) to it and set its gateway address to 192.168.201.1, which can be seen in the following information in the NAT recording node of the R3660.

```
Ruijie# show ip nat translations
Pro Inside global      Inside local        Outside local      Outside global
icmp 192.168.103.6:512  192.168.201.78:512 192.168.207.2:512  192.168.207.2:512
icmp 192.168.12.217:512 192.168.201.78:512 192.168.12.1:512   192.168.12.1:512
Ruijie# show ip route
Codes: C - connected, S - static,  R - RIP
      O - OSPF, IA - OSPF inter area
       E1 - OSPF external type 1, E2 - OSPF external type 2
Gateway of last resort is 192.168.12.1 to network 0.0.0.0
    192.168.103.0/32 is subnetted, 2 subnets
C       192.168.103.6 is directly connected, Virtual-PPP1
C       192.168.103.2 is directly connected, Virtual-PPP1
C    192.168.12.0/24 is directly connected, FastEthernet0/1
C    192.168.201.0/24 is directly connected, FastEthernet0/0
S*   0.0.0.0/0 [1/0] via 192.168.12.1, FastEthernet0/1
Ruijie#
```

Establishing a Tunnel with Cisco 2620

Figure 19 shows the networking topology of the L2TP tunnel established by using Ruijie router and Cisco 2620. Cisco 2620 acts as the L2TP network server (LNS).

Figure 19 Networking topology of the L2TP tunnel established by using Cisco 2620 (LNS)



The configurations of R3660 and Cisco 2620 are respectively described as follows:

19) R3660 configuration

```
R3660# show running-config
Building configuration...
```

```
Current configuration : 1136 bytes
!
hostname R3660
access-list 1 permit any
!
l2tp-class l2x
authentication
hostname branch
password share
!
pseudowire-class pw
encapsulation l2tpv2
protocol l2tpv2 l2x
ip local interface serial1/0
!
!
!
!
!
!
interface serial 1/0
encapsulation PPP
ip address 202.101.93.21 255.255.255.192
ip nat outside
!
interface serial 1/1
clock rate 64000
!
interface serial 1/2
clock rate 64000
!
interface serial 1/3
clock rate 64000
!
interface FastEthernet 0/0
ip address 192.168.201.1 255.255.255.0
ip nat inside
duplex auto
speed auto
!
interface FastEthernet 0/1
duplex auto
speed auto
!
interface Null 0
```

```
!
interface Virtual-ppp 1
pseudowire 202.101.93.23 7 pw-class pw
ppp pap sent-username rgnos password 7 072C04211A01
ip mtu 1460
ip address 192.168.103.3 255.255.255.0
!
router ospf
network 192.168.103.0 0.0.0.255 area 0.0.0.1
network 192.168.201.0 0.0.0.255 area 0.0.0.1
!
ip nat inside source list 1 interface Serial1/0 overload
ip route 0.0.0.0 0.0.0.0 serial 1/0
ip route 192.168.19.0 255.255.255.0 Virtual-ppp 1
!
line con 0
line aux 0
line vty 0 4
!
!
end
R3660#
```

In this configuration, the intranet of the branch shares (through route setting) the L2TP tunnel that the interface virtual-ppp 1 establishes with the headquarters, to access the intranet of the headquarters. The intranet of the branch shares (using the NAT function) the WAN interface Serial 0 to access the Internet. Distribution of such data streams is controlled by means of route setting. Users can also use the interface FastEthernet 0 as the WAN interface as required (for example, using the ADSL line as the WAN line), share this interface through NAT, and use the line connected to the interface Serial 0 for connecting to the headquarters. This configuration can be seen in the routing table and the ARP table.

```
R3660# show ip route
Codes: C - connected, S - static,  R – RIP
      O - OSPF, IA - OSPF inter area
      E1 - OSPF external type 1, E2 - OSPF external type 2
Gateway of last resort is 0.0.0.0 to network 0.0.0.0
    192.168.103.0/32 is subnetted, 2 subnets
C      192.168.103.3 is directly connected, Virtual-PPP1
C      192.168.103.2 is directly connected, Virtual-PPP1
S   192.168.19.0/24 is directly connected, Virtual-PPP1
C   192.168.201.0/24 is directly connected, FastEthernet0/0
    202.101.93.0/24 is variably subnetted, 2 subnets, 2 masks
C      202.101.93.23/32 is directly connected, Serial1/0
C      202.101.93.0/26 is directly connected, Serial1/0
S*  0.0.0.0/0 is directly connected, Serial1/0
R3660#show arp
Protocol  Address        Age (min)  Hardware Addr   Type   Interface
```

```
Internet  192.168.201.213       3   0010.8801.a5c3  ARPA   FastEthernet0/0
Internet  192.168.201.1         -   00d0.f8fb.126e  ARPA   FastEthernet0/0
R3660#
```

20) Cisco 2620 configuration

```
Cisco2620# show running-config
Building configuration...
Current configuration : 1212 bytes
!
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname Cisco2620
!
!
username 163 password 0 163
username rgnos password 0 rgnos
username 263 password 0 263
ip subnet-zero
!
!
no ip domain-lookup
!
vpdn enable
!
vpdn-group 1
! Default L2TP VPDN group
accept-dialin
protocol l2tp
virtual-template 1
l2tp tunnel password 7 0832444F1B1C
!
call rsvp-sync
!
interface FastEthernet0/0
ip address 192.168.19.1 255.255.255.0
duplex auto
speed 10
!
interface Serial0/0
ip address 202.101.93.23 255.255.255.192
encapsulation ppp
fair-queue
clockrate 2000000
```

```
!
interface Serial0/1
no ip address
shutdown
!
interface Virtual-Template1
ip address 192.168.103.2 255.255.255.0
ppp authentication pap
!
router ospf 100
log-adjacency-changes
network 192.168.103.0 0.0.0.255 area 1
!
ip classless
ip http server
!
!
voice-port 1/0/0
!
voice-port 1/0/1
!
dial-peer cor custom
!
!
gatekeeper
shutdown
!
!
line con 0
exec-timeout 0 0
line aux 0
privilege level 15
line vty 0 4
privilege level 15
no login
line vty 5 15
login
!
end
```

Different from the Windows 2000 server, L2TP on Cisco 2620 is not bound with IPSec/IKE. Nevertheless, Cisco L2TP requires tunnel authentication by default, while L2TP on the Windows 2000 server does not support tunnel authentication. Cisco 2620 learns routes reachable to the network 192.168.201.0/24 over OSPF, a dynamic routing protocol, which can be seen in the routing table.

```
Cisco2620# show ip route
```

```
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B – BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2, E – EGP
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
* - candidate default, U - per-user static route, o - ODR
P - periodic downloaded static route
Gateway of last resort is not set
O   192.168.201.0/24 [110/20] via 192.168.103.3, 00:06:26, Virtual-Access1
192.168.103.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.103.3/32 is directly connected, Virtual-Access1
C      192.168.103.0/24 is directly connected, Virtual-Access1
202.101.93.0/24 is variably subnetted, 2 subnets, 2 masks
C      202.101.93.21/32 is directly connected, Serial0/0
C      202.101.93.0/26 is directly connected, Serial0/0
C   192.168.19.0/24 is directly connected, FastEthernet0/0
Cisco2620#
```

The following shows how the host "BLIZZARD" of the branch accesses the Internet and the intranet of the headquarters.

```
Microsoft Windows 2000 [Version 5.00.2195]
(C) Copyright 1985-2000 Microsoft Corp.
C:\>ipconfig /all
Windows 2000 IP Configuration
       Host Name . . . . . . . . . . . . : BLIZZARD
       Primary DNS Suffix  . . . . . . . :
       Node Type . . . . . . . . . . . . : Broadcast
       IP Routing Enabled. . . . . . . . : No
       WINS Proxy Enabled. . . . . . . . : No
Ethernet adapter local connection 2:
       Connection-specific DNS Suffix  . :
       Description . . . . . . . . . . . : NE2000 Compatible
       Physical Address. . . . . . . . . : 00-10-88-01-A5-C3
       DHCP Enabled. . . . . . . . . . . : No
       IP Address. . . . . . . . . . . . : 192.168.201.213
       Subnet Mask . . . . . . . . . . . : 255.255.255.0
       Default Gateway . . . . . . . . . : 192.168.201.1
       DNS Servers . . . . . . . . . . . : 202.101.143.141
C:\>route print
===========================================================================
Interface List
0x1 ........................... MS TCP Loopback interface
0x3000003 ...00 10 88 01 a5 c3 ...... Novell 2000 Adapter.
===========================================================================
===========================================================================
Active Routes:
```

```
Network Destination       Netmask         Gateway      Interface  Metric
         0.0.0.0         0.0.0.0    192.168.201.1  192.168.201.213    1
       127.0.0.0       255.0.0.0        127.0.0.1        127.0.0.1    1
   192.168.201.0   255.255.255.0  192.168.201.213  192.168.201.213    1
  192.168.201.213  255.255.255.255        127.0.0.1        127.0.0.1    1
  192.168.201.255  255.255.255.255  192.168.201.213  192.168.201.213    1
       224.0.0.0       224.0.0.0  192.168.201.213  192.168.201.213    1
  255.255.255.255  255.255.255.255  192.168.201.213  192.168.201.213    1
Default Gateway:   192.168.201.1
===========================================================================
Persistent Routes:
  None
C:\>ping 192.168.103.2
Pinging 192.168.103.2 with 32 bytes of data:
Reply from 192.168.103.2: bytes=32 time=10ms TTL=0
Reply from 192.168.103.2: bytes=32 time<10ms TTL=0
Reply from 192.168.103.2: bytes=32 time<10ms TTL=0
Reply from 192.168.103.2: bytes=32 time<10ms TTL=0
Ping statistics for 192.168.103.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum =  10ms, Average =  2ms
C:\>ping 192.168.19.1
Pinging 192.168.19.1 with 32 bytes of data:
Reply from 192.168.19.1: bytes=32 time<10ms TTL=254
Reply from 192.168.19.1: bytes=32 time<10ms TTL=254
Reply from 192.168.19.1: bytes=32 time<10ms TTL=254
Reply from 192.168.19.1: bytes=32 time<10ms TTL=254
Ping statistics for 192.168.19.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum =  0ms, Average =  0ms
C:\>ping 202.101.93.23
Pinging 202.101.93.23 with 32 bytes of data:
Reply from 202.101.93.23: bytes=32 time<10ms TTL=254
Reply from 202.101.93.23: bytes=32 time<10ms TTL=254
Reply from 202.101.93.23: bytes=32 time<10ms TTL=254
Reply from 202.101.93.23: bytes=32 time<10ms TTL=254
Ping statistics for 202.101.93.23:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum =  0ms, Average =  0ms
C:\>
```

The preceding shows that the host "BLIZZARD" of the branch successfully accesses the Internet and the intranet of the headquarters. This host does not need VPDN configuration. Network administrators need to only allocate an intranet

address (192.168.201.213 here) to it and set its gateway address to 192.168.201.1, which can be seen in the following information in the NAT recording node of the R3660.

```
R3660# show ip nat translations
Pro Inside global     Inside local      Outside local      Outside global
icmp 202.101.93.21:1024 192.168.201.213:1024 202.101.93.23:1024 202.101.93.23:1024
R3660#
```

Establishing a Tunnel with the Windows 2000 PC by Using hostname

Connect Ruijie router to a Windows 2000 PC. For information about the networking topology and PC configuration, see "Establishing a Tunnel with the Windows 2000 Server."

The hostname of the Windows 2000 PC must have been registered on the DNS server. The DNS client function must be enabled on Ruijie router and route configuration must be correct so that Ruijie router can ping the DNS server successfully.

Ruijie LAC router configuration:

```
l2tp-class 1
!
pseudowire-class 1
 encapsulation l2tpv2
!
no service password-encryption
!
ip name-server 192.168.5.119
ip name-server 61.154.22.41
!
no ip ref load-sharing original
!
interface FastEthernet 0/0
 ip ref
 ip address 192.168.52.90 255.255.255.0
 duplex auto
 speed auto
!
interface FastEthernet 0/1
 duplex auto
 speed auto
!
interface Virtual-ppp 1
 pseudowire hostname mm.hxs.meibu.com 1 encapsulation l2tpv2
 ppp pap sent-username user1 password  11
 ip address negotiate
!
ip route 0.0.0.0 0.0.0.0 192.168.52.1
!
```

```
ref parameter 75 400
line con 0
line aux 0
line vty 0 4
 login
```

The tunnel is automatically triggered for connection.

Initiation by the Remote Client

Configuration Task List

- Configuring a local address pool (optional)
- Configuring user information (optional)
- Setting VPDN global parameters (mandatory)
- Configuring a virtual-template interface (mandatory)
- Configuring VPDN-group (mandatory)

Configuring a Local Address Pool

This is an optional step for establishing an L2TP tunnel initiated by the remote client. In order to accept the L2TP connection initiated by the remote client, the LNS must allocate an IP address to the remote client if an IP address used inside the VPN is not set for the remote client. Generally, an idle IP address in a specified address pool is allocated to the client.

Use the following commands to configure a local address pool.

Command	Function
Ruijie(config)# **ip local pool** *poolname first-ip* [*last-ip*]	Creates or sets a local address pool.
Ruijie(config)# **no ip local pool** *poolname*	Deletes an address pool of the specified name.

poolname is the name of the local address pool to be created or set, *first-ip* is the first address in the address range set for the local address pool, and *last-ip* is the last address in the address range set for the local address pool.

Configuring User Information

This is an optional step for establishing an L2TP tunnel initiated by the remote client. The purpose of configuring user information is to authenticate remote L2TP clients that attempt to access the local client.

Use the following commands to configure user information.

Command	Function
Ruijie(config)# **username** *user-name* **password {0|7}** *password*	Configures user information.
Ruijie(config)# **no username** *user-name*	Deletes the specified user.

user-name is the name of the dial-in user who is allowed to access, and *password* is the password of the user. The router locally maintains a database that records names of dial-in users permitted to access and their passwords.

Setting VPDN Global Parameters

This is a mandatory step for establishing an L2TP tunnel initiated by the remote client. VPDN global parameters are set in this step. The operations of setting VPDN global parameters include:

- Enabling or disabling the VPDN function
- Setting the VPDN source address
- Setting the maximum number of VPDN sessions
- Setting the domain resolution option
- Enabling or disabling domain authentication
- Ignoring the source-address check of VPDN
- Setting VPDN rate limit
- Enabling or disabling the VPDN function is mandatory and setting the VPDN source address is optional.

Enabling or Disabling the VPDN Function

If a user requires the router to accept the L2TP access from the remote client and establish an L2TP tunnel and session, the VPDN function must be enabled on the router.

Use the following commands to enable or disable the VPDN function.

Command	Function
Ruijie(config)# **vpdn enable**	Enables the VPDN function.
Ruijie(config)# **no vpdn enable**	Disables the VPDN function.

The VPDN enabling and disabling support instant configuration and use (that is, they are available immediately when they are configured). If the VPDN function is disabled, all the existing L2TP tunnels and sessions will be disconnected.

Setting the VPDN Source Address

After the VPDN source address is set, the destination address of the tunnel set for the remote client must be consistent with the VPDN source address before an L2TP tunnel is established successfully.

Use the following commands to set the VPDN (local) source address.

Command	Function
Ruijie(config)# **vpdn source-ip** *ip-address*	Sets the VPDN source address.
Ruijie(config)# **no vpdn source-ip** *ip-address*	Cancels the set VPDN source address.

The system does not check whether the destination address in the received tunnel establishment request is a specific value by default.

Setting the Maximum Number of VPDN Sessions

After the maximum number of VPDN sessions is set, access requests beyond the maximum value will be denied.

Use the following commands to set the maximum number of sessions supported by the VPDN server.

Command	Function

Ruijie(config)# **vpdn session-limit** *sessions*	Sets the maximum number of VPDN sessions.
Ruijie(config)# **no vpdn session-limit**	Restores the default maximum number of VPDN sessions.

The maximum number of sessions is the one configured by using this command by default.

Setting the Domain Resolution Option

Use the following commands to set the domain resolution option in VPDN domain authentication. Domains of different types can be identified based on configuration.

Command	Function
Ruijie(config)**# vpdn domain-delimiter @/%#-**	Sets the domain delimiter, prefix or suffix.
Ruijie(config)**# no vpdn domain-delimiter**	Cancels the VPDN domain authentication option.

The system does not resolve the domain field by default.

Enabling or Disabling Domain Authentication

Use the following commands to enable or disable the VPDN domain authentication, that is, determine whether to strip the domain field.

Command	Function
Ruijie(config)**# vpdn authorize domain split**	Enables domain authentication, that is, enables domain splitting.
Ruijie(config)**# no vpdn authorize domain**	Disables domain authentication.

Domain authentication is disabled by default.

Ignoring the Source Address Check of VPDN

Use the following commands to ingore errors on received L2TP control packets that do not comply with the RFC specifications so as to ensure the normal negotiation.

Command	Function
Ruijie(config-vpdn)# **vpdn ignore_source**	Ignores the source address check of packets sent from the peer end.
Ruijie(config-vpdn)# **no vpdn ignore_source**	Strictly checks the source address of packets sent from the peer end.

The system strictly checks the source address by default.

Setting VPDN Rate Limit

Use the following commands to limit the rate of establishing VPDN tunnels, namely, to limit the number of VPDN tunnels that can be established at one time.

Command	Function

Ruijie(config)# **vpdn limit_rate** *rate_num*	Enables rate limit. *rate_num* is the number of tunnels that can be established at a time. The value range is 5 to 100.
Ruijie(config)# **no vpdn limit_rate**	Disables rate limit.

Rate limit is disabled by default.

Configuring a Virtual-Template Interface

This is a mandatory step for establishing an L2TP tunnel initiated by the remote client. This interface will become the template of the virtual-access interface that binds and carries L2TP sessions. The operations of configuring a virtual-template interface include:

- Setting a virtual-template interface (mandatory)
- Setting the local IP address (mandatory)
- Setting the authentication mode (optional)
- Setting the peer IP address (optional)

For information about setting the local IP address, setting the authentication mode, and setting the peer IP address, see sections regarding the interface configuration guide.

Setting a Virtual-Template Interface

Use the following commands to set a virtual-template interface.

Command	Function
Ruijie(config)**# interface virtual-template** *number*	Creates or configures a specified virtual-template interface.
Ruijie(config)**# no interface virtual-template** *number*	Deletes the specified virtual-template interface.

number is the sequence number of the specified virtual-template interface. The created virtual-template interface will be used as the configuration template of the virtual-access interface that binds and carries L2TP sessions.

Configuring VPDN-group

This is a mandatory step for establishing an L2TP tunnel initiated by the remote client. VPDN-group parameters are set in this step. The operations of configuring VPDN-group include:

- Setting a VPDN-group interface (mandatory)
- Setting the tunneling mode (mandatory)
- Setting the tunneling protocol (mandatory)
- Setting a virtual template to be used (mandatory)
- Setting the peer name (optional)
- Setting the local name (optional)
- Setting the VPDN-group source address (optional)
- Setting the L2TP control connection parameters (optional)
- Setting L2TP data transmission parameters (optional)
- Setting the vrf option (optional)
- Setting the supported domain name (optional)
- Re-performing PPP negotiation (optional)

- Ignoring errors on control packets (optional)

Setting a VPDN-group Interface

Use the following commands to set a VPDN-group interface.

Command	Function
Ruijie(config)# **vpdn-group** *name*	Creates or configures the specified VPDN-group interface.
Ruijie(config)# **no vpdn-group** *name*	Deletes the specified VPDN-group interface.

name is the name of the specified VPDN-group interface. The created VPDN-group interface allows related clients to access and establish tunnels.

Setting the Tunneling Mode

Use the following commands to set the tunneling mode.

Command	Function
Ruijie (config-vpdn)# **accept-dialin**	Allows access from the dial-in remote client.
Ruijie (config-vpdn)# **no accept-dialin**	Denies the access from the dial-in remote client.

If a user needs the local router to provide the LNS function, access from the dial-in remote client must be allowed.

Setting the Tunneling Protocol

Use the following commands to set the tunneling protocol.

Command	Function
Ruijie(config-vpdn-acc-in)# **protocol** {**any** | **l2tp** | **pptp**}	Sets the tunneling protocol.
Ruijie(config-vpdn-acc-in)# **no protocol**	Cancels the set tunneling protocol.

The tunneling mode must be set before a tunneling protocol is set.

Setting a Virtual Template to Be Used

Use the following commands to set a virtual template used by the VPDN-group.

Command	Function
Ruijie(config-vpdn-acc-in)# **virtual-template** *number*	Sets a virtual template to be used.
Ruijie(config-vpdn-acc-in)# **no virtual-template**	Cancels the virtual template.

The tunneling mode must be set before a virtual template is set for the VPDN-group.

Setting the Peer Name

If the peer name is set, this VPDN-group is effective only to the remote client that matches the host name. If no peer name is set, this VPDN-group is the default VPDN-group and can provide the VPDN service for any remote client.

Use the following commands to set the peer name.

Command	Function
Ruijie(config-vpdn)# **terminate-from hostname** *name*	Sets the name of the peer host.
Ruijie(config-vpdn)# **no terminate-from**	Cancels the set peer name.

name is the name of the peer host.

Setting the Local Name

The local name is sent to the peer end as a record property.

Use the following commands to set the local name.

Command	Function
Ruijie(config-vpdn)# **local name** *name*	Sets the local name.
Ruijie(config-vpdn)# **no local name**	Cancels the set local name.

name is the local name. The router name is used as the local name and sent to the pee host of the tunnel by default.

Setting the VPDN-group Source Address

The destination address in the tunnel establishment request sent from the remote client must match the VPDN-group source adress. In this way, the VPDN-group can be applied.

Use the following commands to set the VPDN-group source address.

Command	Function
Ruijie(config-vpdn)# **source-ip** *src-ip*	Sets the VPDN-group source address.
Ruijie(config-vpdn)# **no source-ip**	Cancels the set VPDN-group source address.

src-ip is the VPDN-group source address.

Setting the L2TP Control Connection

Use the following commands to set the L2TP control connection.

Command	Function
Ruijie(config-vpdn)# **l2tp tunnel authentication**	Enables tunnel authentication.
Ruijie(config-vpdn)# **no l2tp tunnel authentication**	Disables tunnel authentication.
Ruijie(config-vpdn)# **l2tp tunnel hello** *interval*	Sets the interval of sending Hello messages.
Ruijie(config-vpdn)# **no l2tp tunnel hello**	Deletes the set interval of sending Hello messages.
Ruijie(config-vpdn)# **l2tp tunnel password** *pass-word*	Sets the tunnel password.
Ruijie(config-vpdn)# **no l2tp tunnel password**	Deletes the set tunnel password.

Command	Function
Ruijie(config-vpdn)# **l2tp tunnel receive-window** *size*	Sets the size of the receiving window of the tunnel control connection.
Ruijie(config-vpdn)# **no l2tp tunnel receive- window**	Restores the default size of the receiving window of the tunnel control connection.
Ruijie(config-vpdn)# **l2tp tunnel retransmit** {**retries** *number* | **timeout** {**min** | **max**} *seconds*}	Sets retransmission of tunnel control messages.
Ruijie(config-vpdn)# **no l2tp tunnel retransmit** {**retries** | **timeout** {**min**|**max**}}	Restores the default retransmission setting of tunnel control messages.
Ruijie(config-vpdn)# **l2tp tunnel timeout** {**no-session**| **setup**} *seconds*	Sets the maximum interval of establishing a no-session/control connection of the tunnel.
Ruijie(config-vpdn)# **no l2tp tunnel timeout** {**no-session** | **setup**}	Restores the default maximum interval of establishing a no-session/control connection of the tunnel.
Ruijie(config-vpdn)# **l2tp tunnel force_ipsec**	Enables forced encryption. It is used when external encryption is required. After this command is executed, packets can be sent to VPDN tunnels only after encryption.
Ruijie(config-vpdn)# **no l2tp tunnel force_ipsec**	Disables forced encryption.
Ruijie(config-vpdn)# **l2tp tunnel avp-hidden-compatible**	Supports the RFC2661 standard AVP Hidden parsing algorithm compatibly.
Ruijie(config-vpdn)# **no l2tp tunnel avp-hidden-compatible**	Restores the default Cisco standard AVP Hidden parsing algorithm.

Tunnel authentication is not needed for establishing L2TP tunnels by default (but required on Cisco devices by default). The default interval of sending Hello control messages is 60 seconds. The default receiving window size of control messages is 4. The default number of retransmission times of control messages is 5. The default minimum and maximum intervals of retransmitting control messages are 1 second and 8 seconds respectively. The default maximum interval of no session in a tunnel is 600 seconds. The default maximum time supported by tunnels in establishing a control connection is 300 seconds. If L2TP tunnel authentication is required, the same tunnel password must be configured at both ends of the L2TP tunnel. Nevertheless, the system does not configure tunnel passwords for any L2TP tunnels by default and does not require tunnel authentication. The *interval* parameter is the interval of sending Hello messages, in seconds. The unit of the *seconds* parameter is also seconds. The forced IPSec encryption and authentication are disabled by default. The default AVP Hidden parsing algorithm uses the Cisco standard. After the RFC2661 standard AVP Hidden parsing algorithm is supported compatibly, the RFC2661 standard is used to parse and hide AVP.

Setting L2TP Data Transmission Parameters

Use the following commands to set IP/UDP parameters for transmitting L2TP messages.

Command	Function
Ruijie(config-vpdn)# **l2tp ip udp checksum**	Sets the UDP checksum.
Ruijie(config-vpdn)# **no l2tp ip udp Checksum**	Cancels the UDP checksum setting.
Ruijie(config-vpdn)# **ip tos** *tos-value*	Sets the IP TOS field.
Ruijie(config-vpdn)# **no ip tos**	Cancels the IP TOS setting.

Ruijie(config-vpdn)# **ip precedence** *value*	Sets the IP Precedence field.
Ruijie(config-vpdn)# **no ip precedence**	Cancels the IP Precedence setting.

tos-value is the value of the TOS field of the IP header that carries L2TP messages, and *value* is the value of the Precedence field of this IP header. For L2TP messages to be carried in L2TP tunnels of RGOS, the checksum field of UDP that carries L2TP messages must be blank, the TOS of the IP header that carries L2TP messages and the Precedence field of this IP header must be 0 by default.

Note that the TOS and Precedence fields are supported only in L2TP. Though they can be configured in PPTP, the configuration does not take effect.

Setting the VRF Option

Use the following commands to set the VRF to which specified L2TP tunnel packets belong. The configuration maps to the **ip vrf forward** command of the VT interface, implementing VRF spanning.

Command	Function
Ruijie(config-vpdn)#**vpn vrf** *vrf-name*	Sets the VRF attribute for the tunnel.
Ruijie(config-vpdn)# **no vpn vrf**	Deletes the VRF attribute setting of the tunnel.

vrf-name is the name of the VRF.

Setting the Supported Domain Name

The command for setting the supported domain name takes effect after the domain authentication is enabled. Only the domain matching the content of this command can be identified. If a domain does not match the content of this command, another VPDN group is used for matching. If no matched VPDN group is found, the authentication fails.

Use the following commands to set the domain name.

Command	Function
Ruijie(config-vpdn)# **domain** *domain-name* **vrf** *vrf-name*	Sets the authentication domain name and the related VRF.
Ruijie(config-vpdn)# **no domain** *domain-name*	Cancels the domain setting.

domain-name is the name of domain, and *vrf-name* is the name of the VRF.

Setting the Domain Name-Bound Address Pool

The command for setting the domain name-based address pool is configured in **vpdn-domain** command mode. Domain names are authenticated and information about the bound address pool configured using this command is obtained during VPDN tunnel negotiation. After the PPP negotiation is successful, the specified bound address pool is used to assign peer addresses of tunnels. The address pool configured in the virtual-template interface is used for address assignment by default.

Use the following commands to set the domain name-bound address pool.

Command	Function

Ruijie(config-vpdn)# **domain** *domain-name* **vrf** *vrf-name* Ruijie(config-vpdn-domain)# **pool** *pool-name*	Sets the address pool bound to the authentication domain name.
Ruijie(config-vpdn)# **no domain** *domain-name*	Cancels the address pool binding.

domain-name is the name of the domain, *vrf-name* is the name of the VRF, and *pool-name* is the name of the address pool.

Setting the DNS Negotiation Address of PPP Bound to a Domain Name

The command for setting the DNS negotiation address of PPP bound to a domain name is configured in **vpdn-domain** command mode. The domain name is authenticated and information about the bound DNS negotiation address of PPP configured using this command is obtained during VPDN tunnel negotiation. This address is used for DNS negotiation during PPP negotiation. The DNS address of PPP configured in the virtual-template interface is used for negotiation by default.

Use the following commands to set addresses used by DNS during PPP negotation by matching domain names.

Command	Function
Ruijie(config-vpdn)# **domain** *domain-name* **vrf** *vrf-name* Ruijie(config-vpdn-domain)#**dns** *A.B.C.D A.B.C.D*	Sets the DNS negotiation address of PPP bound to the authentication domain name.
Ruijie(config-vpdn)# **no dns**	Cancels the DNS binding.

domain-name is the name of the domain, *vrf-name* is the name of VRF, and *A.B.C.D* is the DNS address.

Re-Performing PPP Authentication

When the client triggers the LAC to start dialing, the LAC acts as the LNS to authenticate the client. This command is used to perform CHAP authentication on the client again after an L2TP tunnel is established. This commad is valid only on the LNS.

Use the following commands to forcibly perform complete PPP authentication again.

Command	Function
Ruijie(config-vpdn)# **force-local-chap**	Forces the LNS to perform CHAP authentication on the client again.
Ruijie(config-vpdn)# **no force-local-chap**	Cancels CHAP re-authentication.

Re-Performing PPP Negotiation

When the client triggers the LAC to start dialing, the LAC acts as the LNS to negotiate with the client. This command is used to perform LCP negotiation with the client again after an L2TP tunnel is established. This commad is valid only on the LNS.

Use the following commands to forcibly perform PPP negotiation again.

Command	Function
Ruijie(config-vpdn)# **force-local-lcp**	Forces the LNS to perform LCP negotiation with the client again.

Ruijie(config-vpdn)# **no force-local-lcp**	Cancels LCP re-negotiation.

Ignoring Errors on Control Packets

Use the following commands to ignore errors on received L2TP control packets that do not comply with the RFC specifications to ensure normal negotiation.

Command	Function
Ruijie(config-vpdn)# **lcp renegotiation always**	Ignores errors on packets from the peer end.
Ruijie(config-vpdn)# **no lcp renegotiation always**	Checks whether control packets comply with RFC specifications.

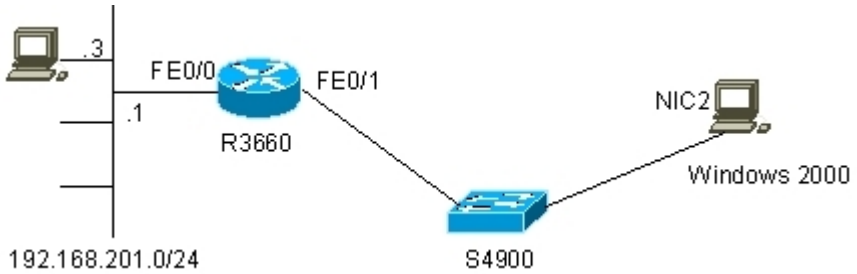
Configuration Examples

Three configuration examples are given below. In one configuration example, the Windows 2000 server is used as the remote L2TP client for access, and tunnel authentication is not performed due to limitations of the Windows 2000 server. In another example, Cisco 3640 is used as the remote L2TP client, and tunnel authentication is required. In the other example, Cisco 2620 is used as the L2TP client, and tunnel authentication is required.

Establishing a Tunnel with the Windows 2000 Server

Figure 20 shows the networking topology of the L2TP tunnel established by using Ruijie router R3660 and the Windows 2000 server.

Figure 20 Networking topology of the L2TP tunnel established by using the Windows 2000 server (LAC)



The configurations of the R3660 and Windows 2000 server are respectively described as follows:

21) R3660 configuration:

```
R3660# show running-config
Building configuration...
Current configuration : 708 bytes
!
hostname R3660
!
vpdn enable
!
vpdn-group 1
! Default L2TP VPDN group
accept-dialin
```

```
protocol l2tp
virtual-template 1
!
!
!
username rgnos password 7 04251F083110
!
ip local pool vpdnusers 192.168.101.3 192.168.101.253
!
interface FastEthernet 0/0
ip address 192.168.201.1 255.255.255.0
duplex auto
speed auto
!
interface FastEthernet 0/1
ip address 192.168.12.217 255.255.255.0
duplex auto
speed auto
!
interface Loopback 1
ip address 192.168.101.2 255.255.255.0
!
interface Null 0
!
interface Virtual-Template 1
ppp authentication pap
ip unnumbered Loopback 1
peer default ip address pool vpdnusers
!
!
line con 0
line aux 0
line vty 0 4
!
!
end
R3660#
```

22) Configuration of the Windows 2000 server:

```
Microsoft Windows 2000 [Version 5.00.2195]
(C) Copyright 1985-2000 Microsoft Corp.
C:\>ipconfig /all
Windows 2000 IP Configuration
       Host Name . . . . . . . . . . . . : BLIZZARD
       Primary DNS Suffix  . . . . . . . :
```

```
      Node Type . . . . . . . . . . . . : Broadcast
      IP Routing Enabled. . . . . . . . : No
      WINS Proxy Enabled. . . . . . . . : No
Ethernet adapter local connection 2:
      Connection-specific DNS Suffix  . :
      Description . . . . . . . . . . . : NE2000 Compatible
      Physical Address. . . . . . . . . : 00-10-88-01-A5-C3
      DHCP Enabled. . . . . . . . . . . : No
      IP Address. . . . . . . . . . . . : 192.168.12.213
      Subnet Mask . . . . . . . . . . . : 255.255.255.0
      Default Gateway . . . . . . . . . : 192.168.12.1
      DNS Servers . . . . . . . . . . . : 202.101.143.141
C:\>route print
===========================================================================
Interface List
0x1 ........................... MS TCP Loopback interface
0x2000003 ...00 10 88 01 a5 c3 ...... Novell 2000 Adapter.
===========================================================================
===========================================================================
Active Routes:
Network Destination       Netmask         Gateway      Interface  Metric
         0.0.0.0         0.0.0.0     192.168.12.1  192.168.12.213    1
       127.0.0.0       255.0.0.0        127.0.0.1       127.0.0.1    1
    192.168.12.0    255.255.255.0  192.168.12.213  192.168.12.213    1
   192.168.12.213  255.255.255.255        127.0.0.1       127.0.0.1    1
   192.168.12.255  255.255.255.255   192.168.12.213  192.168.12.213    1
        224.0.0.0       224.0.0.0   192.168.12.213  192.168.12.213    1
  255.255.255.255  255.255.255.255   192.168.12.213  192.168.12.213    1
Default Gateway:    192.168.12.1
===========================================================================
Persistent Routes:
  None
C:\>
```

In **Network and Dial-up Connections**, click **New connection** and select **Connect to a private network through the Internet** to establish a virtual private connection to the specified LNS, namely, R3660. Set the destination address to **192.168.12.217**. In the properties, set **Security measure** to **Advanced (user-defined setting)**. In **Advanced security settings**, set **Data encryption** to **Optional encryption (connect even if no encryption available)**, click **Password not encrypted (PAP)** to use PAP as the authentication protocol, and click **OK** to save these property settings. Then, you can use the user **RGNOS** set the R3660 and its password to establish a virtual connection.

The following shows the routing and communication information after a virtual connection is established successfully.

23) R3660:

```
R3660# show ip route
Codes: C - connected, S - static,  R - RIP
```

```
O - OSPF, IA - OSPF inter area
E1 - OSPF external type 1, E2 - OSPF external type 2
Gateway of last resort is not set
192.168.101.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.101.8/32 is directly connected, Virtual-Access1
C      192.168.101.0/24 is directly connected, Loopback1
C   192.168.12.0/24 is directly connected, FastEthernet0/1
C   192.168.201.0/24 is directly connected, FastEthernet0/0
R3660#ping 192.168.101.8
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echoes to 192.168.101.8, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
R3660#show vpdn tunnel
L2TP Tunnel Information Total tunnels 1
LocID RemID Remote Name   State  Remote Address  Port  Sessions L2TP Class/
                                                      VPDN Group
7   8    BLIZZARD     est   192.168.12.213  1701  1     1
%No active PPTP tunnels
R3660#
R3660# show vpdn session
L2TP Session Information Total sessions 1
LocID     RemID     TunID     Username, Intf/     State
Last Chg
                            Vcid, Circuit
1      1        7        ,Vi1            est   00:02:08
%No active PPTP tunnels
R3660#
```

24) Windows 2000 server:

```
Microsoft Windows 2000 [Version 5.00.2195]
(C) Copyright 1985-2000 Microsoft Corp.
C:\>ipconfig /all
Windows 2000 IP Configuration
       Host Name . . . . . . . . . . . . : BLIZZARD
       Primary DNS Suffix  . . . . . . . :
       Node Type . . . . . . . . . . . . : Broadcast
       IP Routing Enabled. . . . . . . . : No
       WINS Proxy Enabled. . . . . . . . : No
Ethernet adapter local connection 2:
       Connection-specific DNS Suffix  . :
       Description . . . . . . . . . . . : NE2000 Compatible
       Physical Address. . . . . . . . . : 00-10-88-01-A5-C3
       DHCP Enabled. . . . . . . . . . . : No
       IP Address. . . . . . . . . . . . : 192.168.12.213
       Subnet Mask . . . . . . . . . . . : 255.255.255.0
```

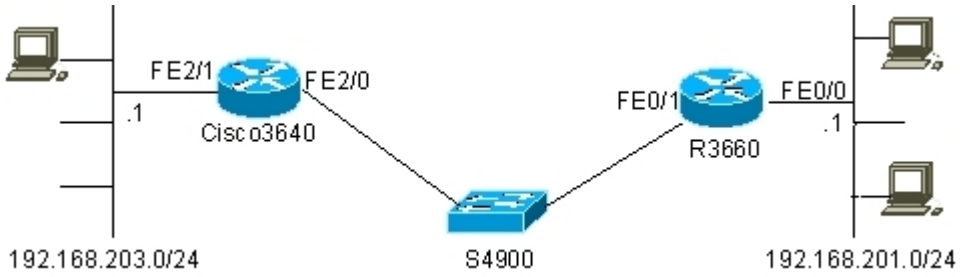
```
       Default Gateway . . . . . . . . . : 192.168.12.1
       DNS Servers . . . . . . . . . . . : 202.101.143.141
PPP adapter L2TP:
       Connection-specific DNS Suffix  . :
       Description . . . . . . . . . . . : WAN (PPP/SLIP) Interface
       Physical Address. . . . . . . . . : 00-53-45-00-00-00
       DHCP Enabled. . . . . . . . . . . : No
       IP Address. . . . . . . . . . . . : 192.168.101.8
       Subnet Mask . . . . . . . . . . . : 255.255.255.255
       Default Gateway . . . . . . . . . : 192.168.101.8
       DNS Servers . . . . . . . . . . . :
C:\>route print
===========================================================================
Interface List
0x1 ........................... MS TCP Loopback interface
0x2000003 ...00 10 88 01 a5 c3 ...... Novell 2000 Adapter.
0xd000004 ...00 53 45 00 00 00 ...... WAN (PPP/SLIP) Interface
===========================================================================
===========================================================================
Active Routes:
Network Destination       Netmask         Gateway      Interface  Metric
         0.0.0.0         0.0.0.0    192.168.12.1  192.168.12.213      2
         0.0.0.0         0.0.0.0   192.168.101.8   192.168.101.8      1
       127.0.0.0       255.0.0.0         127.0.0.1      127.0.0.1      1
    192.168.12.0   255.255.255.0   192.168.12.213  192.168.12.213      1
  192.168.12.213  255.255.255.255        127.0.0.1       127.0.0.1     1
  192.168.12.217  255.255.255.255   192.168.12.213  192.168.12.213     1
  192.168.12.255  255.255.255.255   192.168.12.213  192.168.12.213     1
   192.168.101.2  255.255.255.255    192.168.101.8   192.168.101.8     1
   192.168.101.8  255.255.255.255        127.0.0.1       127.0.0.1     1
 192.168.101.255  255.255.255.255    192.168.101.8   192.168.101.8     1
       224.0.0.0       224.0.0.0   192.168.12.213  192.168.12.213     1
       224.0.0.0       224.0.0.0    192.168.101.8   192.168.101.8    1
 255.255.255.255  255.255.255.255   192.168.12.213  192.168.12.213     1
Default Gateway:   192.168.101.8
===========================================================================
Persistent Routes:
  None
C:\>ping 192.168.101.2
Pinging 192.168.101.2 with 32 bytes of data:
Reply from 192.168.101.2: bytes=32 time<10ms TTL=255
Reply from 192.168.101.2: bytes=32 time<10ms TTL=255
Reply from 192.168.101.2: bytes=32 time<10ms TTL=255
Reply from 192.168.101.2: bytes=32 time<10ms TTL=255
Ping statistics for 192.168.101.2:
```

```
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum =  0ms, Average =  0ms
C:\>ping 192.168.201.1
Pinging 192.168.201.1 with 32 bytes of data:
Reply from 192.168.201.1: bytes=32 time<10ms TTL=255
Reply from 192.168.201.1: bytes=32 time<10ms TTL=255
Reply from 192.168.201.1: bytes=32 time<10ms TTL=255
Reply from 192.168.201.1: bytes=32 time<10ms TTL=255
Ping statistics for 192.168.201.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum =  0ms, Average =  0ms
C:\>ping 192.168.201.3
Pinging 192.168.201.3 with 32 bytes of data:
Reply from 192.168.201.3: bytes=32 time<10ms TTL=254
Reply from 192.168.201.3: bytes=32 time<10ms TTL=254
Reply from 192.168.201.3: bytes=32 time<10ms TTL=254
Reply from 192.168.201.3: bytes=32 time<10ms TTL=254
Ping statistics for 192.168.201.3:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum =  0ms, Average =  0ms
C:\>ping 192.168.12.1
Pinging 192.168.12.1 with 32 bytes of data:
Reply from 192.168.12.1: bytes=32 time=10ms TTL=255
Reply from 192.168.12.1: bytes=32 time<10ms TTL=255
Reply from 192.168.12.1: bytes=32 time<10ms TTL=255
Reply from 192.168.12.1: bytes=32 time<10ms TTL=255
Ping statistics for 192.168.12.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum =  10ms, Average =  2ms
C:\>
```

Establishing a Tunnel with Cisco 3640

Figure 21 shows the networking topology of the L2TP tunnel established by using Ruijie router R3660 and Cisco 3640.

Figure 21 Networking topology of the L2TP tunnel established with Cisco 3640 (LAC)



The configurations of R3660 and Cisco 3640 are respectively described as follows:

25) R3660 tconfiguration:

```
R3660# show running-config
Building configuration...
Current configuration : 766 bytes
!
hostname R3660
!
vpdn enable
!
vpdn-group 1
! Default L2TP VPDN group
accept-dialin
protocol l2tp
virtual-template 1
l2tp tunnel authentication
l2tp tunnel password share
!
!
!
username rgnos password 7 025144391715
!
ip local pool vpdnusers 192.168.101.3 192.168.101.253
!
interface FastEthernet 0/0
ip address 192.168.201.1 255.255.255.0
duplex auto
speed auto
!
interface FastEthernet 0/1
ip address 192.168.12.217 255.255.255.0
duplex auto
speed auto
!
interface Loopback 1
ip address 192.168.101.2 255.255.255.0
!
```

```
interface Null 0
!
interface Virtual-Template 1
ppp authentication pap
ip unnumbered Loopback 1
peer default ip address pool vpdnusers
!
!
line con 0
line aux 0
line vty 0 4
!
!
end
R3660#
```

26) Cisco 3640 configuration:

```
C3640# show running-config
Building configuration...
Current configuration : 2096 bytes
!
version 12.3
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
no service dhcp
!
hostname C3640
!
!
ip subnet-zero
!
l2tp-class l2x
authentication
password 0 share
!
pseudowire-class pw
encapsulation l2tpv2
protocol l2tpv2 l2x
ip local interface FastEthernet2/0
!
no mpls ldp logging neighbor-changes
no scripting tcl init
no scripting tcl encdir
!
no voice hpi capture buffer
```

```
no voice hpi capture destination
!
controller E1 3/0
channel-group 1 timeslots 1-2
!
!
!
interface Loopback0
ip address 132.11.10.2 255.255.255.0
!
interface FastEthernet2/0
ip address 192.168.12.242 255.255.255.0
speed auto
duplex auto
!
interface FastEthernet2/1
ip address 192.168.203.1 255.255.255.0
duplex auto
speed auto
!
interface Serial3/0:1
ip address 192.168.1.2 255.255.255.0
!
interface Virtual-PPP1
ip address negotiated
no cdp enable
ppp pap sent-username rgos password 0 rgos
pseudowire 192.168.12.217 11 pw-class pw
!
no ip http server
ip classless
ip route 0.0.0.0 0.0.0.0 FastEthernet2/0 192.168.12.1
!
!
dial-peer cor custom
!
dial-peer voice 111 voip
session protocol sipv2
codec g711alaw
!
!
line con 0
exec-timeout 0 0
line aux 0
line vty 0 4
```

```
privilege level 15
no login
line vty 5 871
login
!
!
end
```

The following shows the routing and communication information on the R3660 and Cisco 3640 after an L2TP tunnel is established.

27) R3660:

```
R3660# show ip route
Codes: C - connected, S - static,  R - RIP
O - OSPF, IA - OSPF inter area
E1 - OSPF external type 1, E2 - OSPF external type 2
Gateway of last resort is not set
192.168.101.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.101.9/32 is directly connected, Virtual-Access1
C      192.168.101.0/24 is directly connected, Loopback1
C   192.168.12.0/24 is directly connected, FastEthernet0/1
C   192.168.201.0/24 is directly connected, FastEthernet0/0
R3660# show vpdn
L2TP Tunnel and Session Information Total tunnels 1 sessions 1
LocID RemID Remote Name   State  Remote Address  Port  Sessions L2TP Class/
                                                      VPDN Group
9    21511 C3640       est   192.168.12.242  1701  1      1
LocID     RemID     TunID     Username, Intf/     State  Last Chg
                            Vcid, Circuit
1      14       9        ,Vi1           est   00:18:06
%No active PPTP tunnels
R3660#ping 192.168.101.9
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echoes to 192.168.101.9, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
R3660#
```

The preceding information shows that an L2TP tunnel has been established successfully and communication can be made successfully.

28) Cisco 3640:

```
C3640# show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
```

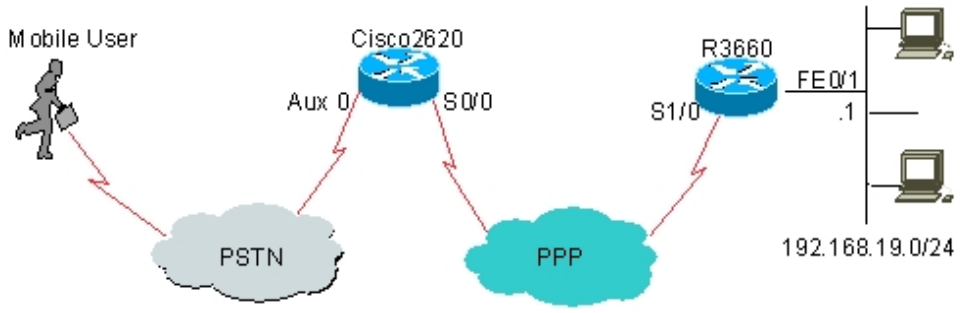
```
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route
Gateway of last resort is 192.168.12.1 to network 0.0.0.0
C    192.168.12.0/24 is directly connected, FastEthernet2/0
     132.11.0.0/24 is subnetted, 1 subnets
C    132.11.10.0 is directly connected, Loopback0
C    192.168.1.0/24 is directly connected, Serial3/0:1
     192.168.101.0/32 is subnetted, 2 subnets
C    192.168.101.9 is directly connected, Virtual-PPP1
C    192.168.101.2 is directly connected, Virtual-PPP1
S*   0.0.0.0/0 [1/0] via 192.168.12.1, FastEthernet2/0
C3640# show vpdn
%No active L2F tunnels
L2TP Tunnel and Session Information Total tunnels 1 sessions 1
LocID RemID Remote Name   State  Remote Address  Port  Sessions L2TP Class/
                                                       VPDN Group
21511 9    Ruijie        est   192.168.12.217  1701  1       l2x
LocID     RemID     TunID     Username, Intf/     State  Last Chg Uniq ID
                              Vcid, Circuit
14       1        21511       11, Vp1           est   00:23:58 2
%No active PPTP tunnels
C3640# ping 192.168.101.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echoes to 192.168.101.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
C3640#
```

The preceding information shows that an L2TP tunnel has been established successfully on Cisco 3640 and communication can be made successfully.

Establishing a Tunnel with Cisco 2620

Figure 22 shows the networking topology of the L2TP tunnel established by using the Ruijie router R3660 and Cisco 2620. Here, Cisco 2620 actually works as both the access server (AS) and LAC. The AS and LAC functions are generally provided by ISPs, and devices with the same functions but with more powerful performance, such as Cisco AS5300 or Cisco AS5800, are often used to provide the functions. Cisco 2620 is used to establish an L2TP tunnel here. The L2TP tunnel is established between Cisco 2620 and the R3660, but PPP negotiation is performed between mobile or dial-up users (mobile user in Figure 22) and the R3660. The mobile user needs to only configure a dial-up connection and connect to the server in dial-up mode by using the allocated user name and password, which are not closely related to L2TP here. This is also an advantage of this tunneling mode. L2TP tunnel settings are transparent to users. The mobile user configuration and usage are not described here. For information about dial-up setting, see instructions of the related operating system.

Figure 22 Networking topology of the L2TP tunnel established with Cisco 2620 (LAC)



The configurations of R3660 and Cisco 2620 are respectively described as follows:

29) R3660 configuration:

```
R3660# show running-config
Building configuration...
Current configuration : 989 bytes
!
hostname R3660
!
vpdn enable
!
vpdn-group 1
! Default L2TP VPDN group
accept-dialin
protocol l2tp
virtual-template 1
l2tp tunnel authentication
l2tp tunnel password share
!
!
!
username rgnos password 7 025144391715
username pc@i-net.com.cn password 7 127654431B
!
ip local pool vpdnusers 192.168.101.3 192.168.101.253
!
interface serial 1/0
encapsulation PPP
ip address 202.101.93.21 255.255.255.0
!
interface serial 1/1
clock rate 64000
!
interface serial 1/2
clock rate 64000
!
interface serial 1/3
```

```
clock rate 64000
!
interface FastEthernet 0/0
duplex auto
speed auto
!
interface FastEthernet 0/1
ip address 192.168.19.1 255.255.255.0
duplex auto
speed auto
!
interface Loopback 1
ip address 192.168.101.2 255.255.255.0
!
interface Null 0
!
interface Virtual-Template 1
ppp authentication pap
ip unnumbered Loopback 1
peer default ip address pool vpdnusers
!
!
line con 0
line aux 0
line vty 0 4
!
!
end
R3660#
```

30) Cisco 2620 configuration:

```
Cisco2620# show running-config
Building configuration...
Current configuration : 1677 bytes
!
version 12.3
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
no service dhcp
!
hostname Cisco2620
!
!
username pc password 0 1111
username 163 password 0 163
```

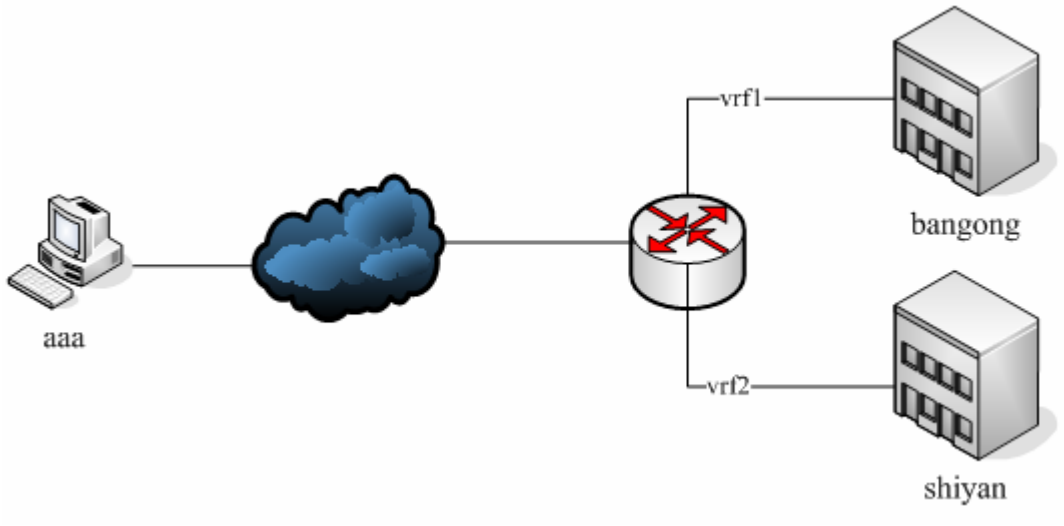
```
no aaa new-model
ip subnet-zero
!
!
!
vpdn enable
!
vpdn-group 1
request-dialin
protocol l2tp
domain i-net.com.cn
initiate-to ip 202.101.93.21
l2tp tunnel password 7 0832444F1B1C
!
interface FastEthernet0/0
ip address 192.168.7.1 255.255.255.0
duplex auto
speed 10
!
interface Serial0/0
ip address 202.101.93.23 255.255.255.0
encapsulation ppp
fair-queue
clockrate 2000000
!
interface Serial0/1
no ip address
shutdown
!
interface Async65
ip address 5.5.5.5 255.255.255.0
encapsulation ppp
dialer in-band
dialer idle-timeout 30000
dialer string 8435
dialer-group 1
async mode dedicated
peer default ip address 5.5.5.6
ppp authentication pap
!
no ip http server
ip classless
!
dialer-list 1 protocol ip permit
!
```

```
!
line con 0
exec-timeout 0 0
line aux 0
login local
modem InOut
transport input all
autoselect during-login
autoselect ppp
line vty 0 4
privilege level 15
no login
line vty 5 15
login
!
no scheduler allocate
end
Cisco2620#
```

The mobile user can access the intranet 192.168.19.0/24 connected to the R3660 through the L2TP tunnel simply by using the user name **pc@i-net.com.cn** and password **1111**.

Configuration Example of Domain Authentication

The following figure shows the networking topology for one user to connect to two networks by using one public network address based on domain information.




```
ip vrf vrf1
ip vrf vrf2
!
vpdn enable
vpdn domain-delimiter @/%#-\ suffix
vpdn authorize domain split
```

```
!
vpdn-group 1
! Default L2TP VPDN group
accept-dialin
protocol l2tp
virtual-template 1
domain bangong vrf vrf1   /*Specify the domain name*/
domain shiyan vrf vrf2   /*Specify the domain name*/
!
!
username rgos password 7 025144391715
username pc@i-net.com.cn password 7 127654431B
!
ip local pool vpdnusers 192.168.101.3 192.168.101.253
!
interface FastEthernet 0/1
ip address 192.168.19.1 255.255.255.0
duplex auto
speed auto
!
interface Loopback 1
ip vrf forward vrf1
ip address 192.168.101.2 255.255.255.0
!
interface Loopback 2
ip vrf forward vrf2
ip address 192.168.101.2 255.255.255.0
!
interface Null 0
!
interface Virtual-Template 1
ppp authentication pap
ip unnumbered Loopback 1
peer default ip address pool vpdnusers
!
!
line con 0
line aux 0
line vty 0 4
!
!
End
```

Note

When you need to connect to the same LNS in dial-up mode on the same device, VP ports must belong to different VRFs if different domains are used. Otherwise, the same destination address will be assigned to two VP ports, the routes of the two VP ports are dupliated, and only one route is available. On the LNS side, two VA ports belong to different VRFs, and packets forwarded by different tunnels will be sent to different VRFs. Packets sent from the LNS to one VP port may be returned by the other VP port, resulting in route dissymmetry. In this case, data forwarding is not affected, but pinging the peer address from the LNS may fail.

Monitoring and Maintaining L2TP Tunnels

RGOS provides L2TP monitoring and maintenance functions.

Monitoring L2TP Tunnels

Use the following commands to monitor L2TP tunnels.

Command	Function
Ruijie# **show vpdn** [**session | tunnel** [**l2tp** *locid*]] Or Ruijie> **show vpdn** [**session | tunnel** [**l2tp** *locid*]]	Displays information about the current VPDN tunnel and session. Displays information about the tunnel of the specified ID.
Ruijie# **debug vpdn error**	Enables the VPDN error debugging function.
Ruijie# **no debug vpdn error**	Disables the VPDN error debugging function.
Ruijie# **debug vpdn event**	Enables the VPDN event debugging function.
Ruijie# **no debug vpdn event**	Disables the VPDN event debugging function.
Ruijie# **debug vpdn packet**	Enables the VPDN packet debugging function.
Ruijie# **no debug vpdn packet**	Disables the VPDN packet debugging function.
Ruijie# **debug vpdn l2x-data**	Enables the VPDN l2x-data debugging function.
Ruijie# **no debug vpdn l2x-data**	Disables the VPDN l2x-data debugging function.
Ruijie# **debug vpdn l2x-errors**	Enables the VPDN l2x-errors debugging function.
Ruijie# **no debug vpdn l2x-errors**	Disables the VPDN l2x-errors debugging function.
Ruijie# **debug vpdn l2x-events**	Enables the VPDN l2x-events debugging function.
Ruijie# **no debug vpdn l2x-events**	Disables the VPDNl2x-events debugging function.
Ruijie# **debug vpdn l2x-packets**	Enables the VPDN l2x-packets debugging function.
Ruijie# **no debug vpdn l2x-packets**	Disables the VPDN l2x-packets debugging function.

Displaying Information About the Current L2TP Tunnel

You can use the **show vpdn** command in real time as required to view information about the current L2TP tunnel (including channel information and session information).

Note The length of usernames is unlimited. The **show vpdn** command displays only the first 12 charaters of a username for the sake of format alignment. You can use the **show vpdn tunnel l2tp** *locid* command to view the full username.

```
Ruijie# show vpdn tunnel
L2TP Tunnel Information Total tunnels 1
LocID RemID Remote Name   State  Remote Address  Port  Sessions L2TP Class/
                                                       VPDN Group
1    35390 C3640        est    192.168.12.242  1701  1       1
%No active PPTP tunnels
Ruijie# show vpdn session
L2TP Session Information Total sessions 1
LocID     RemID     TunID     Username, Intf/     State
Last Chg
                            Vcid, Circuit
1         1261      1         rgnos,Vi1              est
01:04:42
%No active PPTP tunnels
Ruijie# show vpdn
L2TP Tunnel and Session Information Total tunnels 1 sessions 1
LocID RemID Remote Name   State  Remote Address  Port  Sessions L2TP Class/
                                                       VPDN Group
1    35390 C3640        est    192.168.12.242  1701  1       1
LocID     RemID     TunID     Username, Intf/     State  Last Chg
                            Vcid, Circuit
1         1261      1         rgnos,Vi1              est
01:04:45
%No active PPTP tunnels
Ruijie#
Ruijie# show vpdn tunnel l2tp 1
L2TP tunnel locid 1 is up, remote id is 35390, 1 active sessions
  Tunnel state is est
  Tunnel transport is UDP
  Remote tunnel name is C3640
    Internet Address 192.168.12.242, port 1701
  Local tunnel name is Ruijie
    Internet Address 192.168.12. 217, port 1701
  VPDN group for tunnel is 1
  Tunnel domain unknown
  ip mtu adjust disabled
  Control Ns 2, Nr 4
```

Performing Overall VPDN Debugging

RGOS provides VPDN debugging functions, which are useful to both L2TP and PPTP. The following is an overall VPDN debugging example, in which the LNS accepts the dial-in request from the peer end and finally establishes a tunnel (including channels and sessions).

```
Ruijie# debug vpdn error
vpdn protocol errors debugging is on
Ruijie# debug vpdn event
vpdn events debugging is on
Ruijie# debug vpdn packet
vpdn packet debugging is on
Ruijie# show debug
VPDN:
vpdn events debugging is on
vpdn protocol errors debugging is on
vpdn packet debugging is on
Ruijie#
VPDN PROCESS From tunnel: Received 158 byte pak
L2X: UDP socket write 168 bytes, 192.168.12.217(1701) to 192.168.12.242(1701)
L2X: UDP socket write 40 bytes, 192.168.12.217(1701) to 192.168.12.242(1701)
VPDN PROCESS From tunnel: Pak consumed
VPDN PROCESS From tunnel: Received 70 byte pak
L2X: UDP socket write 40 bytes, 192.168.12.217(1701) to 192.168.12.242(1701)
VPDN PROCESS From tunnel: Pak consumed
VPDN PROCESS From tunnel: Received 76 byte pak
Get virtual-access from free queue: Virtual-Access1
Clone virtual-access from interface Virtual-Template1
L2X: UDP socket write 56 bytes, 192.168.12.217(1701) to 192.168.12.242(1701)
L2X: UDP socket write 40 bytes, 192.168.12.217(1701) to 192.168.12.242(1701)
VPDN PROCESS From tunnel: Pak consumed
VPDN PROCESS From tunnel: Received 76 byte pak
L2X: UDP socket write 40 bytes, 192.168.12.217(1701) to 192.168.12.242(1701)
Vi1 Tnl/Sn 3/1 L2TP: Virtual interface created for unknown, bandwidth 1024 Kbps
Vi1 Tnl/Sn 3/1 L2TP: VPDN session up
VPDN PROCESS From tunnel: Pak consumed
VPDN PROCESS From tunnel: Received 50 byte pak
Vi1 VPDN PROCESS From tunnel: Queue 14 byte pak to ppp parse and iqueue
Vi1 VPDN PROCESS From tunnel: Pak send successful
%UPDOWN: Interface Virtual-Access1, changed state to up
Vi1 VPDN PROCESS Into tunnel: Sending 54 byte pak
L2X: UDP socket write 54 bytes, 255.255.255.255(1701) to 4.83.68.68(1701)
VPDN PROCESS From tunnel: Received 50 byte pak
Vi1 VPDN PROCESS From tunnel: Queue 14 byte pak to ppp parse and iqueue
Vi1 VPDN PROCESS From tunnel: Pak send successful
Vi1 VPDN PROCESS Into tunnel: Sending 50 byte pak
```

```
L2X: UDP socket write 50 bytes, 255.255.255.255(1701) to 4.83.68.68(1701)
Vi1 VPDN PROCESS Into tunnel: Sending 54 byte pak
L2X: UDP socket write 54 bytes, 255.255.255.255(1701) to 4.83.68.68(1701)
VPDN PROCESS From tunnel: Received 50 byte pak
Vi1 VPDN PROCESS From tunnel: Queue 14 byte pak to ppp parse and iqueue
Vi1 VPDN PROCESS From tunnel: Pak send successful
Vi1 VPDN PROCESS Into tunnel: Sending 50 byte pak
L2X: UDP socket write 50 bytes, 255.255.255.255(1701) to 4.83.68.68(1701)
Vi1 VPDN PROCESS Into tunnel: Sending 54 byte pak
L2X: UDP socket write 54 bytes, 255.255.255.255(1701) to 4.83.68.68(1701)
VPDN PROCESS From tunnel: Received 50 byte pak
Vi1 VPDN PROCESS From tunnel: Queue 14 byte pak to ppp parse and iqueue
Vi1 VPDN PROCESS From tunnel: Pak send successful
Vi1 VPDN PROCESS Into tunnel: Sending 50 byte pak
L2X: UDP socket write 50 bytes, 192.168.12.217(1701) to 192.168.12.242(1701)
Vi1 VPDN PROCESS Into tunnel: Sending 54 byte pak
L2X: UDP socket write 54 bytes, 192.168.12.217(1701) to 192.168.12.242(1701)
VPDN PROCESS From tunnel: Received 54 byte pak
Vi1 VPDN PROCESS From tunnel: Queue 18 byte pak to ppp parse and iqueue
Vi1 VPDN PROCESS From tunnel: Pak send successful
VPDN PROCESS From tunnel: Received 56 byte pak
Vi1 VPDN PROCESS From tunnel: Queue 20 byte pak to ppp parse and iqueue
Vi1 VPDN PROCESS From tunnel: Pak send successful
Vi1 VPDN PROCESS Into tunnel: Sending 45 byte pak
L2X: UDP socket write 45 bytes, 192.168.12.217(1701) to 192.168.12.242(1701)
Vi1 VPDN PROCESS Into tunnel: Sending 50 byte pak
L2X: UDP socket write 50 bytes, 192.168.12.217(1701) to 192.168.12.242(1701)
VPDN PROCESS From tunnel: Received 50 byte pak
Vi1 VPDN PROCESS From tunnel: Queue 14 byte pak to ppp parse and iqueue
Vi1 VPDN PROCESS From tunnel: Pak send successful
Vi1 VPDN PROCESS Into tunnel: Sending 50 byte pak
L2X: UDP socket write 50 bytes, 192.168.12.217(1701) to 192.168.12.242(1701)
VPDN PROCESS From tunnel: Received 50 byte pak
Vi1 VPDN PROCESS From tunnel: Queue 14 byte pak to ppp parse and iqueue
Vi1 VPDN PROCESS From tunnel: Pak send successful
VPDN PROCESS From tunnel: Received 50 byte pak
Vi1 VPDN PROCESS From tunnel: Queue 14 byte pak to ppp parse and iqueue
Vi1 VPDN PROCESS From tunnel: Pak send successful
Vi1 VPDN PROCESS Into tunnel: Sending 50 byte pak
L2X: UDP socket write 50 bytes, 192.168.12.217(1701) to 192.168.12.242(1701)
%UPDOWN: Line protocol on Interface Virtual-Access1, changed state to up
Ruijie# show ip route
Codes: C - connected, S - static,  R - RIP
O - OSPF, IA - OSPF inter area
E1 - OSPF external type 1, E2 - OSPF external type 2
```

```
Gateway of last resort is not set
192.168.101.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.101.5/32 is directly connected, Virtual-Access1
C      192.168.101.0/24 is directly connected, Virtual-Access1
C   192.168.12.0/24 is directly connected, FastEthernet0
C   192.168.201.0/24 is directly connected, Ethernet0
Ruijie#
```

Performing L2TP Data Debugging

If a user needs to check whether L2TP can send control messages successfully, enable the L2TP data debugging function. The following is an L2TP data debugging example, in which the LNS accepts the dial-in request from the peer end and finally establishes a tunnel (including channels and sessions) after the l2x-data debugging function is enabled.

```
Ruijie# no debug all
All possible debugging has been turned off
Ruijie# debug vpdn l2x-data
L2X data packets debugging is on
Ruijie#
L2X: Punting to L2TP control message queue
L2X: Punting to L2TP control message queue
L2X: Punting to L2TP control message queue
L2X: Punting to L2TP control message queue
L2X: Punting to L2TP control message queue
L2X: Punting to L2TP control message queue
%UPDOWN: Interface Virtual-Access1, changed state to up
%UPDOWN: Line protocol on Interface Virtual-Access1, changed state to up
Ruijie#
```

Performing L2TP Error Debugging

Users can enable the l2x-erorrs debugging function to check whether a tunnel estabishment failure results from configuration inconsistency at both ends (for example, different tunnel authentication passwords at both ends). The following is an example of errors reported due to a tunnel authentcation failure.

```
Ruijie# no debug all
All possible debugging has been turned off
Ruijie# debug vpdn l2x-errors
L2X protocol errors debugging is on
Ruijie# config terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface virtual-ppp 1
Ruijie(config-if)# no shutdown
Ruijie(config-if)# end
Ruijie#
Tnl 14 L2TP: Tunnel auth failed for BLIZZARD
Tnl 14 L2TP: Expected
```

```
9E 8D 7A 8E 78 EA 41 9F A1 74 01 21 DE 4F F3 F0
Tnl 14 L2TP: Got
84 E5 62 69 AE 46 A5 98 4E FE E2 38 EE F2 B7 E2
Ruijie# no debug all
All possible debugging has been turned off
Ruijie#
```

Performing L2TP Event Debugging

Users can enable the l2x-events debugging function to check the entire process of L2TP tunnel negotiation and establishment. The following is an L2TP event debugging example, in which the LNS accepts the dial-in request from the peer end and finally establishes a tunnel (including channels and sessions) after the l2x-events debugging function is enabled. The tunnel authentication function is enabled here.

```
Ruijie# show vpdn tunnel
%No active L2TP tunnels
%No active PPTP tunnels
Ruijie# no debug all
All possible debugging has been turned off
Ruijie# debug vpdn l2x-events
L2X protocol events debugging is on
Ruijie#
L2TP: I SCCRQ from C3640 tnl 26656
New tunnel created for remote C3640, address 192.168.12.242
Tnl 0 L2TP: Got a challenge in SCCRQ, C3640
Tnl 20 L2TP: O SCCRP  to C3640 tnlid 26656
Tnl 20 L2TP: Control channel retransmit delay set to 1 seconds
Tnl 20 L2TP: Tunnel state change from idle to wait-ctl-conn
Tnl 20 L2TP: I SCCCN from C3640 tnl 26656
Tnl 20 L2TP: Got a Challenge Response in SCCCN, C3640
Tnl 20 L2TP: Tunnel Authentication success
Tnl 20 L2TP: Tunnel state change from wait-ctl-conn to established
Tnl 20 L2TP: SM State established
Tnl 20 L2TP: I ICRQ from C3640 tnl 26656
Tnl/Sn 20/1 L2TP: Accepted ICRQ, new session created
Tnl/Sn 20/1 L2TP: O ICRP to C3640 26656/1279
Tnl/Sn 20/1 L2TP: Session state change from idle to wait-connect
Tnl 20 L2TP: Control channel retransmit delay set to 1 seconds
Tnl/Sn 20/1 L2TP: I ICCN from C3640 tnl 26656, cl 1279
Tnl/Sn 20/1 L2TP: Session state change from wait-connect to wait-for-service-sel
ection-iccn
Vi1 Tnl/Sn 20/1 L2TP: Session state change from wait-for-service-selection- iccn to established
%UPDOWN: Interface Virtual-Access1, changed state to up
%UPDOWN: Line protocol on Interface Virtual-Access1, changed state to up
Ruijie# show ip route
Codes: C - connected, S - static,  R - RIP
```

```
O - OSPF, IA - OSPF inter area
E1 - OSPF external type 1, E2 - OSPF external type 2
Gateway of last resort is not set
192.168.101.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.101.7/32 is directly connected, Virtual-Access1
C      192.168.101.0/24 is directly connected, Virtual-Access1
C    192.168.12.0/24 is directly connected, FastEthernet0
C    192.168.201.0/24 is directly connected, Ethernet0
Ruijie# show vpdn
L2TP Tunnel and Session Information Total tunnels 1 sessions 1
LocID RemID Remote Name   State  Remote Address  Port  Sessions L2TP Class/
                                                       VPDN Group
20    26656 C3640      est    192.168.12.242  1701  1    1
LocID   RemID    TunID   Username, Intf/    State  Last Chg
                            Vcid, Circuit
1     1279      20        rgnos,Vi1       est    00:00:38
%No active PPTP tunnels
Ruijie#
```

The following is an L2TP event debugging example, in which the LNS accesses the remote L2TP server and finally establishes a tunnel (including channels and sessions) after the l2x-events debugging function is enabled. The tunnel authentication function is disabled here.

```
Ruijie# no debug all
All possible debugging has been turned off
Ruijie# debug vpdn l2x-events
L2X protocol events debugging is on
Ruijie# config terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface virtual-ppp 1
Ruijie(config-if)# no shut
Ruijie(config-if)# end
Ruijie#
Tnl 21 L2TP: SM State idle
Tnl 21 L2TP: O SCCRQ
Tnl 21 L2TP: Control channel retransmit delay set to 1 seconds
Tnl 21 L2TP: Tunnel state change from idle to wait-ctl-reply
Tnl 21 L2TP: SM State wait-ctl-reply
Tnl 21 L2TP: O Resend SCCRQ, flg TLS, ver 2, len 96, tnl 0, ns 0, nr 0
Tnl 21 L2TP: Control channel retransmit delay set to 1 seconds
Tnl 21 L2TP: I SCCRP from
Tnl 21 L2TP: O SCCCN  to BLIZZARD tnlid 40
Tnl 21 L2TP: Control channel retransmit delay set to 1 seconds
Tnl 21 L2TP: Tunnel state change from wait-ctl-reply to established
Tnl 21 L2TP: SM State established
Vi1 Tnl/Sn 21/1 L2TP: O ICRQ to BLIZZARD 40/0
```

```
Vi1 Tnl/Sn 21/1 L2TP: Control channel retransmit delay set to 1 seconds
Vi1 Tnl/Sn 21/1 L2TP: Session state change from wait-for-tunnel to wait-reply
Vi1 Tnl/Sn 21/1 L2TP: I ICRP from BLIZZARD
Vi1 Tnl/Sn 21/1 L2TP: O ICCN to BLIZZARD 40/1
Vi1 Tnl/Sn 21/1 L2TP: Control channel retransmit delay set to 1 seconds
Vi1 Tnl/Sn 21/1 L2TP: Session state change from wait-reply to established
%UPDOWN: Interface Virtual-PPP1, changed state to up
%UPDOWN: Line protocol on Interface Virtual-PPP1, changed state to up
Ruijie# show vpdn
L2TP Tunnel and Session Information Total tunnels 1 sessions 1
LocID RemID Remote Name  State  Remote Address  Port  Sessions L2TP Class/
                                                      VPDN Group
21   40   BLIZZARD     est   192.168.12.213  1701  1
LocID   RemID  TunID   Username, Intf/   State  Last Chg
                           Vcid, Circuit
1      1        21       13,Vi1         est   00:00:27
%No active PPTP tunnels
Ruijie#
```

Performing L2TP Message Data Debugging

L2TP message data debugging refers to displaying the content of an L2TP control message after a user enables the l2x-packets debugging function. The following is an L2TP message data debugging example, in which the LNS accepts the dial-in request from the peer end and finally establishes a tunnel (including channels and sessions) after the l2x-packets debugging function is enabled. The tunnel authentication function is enabled here.

```
Ruijie# no debug all
All possible debugging has been turned off
Ruijie# debug vpdn l2x-packets
L2X control packets debugging is on
Ruijie# show vpdn
%No active L2TP tunnels
%No active PPTP tunnels
Ruijie#
L2TP: I SCCRQ from C3640 tnl 18889
L2X: Parse  AVP 0, len 8, flag 0x8000 (M)
L2X: Parse SCCRQ
L2X: Parse  AVP 2, len 8, flag 0x8000 (M)
L2X: Protocol Ver 1
L2X: Parse  AVP 6, len 8, flag 0x0
L2X: Firmware Ver 0x1130
L2X: Parse  AVP 7, len 11, flag 0x8000 (M)
L2X: Hostname C3640
L2X: Parse  AVP 8, len 25, flag 0x0
L2X: Vendor Name Cisco Systems, Inc.
L2X: Parse  AVP 10, len 8, flag 0x8000 (M)
```

```
L2X: Rx Window Size 800
L2X: Parse  AVP 11, len 22, flag 0x8000 (M)
L2X: Chlng
       98 20 4E 34 6A 4C E1 E7 FA CF 58 07 FF 4E 56 A3
L2X: Parse  AVP 9, len 8, flag 0x8000 (M)
L2X: Assigned Tunnel ID 18889
L2X: Parse  AVP 3, len 10, flag 0x8000 (M)
L2X: Framing Cap 0x3
L2X: Parse  AVP 4, len 10, flag 0x8000 (M)
L2X: Bearer Cap 0x3
L2X: No missing AVPs in SCCRQ
L2X: I SCCRQ, flg TLS, ver 2, len 130, tnl 0, ns 0, nr 0 contiguous pak, size 130
C8 02 00 82 00 00 00 00 00 00 00 80 08 00 00
00 00 00 01 80 08 00 00 00 02 01 00 00 08 00 00
00 06 11 30 80 0B 00 00 00 07 43 33 36 34 30 00
19 00 00 00 08 43 69 73 63 6F 20 53 79 73 74 65
6D 73 2C 20 49 6E 63 2E ...
Tnl 22 L2TP: O SCCRP  to C3640 tnlid 18889
Tnl 22 L2TP: O SCCRP, flg TLS, ver 2, len 140, tnl 18889, ns 0, nr 1
C8 02 00 8C 49 C9 00 00 00 00 00 01 80 08 00 00
00 00 00 02 80 08 00 00 00 02 01 00 80 0A 00 00
00 03 00 00 00 01 80 0A 00 00 00 04 00 00 00 00
00 08 00 00 00 06 11 30 80 0A 00 00 00 07 52 36
32 31 00 0E 00 00 00 08 ...
Tnl 22 L2TP: O ZLB ctrl ack, flg TLS, ver 2, len 12, tnl 18889, ns 1, nr 1
C8 02 00 0C 49 C9 00 00 00 01 00 01
Tnl 22 L2TP: Parse  AVP 0, len 8, flag 0x8000 (M)
Tnl 22 L2TP: Parse SCCCN
Tnl 22 L2TP: I SCCCN from C3640 tnl 18889
Tnl 22 L2TP: Parse  AVP 13, len 22, flag 0x8000 (M)
Tnl 22 L2TP: Chlng Resp
5C D5 A4 37 36 A6 7D 0F FE EF 22 48 B8 DF F5 12
Tnl 22 L2TP: No missing AVPs in SCCCN
Tnl 22 L2TP: I SCCCN, flg TLS, ver 2, len 42, tnl 22, ns 1, nr 1 contiguous pak, size 42
C8 02 00 2A 00 16 00 00 00 01 00 01 80 08 00 00
00 00 00 03 80 16 00 00 00 0D 5C D5 A4 37 36 A6
7D 0F FE EF 22 48 B8 DF F5 12
Tnl 22 L2TP: O ZLB ctrl ack, flg TLS, ver 2, len 12, tnl 18889, ns 1, nr 2
C8 02 00 0C 49 C9 00 00 00 01 00 02
Tnl 22 L2TP: Parse  AVP 0, len 8, flag 0x8000 (M)
Tnl 22 L2TP: Parse ICRQ
Tnl 22 L2TP: I ICRQ from C3640 tnl 18889
Tnl 22 L2TP: Parse  AVP 15, len 10, flag 0x8000 (M)
Tnl 22 L2TP: Serial Number -1714567290
Tnl 22 L2TP: Parse  AVP 14, len 8, flag 0x8000 (M)
```

```
Tnl 22 L2TP: Assigned Call ID 1280
Tnl 22 L2TP: Parse  AVP 18, len 10, flag 0x8000 (M)
Tnl 22 L2TP: Bearer Type 0
Tnl 22 L2TP: No missing AVPs in ICRQ
Tnl 22 L2TP: I ICRQ, flg TLS, ver 2, len 48, tnl 22, ns 2, nr 1 contiguous pak,size 48
C8 02 00 30 00 16 00 00 00 02 00 01 80 08 00 00
00 00 00 0A 80 0A 00 00 00 0F 99 CD C7 86 80 08
00 00 00 0E 05 00 80 0A 00 00 00 12 00 00 00 00
Tnl/Sn 22/1 L2TP: O ICRP to C3640 18889/1280
Tnl/Sn 22/1 L2TP: O ICRP, flg TLS, ver 2, len 28, tnl 18889, lsid 1, rsid 1280,ns 1, nr 3
C8 02 00 1C 49 C9 05 00 00 01 00 03 80 08 00 00
00 00 00 0B 80 08 00 00 00 0E 00 01
Tnl 22 L2TP: O ZLB ctrl ack, flg TLS, ver 2, len 12, tnl 18889, ns 2, nr 3
       C8 02 00 0C 49 C9 00 00 00 02 00 03
Tnl/Sn 22/1 L2TP: I ICCN from C3640 tnl 18889, cl 1280
Tnl/Sn 22/1 L2TP: Parse  AVP 0, len 8, flag 0x8000 (M)
Tnl/Sn 22/1 L2TP: Parse ICCN
Vi1 Tnl/Sn 22/1 L2TP: Parse  AVP 24, len 10, flag 0x8000 (M)
Vi1 Tnl/Sn 22/1 L2TP: Connect Speed 0
Vi1 Tnl/Sn 22/1 L2TP: Parse  AVP 19, len 10, flag 0x8000 (M)
Vi1 Tnl/Sn 22/1 L2TP: Framing Type 1
Tnl/Sn 22/1 L2TP: No missing AVPs in ICCN
Tnl/Sn 22/1 L2TP: I ICCN, flg TLS, ver 2, len 48, tnl 22, lsid 1, rsid 1280, ns 3, nr 2 contiguous
pak, size 48
C8 02 00 30 00 16 00 01 00 03 00 02 80 08 00 00
00 00 00 0C 80 0A 00 00 00 18 00 00 00 00 80 0A
00 00 00 13 00 00 00 01 00 08 00 00 00 1D 00 04
Tnl 22 L2TP: O ZLB ctrl ack, flg TLS, ver 2, len 12, tnl 18889, ns 2, nr 4
C8 02 00 0C 49 C9 00 00 00 02 00 04
%UPDOWN: Interface Virtual-Access1, changed state to up
%UPDOWN: Line protocol on Interface Virtual-Access1, changed state to up
Ruijie# show vpdn
L2TP Tunnel and Session Information Total tunnels 1 sessions 1
LocID RemID Remote Name  State  Remote Address  Port  Sessions L2TP Class/
                                                      VPDN Group
22   18889 C3640    est    192.168.12.242  1701  1       1
LocID    RemID    TunID    Username, Intf/    State  Last Chg
                            Vcid, Circuit
1      1280      22        ,Vi1            est    00:00:19
%No active PPTP tunnels
Ruijie# show ip route
Codes: C - connected, S - static,  R - RIP
O - OSPF, IA - OSPF inter area
E1 - OSPF external type 1, E2 - OSPF external type 2
Gateway of last resort is not set
```

```
192.168.101.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.101.8/32 is directly connected, Virtual-Access1
C      192.168.101.0/24 is directly connected, Virtual-Access1
C   192.168.12.0/24 is directly connected, FastEthernet0
C   192.168.201.0/24 is directly connected, Ethernet0
Ruijie#
```

The following is an L2TP message data debugging example, in which the LAC accesses the remote L2TP server and finally establishes a tunnel (including channels and sessions), after the l2x-packets debugging function is enabled. The tunnel authentication function is disabled here.

```
Ruijie# no debug all
All possible debugging has been turned off
Ruijie# debug vpdn l2x-packets
L2X control packets debugging is on
Ruijie# config terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface virtual-ppp 1
Ruijie(config-if)# no shutdown
Ruijie(config-if)# end
Ruijie#
Tnl 21 L2TP: O SCCRQ
Tnl 21 L2TP: O SCCRQ, flg TLS, ver 2, len 96, tnl 0, ns 0, nr 0
C8 02 00 60 00 00 00 00 00 00 00 80 08 00 00
00 00 00 01 80 08 00 00 00 02 01 00 80 0A 00 00
00 03 00 00 00 01 80 0A 00 00 00 04 00 00 00 00
00 08 00 00 00 06 11 30 80 0A 00 00 00 07 52 36
32 31 00 0E 00 00 00 08 ...
Tnl 21 L2TP: Parse  AVP 0, len 8, flag 0x8000 (M)
Tnl 21 L2TP: Parse SCCRP
Tnl 21 L2TP: Parse  AVP 2, len 8, flag 0x8000 (M)
Tnl 21 L2TP: Protocol Ver 1
Tnl 21 L2TP: Parse  AVP 3, len 10, flag 0x8000 (M)
Tnl 21 L2TP: Framing Cap 0x1
Tnl 21 L2TP: Parse  AVP 4, len 10, flag 0x8000 (M)
Tnl 21 L2TP: Bearer Cap 0x0
Tnl 21 L2TP: Parse  AVP 6, len 8, flag 0x0
Tnl 21 L2TP: Firmware Ver 0x500
Tnl 21 L2TP: Parse  AVP 7, len 14, flag 0x8000 (M)
Tnl 21 L2TP: Hostname BLIZZARD
Tnl 21 L2TP: Parse  AVP 8, len 15, flag 0x0
Tnl 21 L2TP: Vendor Name Microsoft
Tnl 21 L2TP: Parse  AVP 9, len 8, flag 0x8000 (M)
Tnl 21 L2TP: Assigned Tunnel ID 41
Tnl 21 L2TP: Parse  AVP 10, len 8, flag 0x8000 (M)
Tnl 21 L2TP: Rx Window Size 8
```

```
Tnl 21 L2TP: No missing AVPs in SCCRP
Tnl 21 L2TP: I SCCRP, flg TLS, ver 2, len 101, tnl 21, ns 0, nr 1 contiguous pak, size 101
C8 02 00 65 00 15 00 00 00 00 01 80 08 00 00
00 00 00 02 80 08 00 00 00 02 01 00 80 0A 00 00
00 03 00 00 00 01 80 0A 00 00 00 04 00 00 00 00
00 08 00 00 00 06 05 00 80 0E 00 00 00 07 42 4C
49 5A 5A 41 52 44 00 0F ...
Tnl 21 L2TP: O SCCCN  to BLIZZARD tnlid 41
Tnl 21 L2TP: O SCCCN, flg TLS, ver 2, len 20, tnl 41, ns 1, nr 1
C8 02 00 14 00 29 00 00 00 01 00 01 80 08 00 00
00 00 00 03
Vi1 Tnl/Sn 21/1 L2TP: O ICRQ to BLIZZARD 41/1
Vi1 Tnl/Sn 21/1 L2TP: O ICRQ, flg TLS, ver 2, len 48, tnl 41, lsid 1, rsid 1, ns 2, nr 1
C8 02 00 30 00 29 00 00 00 02 00 01 80 08 00 00
00 00 00 0A 80 08 00 00 00 0E 00 01 80 0A 00 00
00 0F 00 00 00 00 80 0A 00 00 00 12 00 00 00 02
Tnl 21 L2TP: O ZLB ctrl ack, flg TLS, ver 2, len 12, tnl 41, ns 3, nr 1
C8 02 00 0C 00 29 00 00 00 03 00 01
Tnl 21 L2TP: I ZLB ctrl ack, flg TLS, ver 2, len 12, tnl 21, ns 1, nr 2
Tnl 21 L2TP: I ZLB ctrl ack, flg TLS, ver 2, len 12, tnl 21, ns 1, nr 3
Vi1 Tnl/Sn 21/1 L2TP: Parse  AVP 0, len 8, flag 0x8000 (M)
Vi1 Tnl/Sn 21/1 L2TP: Parse ICRP
Vi1 Tnl/Sn 21/1 L2TP: Parse  AVP 14, len 8, flag 0x8000 (M)
Vi1 Tnl/Sn 21/1 L2TP: Assigned Call ID 1
Vi1 Tnl 21/1 L2TP: No missing AVPs in ICRP
Vi1 Tnl/Sn 21/1 L2TP: I ICRP, flg TLS, ver 2, len 28, tnl 21, lsid 1, rsid 1, ns 1, nr 3 contiguous
pak, size 28
C8 02 00 1C 00 15 00 01 00 01 00 03 80 08 00 00
00 00 00 0B 80 08 00 00 00 0E 00 01
Vi1 Tnl/Sn 21/1 L2TP: O ICCN to BLIZZARD 41/1
Vi1 Tnl/Sn 21/1 L2TP: O ICCN, flg TLS, ver 2, len 40, tnl 41, lsid 1, rsid 1, ns 3, nr 2
C8 02 00 28 00 29 00 01 00 03 00 02 80 08 00 00
00 00 00 0C 80 0A 00 00 00 18 00 98 96 80 80 0A
00 00 00 13 00 00 00 01
Tnl 21 L2TP: O ZLB ctrl ack, flg TLS, ver 2, len 12, tnl 41, ns 4, nr 2
C8 02 00 0C 00 29 00 00 00 04 00 02
Tnl 21 L2TP: I ZLB ctrl ack, flg TLS, ver 2, len 12, tnl 21, ns 2, nr 4
%UPDOWN: Interface Virtual-PPP1, changed state to up
%UPDOWN: Line protocol on Interface Virtual-PPP1, changed state to up
Ruijie# show vpdn
L2TP Tunnel and Session Information Total tunnels 1 sessions 1
LocID RemID Remote Name  State  Remote Address  Port  Sessions L2TP Class/
                                                      VPDN Group
21   41   BLIZZARD     est   192.168.12.213  1701  1
LocID     RemID     TunID     Username, Intf/     State  Last Chg
```

```
                            Vcid, Circuit
1        1        21       13,Vi1            est    00:00:13
%No active PPTP tunnels
Ruijie#
```

Maintaining L2TP Tunnels

Use the following command to clear a specified L2TP tunnel.

Command	Function
Ruijie**# clear vpdn tunnel** [{ **pptp** | **l2tp**} [*remote-host-name*]]	Clears a specified tunnel.

remote-host-name is the name of the peer host of a tunnel. In addition, all L2TP-related configuration commands in RGOS support instant configuration and use. Users can set or change L2TP parameters as required. The following is an example of clearing all tunnels.

```
Ruijie# show vpdn
L2TP Tunnel and Session Information Total tunnels 1 sessions 1
LocID RemID Remote Name   State  Remote Address  Port  Sessions L2TP Class/
                                                  VPDN Group
22   18889 C3640     est   192.168.12.242  1701  1       1

LocID   RemID   TunID    Username, Intf/    State  Last Chg
                           Vcid, Circuit
1     1280      22       ,Vi1            est    00:14:52
%No active PPTP tunnels
Ruijie# clear vpdn tunnel
Ruijie#
%UPDOWN: Line protocol on Interface Virtual-Access1, changed state to down
%CHANGED: Interface Virtual-Access1, changed state to administratively down
Ruijie# show vpdn
%No active L2TP tunnels
%No active PPTP tunnels
Ruijie#
```

FAQs

Common questions about L2TP tunnel establishment on the RGOS and their answers are presented as follows:

- Establishing an L2TP tunnel by interconnecting with a Windows PC: Note that L2TP is supported only in Microsoft Windows 2000 and later versions. Only the PPTP tunneling protocol is supported in earlier versions. Windows 2000 and Windows XP support L2TP by binding L2TP to IPSec/IKE. If you need to use a Windows 2000/XP PC to establish L2TP tunnels with other non-Microsoft network products, you must modify its registry to cancel this binding.
- Establishing an L2TP tunnel by interconnecting with a Windows PC: When you click **New connection** in **Network and Dial-up Connections** to create a virtual private connection (namely, **Connect to a private network through the Internet (V)**), the **Require data encryption (disconnect if none)** checkbox is selected by default and **Password requiring security measure** instead of PAP is used for authentication. However, the commoner method

is to use PAP or CHAP for authentication and not to encrypt data for transmission. Therefore, you need to modify the properties of this connection manually.

- Establishing an L2TP tunnel by interconnecting with a Windows PC: When you click **New connection** and **Accept incoming connections (A)** in **Network and Dial-up Connections** to create a connection, the MS-CHAPv2 method is used for user authentication by default and CHAP is forbidden for authentication. If you need to use CHAP for authentication, you must modify the configuration file of **Remote access policy** in the settings of the started **Routing and remote access** service, that is, add CHAP as an optional authentication method.
- Establishing an L2TP tunnel by interconnecting with a Windows PC: L2TP on Windows does not support the tunnel authentication function. The tunnel authentication function must be disabled in the L2TP settings of Ruijie router connected to the Windows PC. Tunnel authentication is disabled on Ruijie router by default.
- Establishing an L2TP tunnel by interconnecting with a Cisco device: Cisco IOS requires tunnel authentication by default, whereas tunnel authentication is diabled on Ruijie router by default.
- Establishing an L2TP tunnel by interconnecting with a Cisco device: If Ruijie router acts as the LNS and the Cisco device acts as the LAC to provide the L2TP tunnel service for remote dial-up users, **ip domain-lookup** instead of **ip cef** must be set on the Cisco device, just as on Cisco 2620 (LAC) in the preceding configuration example. Otherwise, the Cisco device will not forward PPP negotiation packets and other data to dial-up users.
- Establishing an L2TP tunnel by means of negotiation: The tunnel authentication settings at both ends of a tunnel must be consistent, that is, tunnel authentication is enabled or disabled at the same time at both ends. If it is enabled at both ends, the same tunnel authentication password must be set.
- Do not attempt to use Cisco routers (IOS versions 12.2 and 12.3) to establish an L2TP tunnel with a Windows 2000 PC, because it will be a waste of time.
- In consideration of being compatible with L2TP on different Windows versions and Cisco IOS of earlier versions, as well as the forwarding efficiency, RGOS does not support the AVP Hidden function and data message sequencing function. When an L2TP tunnel is etablished by interconnecting with Cisco IOS of later versions, ensure that the AVP Hidden function and data message sequencing function are disabled and default settings of the system are used.
- RGOS provides the LAC function, but does not support the LAC access server function.
- When RGOS is used to implement the LNS function, it is recommended that the address of the virtual-template interface be set in IP unnumbered mode, just as the settings on Cisco devices in consideration of fast route forwarding. Generally, IP unnumbered is bound to a loopback interface, as shown in the examples.
- In terms of instant configuration and use property of L2TP, effective changes (namely, non-repetitive operations) of control connection properties will cause the active disconnection of the related L2TP tunnel and all sessions on the tunnel. Effective changes of data transmission properties affects data transmission immediately.
- When the RGOS router is located behind a firewall, UDP port 1701 of the firewall must be enabled.
- When designing an L2TP tunnel, ensure that the route between the client and the server is available. When a router acts as the client, routes generated after an L2TP tunnel is established are different from those generated when a Windows PC acts as the client. If an L2TP tunnel is successfully established on a router (either a Cisco or a Ruijie product), two routes are generated, just as routes generated after other PPP link interfaces become UP. One is reachable to the server network segment, and the other is a direct route. However, when a Windows PC is used as the client, after an L2TP tunnel is established, a new route that traverses the L2TP tunnel and is reachable to the network 0.0.0.0/0 is added, in addition to the original route and the preceding two new routes.

Configuring the Digital Certificate

Overview

To ensure the security, authenticity, reliability, integrity and non-repudiation of the information transmitted between clients over network, the identity of clients must be verified, while the digital certificate is one of the methods to realize this function. PKI digital certificate technology associates the identity of individual or entity with a public key, and centrally issues the certificate through Certificate Authority (CA) to guarantee the validity and security of certificates. The digital certificates are electronic files issued by CA and binding the identity, public key and CA signature of the entity, with public key and private key forming a key pair in the public key cryptography system. Both sides of communication verify the validity of the certificate through CA signature in digital certificate, and use the public key contained in the certificate to verify the digital signature created by the peer device using the private key, thus completing authentication. There are two types of digital certificates: X.509 certificates and PGP certificates. X.509 certificates are supported by Ruijie products.

Digital certificates can be used in the IKE negotiation and SSL of IPSec. Certificate authentication can be used in the IKE configuration of IPSec and boasts the following merits:

- Higher security than PSK
- No need to separately configure PSK between every two peers of communication (easy to use)
- Security problems caused by key compromise can be addressed through certificate revocation.
- Use of overdue keys can be avoided by controlling the duration of key pairs through certificate validity

The X.509 certificate on the router can be acquired manually and through SCEP protocol. The merits of using the SCEP protocol to acquire the digital certificate of the router are shown below:

- The private key remains in the cryptographic equipment, ensuring higher security.
- The SCEP protocol adopts PKCS7 digital envelop during communication, ensuring the security of communication process.
- Supported by CA, SCEP is capable of updating digital certificates automatically.

Terminology

Public-Key Infrastructure (PKI) is a set of hardware, software, people, policies, and procedures needed to create, manage, distribute, use, store, and revoke digital certificates.

X.509: X.509 is an international standard recommended by ITU-T, and defines a widely accepted PKI, including data format and the process of public key distribution through the digital certificate issued by CA.

CA: As an authoritative, trustworthy and impartial third-party organization, CA is responsible for issuing and managing the digital certificates of all entities participating in online transaction. It effectively manages the key and issues digital certificates to prove the validity of such key, and associates the public key with one entity.

Root CA: CA at the top of the hierarchy.

Certificate or digital certificate: In this chapter, it refers to X.509 certificate (data structure defined by X.509), and is used to associate an entity with a public key to indicate the identity of the entity. A certificate contains a public key, name

and digital signature of CA. Generally, the certificate also contains the validity period of the key, name of CA, serial number and etc, with format complying with ITUT X.509 standard.

CA root certificate: the self-signed certificate issued by root CA for itself; it is used to sign the other certificates issued by root CA.

Privacy-enhanced Mail (PEM): base64 encoded text format defined in RFC 1421-RFC 1424; generally used for e-mail and certificate import/export.

PKCS: A group of public-key cryptography standards devised and published by RSA Security, and is a widely-applied industry standard in information transfer. PKCS#1 defines a RSA encryption and signature algorithm; PKCS#7 defines a syntactic representation of enciphered message; PKCS#12 defines a method to create the security archive (PKCS12 can contain certificate, private key and other security achieves, and is a commonly used format for issuing certificates). The files exported in PKCS format are DER encoded binary files, and sometimes need to be converted into PEM encoded text files.

Certificate Revocation List (CRL): a list with time stamp to specify the certificates revoked by a CA. It can be freely obtained from the public directory, and is one of the two methods specified by Internet Public-Key Infrastructure (X.509) working group (PKIX) to check certificate state. Each certificate in the CRL is identified using its serial number. Therefore, by querying the serial number of certificate in the recently released CRL, the user's certificate system can check whether a certificate has been revoked; if the certificate is contained in CRL, then the certificate should be rejected. X.509 version 2 CRL contains version number, issuer DN (globally unique), validity period, serial number of the revoked certificate, time of revocation, reason of revocation, the algorithm for CA to issue this CRL and the signature thereof.

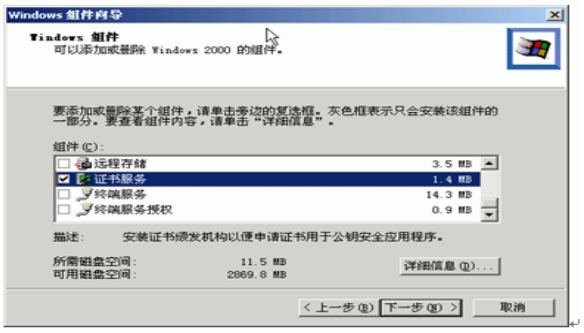
Simple Certificate Enrollment Protocol (SCEP): A draft protocol defined by Cisco to securely apply for a certificate for the router from CA. It is currently deployed on various network devices.

Configuring CA Server and Applying for & Exporting a Certificate

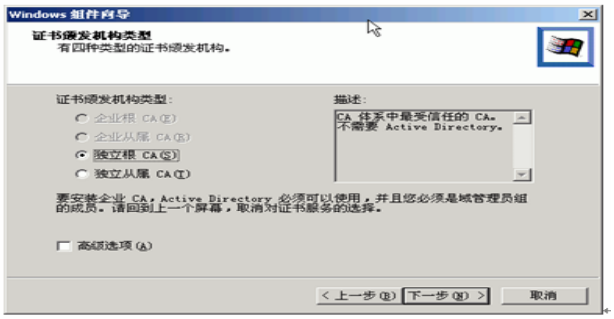
Installing the Certificate Services on a Windows 2003 Server

Step 1: Select Add/Remove Programs in Control Panel and click Add/Remove Windows Components.

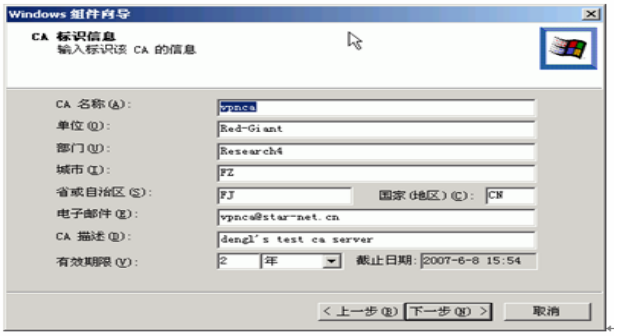
Step 2: Select **Certificate Services** in the pop-up window, as shown below:



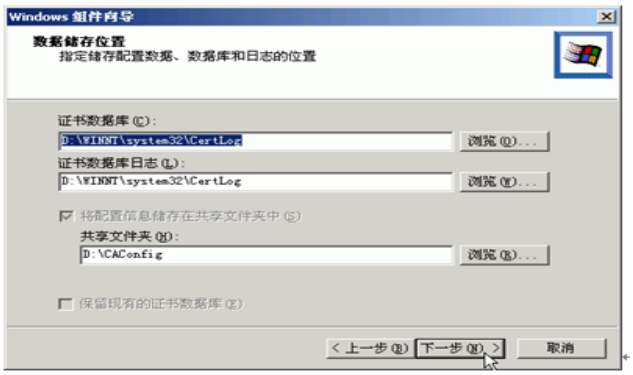
Step 3: Click **Next** and select **Stand-alone root CA** in the pop-up window, as shown below:



Step 4: Click **Next** and fill in CA related information.



Step 5: Click **Next** and set a database directory (or use the default path).

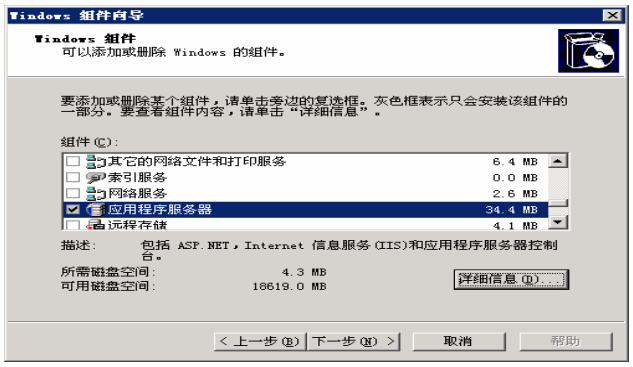


Step 6: Click **Next** to install the certificate services.

Setting Up CA Server on IIS

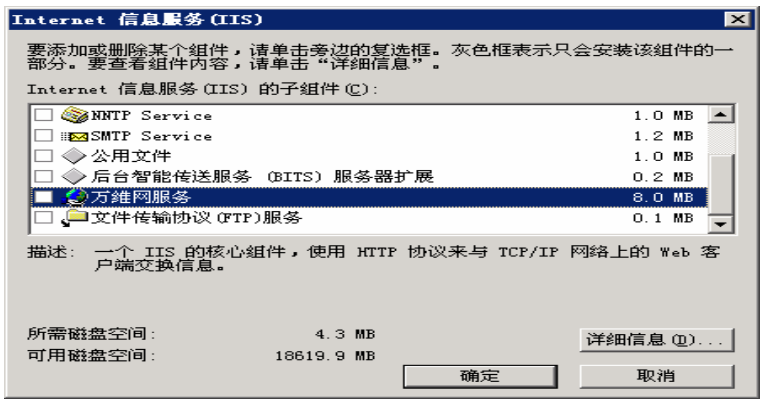
Step 1: Select Add/Remove Programs and click Add/Remove Windows Components.

Step 2: Select **Application Server** and then click **Details**.

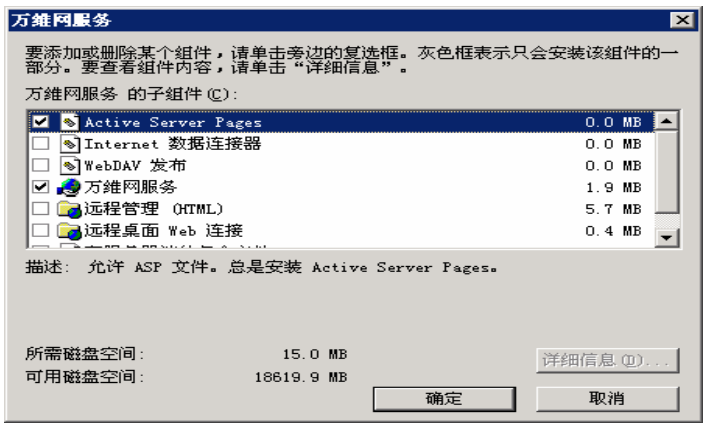


Step 3: In the following dialog box, select **Internet information services (IIS)** and then click **Details**.

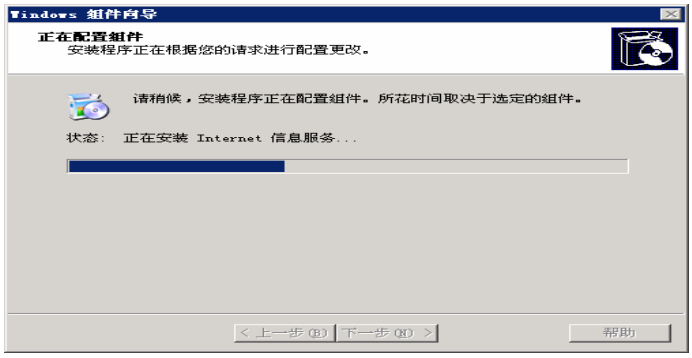
Step 4: In the following dialog box, select **World Wide Web Service** and then click **Details**.



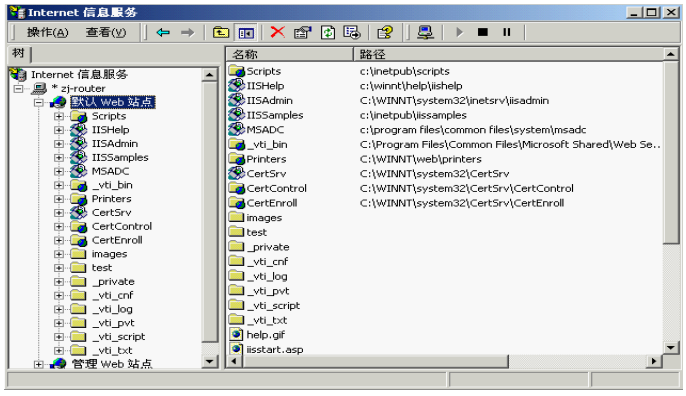
Step 5: In the following dialog box, select **Active Server Pages** and **World Wide Web Service** and click **OK** for three times. If **World Wide Web Publishing Service** is selected, **Common Files** and **Internet Service Manager** will be selected as well by default.



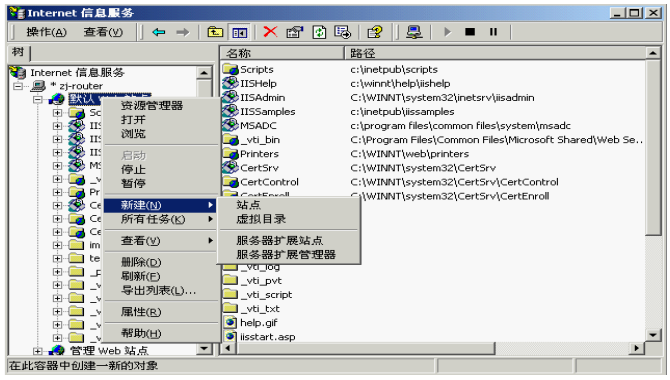
Step 6: Return to the main window and click **Next** to proceed with installation.



Step 7: Enter Control Panel and select Administrative Tools; select Internet Services Manager, as shown below:

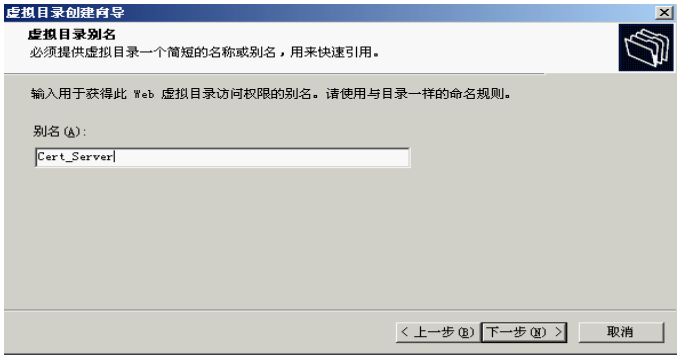


Step 8: Right-click the default website, as shown below:



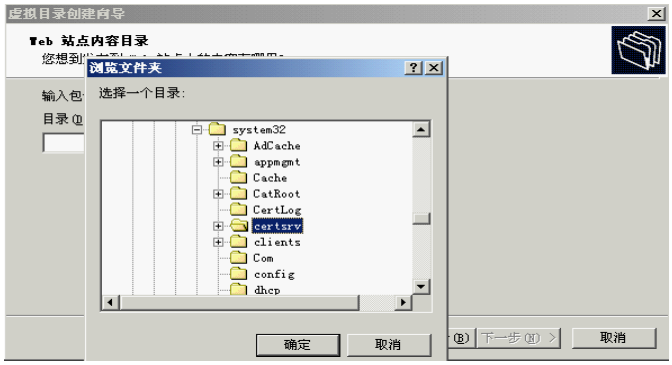
Step 9: Select **Virtual Directory**, as shown below:

Step 10: Click **Next** and enter the alias of the virtual directory, as shown below:

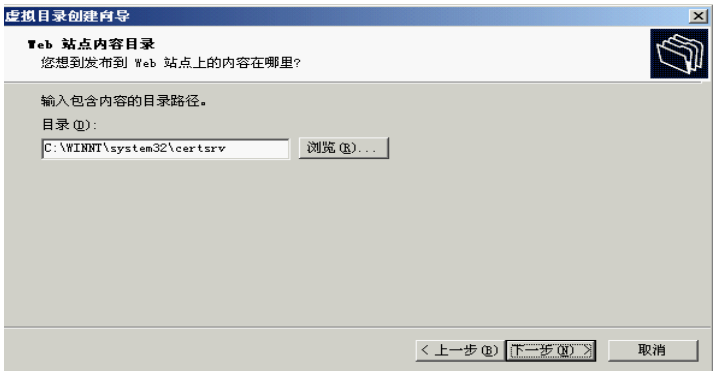


Step 11: Click **Next** and configure a content directory, as shown below:

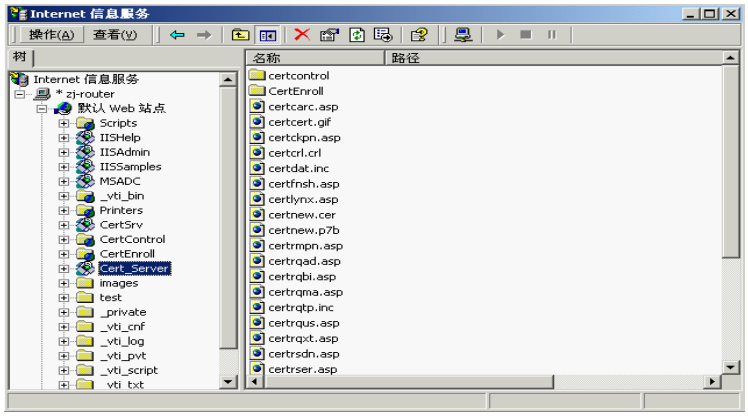
Step 12: Click the **Browse** button and select the directory for installing certificate services, as shown below:



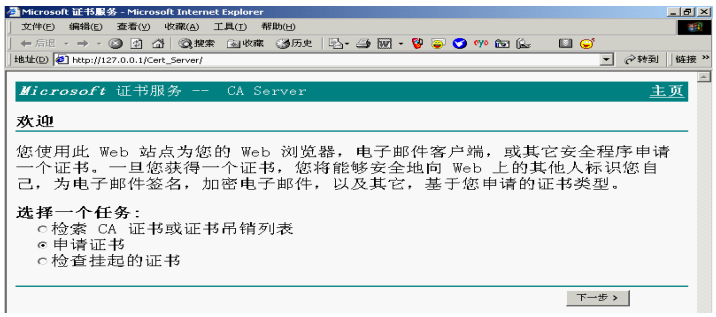
Note On a Windows 2003 server, the installation directory of certificate services is shown below:



Step 13: Click **Next** and complete virtual directory configuration using default settings, the following window will pop up:



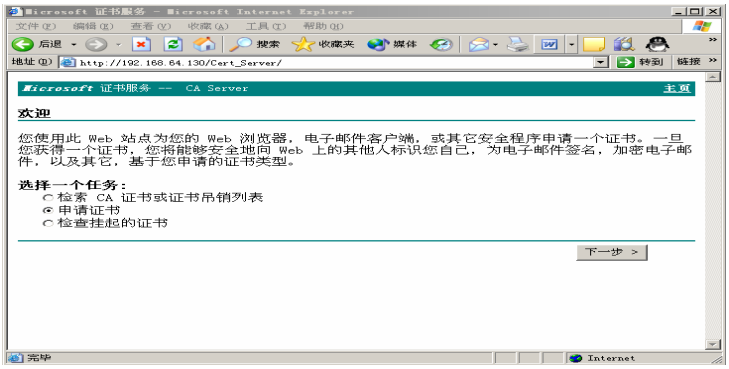
Step 14: Start the Internet explorer on the CA server and type in "127.0.0.1/Cert_Server", the following page will show up if the configuration is completed successfully:



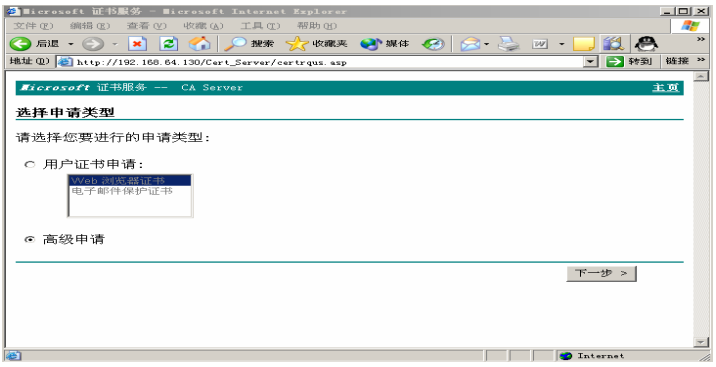
Applying for and Exporting a Certificate

Currently, certificates to be installed on Ruijie routers are acquired on the PC. Suppose the IP address of a CA server is 192.168.64.130. Perform the following steps to apply for a certificate.

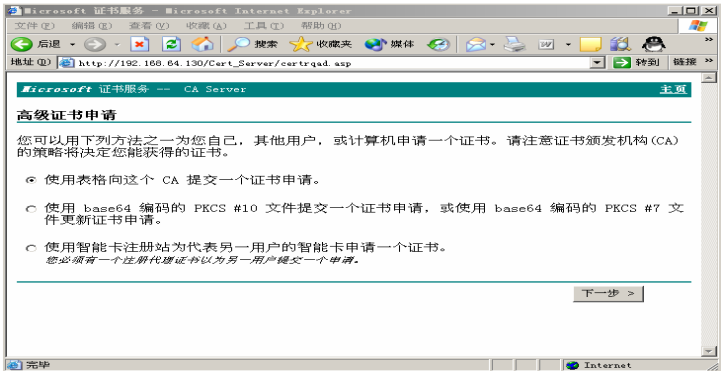
Step 1: Start the Internet explorer on a client (usually a PC) and type in "192.168.64.130/Cert_Server", as shown below:



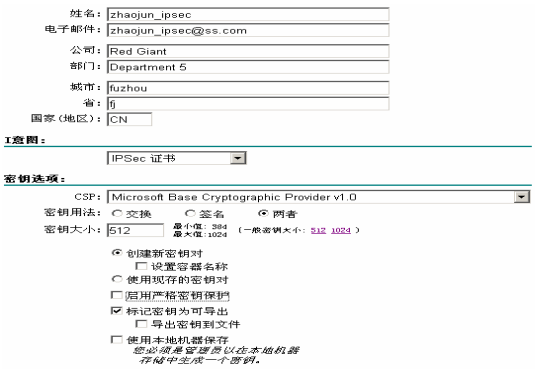
Step 2: Click **Next** and select **Advanced Application** as the application type, as shown below:



Step 3: Click **Next** and select a method of submitting an application (using a form), as shown below:



Step 4: Click **Next** and fill in detailed information, as shown below:

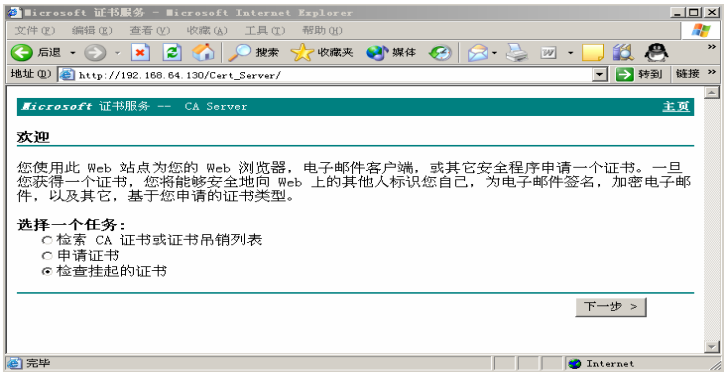


Note

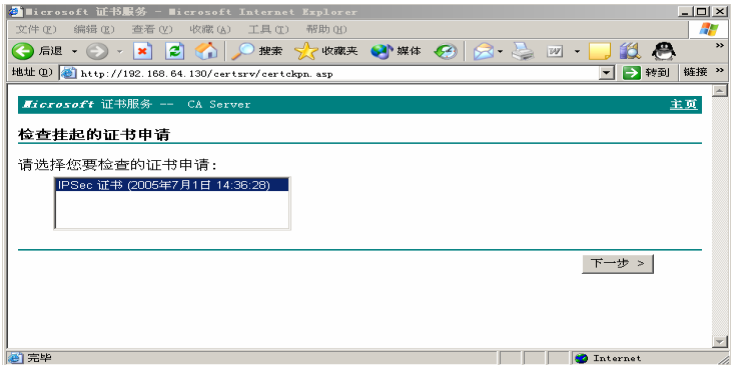
Mark keys as exportable must be checked, as RSA key pairs applicable to Ruijie routers are generated by a CA server, and certificates and key pairs must be exported eventually.

Step 5: Click **Submit** to complete certificate application.

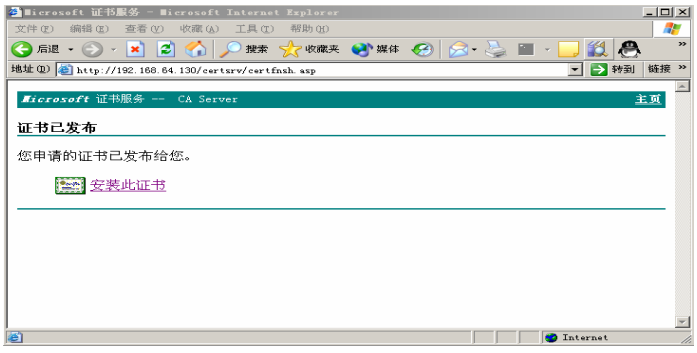
Step 6: Return to homepage and select **Check on a pending certificate**, as shown below:



Step 7: Click **Next**. If the CA center has issued a certificate, the certificate is displayed as shown in the following figure:

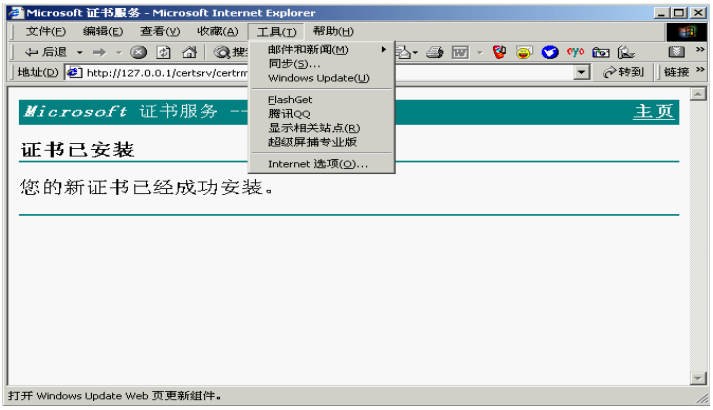


Step 8: Click **Next** and prepare to install this certificate, as shown below:

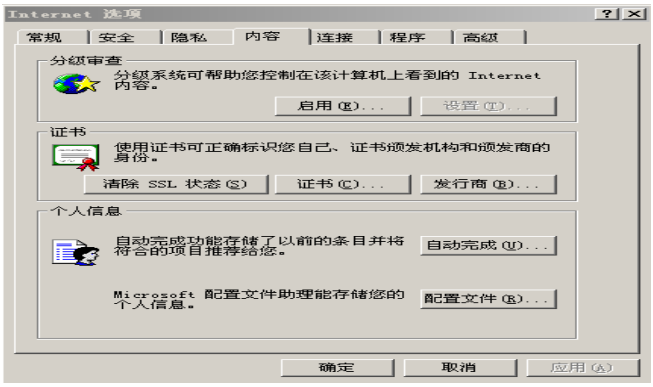


Step 9: Click **Install this certificate**. The system will prompt that this certificate is successfully installed.

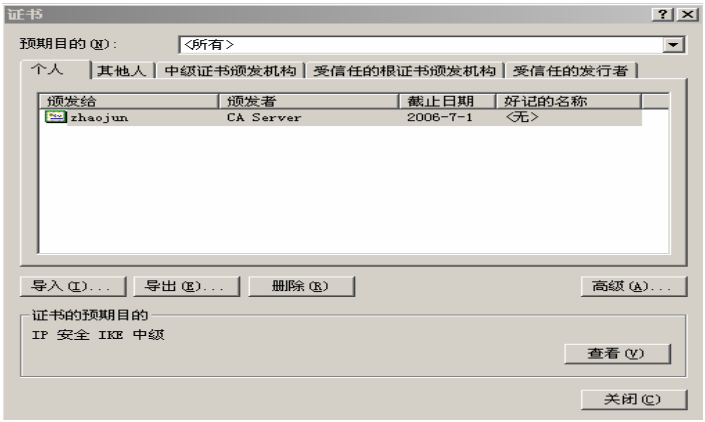
Step 10: After installation of a certificate, the certificate needs to be exported, as shown below:



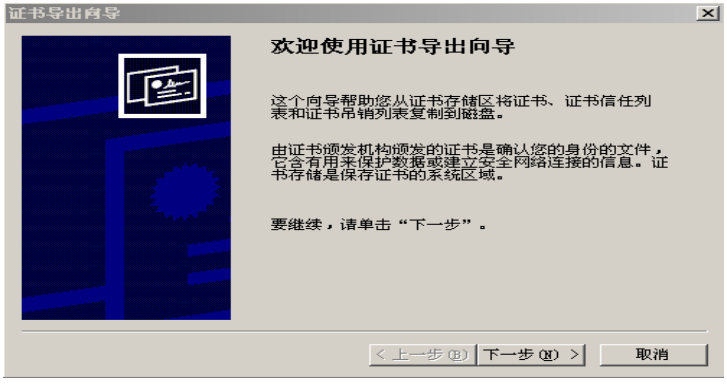
Step 11: Select **Internet Options** and click the **Content** tab, as shown below:



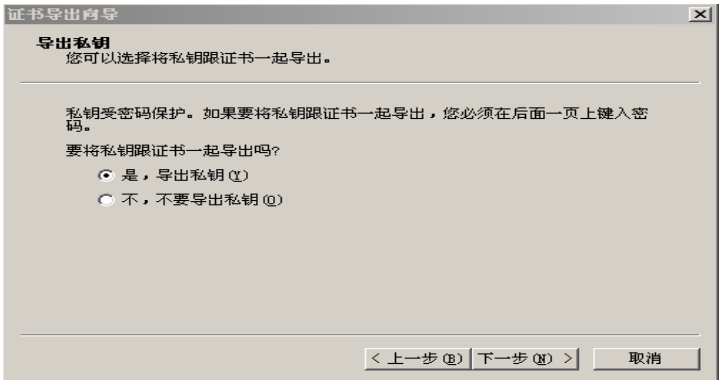
Step 12: Click the **Certificate** button, the following window will pop up:



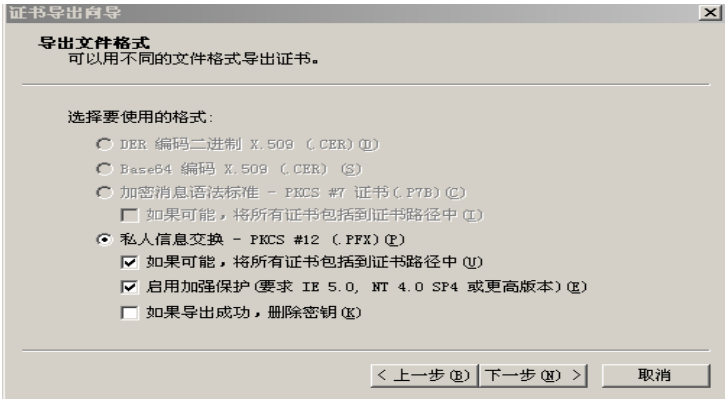
Step 13: Select the certificate to be exported and click **Export**:



Step 14: Click **Next**. The following window pops up:

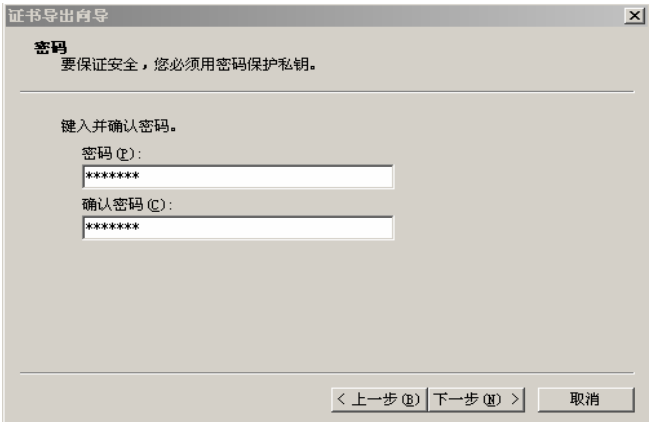


Step 15: Click **Next**. The following window pops up:

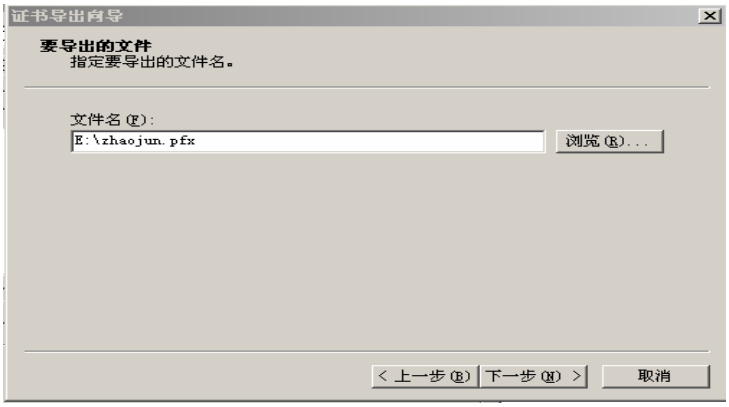


Note **Include all certificates in the certification path if possible** must be checked. This export certificate file contains the issued certificate, private key and CA root certificate.

Step 16: Click **Next** and enter a file protection password, as shown below:

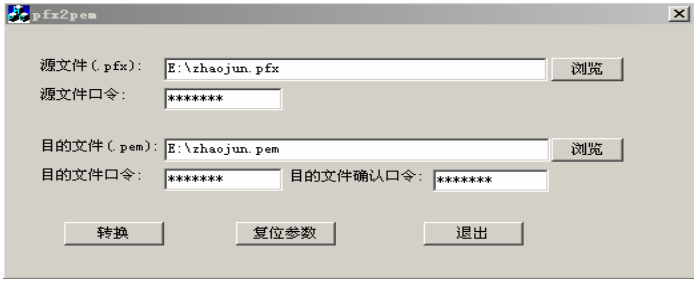


Step 17: Click **Next** and enter the name of the file saving this certificate, as shown below:

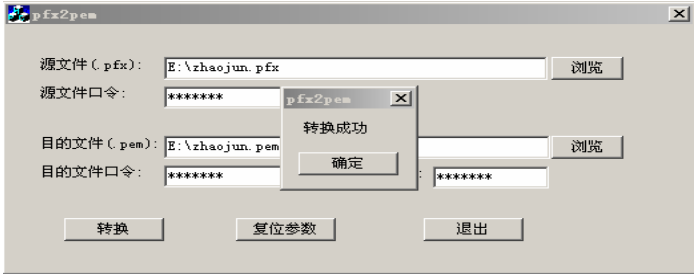


Step 18: Click **Next** and confirm the information, and then Click **Finish** to export the certificate, as shown below:

Step 19: The certificate is exported as a pfx file. Then you need to convert the pfx file into a pem file by using "pfx2pem" tool available in the CD-ROM, as shown below:



Step 20: Click **Convert**, the following dialog box will pop up:



By this time, you will find the converted pem file in the corresponding directory. Use the Wordpad program to open this pem file; you will find the private key, certificate and the corresponding root certificate.

Caution

The password of source file is the password entered while exporting the certificate on IE; the password of the target file is the password you need to set currently. This password must be entered when you import the certificate to a device. See the "Exporting a certificate" section.

Configuring the URL of CRL

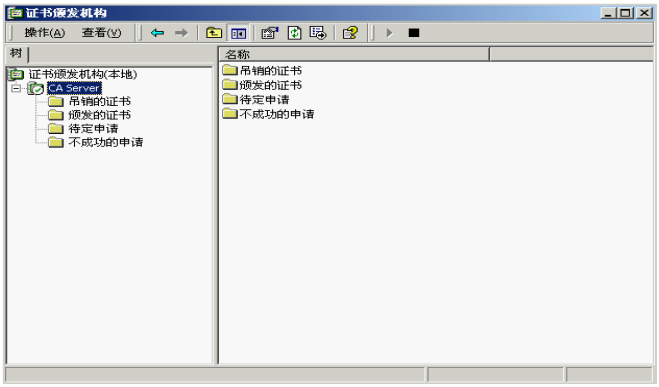
After the certificate services are installed, the default URLs of CRL are:

http://%SERVER_DNS_NAME%/CertEnroll/%CA_NAME%%CRL_SUFFIX%.crl

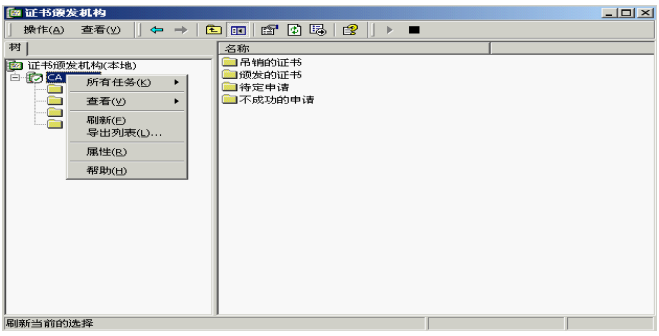
file://\\%SERVER_DNS_NAME%\CertEnroll\%CA_NAME%%CRL_SUFFIX%.crl

Where, the default value of *%SERVER_DNS_NAME%* is the hostname of this system rather than the domain name or IP address; if the domain name or stationary IP address must be used, CA server configurations must be changed. To change CA server configurations, perform the following steps:

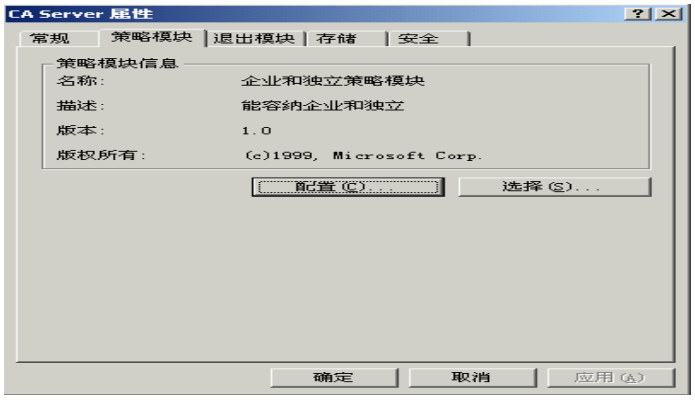
Step 1: Select **Control Panel** and double-click **Administrative Tools**, and select **Certification Authority**. The following window pops up:



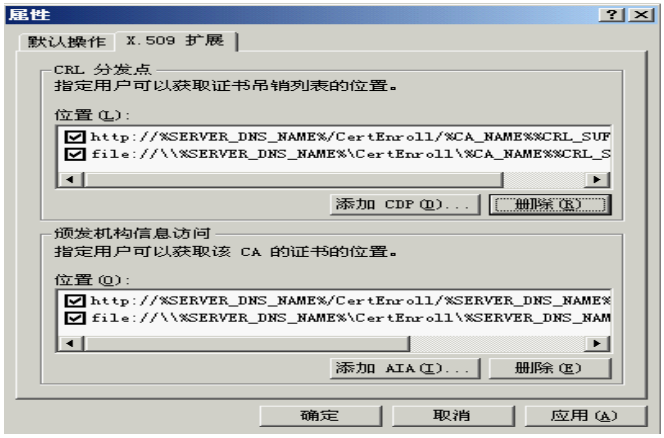
Step 2: Right-click **CA Server**, as shown below:



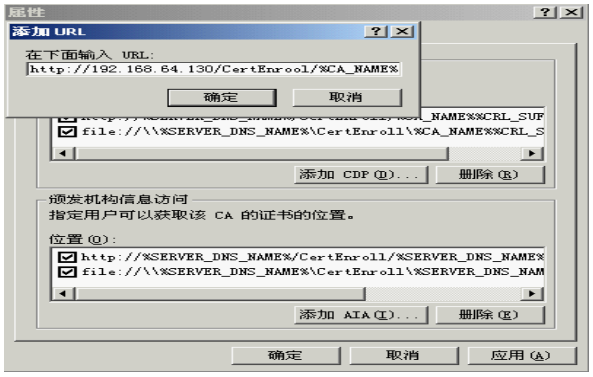
Step 3: Select **Properties** and click the **Policy Module** tab in the pop-up window, as shown below:



Step 4: Click **Configure** and click the **X.509 Extensions** tab in the **Properties** window, as shown below:



Step 5: Click **Add CDP**, the following dialog box will pop up:



Step 6: Click **OK** to add a new CRL address

Example:

To specify an IP address:

Type in: http://192.168.64.130/CertEnroll/%CA_NAME%%CRL_SUFFIX%.crl

Type in: file:\\192.168.64.130\CertEnroll\%CA_NAME%%CRL_SUFFIX%.crl

To specify a domain name:

Type in: http://www.ruijie.com.cn/CertEnroll/%CA_NAME%%CRL_SUFFIX%.crl

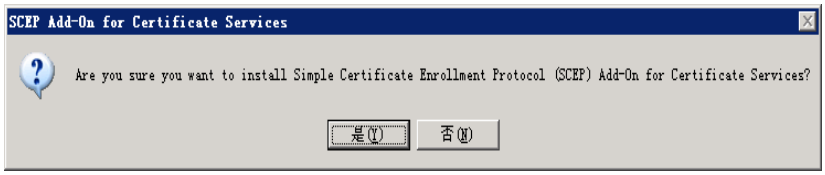
Type in: file://\\www.ruijie.com.cn\CertEnroll\%CA_NAME%%CRL_SUFFIX%.crl

Note

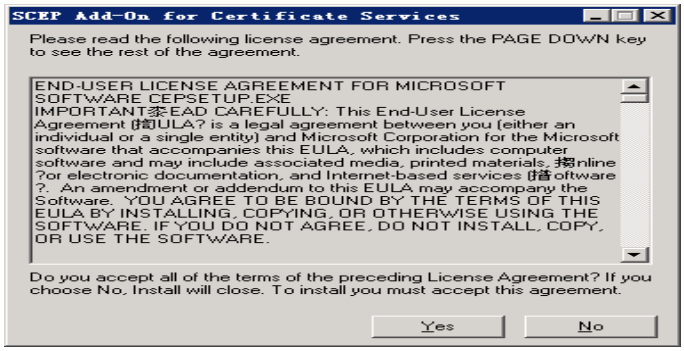
Currently, only the first CRL address is considered valid on Ruijie routers. Therefore, the desired CRL address should be placed on the top.

Installing SCEP Add-on

Step 1: Download the SCEP add-on for Windows Server 2003 from the following website: http://go.microsoft.com/fwlink/?LinkId=32060, and then double-click it to install.

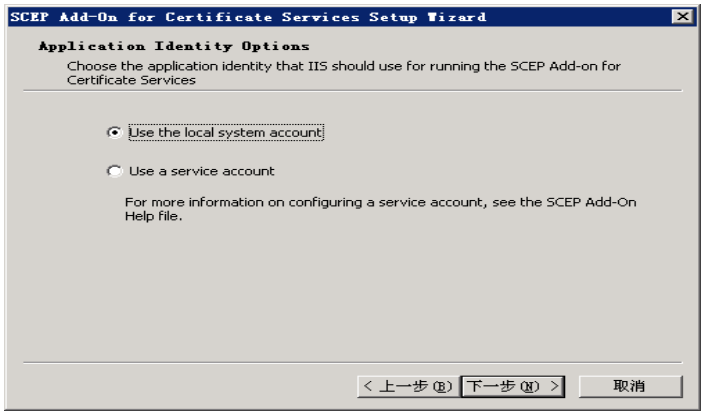


Step 2: Click **Yes** to accept the license agreement.

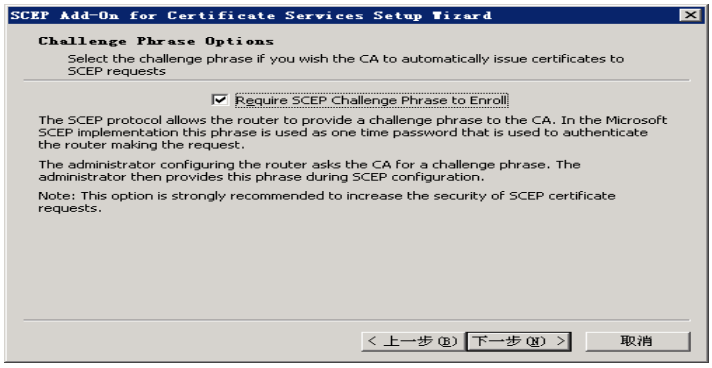


Step 3: Click **Next** to proceed with installation.

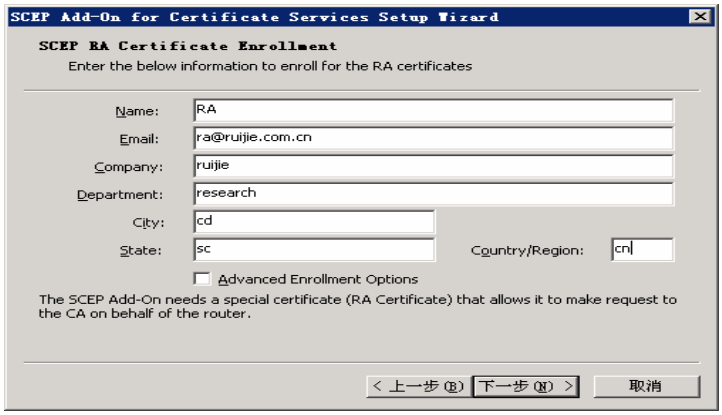
Step 4: Select **Use the local system account** and then click **Next**.



Step 5: It is suggested that you check **Require SCEP Challenge Phrase to Enroll**. After the device is ready to use CA to enroll, visit http://ca/certsrv/mscep/msdep.dll (from any client). The user will be required to provide the "passphrase" needed for enrollment. The "passphrase" is effective within 60 minutes. Click **Next**.



Step 6: Click **Next**.



Step 7: Check the settings and click **Finish**.

Step 8: The URL used for SCEP enrollment is shown below:

Digital Certificate Configuration

Digital Certificate Configuration Tasks

The purpose of digital certificate configuration is to enable the device to have its own certificate and verify the certificate of the communication peer.

Digital certificate configuration involves the following tasks:

- **Acquire certificate:** Acquire CA root certificate and the router certificate and private key issued directly by this CA. RGOS currently supports offline certificate application. The detailed steps are shown in the "Applying for and Exporting a Certificate" section. It also supports online SCEP certificate application and application for a certificate application file.
- **Import certificate:** Import the CA root certificate and router certificate and private key issued directly by this CA into the device.
- **Acquire router certificate through SCEP:** Acquire router certificate from the specified CA through SCEP.
- **Certificate configuration command (optional):** Configure a certificate chain and configure a certificate by importing binary certificate file (DER formatted file) in hexadecimal format.
- **Configure certificate revocation checking policy (optional):** Configure whether to check CRL during certificate check in order to verify whether the certificate has been revoked.
- **Download CRL (optional):** Configure the URL for downloading a CRL and start CRL download immediately through the command.

Importing a Certificate

Through the aforementioned steps, you may have acquired PEM-formatted CA root certificate, router certificate and private key. Run the following commands in global configuration mode to import these contents into the device:

Command	Function
Ruijie(config)# **crypto pki import pem terminal** *password*	Starts the interactive process to import CA root certificate, router certificate and private key. Password refers to the protective password of PEM-formatted private key. For details, see the "Applying for and Exporting a Certificate" section.

Caution **Caution** The system will check certificate validity during the import process, and expired or inactive certificates will not be imported. Therefore, before importing a certificate, you must check whether the system time is the current Beijing time. To change system time, you can use the **clock** or **calendar** command. Refer to the "Basic System Management" chapter of *Basic Configuration Guide* for details.

Certificate import interface and process are shown below:

Assuming that PEM-formatted certificate data you acquired have been archived in one file, use a text editor (Windows Wordpad is recommended) to open the file and you will see the following contents:

```
Bag Attributes
localKeyID: 01 00 00 00
1.3.6.1.4.1.311.17.1: Microsoft Base Cryptographic Provider v1.0
friendlyName: 0929c7381e7517bdc65cdc7cc2ea0374_60e7aaa8-2e04-4953-9ba8-96bcaf0bfdf7
Key Attributes
X509v3 Key Usage: 10
-----BEGIN RSA PRIVATE KEY-----
Proc-Type: 4,ENCRYPTED
DEK-Info: DES-EDE3-CBC,251F9D955610C376
GDG2s1mbs/MJCpo5w2bu972jK1OZYtv3RQunH4I29c9H5uq3LtyvNA9RwrlpRQ3t
iUmkvQrU3/6SBp4Rqx1EU2UWgv1KRqqYwRVbdPdBZYVJLrso3Ov/9eaS4TiD+4Dl
NfJ1sAA4OONdVKDCLcGZIB43Wq5rAlqzsyjcF6tx3fWsSankVjQfroTv7UvP+ijj
uGndmJwbXEiATxlt+Smvt2/CGjr8nIC55T1W+tW0itkBdZhnvBJekOFM4BdgoLZc
3vueTIHmTurHvvdLIytYjQHsxVsf3vRGMcQhohM98nAYsIDBil4OIh1hc+ZnhGsn
TFLPMmMuJnBWMYopfaMPNrcdbpu+n4Qj2QiRoVTEoI7P1IAY/Oa2uc+kDuUX3KlW
sQQPnFNiU0Q/T9BrsolxI2Wkak7cvaNxbmhuU+5wNUGybQfcfP3CWg==
-----END RSA PRIVATE KEY-----
Bag Attributes
    localKeyID: 01 00 00 00
subject=/Email=dingjs@star-net.cn/C=CN/ST=FuJian/L=FuZhou/O=Regiant Network Co.
Ltd/OU=Research Apartment 5/CN=dingjs
issuer=/Email=dingjs@star-net.cn/C=CN/ST=FuJian/L=FuZhou/O=Regiant Network Co.
Ltd/OU=Research Apartment 5/CN=CA test server
-----BEGIN CERTIFICATE-----
MIIEsTCCBFugAwIBAgIKEffFFwABAAAAPjANBgkqhkiG9w0BAQUFADCBrDEhMB8G
CSqGSIb3DQEJARYSZGluZ2pzQHN0YXItbmV0LmNuMQswCQYDVQQGEwJDTjEPMA0G
A1UECBMGRnVKaWFuMQ8wDQYDVQQHEwZGdVpob3UxIDAeBgNVBAoTF1JlZ2lhbnQg
TmV0d29yayBDby4gTHRkMR0wGwYDVQQLExRSZXNlYXJjaCBBcGFydG1lbnQgNTEX
```

```
MBUGA1UEAxMOQ0EgdGVzdCBzZXJ2ZXIwHhcNMDUwNDEyMDkyOTUzWhcNMDYwNDEy
MDkzOTUzWjCBpDEhMB8GCSqGSIb3DQEJARYSZGluZ2pzQHN0YXItbmV0LmNuMQsw
CQYDVQQGEwJDTjEPMA0GA1UECBMGRnVKaWFuMQ8wDQYDVQQHEwZGdVpob3UxIDAe
BgNVBAoTF1JlZ2lhbnQgTmV0d29yayBDby4gTHRkMR0wGwYDVQQLExRSZXNlYXJj
aCBBcGFydG1lbnQgNTEPMA0GA1UEAxMGZGluZ2pzMFwwDQYJKoZIhvcNAQEBBQAD
SwAwSAJBAM0sOymB/5v35vnf/PlJX+aqZpH9drtevsNaHkj4i3XdaJ55rFo2wLT0
qpWTI0nu638ktUa4dEIfF0AQM67sP0ECAwEAAaOCAmMwggJfMA4GA1UdDwEB/wQE
AwIE8DATBgNVHSUEDDAKBggrBgEFBQgCAjAdBgNVHQ4EFgQUIWVn8+ciY7JJkOFN
7MIkcRWWpx8wgegGA1UdIwSB4DCB3YAUckOEHCsDRS2CWPWEQ3f1IapLLCGhgbKk
ga8wgawxITAfBgkqhkiG9w0BCQEWEmRpbmdqc0BzdGFyLW5ldC5jbjELMAkGA1UE
BhMCQ04xDzANBgNVBAgTBkZ1SmlhbjEPMA0GA1UEBxMGRnVaaG91MSAwHgYDVQQK
ExdSZWdpYW50IE5ldHdvcmsgQ28uIEx0ZDEdMBsGA1UECxMUUmVzZWFyY2ggQXBh
cnRtZW50IDUxFzAVBgNVBAMTDkNBIHRlc3Qgc2VydmVyghBWrgc8EKF+jEWujT8V
UjNXMH8GA1UdHwR4MHYwOKA2oDSGMmh0dHA6Ly96ai1yb3V0ZXIvQ2VydEVucm9s
bC9DQSUyMHRlc3QlMjBzZXJ2ZXIuY3JsMDqgOKA2hjRmaWxlOi8vXFx6ai1yb3V0
ZXJcQ2VydEVucm9sbFxDQSUyMHRlc3QlMjBzZXJ2ZXIuY3JsMIGsBggrBgEFBQcB
AQSBnzCBnDBLBggrBgEFBQcwAoY/aHR0cDovL3pqLXJvdXRlci9DZXJ0RW5yb2xs
L3pqLXJvdXRlcl9DQSUyMHRlc3QlMjBzZXJ2ZXIuY3JsMIGsBggrBgEFBQcwAo
hkFmaWxlOi8vXFx6ai1yb3V0ZXJcQ2VydEVucm9sbFx6ai1yb3V0ZXJfQ0ElMjB0
ZXN0JTIwc2VydmVyKDEpLmNydDANBgkqhkiG9w0BAQUFAANBABSEeYlEi7fm06en
NDdkZMjYV8LZB1JjniePwy1sUEEDa2bH9ZrcpTnJ+CSkCkxXBTc5ZWZnFTiSH/Oc
uVyQ9D8=
-----END CERTIFICATE-----
Bag Attributes: <Empty Attributes>
subject=/Email=dingjs@star-net.cn/C=CN/ST=FuJian/L=FuZhou/O=Regiant Network Co.
Ltd/OU=Research Apartment 5/CN=CA test server
issuer=/Email=dingjs@star-net.cn/C=CN/ST=FuJian/L=FuZhou/O=Regiant Network Co.
Ltd/OU=Research Apartment 5/CN=CA test server
-----BEGIN CERTIFICATE-----
MIIDLjCCAtigAwIBAgIQVq4HPBChfoxFro0/FVIzVzANBgkqhkiG9w0BAQUFADCB
rDEhMB8GCSqGSIb3DQEJARYSZGluZ2pzQHN0YXItbmV0LmNuMQswCQYDVQQGEwJD
TjEPMA0GA1UECBMGRnVKaWFuMQ8wDQYDVQQHEwZGdVpob3UxIDAeBgNVBAoTF1Jl
Z2lhbnQgTmV0d29yayBDby4gTHRkMR0wGwYDVQQLExRSZXNlYXJjaCBBcGFydG1l
bnQgNTEXMBUGA1UEAxMOQ0EgdGVzdCBzZXJ2ZXIwHhcNMDUwMjI1MDg0NjAyWhcN
MDcwMzAxMDIzNjIzWjCBrDEhMB8GCSqGSIb3DQEJARYSZGluZ2pzQHN0YXItbmV0
LmNuMQswCQYDVQQGEwJDTjEPMA0GA1UECBMGRnVKaWFuMQ8wDQYDVQQHEwZGdVpo
b3UxIDAeBgNVBAoTF1JlZ2lhbnQgTmV0d29yayBDby4gTHRkMR0wGwYDVQQLExRS
ZXNlYXJjaCBBcGFydG1lbnQgNTEXMBUGA1UEAxMOQ0EgdGVzdCBzZXJ2ZXIwXDAN
BgkqhkiG9w0BAQEFAANLADBIAkEA2R8axg75UZJM3JZNREP62r5T8t31E7Y0taah
n/1XoWxvevShE8FZPQxMPo5i3nbYokzyLPjagqoX0+jMgMKVjwIDAQABo4HTMIHQ
MAsGA1UdDwQEAwIBxjAPBgNVHRMBAf8EBTADAQH/MB0GA1UdDgQWBBRyQ4QcKwNF
LYJY9YRDd/UhqkssITB/BgNVHR8EeDB2MDigNqA0hjJodHRwOi8vemotcm91dGVy
L0NlcnRFbnJvbGwvQ0ElMjB0ZXN0JTIwc2VydmVyLmNybDA6oDigNoY0ZmlsZTov
L1xcemotcm91dGVyXENlcnRFbnJvbGxcQ0ElMjB0ZXN0JTIwc2VydmVyLmNybDAQ
BgkrBgEEAYI3FQEEAwIBATANBgkqhkiG9w0BAQUFAANBAH8ufRZ2tVYO3R7YC0IF
```

```
OzmnQrjgaBN4bpmSLkxYYKtK8ZNjo0FwUL11aq6nCGp6n8Ks0dijoMxnedB2zn0a
f0w=
-----END CERTIFICATE-----
```

Caution **Caution** Where, contents between "-----BEGIN CERTIFICATE-----" and "-----END CERTIFICATE-----" are certificate texts; contents between "-----BEGIN RSA PRIVATE KEY-----" and "-----END RSA PRIVATE KEY-----" are private key texts; other contents are descriptions about the PKCS12#format.

Note the difference between CA root certificate and router certificate: The subject and issuer of CA root certificate are the same, while those of router certificate are different. Taking the above-given process as the example, the relevant information about CA root certificate is shown below:

```
subject=/Email=dingjs@star-net.cn/C=CN/ST=FuJian/L=FuZhou/O=Regiant Network Co.
Ltd/OU=Research Apartment 5/CN=CA test server
issuer=/Email=dingjs@star-net.cn/C=CN/ST=FuJian/L=FuZhou/O=Regiant Network Co.
Ltd/OU=Research Apartment 5/CN=CA test server
The subject and issuer of router certificate are shown below:
subject=/Email=dingjs@star-net.cn/C=CN/ST=FuJian/L=FuZhou/O=Regiant Network Co.
Ltd/OU=Research Apartment 5/CN=dingjs
issuer=/Email=dingjs@star-net.cn/C=CN/ST=FuJian/L=FuZhou/O=Regiant Network Co.
Ltd/OU=Research Apartment 5/CN=CA test server
```

Run the command for importing a certificate on the control console (operation instructions are given in brackets)

```
Ruijie (config)# crypto pki import pem terminal 12345678
% Enter PEM-formatted CA certificate.(prompting you to enter PEM-formatted CA root certificate
texts)
% End with a blank line or "quit" on a line by itself.(prompting you to enter blank line or
enter "quit" to exit)
(Copy the texts of CA root certificate shown in Step 1 and paste here, as shown below)
-----BEGIN CERTIFICATE-----
MIIDLjCCAtigAwIBAgIQVq4HPBChfoxFro0/FVIzVzANBgkqhkiG9w0BAQUFADCB
rDEhMB8GCSqGSIb3DQEJARYSZGluZ2pzQHN0YXItbmV0LmNuMQswCQYDVQQGEwJD
TjEPMA0GA1UECBMGRnVKaWFuMQ8wDQYDVQQHEwZGdVpob3UxIDAeBgNVBAoTF1Jl
Z2lhbnQgTmV0d29yayBDby4gTHRkMR0wGwYDVQQLExRSZXNlYXJjaCBBcGFydG1l
bnQgNTEXMBUGA1UEAxMOQ0EgdGVzdCBzZXJ2ZXIwHhcNMDUwMjI1MDg0NjAyWhcN
MDcwMzAxMDIzNjIzWjCBrDEhMB8GCSqGSIb3DQEJARYSZGluZ2pzQHN0YXItbmV0
LmNuMQswCQYDVQQGEwJDTjEPMA0GA1UECBMGRnVKaWFuMQ8wDQYDVQQHEwZGdVpo
b3UxIDAeBgNVBAoTF1JlZ2lhbnQgTmV0d29yayBDby4gTHRkMR0wGwYDVQQLExRS
ZXNlYXJjaCBBcGFydG1lbnQgNTEXMBUGA1UEAxMOQ0EgdGVzdCBzZXJ2ZXIwXDAN
BgkqhkiG9w0BAQEFAANLADBIAkEA2R8axg75UZJM3JZNREP62r5T8t31E7Y0taah
n/1XoWxvevShE8FZPQxMPo5i3nbYokzyLPjagqoX0+jMgMKVjwIDAQABo4HTMIHQ
```

```
MAsGA1UdDwQEAwIBxjAPBgNVHRMBAf8EBTADAQH/MB0GA1UdDgQWBBRyQ4QcKwNF
LYJY9YRDd/UhqkssITB/BgNVHR8EeDB2MDigNqA0hjJodHRwOi8vemotcm91dGVy
L0NlcnRFbnJvbGwvQ0ElMjB0ZXN0JTIwc2VydmVyLmNybDA6oDigNoY0ZmlsZTov
L1xcemotcm91dGVyXENlcnRFbnJvbGxcQ0ElMjB0ZXN0JTIwc2VydmVyLmNybDAQ
BgkrBgEEAYI3FQEEAwIBATANBgkqhkiG9w0BAQUFAANBAH8ufRZ2tVYO3R7YC0IF
OzmnQrjgaBN4bpmSLkxYYKtK8ZNjo0FwUL11aq6nCGp6n8Ks0dijoMxnedB2zn0a
f0w=
-----END CERTIFICATE-----
quit
Certificate has the following attributes:
Fingerprint: B286A3F4 4930D46D 81D4A544 885D611C (Fingerprint of CA root certificate)
% Do you accept this certificate? [yes/no]: yes(Prompting you to confirm the fingerprint)
% Certificate successfully imported
% Enter PEM-formatted encrypted private key.(Prompting you to enter PEM-formatted private key
texts)
% End with "quit" on a line by itself.(Prompting you to type in "quit" to exit)
(Copy the texts of private key shown in Step 1 and paste here, as shown below)
-----BEGIN RSA PRIVATE KEY-----
Proc-Type: 4,ENCRYPTED
DEK-Info: DES-EDE3-CBC,251F9D955610C376
GDG2s1mbs/MJCpo5w2bu972jK1OZYtv3RQunH4I29c9H5uq3LtyvNA9RwrlpRQ3t
iUmkvQrU3/6SBp4Rqx1EU2UWgv1KRqqYwRVbdPdBZYVJLrso3Ov/9eaS4TiD+4Dl
NfJ1sAA4OONdVKDCLcGZIB43Wq5rAlqzsyjcF6tx3fWsSankVjQfroTv7UvP+ijj
uGndmJwbXEiATxlt+Smvt2/CGjr8nIC55T1W+tW0itkBdZhnvBJekOFM4BdgoLZc
3vueTIHmTurHvvdLIytYjQHsxVsf3vRGMcQhohM98nAYsIDBil4OIh1hc+ZnhGsn
TFLPMmMuJnBWMYopfaMPNrcdbpu+n4Qj2QiRoVTEoI7P1IAY/Oa2uc+kDuUX3KlW
sQQPnFNiU0Q/T9BrsolxI2Wkak7cvaNxbmhuU+5wNUGybQfcfP3CWg==
-----END RSA PRIVATE KEY-----
quit
% RSA private key successfully imported
Enter the base 64 encoded certificate.(Prompting you to enter PEM-formatted router certificate
texts)
End with a blank line or the word "quit" on a line by itself(prompting you to enter blank line
or enter "quit" to exit)
```

(Copy the texts of router certificate shown in Step 1 and paste here, as shown below)

```
-----BEGIN CERTIFICATE-----
MIIEsTCCBFugAwIBAgIKEffFFwABAAAAPjANBgkqhkiG9w0BAQUFADCBrDEhMB8G
CSqGSIb3DQEJARYSZGluZ2pzQHN0YXItbmV0LmNuMQswCQYDVQQGEwJDTjEPMA0G
A1UECBMGRnVKaWFuMQ8wDQYDVQQHEwZGdVpob3UxIDAeBgNVBAoTF1JlZ2lhbnQg
TmV0d29yayBDby4gTHRkMR0wGwYDVQQLExRSZXNlYXJjaCBBcGFydG1lbnQgNTEX
MBUGA1UEAxMOQ0EgdGVzdCBzZXJ2ZXIwHhcNMDUwNDEyMDkyOTUzWhcNMDYwNDEy
MDkzOTUzWjCBpDEhMB8GCSqGSIb3DQEJARYSZGluZ2pzQHN0YXItbmV0LmNuMQsw
CQYDVQQGEwJDTjEPMA0GA1UECBMGRnVKaWFuMQ8wDQYDVQQHEwZGdVpob3UxIDAe
BgNVBAoTF1JlZ2lhbnQgTmV0d29yayBDby4gTHRkMR0wGwYDVQQLExRSZXNlYXJj
```

```
aCBBcGFydG1lbnQgNTEPMA0GA1UEAxMGZGluZ2pzMFwwDQYJKoZIhvcNAQEBBQAD
SwAwSAJBAM0sOymB/5v35vnf/PlJX+aqZpH9drtevsNaHkj4i3XdaJ55rFo2wLT0
qpWTI0nu638ktUa4dEIfF0AQM67sP0ECAwEAAaOCAmMwggJfMA4GA1UdDwEB/wQE
AwIE8DATBgNVHSUEDDAKBggrBgEFBQgCAjAdBgNVHQ4EFgQUIWVn8+ciY7JJkOFN
7MIkcRWWpx8wgegGA1UdIwSB4DCB3YAUckOEHCsDRS2CWPWEQ3f1IapLLCGhgbKk
ga8wgawxITAfBgkqhkiG9w0BCQEWEmRpbmdqc0BzdGFyLW5ldC5jbjELMAkGA1UE
BhMCQ04xDzANBgNVBAgTBkZ1SmlhbjEPMA0GA1UEBxMGRnVaaG91MSAwHgYDVQQK
ExdSZWdpYW50IE5ldHdvcmsgQ28uIEx0ZDEdMBsGA1UECxMUUmVzZWFyY2ggQXBh
cnRtZW50IDUxFzAVBgNVBAMTDkNBIHRlc3Qgc2VydmVyghBWrgc8EKF+jEWujT8V
UjNXMH8GA1UdHwR4MHYwOKA2oDSGMmh0dHA6Ly96ai1yb3V0ZXIvQ2VydEVucm9s
bC9DQSUyMHRlc3QlMjBzZXJ2ZXIuY3JsMDqgOKA2hjRmaWxlOi8vXFx6ai1yb3V0
ZXJcQ2VydEVucm9sbFxDQSUyMHRlc3QlMjBzZXJ2ZXIuY3JsMIGsBggrBgEFBQcB
AQSBnzCBnDBLBggrBgEFBQcwAoY/aHR0cDovL3pqLXJvdXRlci9DZXJ0RW5yb2xs
L3pqLXJvdXRlcl9DQSUyMHRlc3QlMjBzZXJ2ZXIoMSkuY3J0ME0GCCsGAQUFBzAC
hkFmaWxlOi8vXFx6ai1yb3V0ZXJcQ2VydEVucm9sbFx6ai1yb3V0ZXJfQ0ElMjB0
ZXN0JTIwc2VydmVyKDEpLmNydDANBgkqhkiG9w0BAQUFAANBABSEeYlEi7fm06en
NDdkZMjYV8LZB1JjniePwy1sUEEDa2bH9ZrcpTnJ+CSkCkxXBTc5ZWZnFTiSH/Oc
uVyQ9D8=
-----END CERTIFICATE-----
quit
% Certificate successfully imported
Ruijie (config)#
```

Caution **Caution** Currently, Ruijie products can only support one CA root certificate and one router certificate. If another certificate is imported, the previous one is overwritten.

The import is only considered successful when CA root certificate, private key and router certificate are all successfully imported, and device configurations will be updated then, or else all import operations will be cancelled without causing any impact on the configurations. For example, when the import of router certificate fails, the import of CA root certificate and private key will all be cancelled

While copying and pasting certificate texts, do not omit any character, especially the "begin" and "end" lines.

After successful import, execute the "write" operation to store the certificate and private key into FLASH, or else the import contents will be lost after shutdown.

The fingerprint of CA root certificate is used to avoid the artificial falsification of CA root certificate during the process of transmission. The CA will issue fingerprint information (including fingerprint and the hmac algorithm for fingerprint calculation) together with the CA root certificate. The user of CA root certificate must use the same fingerprint algorithm used by CA to calculate fingerprint, and check with the fingerprint issued by the CA. RGOS supports the fingerprint algorithm of SHA-1.

Verify the result of certificate import. After a successful import, the certificate will be stored in DER-encoded hexadecimal format in the system configuration file. Run the **show running** command to query the serial number and DER encoded contents of the certificate (refer to the "Configuration Example" section), or you can also run the **show crypto pki cert** command (see the "Monitoring and Maintenance" section). Note that the private key will not be displayed.

Acquiring Router Certificate Through SCEP

To generate a public/private key pair for a router, run the following command:

Command	Function
Ruijie (config)**#crypto pki key generate rsa**	Creates an RSA public/private key pair.

To configure a trustpoint, run the following commands:

Command	Function
Ruijie (config)**#crypto pki trustpoint** *CA_name*	Enters trustpoint configuration mode. *CA_name* is the common name of the CA corresponding to this trustpoint, namely the character string entered in the **Common name for this CA** field in Step 9 of the "Installing the Certificate Services on a Windows 2003 Server" section.
Ruijie (ca-trustpoint)**#enrollment url** *http://192.168.50.203/certsrv/mscep/mscep.dll*	Configures the certificate enrollment URL of this trustpoint, namely the URL shown in step 8 of the "Installing SCEP add-on" section (domain name); if there is no DNS server, an IP address can also be used; manually replace the domain name with the corresponding IP address.
Ruijie (ca-trustpoint)**#enrollment retry period** *number*	Configures the polling period when this trustpoint enters the polling state during certificate enrollment. Number is a numeric value (unit: minute); the default value is one minute.
Ruijie (ca-trustpoint)**#enrollment retry count** *number*	Configures the polling count when this trustpoint enters the polling state during certificate enrollment. Number is a numeric value (unit: time); the default value is 60 times.
Ruijie (ca-trustpoint)**# enrollment auto-enroll** *percentage*	Specifies the update period of the certificate corresponding to the trustpoint; percentage ranges from 1 through 100 to specify when the certificate will be updated.
Ruijie (ca-trustpoint)**# enrollment renewable**	Enables the CA server corresponding to the trustpoint to support certificate update
Ruijie (ca-trustpoint)**#exit**	Exits trustpoint configuration mode.

To acquire a CA root certificate, run the following command:

Command	Function
Ruijie (config)**# crypto pki authenticate** *CA_name*	Acquires the CA root certificate.

To register a certificate, run the following command:

Command	Function
Ruijie (config)**# crypto pki enroll** *CA_name*	Enrolls trustpoint and acquires the router certificate corresponding to this trustpoint.

The process of acquiring a router certificate through SCEP is as follows:

Ensure the time matches with standard time on each device. Use the **show clock** command on the router to ensure that the time is correct.

Configure an IP address to ensure that the router can access the CA server.

Configure the hostname of the router

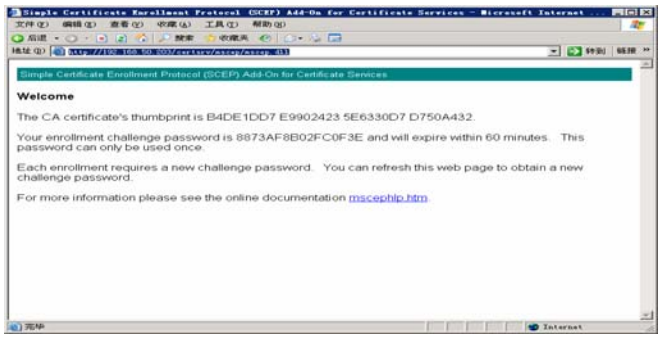
```
ruijie(config)#hostname router
router(config)#
Generate a key
router(config)#crypto pki key generate rsa
gernerate-key
Choose the size of the key modulus in the range of 360 to 2048 for your General Purpose Keys.
Choosing a key modulus greater than 512 may take a few minutes.
How many bits in the modulus:1024  //Modulus size of the key
Configure the trustpoint corresponding to the CA
router(config)#crypto pki trustpoint CA
router(ca-trustpoint)#enrollment url http://192.168.50.203/certsrv/mscep/mscep.dll //URL
for enrollment
router(ca-trustpoint)#exit
```

Acquire and verify the CA root certificate.

```
router(config)#crypto pki authenticate CA
Certificate has the following attributes:
MD5 fingerprint: B4DE1DD7 E9902423 5E6330D7 D750A432
SHA1 fingerprint: AD070162 672A7C57 BD5EE522 A95AAFA1 351524D0
% Do you accept this certificate?[yes/no]:yes   //Enter yes to accept the CA certificate
Trustpoint CA certificate accepted.
```

To acquire the fingerprint and passphrase of the certificate, visit: http://ca-ip-address/certsrv/mscep/mscep.dll.

The following webpage will be displayed, prompting you to proceed with authentication. Make sure that the administrator can visit this website using the fingerprint and passphrase.



Now the fingerprint and passphrase are acquired. You need to enter the following contents on the router (replies from CA are also provided for your reference)

router(config)#crypto pki enroll CA

```
%
%Start certificate enrollment ..
```

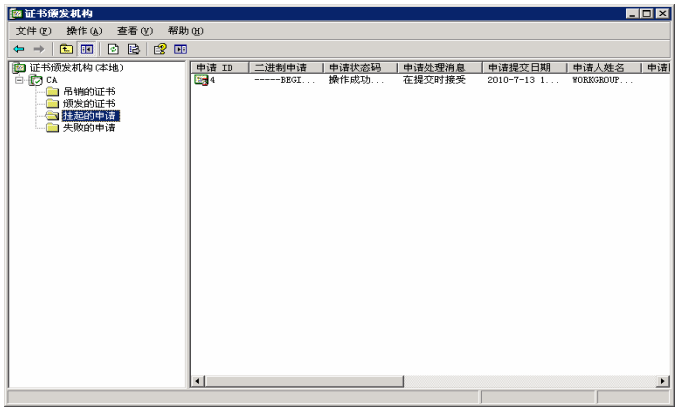
```
%Create a challenge password. You will need to verbally provide this
   password to the CA Administrator in order to revoke your certificate.
   For security reasons your password will not be saved in the configuration.
   Please make a note of it.

Password:F4EEE4FEB3766007    //Enter the password acquired from CA
Re-enter password:F4EEE4FEB3766007
%The subject name in the certificate will include: router
```

Display the state of the trustpoint

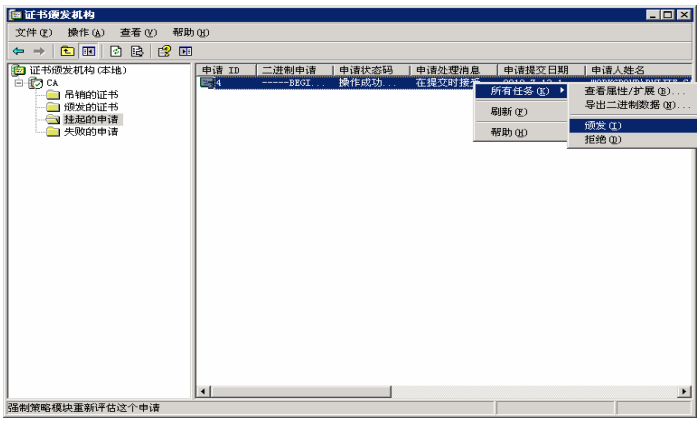
router(config)#show crypto pki trustpoints CA status

```
Trustpoint CA Status:
  Issuing CA certificate configured:
    Subject Name:
      /CN=CA
    Fingerprint MD5: B4DE1DD7 E9902423 5E6330D7 D750A432
    Fingerprint SHA1: AD070162 672A7C57 BD5EE522 A95AAFA1 351524D0
  Router General Purpose certificate pending:    Requested Subject Name:
      /unstructuredName=router
    Request Fingerprint MD5: E8F50E2A 1FB46B00 52C6A9DB CC20AA42
Request Fingerprint SHA1: B1031204 E7A2D547 CC48F0A6 2BAE8420 829637D8
    Enrollment polling: 2 times (58 left)
  Last enrollment status: Pending    //In pending state
  State:
    Keys generated ............. Generated
    Issuing CA authenticated ....... Yes
Certificate request(s) ..... Pending
```

When "Certificate requests pending" shows up (as shown above), check "Pending Requests" on the CA server and issue this certificate. Generally, the request will take 10 to 15 seconds.



Right-click the certificate and choose **All Tasks** > **Issue**.



The certificate will then be moved to the "Issued Certificate" node. Return to the router console and query trustpoint status.

router(config)#show crypto pki trustpoints CA status

```
Trustpoint CA Status:
  Issuing CA certificate configured:
    Subject Name:
      /CN=CA
    Fingerprint MD5: B4DE1DD7E 99024235 E6330D7D 750A432
    Fingerprint SHA1: AD070162 672A7C57 BD5EE522 A95AAFA1 351524D0
  Router General Purpose certificate configured:
    Subject Name:
      /unstructuredName=router
    Fingerprint MD5: 7FFF7F4C 225850A3 D0D39EA3 EFAD8D5A
    Fingerprint SHA1: 84E3678C F2DE94DD 63397145 87CDC9C6 1010A82F
  Last enrollment status: Granted   //Certificate application is successful
  State:
    Keys generated ..... Generated
    Issuing CA authenticated ..... Yes
    Certificate request(s) ..... Yes
```

Configuring SNC certificate

Configure trustpoint:

Command	Function
Ruijie (config)#**crypto pki trustpoint** *CA_name*	Enters trustpoint configuration mode. *CA-name* is the common name of the corresponding CA, namely, the string entered in the **CA common name (C)** field in step 9 in the “Installing Certificate Services on a Windows 2003 Server” section.
Ruijie (ca-trustpoint)#**enrollment url** *http://192.168.50.203/certsrv/mscep/mscep.dll* **auto-up**	Configures the certificate enrollment URL of this trustpoint, namely the URL shown in step 8 of the "Installing SCEP add-on" section; if there is no DNS server, an IP address can also be used; manually replace the domain name with the corresponding IP address. adds **auto-up** in this command to get automatically generated certificate.

Ruijie (ca-trustpoint)**#exit**	Exits trustpoint configuration mode.

The configuration of getting SNC certificate and SECP certificate are similar. The only difference lies in **auto-up** at the end of SNC certificate enrollment URL configuration., as shown below:

```
router(config)#crypto pki trustpoint CA
router(ca-trustpoint)#enrollment url http://192.168.50.203/certsrv/mscep/mscep.dll auto-up
//enrollment url
router(ca-trustpoint)#exit
```

Configuring an Offline Certificate

To generate a public/private key pair, run the following command:

Command	Function
Ruijie (config)**#crypto pki key generate rsa**	Generates an RSA public/private key pair.

Configure trustpoint:

Command	Function
Ruijie (config)**#crypto pki trustpoint** *CA_name*	Enters trustpoint configuration mode. *CA-name* is the common name of the corresponding CA, namely, the string entered in the **CA common name (C)** field in step 9 in the “Installing Certificate Services on a Windows 2003 Server” section.
Ruijie (ca-trustpoint)**# enrollment offline subject**	Configures the unique name of the router.
Ruijie (ca-trustpoint)**#exit**	Exits trustpoint configuration mode.

To register a certificate, run the following command:

Command	Function
Ruijie (config)**# crypto pki enroll** *CA_name*	Registers trustpoint and obtains the router certificate corresponding to the trustpoint.

The process for configuring an offline certificate is as follows:

- Step 1 Generate an RSA public/private key pair (mandatory).
- Step 2 Define a CA (mandatory).
- Step 3 Register an offline certificate (mandatory).
- Step 4 The CA issues a certificate (mandatory).
- Step 5 Import the certificate (mandatory).

Generate an RSA key pair:

```
Ruijie (config)#crypto pki key generate rsa //Generate a key.
Ruijie (config)#crypto pki trustpoint CA_name //Define a CA. CA-name: FQDN of the CA,
which will be provided by the CA administrator
```

```
ruijie(ca-trustpoint)#enrollment offline subject //Set DN information of the offline certificate
```

You are about to be asked to enter you Distinguished Name(DN) information that will be incorporated into your certificate request. There are quite a few fields but you can leave some blank.

Common Name (eg, YOUR name) []: //Your first name and last name

Organizational Unit Name (eg, section) []: //Your organizational unit name

Organization Name (eg, company) []: //Your organization name

Locality Name (eg, city) []: //Your city or region

State or Province Name (full name) []: //Your state or province

Country Name (2 letter code) [CN]: //2-letter country code of your organization

```
The subject name is: cn=fhsjflsdgingsd,ou=research,o=ruijie,l=CD,st=SC,c=CN
Is it correct[yes/no]:yes
ruijie(config)#crypto pki enroll CA_name          //Register an offline certificate
%The subject name in the certificate will include:
cn=fhsjflsdgingsd,ou=research,o=ruijie,l=CD,st=SC,c=CN
-----BEGIN CERTIFICATE REQUEST-----
MIIBpDCCAQ0CAQAwZDEXMBUGA1UEAxMOZmhzamZsc2RnaW5nc2QxETAPBgNVBAsT
CHJlc2VhcmNoMQ8wDQYDVQQKEwZydWlqaWUxCzAJBgNVBAcTAkNEMQswCQYDVQQI
EwJTQzELMAkGA1UEBhMCQ04wgZ8wDQYJKoZIhvcNAQEBBQADgY0AMIGJAoGBANep
/WFrf0uBBp7ZIPMC7Dq22mUtzc3xWrT3V5sk/P98+KTXlKYy7aYCKZqhgCw/5XHP
6fAV9d7kKcs9ynptjbagjdFpeWSRpRzJ0U+fYg1muJf7U3ZuyFMBOQgwOvofwcOa
sJ53RhmadZqdAHzPDtQT9XVbl4tSNYckGiOm3My3AgMBAAGgADANBgkqhkiG9w0B
AQQFAAOBgQBFAC/oAVXrKpVvks0Mvk+84bKIR0tY2opqyRo9Ax26rZM8hK4oULQS
n3Ar7O3pBoWt1YbX0ZpUpEgu1IRCm0PwIeQ6uN6KwnO3a6A3AMLgWrwQ29rn7kQG
JbsHZ+Okk80CzZu6s8OBtasB6VU4LFCGwBAtbL83Syp973c8cYGPWg==
-----END CERTIFICATE REQUEST-----
Copy the contents (PKCS10 format) between “-----BEGIN CERTIFICATE REQUEST-----“ and “-----END CERTIFICATE REQUEST-----” to the CA to issue a certificate.
% Enter PEM-formatted CA certificate.
% End with a blank line or "quit" on a line by itself.
```

//Paste the CA root certificate in PEM format.

Certificate has the following attributes:

```
MD5 fingerprint: D869FAEE D797E625 B248217D 2050BF48
SHA1 fingerprint: D0B10C45 751402F0 646B4DBF E5B26AE2 74207498
%% Do you accept this certificate?[yes/no]:yes
% CA Certificate successfully imported
% Enter PEM-formatted certificate.
% End with a blank line or "quit" on a line by itself.
```

//Paste the router certificate in PEM format issued by the CA.

```
% Router Certificate successfully imported
```

Certificate Configuration Commands (Optional)

Certificate configuration commands include certificate chain configuration commands and certificate configuration commands.

To create a certificate chain, run the following command in global configuration mode. Use the **no** form of this command to delete a certificate chain:

Command	Function
Ruijie(config)# **crypto pki certificate chain**	Creates a router certificate chain and enters certificate chain configuration mode (config_cert_chain).

To add a certificate to the certificate chain, run the following command in certificate chain configuration mode. Use the **no** form of this command to delete the certificate:

Command	Function
Ruijie(config_cert_chain)# **certificate** [**CA**] *serial_num*	Enters certificate configuration mode (config-pubkey) in order to enter certificate data with the specified serial number; *serial_num* is the serial number of the certificate; The *CA* parameter indicates the CA root certificate.

To enter certificate data, run the following command line by line in certificate configuration mode (config-pubkey).

Command	Function
Ruijie(config-pubkey)# *308202E6 30820290 A0030201 0202107F FFBB3997 39B4814B E16B4FF9 067A4B30*	Enters certificate data.

To exit certificate configuration mode, type in "quit" and the system will immediately analyze and verify the certificate data. If the certificate data is illegal, the contents entered will be cancelled. Note that "exit" and "Ctrl+Z" do not take effect in certificate configuration mode.

Command	Function
Ruijie(config-pubkey)# **quit**	Ends certificate data input and exits certificate configuration mode.

Caution The commands configured in this section are only used to store, display and delete certificates. It is not recommended that you configure the certificate by entering certificate data line by line manually, as it is quite troublesome. Refer to relevant instructions for certificate import. After a successful import, run the **show running** command and you will see that the system has automatically created the certificate chain and converted CA certificate and router certificate into the format shown herein as system configurations. Actually, as Ruijie products do not provide the command for separately configuring private keys, you can only import the certificate as per relevant instructions.

If you want to manually configure the certificate by using the **certificate** command, configure the CA root certificate first and then configure the router certificate, as the former one will be needed for verification while configuring the later one.

When using the **no** form of the command to delete a CA root certificate or certificate chain, the CA root certificate, router certificate and private key in system configuration all will be deleted.

To check certificate configurations, run the **show running** command or the **show crypto pki cert** command. For details, refer to the "Monitoring and Maintenance" section.

Example of manually configuring a CA root certificate:

```
Ruijie(config)# crypto pki certificate chain
Ruijie(config-cert-chain)# certificate ca
7FFFBB399739B4814BE16B4FF9067A4B
Ruijie(config-pubkey)# 308202E6 30820290 A0030201 0202107F FFBB3997 39B4814B E16B4FF9
067A4B30
Ruijie(config-pubkey)# 0D06092A 864886F7 0D010105 05003081 8F312330 2106092A 864886F7
0D010901
Ruijie(config-pubkey)# 1614776C 6370796A 77624073 7461722D 6E65742E 636E310B 30090603
55040613
Ruijie(config-pubkey)# 02434E31 0B300906 03550408 1302666A 310F300D 06035504 07130666
757A686F
Ruijie(config-pubkey)# 75311230 10060355 040A1309 52656420 4769616E 74311530 13060355
040B130C
Ruijie(config-pubkey)# 44657061 72746D65 6E742035 31123010 06035504 03130943 41205365
72766572
Ruijie(config-pubkey)# 301E170D 30353036 32323035 34363332 5A170D30 37303632 32303535
3434355A
Ruijie(config-pubkey)# 30818F31 23302106 092A8648 86F70D01 09011614 776C6370 796A7762
40737461
Ruijie(config-pubkey)# 722D6E65 742E636E 310B3009 06035504 06130243 4E310B30 09060355
04081302
Ruijie(config-pubkey)# 666A310F 300D0603 55040713 0666757A 686F7531 12301006 0355040A
13095265
Ruijie(config-pubkey)# 64204769 616E7431 15301306 0355040B 130C4465 70617274 6D656E74
20353112
Ruijie(config-pubkey)# 30100603 55040313 09434120 53657276 6572305C 300D0609 2A864886
F70D0101
Ruijie(config-pubkey)# 01050003 4B003048 024100BE D1E81427 7A302B5E 11CA43FD 2F2B7EA9
8A0796A2
Ruijie(config-pubkey)# CFFE9DB7 D3DA54C3 034AA844 B3F011DC 8ABB7253 9758B13F DF6B8A9E
5F46D300
Ruijie(config-pubkey)# 402E24D3 85A74142 55F77502 03010001 A381C530 81C2300B 0603551D
0F040403
Ruijie(config-pubkey)# 0201C630 0F060355 1D130101 FF040530 030101FF 301D0603 551D0E04
16041464
```

```
Ruijie(config-pubkey)# 4612C027 A49E010C 65DAF86E E7FEC656 ECADD430 71060355 1D1F046A
30683031
Ruijie(config-pubkey)# A02FA02D 862B6874 74703A2F 2F7A6A2D 726F7574 65722F43 65727445
6E726F6C
Ruijie(config-pubkey)# 6C2F4341 25323053 65727665 722E6372 6C3033A0 31A02F86 2D66696C
653A2F2F
Ruijie(config-pubkey)# 5C5C7A6A 2D726F75 7465725C 43657274 456E726F 6C6C5C43 41253230
53657276
Ruijie(config-pubkey)# 65722E63 726C3010 06092B06 01040182 37150104 03020100 300D0609
2A864886
Ruijie(config-pubkey)# F70D0101 05050003 4100342F 8D936843 607B685F F07E910C 5CE35898
7C5395AE
Ruijie(config-pubkey)# C2B81CFF 82A4AE95 A881A88A FFF96F92 723EFA6F 847D8347 930F8576
48AE68B9
Ruijie(config-pubkey)# 5A72CF09 50BE1BA7 E187
Ruijie(config-pubkey)# quit
```

Configuring Certificate Revocation Check Policy (Optional)

When checking whether the certificate of the communication peer is valid, Ruijie products provide strict and loose verification. In strict verification mode, the certificate must be verified for revocation. If the correct CRL is not found, the peer certificate will not be accepted; in loose verification mode, the certificate will not be verified for revocation. By default, the strict mode will be used. Run the following command in global configuration mode, you can change the check policy to loose mode, and use the **no** form of this command to restore to strict mode.

Command	Function
Ruijie(config)# **crypto pki revocation-check none**	When this command is used, there is no need to check whether the certificate has been revoked according to CRL while checking the certificate of communication peer.

Note

The check policy shall be determined according to the fact that whether the device may receive the revoked peer certificate. For example, when the certificate is used in IKE center-branch network model, as the central device needs to accept the negotiation requests initiated by many dialers, and some certificates may have been revoked, the strict mode must be configured then to avoid unauthorized access. The branch devices only initiate the negotiation attempt with the central device, and are not possible to receive a revoked certificate. Therefore, the loose mode will be sufficient and network resources needed for CRL update can also be saved.

Downloading a CRL (Optional)

By default, strict certificate revocation is used. At this time, you must download a CRL. The maximum size of a CRL file allowed by the RGOS is 1 MB; otherwise, CRL download will be rejected. On Ruijie products, a CRL file can be downloaded through HTTP from a URL obtained in the following methods (priority arranged in descending order):

31) Specified by using the **crypto pki crl url** *http://www.myca.cn/certsrv/certcrl.crl* command
32) Extension of CRL distribution point of CA root certificate configured on the device;
33) Extension of CRL distribution point of router certificate configured on the device;

CRL can be downloaded by the following means:

- Manually download CRL by using the **crypto pki crl request** command;
- When CA root certificate and router certificate are configured and strict mode is adopted for certificate check, the CRL will be detected every one minute for presence and expiration, and will be downloaded automatically;
- When strict mode is adopted for certificate check, the system will verify whether the local CRL has expired or not and download immediately during certificate check if the local CRL has expired.


Note

Note When a digital certificate is no longer needed by the device, delete relevant configurations or configure a loose certificate revocation check policy for the following considerations:
1. CRL expiration check executed once every minute can be saved;
2. If the CRL file is large, automatic update will consume certain network resources and occupy FLASH space and memory space.

To manually specify the URL for downloading CRL, run the following command in global configuration mode; use the **no** form of this command to delete this configuration:

Command	Function
Ruijie(config)# **crypto pki crl url** *url_string*	Manually specifies the URL for downloading a CRL file.


Caution

url_string must begin with http://; port 80 is used as the downloading port by default, or else you must specify a port after the domain name, for example, http://www.myca.cn:1020/; the directory name is **certsrv** by default, or you can specify a directory by running the **http://www.myca.cn/***CertDir/* command; the CRL file is **certcrl.crl** by default, or you can specify it by running the **http://www.myca.cn/certsrv/***mycertcrl.crl*; the value of *url_string* must contain no space; if your URL must contain spaces, you can type in "%20" instead, for example, http://www.myca.cn/certsrv/CA%20Server%20Crl.crl.
The domain of url_string can use an IP address directly, such as http://202.101.211.123, or an internal host name, such as http://myserver. No matter the URL is obtained through manual configuration or certificate, the device will automatically proceed with domain name resolution or host name resolution while starting to download CRL file. Make sure the relevant configurations are correct. If domain name resolution is needed, the correct DNS server address must be configured; if internal host name resolution is needed, use the **ip host** command to configure the IP address of the host.
The extension of CRL distribution point may contain multiple URLs. RGOS can only use one URL. Pay attention to this issue during CA server configuration.

To manually download a CRL, run the following command in global configuration mode:

Command	Function
Ruijie(config)# **crypto pki crl request**	Manually starts CRL download; start CRL download according to the currently configured certificate and URL (this command cannot be stored).

During CRL download, run the **crypto pki crl request** command and the system will prompt that the download process has started. Upon successful download, the message “%Crl download and decode successfully!” will be displayed on the console; use the **dir** command to check the file in FLASH and its creation time, or you can check the result of CRL download, as shown below:

```
Ruijie# dir
Directory of flash:/
5    an      68 0xdbc28957 Jan  1 2005 00:00:00 tftp_config.bin
8    an  4301816 0x3e415b47 Jun 28 2005 15:03:46 rgos.bin
20    an    5311 0xeaa56cb0 Jul  4 2005 10:04:37 config.text
26    an     427 0x5bd43f32 Jun 29 2005 10:00:07 certcrl.crl
Ruijie# show clock
clock: 2005-6-29 10:0:19
```

The name of the CRL file is **certcrl.crl**; the download time is 2005-6-29 10:00:07; the current time is 10:00:19. We can see that this CRL was downloaded just now.

In addition, Ruijie products also allow you to use the **show crypto pki crl** command to query information about the present CRL file (see the "Monitoring and Maintenance" section).

Configuration Example

This section shows the outputs of the **show running** command after completing certificate configuration. It shall be noted that the private key will not be displayed in the system configuration file as it is considered private information. Therefore, certificate configuration cannot be completed by copying and pasting the following configurations to the console or running the **copy tft flash** command to copy the configuration file to **config.txt**. To configure a certificate, you must run the **crypto pki import pem terminal** Command to import the certificate. This example only shows the visible configuration results.

Caution For how the certificate application module uses the digital certificate, refer to instructions on relevant application modules.

Configuration example is shown below:

```
Ruijie# sh run
Building configuration...
Current configuration : 5331 bytes
!
version 8.31(building 1)
hostname Ruijie
!
crypto pki certificate chain
```

```
certificate ca 7FFFBB399739B4814BE16B4FF9067A4B
308202E6 30820290 A0030201 0202107F FFBB3997 39B4814B E16B4FF9 067A4B30
0D06092A 864886F7 0D010105 05003081 8F312330 2106092A 864886F7 0D010901
1614776C 6370796A 77624073 7461722D 6E65742E 636E310B 30090603 55040613
02434E31 0B300906 03550408 1302666A 310F300D 06035504 07130666 757A686F
75311230 10060355 040A1309 52656420 4769616E 74311530 13060355 040B130C
44657061 72746D65 6E742035 31123010 06035504 03130943 41205365 72766572
301E170D 30353036 32323035 34363332 5A170D30 37303632 32303535 3434355A
30818F31 23302106 092A8648 86F70D01 09011614 776C6370 796A7762 40737461
722D6E65 742E636E 310B3009 06035504 06130243 4E310B30 09060355 04081302
666A310F 300D0603 55040713 0666757A 686F7531 12301006 0355040A 13095265
64204769 616E7431 15301306 0355040B 130C4465 70617274 6D656E74 20353112
30100603 55040313 09434120 53657276 6572305C 300D0609 2A864886 F70D0101
01050003 4B003048 024100BE D1E81427 7A302B5E 11CA43FD 2F2B7EA9 8A0796A2
CFFE9DB7 D3DA54C3 034AA844 B3F011DC 8ABB7253 9758B13F DF6B8A9E 5F46D300
402E24D3 85A74142 55F77502 03010001 A381C530 81C2300B 0603551D 0F040403
0201C630 0F060355 1D130101 FF040530 030101FF 301D0603 551D0E04 16041464
4612C027 A49E010C 65DAF86E E7FEC656 ECADD430 71060355 1D1F046A 30683031
A02FA02D 862B6874 74703A2F 2F7A6A2D 726F7574 65722F43 65727445 6E726F6C
6C2F4341 25323053 65727665 722E6372 6C3033A0 31A02F86 2D66696C 653A2F2F
5C5C7A6A 2D726F75 7465725C 43657274 456E726F 6C6C5C43 41253230 53657276
65722E63 726C3010 06092B06 01040182 37150104 03020100 300D0609 2A864886
F70D0101 05050003 4100342F 8D936843 607B685F F07E910C 5CE35898 7C5395AE
C2B81CFF 82A4AE95 A881A88A FFF96F92 723EFA6F 847D8347 930F8576 48AE68B9
5A72CF09 50BE1BA7 E187
quit
!
certificate 162A7A1D000000000002
308204F9 308204A3 A0030201 02020A16 2A7A1D00 00000000 02300D06 092A8648
86F70D01 01050500 30818F31 23302106 092A8648 86F70D01 09011614 776C6370
796A7762 40737461 722D6E65 742E636E 310B3009 06035504 06130243 4E310B30
09060355 04081302 666A310F 300D0603 55040713 0666757A 686F7531 12301006
0355040A 13095265 64204769 616E7431 15301306 0355040B 130C4465 70617274
6D656E74 20353112 30100603 55040313 09434120 53657276 6572301E 170D3035
30363232 30353530 34385A17 0D303630 36323230 36303034 385A3081 80311630
1406092A 864886F7 0D010901 16077A68 616F6A75 6E310B30 09060355 04061302
434E310B 30090603 55040813 02666A31 0F300D06 03550407 13066675 7A686F75
31123010 06035504 0A130952 65642047 69616E74 31153013 06035504 0B130C44
65706172 746D656E 74203531 10300E06 03550403 13077A68 616F6A75 6E308201
22300D06 092A8648 86F70D01 01010500 0382010F 00308201 0A028201 0100C6E2
7AE88D6D D8BB56A8 9C036214 E52E23E5 A526313D B22465B1 F2CC07E3 EFCC023C
D06E008D FCCE3AB6 457ACBA0 87941FC3 9243366A B27C9CD5 CA7E83BA 76497FBE
F41F4AA1 0B982296 E27954A0 ED1C6230 B7EE6A6E CB72E99C D9E8B0DC F5C6198F
2B2A85FA BFFF0840 7EF2A1DF D18BEF68 321E1A45 FA16DE33 B06290BD 9C8EEC7C
6E494875 E65CCEB1 8E1C80F3 5B796CA1 31B2A948 379FED45 9585BA98 0F42C578
```

```
4C3DA245 73903D0B 1A7C53B5 971AA643 2F44540F A1513A0E 9F8B2ED1 70CB3699
9157D2B7 9D7CEE07 CF4AC7CD 71DCCE72 DC75A003 B236BE8E AFCA9946 038327D3
FF241E4C 0C2199B4 FE5A4D61 B5E9B438 DC592C37 F39302FC 0988021B D0450203
010001A3 82022430 82022030 0E060355 1D0F0101 FF040403 0206C030 13060355
1D25040C 300A0608 2B060105 05080202 301D0603 551D0E04 16041484 7E33A391
A5261D2D BB5465BF C72A2A2E 87D5A930 81CB0603 551D2304 81C33081 C0801464
4612C027 A49E010C 65DAF86E E7FEC656 ECADD4A1 8195A481 9230818F 31233021
06092A86 4886F70D 01090116 14776C63 70796A77 62407374 61722D6E 65742E63
6E310B30 09060355 04061302 434E310B 30090603 55040813 02666A31 0F300D06
03550407 13066675 7A686F75 31123010 06035504 0A130952 65642047 69616E74
31153013 06035504 0B130C44 65706172 746D656E 74203531 12301006 03550403
13094341 20536572 76657282 107FFFBB 399739B4 814BE16B 4FF9067A 4B307106
03551D1F 046A3068 3031A02F A02D862B 68747470 3A2F2F7A 6A2D726F 75746572
2F436572 74456E72 6F6C6C2F 43412532 30536572 7665722E 63726C30 33A031A0
2F862D66 696C653A 2F2F5C5C 7A6A2D72 6F757465 725C4365 7274456E 726F6C6C
5C434125 32305365 72766572 2E63726C 30819806 082B0601 05050701 0104818B
30818830 4106082B 06010505 07300286 35687474 703A2F2F 7A6A2D72 6F757465
722F4365 7274456E 726F6C6C 2F7A6A2D 726F7574 65725F43 41253230 53657276
65722E63 72743043 06082B06 01050507 30028637 66696C65 3A2F2F5C 5C7A6A2D
726F7574 65725C43 65727445 6E726F6C 6C5C7A6A 2D726F75 7465725F 43412532
30536572 7665722E 63727430 0D06092A 864886F7 0D010105 05000341 0037500C
D66C236D 2D813702 6C22EFE2 9598DC91 25FE0A3B B0F24869 2C6B9866 BE6B09EF
DE2FDBED 710E04A5 12388B30 2BEBC9D9 881EA210 2C86D23D 25FD9CDF B4
quit
!
!
crypto pki crl url http://zj-router/certsrv/certcrl.crl
!
ip host zj-router 192.168.64.145
!
interface FastEthernet 0/0
ip address 202.101.100.1 255.255.255.0
ip address 192.168.64.199 255.255.255.0 secondary
!
interface FastEthernet 1/0
duplex auto
speed auto
!
interface Null 0
!
!
!
line con 0
line vty 0 4
exec-timeout 0 0
```

```
privilege level 15
no login
!
!
end
Ruijie#
```

Monitoring and Maintenance

Ruijie products allow you to query certificate information by using the following command in privileged user mode:

Command	Function
Ruijie**# show crypto pki certificate**	Displays CA root certificate and router certificate configured in the system. When no certificate is configured, there will be no output.

The following shows an example of the **show crypto pki certificate** command output:

```
Ruijie# show crypto pki certificate
%CA certificate info:                              //CA certificate information
Certificate:
Data:
Version: 3 (0x2)                                  //X.509v3
Serial Number:                                      //Certificate serial number
7f:ff:bb:39:97:39:b4:81:4b:e1:6b:4f:f9:06:7a:4b
Signature Algorithm: sha1WithRSAEncryption         //Signature algorithm
Issuer: emailAddress=wlcpyjwb@star-net.cn, C=CN, ST=fj, L=fuzhou, O=Red Giant, OU=Department
5, CN=CA Server  //DN name of the issuer
Validity                                         //Certificate validity information
Not Before: Jun 22 05:46:32 2005 GMT      //Effective time in UTC
Not After : Jun 22 05:54:45 2007 GMT      //Time of expiration in UTC
Subject: emailAddress=wlcpyjwb@star-net.cn, C=CN, ST=fj, L=fuzhou, O=Red Giant, OU=Department
5, CN=CA Server
//DN name of certificate subject
Subject Public Key Info:                           //Information about the subject public key
Public Key Algorithm: rsaEncryption       //Public key algorithm: RSA encryption
RSA Public Key: (512 bit)                    //512-bit RSA public key
Modulus (512 bit):
00:be:d1:e8:14:27:7a:30:2b:5e:11:ca:43:fd:2f:
2b:7e:a9:8a:07:96:a2:cf:fe:9d:b7:d3:da:54:c3:
03:4a:a8:44:b3:f0:11:dc:8a:bb:72:53:97:58:b1:
3f:df:6b:8a:9e:5f:46:d3:00:40:2e:24:d3:85:a7:
41:42:55:f7:75
Exponent: 65537 (0x10001)
X509v3 extensions:                               //Certificate extensions
X509v3 Key Usage:                                 //Key usage flag
```

```
Digital Signature, Non Repudiation, Certificate Sign, CRL Sign          //Including digital
signature, anti-replay, certificate signature, and CRL signature
X509v3 Basic Constraints: critical
CA:TRUE
X509v3 Subject Key Identifier:                  //Subject key identifier
64:46:12:C0:27:A4:9E:01:0C:65:DA:F8:6E:E7:FE:C6:56:EC:AD:D4
X509v3 CRL Distribution Points:                //Information about CRL distribution point
URI:http://zj-router/CertEnroll/CA%20Server.crl
URI:file://\\zj-router\CertEnroll\CA%20Server.crl
1.3.6.1.4.1.311.21.1:
...
Signature Algorithm: sha1WithRSAEncryption          //Signature algorithm
34:2f:8d:93:68:43:60:7b:68:5f:f0:7e:91:0c:5c:e3:58:98:
7c:53:95:ae:c2:b8:1c:ff:82:a4:ae:95:a8:81:a8:8a:ff:f9:
6f:92:72:3e:fa:6f:84:7d:83:47:93:0f:85:76:48:ae:68:b9:
5a:72:cf:09:50:be:1b:a7:e1:87                       //Certificate signature
%Router certificate info:                 //Information about the router certificate
Certificate:
Data:
Version: 3 (0x2)                              //X.509v3
Serial Number:                                   //Certificate serial number
16:2a:7a:1d:00:00:00:00:00:02
Signature Algorithm: sha1WithRSAEncryption         //Signature algorithm
Issuer: emailAddress=wlcpyjwb@star-net.cn, C=CN, ST=fj, L=fuzhou, O=Red Giant, OU=Department
5, CN=CA Server  //DN name of the issuer
Validity                                         //Certificate validity information
Not Before: Jun 22 05:50:48 2005 GMT      //Effective time in UTC
Not After : Jun 22 06:00:48 2006 GMT      //Time of expiration in UTC
Subject: emailAddress=zhaojun, C=CN, ST=fj, L=fuzhou, O=Red Giant, OU=De partment 5, CN=zhaojun
//DN name of certificate subject
Subject Public Key Info:                        //Information about the subject public key
Public Key Algorithm: rsaEncryption      //Public key algorithm: RSA encryption
RSA Public Key: (2048 bit)                //2048-bit RSA public key
Modulus (2048 bit):
00:c6:e2:7a:e8:8d:6d:d8:bb:56:a8:9c:03:62:14:
e5:2e:23:e5:a5:26:31:3d:b2:24:65:b1:f2:cc:07:
e3:ef:cc:02:3c:d0:6e:00:8d:fc:ce:3a:b6:45:7a:
cb:a0:87:94:1f:c3:92:43:36:6a:b2:7c:9c:d5:ca:
7e:83:ba:76:49:7f:be:f4:1f:4a:a1:0b:98:22:96:
e2:79:54:a0:ed:1c:62:30:b7:ee:6a:6e:cb:72:e9:
9c:d9:e8:b0:dc:f5:c6:19:8f:2b:2a:85:fa:bf:ff:
08:40:7e:f2:a1:df:d1:8b:ef:68:32:1e:1a:45:fa:
16:de:33:b0:62:90:bd:9c:8e:ec:7c:6e:49:48:75:
e6:5c:ce:b1:8e:1c:80:f3:5b:79:6c:a1:31:b2:a9:
48:37:9f:ed:45:95:85:ba:98:0f:42:c5:78:4c:3d:
```

```
a2:45:73:90:3d:0b:1a:7c:53:b5:97:1a:a6:43:2f:
44:54:0f:a1:51:3a:0e:9f:8b:2e:d1:70:cb:36:99:
91:57:d2:b7:9d:7c:ee:07:cf:4a:c7:cd:71:dc:ce:
72:dc:75:a0:03:b2:36:be:8e:af:ca:99:46:03:83:
27:d3:ff:24:1e:4c:0c:21:99:b4:fe:5a:4d:61:b5:
e9:b4:38:dc:59:2c:37:f3:93:02:fc:09:88:02:1b:
d0:45
Exponent: 65537 (0x10001)
X509v3 extensions:                          //Certificate extensions
X509v3 Key Usage: critical          //Key usage flag, which is a key extension
Digital Signature, Non Repudiation      //Including digital signature and anti-replay
X509v3 Extended Key Usage:                    //Extended key usage
1.3.6.1.5.5.8.2.2
X509v3 Subject Key Identifier:                //Subject key identifier
84:7E:33:A3:91:A5:26:1D:2D:BB:54:65:BF:C7:2A:2A:2E:87:D5:A9
X509v3 Authority Key Identifier:          //Authority key identifier
keyid:64:46:12:C0:27:A4:9E:01:0C:65:DA:F8:6E:E7:FE:C6:56:EC:AD:D4
DirName:/emailAddress=wlcpyjwb@star-net.cn/C=CN/ST=fj/L=fuzhou/O
=Red Giant/OU=Department 5/CN=CA Server
serial:7F:FF:BB:39:97:39:B4:81:4B:E1:6B:4F:F9:06:7A:4B
X509v3 CRL Distribution Points:               //Information about CRL distribution point
URI:http://zj-router/CertEnroll/CA%20Server.crl
URI:file://\\zj-router\CertEnroll\CA%20Server.crl
Authority Information Access:           //Authority information access point
CA Issuers - URI:http://zj-router/CertEnroll/zj-router_CA%20Serv
er.crt
CA Issuers - URI:file://\\zj-router\CertEnroll\zj-router_CA%20Se
rver.crt
Signature Algorithm: sha1WithRSAEncryption          //Signature algorithm
37:50:0c:d6:6c:23:6d:2d:81:37:02:6c:22:ef:e2:95:98:dc:
91:25:fe:0a:3b:b0:f2:48:69:2c:6b:98:66:be:6b:09:ef:de:
2f:db:ed:71:0e:04:a5:12:38:8b:30:2b:eb:c9:d9:88:1e:a2:
10:2c:86:d2:3d:25:fd:9c:df:b4/                   //Certificate signature
Ruijie#
```

Ruije products allow you to query the CRL information by using the following command in privileged user mode:

Command	Function
Ruijie# show crypto pki crls	Displays CRL information downloaded by the system.

The following shows an example of the **show crypto pki crl** command output:

```
Ruijie# sh crypto pki crls
Certificate Revocation List (CRL):
Version 2 (0x1)                           //CRL version of X.509v2
Signature Algorithm: sha1WithRSAEncryption          //Signature algorithm
```

```
Issuer: /emailAddress=wlcpyjwb@star-net.cn/C=CN/ST=fj/L=fuzhou/O=Red Giant/OU=Department
5/CN=CA Server               //DN of the issuer
Last Update: Jun 22 06:10:27 2005 GMT    //Time of last update in UTC
Next Update: Jun 29 18:30:27 2005 GMT  //Time of next update in UTC, namely the expiration
time of CRL
CRL extensions:                          //CRL extensions are shown below
X509v3 Authority Key Identifier:          //Authority key identifier
keyid:64:46:12:C0:27:A4:9E:01:0C:65:DA:F8:6E:E7:FE:C6:56:EC:AD:D4
1.3.6.1.4.1.311.21.1:
...
Revoked Certificates:                      //List of revoked certificates are shown below
Serial Number: 162A7A1D000000000002           //Serial number of the revoked certificate
Revocation Date: Jun 22 06:19:53 2005 GMT          //Revocation date
CRL entry extensions:                          //CRL entry extensions
X509v3 CRL Reason Code:                      //CRL revocation reason code
Key Compromise                                    //Key compromise
Serial Number: 1635E5E3000000000003
Revocation Date: Jun 22 06:19:53 2005 GMT
CRL entry extensions:
X509v3 CRL Reason Code:
Key Compromise                                   //Key compromise
Signature Algorithm: sha1WithRSAEncryption         //Signature algorithm
5d:a2:ab:07:ff:7e:0e:9a:af:b2:25:11:7f:31:86:aa:21:48:
37:e7:22:99:e3:b2:15:e0:f9:80:63:66:5e:2f:f2:d6:c0:ea:
ef:46:7e:d1:c1:b2:66:0e:0b:d3:74:d1:55:bc:5c:13:46:e8:
56:ec:40:83:7b:1b:75:f2:68:87                      //Signature value
Ruijie#
```

Caution When the **crypto pki revocation-check none** command is used during startup, the existing URL file will not be resolved automatically after startup, and the **show crypto pki crl** command has no output.

Ruijie products allow you to query system debugging information displayed in certificate operations by using the follow0069ng commands in privileged user mode:

Command	Function
Ruijie# **debug crypto pki event**	Displays event tracking information about relevant certificate operations
Ruijie# **debug crypto pki error**	Displays error tracking information about relevant certificate operations

The preceding debugging information will help you diagnose the problems arising during digital certificate configuration and application.

Configuring the Tunnel Interface

Understanding the Tunnel interface

Overview

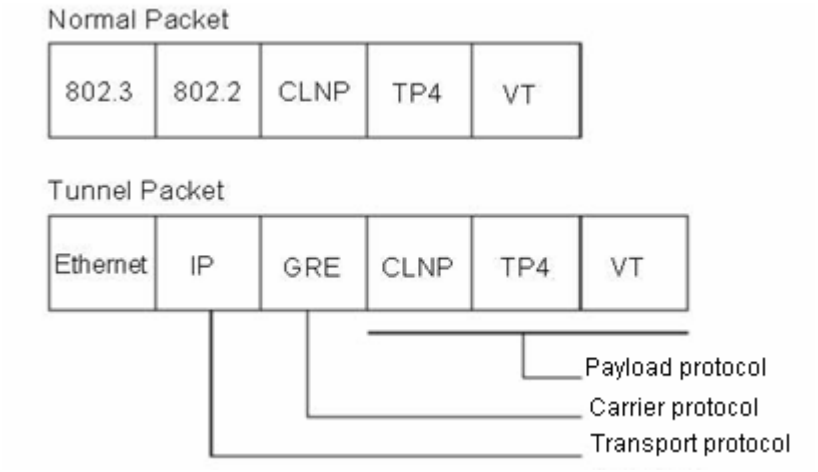
The tunnel interface is used to realize tunnel functions. Without specifically binding a certain transport protocol or payload protocol, the tunnel interface provides a standard point-to-point transmission link, and hence one tunnel interface must be configured for each separate link.

Tunnel function involves the following three key components:

34) Payload protocol: The protocol for encapsulating the payload (network data) transmitted through a tunnel. Currently, software of Ruijie products only support the use of the IP protocol as the payload protocol on the tunnel interface;
35) Carrier protocol: The protocol for secondary encapsulation and identification of the payload to be transmitted. Ruijie products support the following encapsulation modes on the tunnel interface: GRE and IPIP;
36) Transport protocol: The network protocol for transmitting the payload packets further encapsulated by the carrier protocol. Ruijie products use the most widely applied IP protocol as the transport protocol.

Figure 23 shows the formation of a data packet encapsulated for transmission over an IP tunnel before and after the transmission.

Figure 23 The formation of data packet transmitted over the tunnel network before and after the transmission



IP tunnel transmission function is accomplished through GRE Ethernet encapsulation. In practice, if two private networks using the same protocol need to communicate with each other through the public network using a different protocol, they can use the tunnel function.

Tunnel transmission is applicable to the following circumstances:

37) Allowing the communication between non-IP local networks over a single-protocol network (IP network), as a tunnel supports different payload protocols; allowing the scope enlargement of a network running a hop-limited protocol;
38) Allowing the connection of discontinuous subnets over a single-protocol network (IP network);

39) Allowing the provision of VPN (virtual private network) over wide area network.

Since a tunnel will encapsulate the payload before transmission, such complexity in processing requires you to pay attention to the following issues under certain circumstances.

40) Since a tunnel is a point-to-point link which seems to have only one hop during routing, the actual routing overhead may involve multiple hops. Note that routing on a tunnel link may be different from the actual condition.
41) Since a tunnel will encapsulate the payload into a transport protocol, you need to give the corresponding consideration when configuring the firewall, especially the ACL. It shall also be noted that the transmission bandwidth (such as MTU) of a payload protocol is smaller than the theoretical value.

The followings will only introduce the attributes specific to the tunnel interface. The configuration of other attributes (including IP address and other relevant parameters, firewall and parameters of backup center) will be introduced in relevant sections.

Configuring the Tunnel Interface

Tunnel interface configuration tasks

Entering designated Tunnel interface configuration mode

To create a tunnel interface and enter interface configuration mode, run the following commands in global configuration mode:

Command	Function
Ruijie(config)# **interface tunnel** *tunnel-number*	Enters designated tunnel interface configuration mode.
Ruijie(config)# **no interface tunnel** *tunnel-number*	Deletes the existing tunnel interface.

Same as other logic interfaces, a tunnel interface is created once you enter the designated tunnel interface for the first time.

Configuring the source address of a Tunnel interface

A tunnel interface needs to identify the source address and destination address of the tunnel configured. In order to ensure the stability of a tunnel interface, the Loopback address is generally used as the source address and destination address of tunnel. Before normal operations of tunnel interface, check the connectivity between source address and destination address.

To configure the source address of a tunnel interface, run the following commands in tunnel interface configuration mode:

Command	Function
Ruijie(config-if)# **tunnel source** {*ip-address* | **interface-name** *interface-number*}	Configures the source address of the tunnel interface.
Ruijie(config-if)# **no tunnel source**	Removes the source address configuration of the tunnel interface.

The **tunnel source** command configures the actual source address for communication over a tunnel interface, namely the local endpoint of the tunnel.

Configuring the destination address of a Tunnel interface

To configure the destination address of a tunnel interface, run the following commands in tunnel interface configuration mode:

Command	Function
Ruijie(config-if)# **tunnel destination** { *ip-address* }	Configures the destination address of the tunnel interface.
Ruijie(config-if)# **no tunnel destination**	Removes destination address configuration of the tunnel interface.

The **tunnel destination** command configures the actual destination address for communication over a tunnel interface, namely the remote endpoint of the tunnel.


Caution On the same router, tunnel interfaces that use the same encapsulation protocol cannot have the same source address or destination address.

Configuring Tunnel mode

The tunnel mode is referred to as the carrier protocol of a tunnel. The default tunnel mode is GRE. Of course, the user can also select a tunnel mode according to actual application.

Command	Function
Ruijie(config-if)# **tunnel mode** { **gre** {ip | ipv6}| **ipip** | ipv6ip}	Configures tunnel mode.
Ruijie(config-if)# **no tunnel mode**	Removes tunnel mode configuration and restores the default setting.


Caution The use of the **tunnel mode** command is related to device models.

Configuring Tunnel checksum

Under certain circumstances, tunnel checksum needs to be used to guarantee data integrity.

Command	Function
Ruijie(config-if)# **tunnel checksum**	Configures tunnel checksum.
Ruijie(config-if)# **no tunnel checksum**	Disables tunnel checksum.

By default, the checksum function of a tunnel interface is disabled.


Caution This command is only supported by the router.

Configuring the key of a tunnel interface

The key of a tunnel interface can ensure the security on both ends of a tunnel to a certain extent and prevent sniffing and attack from outside.

Command	Function
Ruijie(config-if)# **tunnel key** *key-value*	Configures the key of the tunnel interface.
Ruijie(config-if)# **no tunnel key**	Removes the key of the tunnel interface.

The key of a tunnel interface works only when the tunnel mode is GRE, as each GRE data packet will contain the tunnel key configured.


Caution (1) Both ends of a tunnel must use the same key configuration to allow normal communication;
(2) Although each GRE data packet will contain the key configured when the encapsulation mode is GRE, it is still unwise to guarantee security by relying on this key.
(3) This command is only supported by the router.

Configuring tunnel reception rules

If the payload protocol is inadequate to maintain the order of data packets, Ruijie products allow the configuration of tunnel reception rules to drop the disordered data packets. If the payload protocol is inadequate to maintain the order of data packets, this function can help realize the sequential transmission of data packets.

Command	Function
Ruijie(config-if)# **tunnel sequence-datagrams**	Configures sequential reception of packets on the tunnel.
Ruijie(config-if)# **no tunnel sequence-datagrams**	Removes sequential reception configuration of the tunnel.

This configuration is effective only when the tunnel mode is GRE.


Caution This command is only supported by the router.

Configuring TTL of a tunnel

Since a tunnel is a point-to-point link which seems to have only one hop during routing, the actual routing overhead may involve multiple hops. Ruijie products allow you to configure the TTL of a tunnel, namely to set the TTL in the transport protocol header of the packet transmitted over a tunnel. Being the intermediate node of tunnel, the router will reduce the TTL value in the transport protocol header and drop packets with TTL value being 0.

Command	Function

Ruijie(config-if)# **tunnel ttl** *hop-count*	Configures the TTL of the tunnel.
Ruijie(config-if)# **no tunnel ttl**	Removes TTL configuration of the tunnel and restores to the default value of 255.

By default, the TTL value of a tunnel transport protocol is 255.

Configuring TOS of a tunnel

In tunnel interface mode, configure the ToS byte of outer-layer transport protocol IPv4, or the 8 bits of traffic class of IPv6.

Command	Function
Ruijie(config-if)# **tunnel tos** *num*	Configures the TOS of the tunnel.
Ruijie(config-if)#**no tunnel tos**	Removes TOS configuration of the tunnel.

By default, if both the inner-layer carrier protocol and outer-layer encapsulation protocol of tunnel are IPv4, then the ToS byte of inner-layer IPv4 header will be copied to the outer-layer IPv4 header. If both the inner-layer carrier protocol and outer-layer encapsulation protocol of tunnel are IPv6, then the traffic class 8 bits of inner-layer IPv6 header will be copied to the outer-layer IPv6 header. In other cases, the outer-layer IPv4 ToS and IPv6 traffic class are 0.

Configuring PMTUD of a tunnel

Even if the payload IP message header is configured with DF (Don't Fragment) bit, the size of the payload protocol message may exceed the MTU of the destination outlet of tunnel after encapsulation, resulting in message fragmentation. On the way to the peer terminal of tunnel, the PMTU may become smaller and the intermediate forwarding device will fragment the encapsulated messages. Ruijie products provide the **tunnel path-mtu-discovery** command in interface configuration mode, allowing automatic discovery of PMTU in order to adjust the MTU size of tunnel interface and avoid message fragmentation.

Command	Function
Ruijie(config-if)# **tunnel path-mtu-discovery [age-timer** {*aging-mins* | **infinite} | min-mtu** *mtu-bytes]*	Enables the PMTUD function of the tunnel interface; Age-timer (optional): configures the aging timer of MTU on the tunnel interface; upon expiration of this timer, the MTU on the tunnel interface will reset to the initial MTU less the header length of carrier protocol messages; aging-mins: aging time ranging from 10 to 30 minutes, with default value being 10 minutes; infinite: disable MTU age-timer. Min-mtu (optional): configures MTU lower limit that can be adjusted by PMTUD; mtu-bytes: lower limit of MTU, ranging from 92 to 65535 bytes, with default value being 95 bytes.
Ruijie(config-if)# **no tunnel path-mtu-discovery [age-timer | min-mtu]**	Disables the PMTUD function of the tunnel interface

PMTUD can work only in GRE or IPIP tunnel mode, and is not enabled by default.

Caution The PMTUD function requires the tunnel interfaces on both ends of the tunnel to be able to receive and process ICMP messages, especially when there is a firewall. This command is only supported by RGOS

10.4(2) or later versions.

After you run the **show interface tunnel** command, states of PMTUD are as follows:

Path MTU Discovery state:init

Path MTU Discovery state:keep

Path MTU Discovery state:learning

PMTUD learning has three state machines:

Initially, PMTUD is in init state.

When the timer expires and probe packets are being sent, PMTUD changes to the learning state and then learning packets are sent.

If an MTU change is not detected after five consecutive probe packets are sent, PMTUD changes to the keep state and begins sending keep packets.

Command	Function
Ruijie(config-if)# **tunnel path-mtu-discovery** *aging-mins mtu-bytes*	Enables the PMTUD function of the tunnel interface. Age-timer: configures the aging timer of MTU on the tunnel interface; upon expiration of this timer, the tunnel will send probe messages to discover Path MTU; aging-mins: aging time ranging from 1 to 65535 seconds. Min-mtu: configures MTU lower limit that can be adjusted by PMTUD; mtu-bytes: lower limit of MTU, ranging from 92 to 1500 bytes.
Ruijie(config-if)# **no tunnel path-mtu-discovery**	Disables the PMTUD function of the tunnel interface.

PMTUD can work only in GRE or IPIP tunnel mode, and is not enabled by default.

Caution The PMTUD function requires the tunnel interfaces on both ends of the tunnel to be able to receive and process ICMP messages, especially when there is a firewall. This command is only supported by RGOS 10.4(1) or later versions.

Configuring the keepalive function of a tunnel

When the physical interface sending tunnel messages is UP but the line failure prevents the tunnel messages from reaching the opposite terminal, the tunnel keepalive function can be used to detect the reachability of the tunnel interface.

Command	Function
Ruijie(config-if)# **keepalive** [*seconds* [*retries*]]	Configures the keepalive function of the tunnel.
Ruijie(config-if)# **no keepalive**	Disables the keepalive function of the tunnel

Caution This command is only supported by RGOS 10.4(2) or later versions.

This command cannot be used together with the **tunnel vrf** or **ip vrf forward** command.

This command applies only to GRE IP-capable 4 over 4 tunnels and IPIP tunnels.

Command	Function
Ruijie(config-if)# **tunnel keepalive** *period retries*	Configures the keepalive function of the tunnel.
Ruijie(config-if)# **no tunnel keepalive**	Disables the keepalive function of the tunnel

Caution This command is only supported by RGOS 10.4(1).
This command cannot be used together with the **tunnel vrf** or **ip vrf forward** command.
This command applies only to GRE IP-capable 4 over 4 tunnels and IPIP tunnels.

Configuring Tunnel nested encapsulation limit

Tunnel nested encapsulation refers to the circumstance that messages have undergone multi-level nested tunnel encapsulation on the local device before being sent out. The route change on the local device may result in infinite nested encapsulation. Excessive nesting will result in the continual fragmentation and recombination operations of the router and severely compromise routing performance. In order to avoid the occurrence of aforementioned phenomena, RGOS software can automatically avoid infinite nested encapsulation. Only 4-level nesting is allowed by default. Use the **tunnel nested-limit** command to modify the default value. This command is used on the tunnel interface of the innermost layer.

Command	Function
Ruijie(config-if)**#tunnel nested-limit** *num*	Configures the tunnel nested encapsulation limit. Default value: 4-level; value range: 0-10.
Ruijie(config-if)**#no tunnel nested-limit**	Restores the nested encapsulation limit to the default value.

Configuring Tunnel VRF

Identify which VRF would be used by the outer-layer transport protocol IPv4 for route selection and forwarding. Run the following commands:

Command	Function
Ruijie(config-if)# **tunnel vrf** *vrf-name*	Configures Tunnel VRF.
Ruijie(config-if)# **no tunnel vrf**	Removes Tunnel VRF configuration.

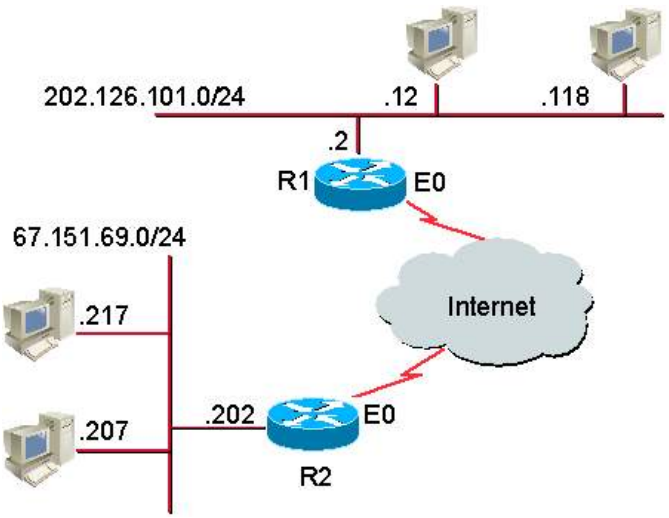
By default, the outer-layer IPv4 uses a global VRF table for route selection and forwarding. The source IP address and destination IP address of outer-layer encapsulation must be in the same VRF table. If in the designated VRF, there is no available route to the destination IP address, then this tunnel interface will be in down state.

Caution Currently, the tunnel VRF function can only support IPv4 over IPv4 GRE tunnel.
This command is only supported by RGOS 10.4(2) or later versions.

Example of Tunnel Interface Configuration

The network connections of this configuration example are shown in Figure 24.

Figure 24 Network connections of Tunnel interface configuration example



In the configuration example, a tunnel is created between R1 and R2. The subnet 202.126.101.0/24 behind R1 communicates with the subnet 67.151.69.0/24 behind R2 via the tunnel between R1 and R2. Such communication is carried out through the tunnel. The external network between R1 and R2 is transparent and invisible: a virtual private network (VPN). Tunnel configurations of R1 and R2 are shown below.

Configuration of R1:

```
interface Tunnel0
ip address 21.21.21.3 255.255.255.0
tunnel source 179.208.12.221
tunnel destination 179.208.12.55
!
interface FastEthernet0/0
ip address 179.208.12.221 255.255.255.0
!
interface FastEthernet0/1
ip address 202.106.101.2 255.255.255.0
!
```

Configuration of R2:

```
interface Tunnel0
ip address 21.21.21.5 255.255.255.0
tunnel source 179.208.12.55
tunnel destination 179.208.12.221
!
interface FastEthernet0/0
ip address 179.208.12.55 255.255.255.0
!
```

```
interface FastEthernet0/1
ip address 67.151.69.202 255.255.255.0
!
```

From the preceding configuration, you can learn that both R1 and R2 use Ethernet interface f0/0 to create a tunnel and use Ethernet interface f0/1 to connect to Intranet and serve as the gateway of Intranet.

Monitoring and Maintaining Tunnel interfaces

Ruijie products enable you to monitor and maintain tunnel interfaces by using the **show interfaces tunnel** and **debug [gre/ip | ipip]** commands.

Command	Function
Ruijie**# show interfaces tunnel** *tunnel-number*	Queries the status of a tunnel interface
Ruijie**# show tunnel gre**	Queries the general configurations of a GRE tunnel
Ruijie**# debug [gre/ip | ipip]**	Turns on tunnel debug switch.
Ruijie**# no debug [gre/ip | ipip]**	Turns off tunnel debug switch.

The examples show how to use **show interfaces tunnel** command and **debug** command.

42) Usage of the show interfaces tunnel command

```
Ruijie# show interfaces tunnel 1
Tunnel 1 is UP  , line protocol is UP
Hardware is  Tunnel
Interface address is: 1.1.1.1/24
MTU 1500 bytes, BW 9 Kbit
Encapsulation protocol is Tunnel, loopback not set
Keepalive interval is 0 sec , no set
Carrier delay is 0 sec
RXload is 1 ,Txload is 1
Tunnel source 192.168.200.200 (FastEthernet 0/0), destination 192.168.200.100
Tunnel protocol/transport GRE/IP, key 0xea
Order sequence numbers 0/0 (tx/rx)
Checksumming of packets enabled  Queueing strategy: WFQ
5 minutes input rate 0 bits/sec, 0 packets/sec
5 minutes output rate 0 bits/sec, 0 packets/sec
0 packets input, 0 bytes, 0 no buffer
Received 0 broadcasts, 0 runts, 0 giants
0 input errors, 0 CRC, 0 frame, 0 overrun, 0 abort
0 packets output, 0 bytes, 0 underruns
0 output errors, 0 collisions, 0 interface resets
```

You can learn about the parameter settings and working status of the tunnel interface from the above information, such as the status of interface and link, IP address configuration, MTU configuration, bandwidth configuration and etc.

43) Usage of the **debug** command

```
Ruijie# debug gre/ip
```

```
Ruijie#
GRE: to decaps 192.168.200.100->192.168.200.200(len=132
ttl=255) 112
```

The above information indicates that a GRE/IP data packet is received from destination terminal (192.168.200.100) and de-encapsulated to obtain the IP payload packet.

Troubleshooting Faults on the Tunnel Interface

If both ends of a tunnel cannot communicate normally, carry out troubleshooting from the following aspects:

44) Make sure there is a reachable physical path between two ends of the tunnel, that is, the two ends are reachable for each other even if this tunnel is unavailable. Normal communication can be carried out between the source address (local terminal) of the tunnel and the destination address (peer terminal) of the tunnel.
45) Make sure the source address corresponds with the destination address, i.e., the source address must be identical with the destination address.
46) Make sure the tunnel uses the correct encapsulation mode (GRE by default), and both ends of the tunnel must use the same encapsulation mode.
47) After using GRE as the tunnel encapsulation protocol, make sure the checksum, Key and reception rule configurations are identical on both ends.

Configuring the AAA Function

Access control specifies the users who are allowed to access a server and lists the services that are accessible on the network. Authentication, authorization and accounting (AAA) is a key security mechanism for access control.

Overview

AAA presents a unified framework for configuring the authentication, authorization and accounting functions, which is supported by Ruijie products.

AAA provides the following services in a modular manner:

- Authentication: It verifies whether a user can get the right to access. User authentication is performed using RADIUS, TACACS+, or Local before a user accesses the network or a service on the network.
- Authorization: It determines the services which are accessible to a user by defining a series of attribute-value pairs (AVPs). These AVPs describe the operations the user is authorized to do. These AVPs can be stored on a network device or a remote RADIUS security server.
- Accounting: It records network resource usage of users. The network device starts sending resource usage of users to the Radius security server in the form of statistics when the accounting function is enabled. Every accounting record is stored in the security server as AVPs. These records can be read by special software to implement the accounting, statistics and tracing of network resource usage.

Note Some products only provide the authentication function. For all problems with product specifications, contact the marketing or technical support personnel.

Although AAA is the primary access control method boasting superior security protection, Ruijie products also provide simpler control access methods, such as the local username authentication and line password authentication.

AAA has the following advantages:

- Excellent flexibility and controllability
- Expandability
- Standardized authentication
- Multiple backup systems

Basic AAA Principles

AAA types can be dynamically configured on a per-user (line) or per-server basis by creating method lists and applying them to specific services or interfaces.

Method List

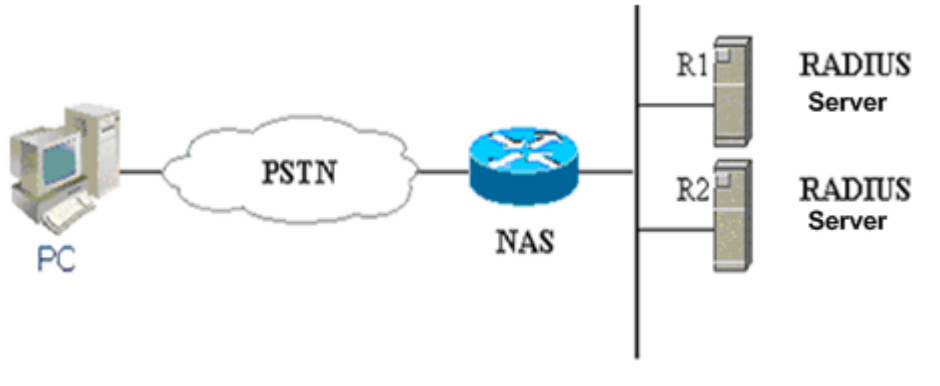
Since a variety of methods are available for user AAA, a method list should be used to define the sequence in which these methods are performed. The method list can define one or more security protocols for authentication, so that a backup

system takes effect when the first method fails. In Ruijie products, a next method is selected if no response is received from the previous method till there is successful communication with a method or all methods in the list are attempted. If all methods listed are attempted but communication is not set up, AAA fails.

Caution

Only when there is no response from a method, Ruijie products will attempt the next method. During the authentication, if the user access is refused by a method, the authentication process ends and no other methods will be attempted.

Figure 25 Typical AAA network configuration



The preceding figure illustrates typical AAA network configuration, including two RADIUS security servers R1 and R2 and a network access server (NAS) that can function as a RADIUS server.

Supposed the system administrator has defined a method list, where user identity information is first obtained from R1, R2, and then the local username database on the NAS. If a remote PC user attempts to access the network via dialup, the NAS first queries the authentication information from R1. If the user is authenticated by R1, R1 sends a ACCEPT reply to the NAS, allowing the user to access the network. If R1 returns a REJECT reply, the user access is refused and connection from the user is rejected. If R1 does not reply, the NAS regards that timeout occurs and queries authentication information from R2. This process continues unless the user is authenticated, user access is rejected, or the session is terminated. If TIMEOUT is returned for all methods, the authentication fails and the user is disconnected.

Caution

The REJECT response is different from the TIMEOUT response. The server returns a REJECT message if a user fails to comply with the standard in the available authentication database. The server returns a TIMEOUT message if there is no response from the security server to the authentication. When an TIMEOUT message is detected, the next authentication method in the method list is selected to continue the authentication process.

Note This document uses RADIUS for an example to describe the AAA function of security servers. For security access implementation based on TACACS+, see *Configuring TACACS+*.

AAA Configuration Steps

First you shall choose a security solution, evaluate the potential security risks in the specific network and select the proper measures to prevent unauthorized access. It is recommended that AAA be used to ensure network security.

AAA Configuration Description

AAA configuration may become simple when you understand the basic operation process of AAA. To configure AAA on network devices of Ruijie, perform the following steps:

48) Enable AAA by using the **aaa new-model** command in global configuration mode.
49) Configure parameters of the security protocol, RADIUS for example if you decide to use the security server.
50) Define the authentication method list by using the **aaa authentication** command.
51) Apply the method list to specific interface or line, if necessary.

Caution When the specific method list is used, if no named method list is specified, the default authentication method list will apply.
As a result, if you do not want to use the default authentication method list, you shall define a specific method list.

For complete descriptions of the commands mentioned in this chapter, see related chapters in the *Security Configuration Command Reference*.

Enabling AAA

Before activating AAA security features, be sure to enable AAA.

To enable AAA, use the following command in global configuration mode:

Command	Function
Ruijie(config)# **aaa new-model**	Enables AAA.

Disabling AAA

To disable AAA, use the following command in global configuration mode:

Command	Function
Ruijie(config)# **no aaa new-model**	Disables AAA.

Follow-up Configuration

The following tables lists the possible configuration tasks that need to be completed after AAA enabling and chapters they are described in.

AAA access control security solution

Configuration task	Chapter
Configuring RADIUS Security Parameters	Configuring RADIUS
Configuring Local Login Authentication	Configuring Authentication
Defining AAA Authentication Method List	Configuring Authentication
Applying Method List to Specific Interface or Line	Configuring Authentication
Configuring RADIUS Authorization	Configuring Authorization
Enabling RADIUS Accounting	Configuring Accounting

If you are using AAA for authentication, see the *"Configuring Authentication" section*.

Configuring Authentication

Users need to be authenticated before they access network resources. In most cases, AAA is recommended for authentication.

Defining AAA Authentication Method List

To configure the AAA authentication, the first step is to define a named list of authentication methods, and then the applications use the defined method list for authentication. The method list defines the authentication types and sequence in which they are performed. The defined authentication methods, except the default method list, are specific to applications. Before a named method list is defined, all applications use the default method list.

A method list is simply a named list describing the authorization methods to be queried in sequence. Method lists enable you to designate one or more security protocols to be used for authorization, thus ensuring a backup system in case the initial method fails. Ruijie products use the first method listed to authorize users for specific network services; if that method fails to respond, Ruijie products select the next method listed in the method list. This process continues till there is successful communication with a listed authorization method, or all methods defined are exhausted.

Caution Only when there is no response from a method, Ruijie products will attempt the next method. During the authentication, if the user access is refused by a method, the authentication process ends and no other methods will be attempted.

Configuration Examples

A typical AAA network has two RADIUS servers: R1 and R2. Suppose the network administrator has chosen a security solution, and the NAS authentication uses an authentication method to authenticate the Telnet connection. User authentication is initially attempted on R1, then on R2 if there is no response from, R1, and finally in the local database of the NAS if there is no response from R2 either. To design such an authentication process, you must configure an authentication method list accordingly by using the following commands:

Command	Function
configure terminal	Enters global configuration mode.
aaa authentication login default group radius local	Configures a default authentication method list named *default*. The protocols included in this method list are arranged behind the name according to the order in which they will be queried. The default method list applies to all applications by default.

To apply a method list to a specific Login connection, the system administrator must create a named method list and then apply it to the specific connection. The following example shows how to apply the authentication method list to line 2 only.

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa authentication login test group radius local	Defines a method list named test in global configuration mode.
line vty *2*	Enters VTY line 2 configuration mode.
login authentication *test*	Applies the test method list to VTY line 2 in line configuration mode

If a remote PC user attempts to Telnet the NAS, the NAS first queries the authentication information from R1. If the user is authenticated by R1, R1 sends a ACCEPT reply to the NAS, allowing the user to access the network. If R1 returns a REJECT reply, the user access is refused and connection from the user is rejected. If R1 does not reply, the NAS regards that timeout occurs and queries authentication information from R2. This process continues unless the user is authenticated, user access is rejected, or the session is terminated. If both servers (R1 and R2) return TIMEOUT, the authentication will be performed by the local database of the NAS.

Caution The REJECT response is different from the TIMEOUT response. The server returns a REJECT message if a user fails to comply with the standard in the available authentication database. The server returns a TIMEOUT message if there is no response from the security server to the authentication. When an TIMEOUT message is detected, the next authentication method in the method list is selected to continue the authentication process.

Authentication Type

Ruijie products support the following authentication types:

- Login authentication -- applies when a user tries to log in to the NAS through the command line interface (CLI).
- Enable authentication -- applies when an online user requests more rights on the CLI.
- PPP authentication -- applies to PPP dial-up users.
- DOT1X(IEEE802.1x) authentication -- applies to users who try to access through IEEE802.1x.

Configuring AAA Authentication

The following tasks are common for the configuration of AAA authentication.

- Enable AAA by using the **aaa new-model** command in global configuration mode.
- Configure the security protocol parameters if you decide to use the security server, such as RADIUS and TACACS+. See the "Configuring Radius" and "Configuring TACACS+" sections for details.
- Define the authentication method list by using the **aaa authentication** command.
- Applying the method list to a specific interface or line, if possible.


Caution TACACS+ is not supported by the DOT1X authentication on Ruijie products.

Configuring the AAA Login Authentication

This section describes how to configure the AAA Login authentication methods supported by Ruijie products:


Caution AAA security features can be made available only after AAA is enabled by using the **aaa new-model** command in global configuration mode. For the details, see the "AAA Overview" chapter.

In many cases, the user needs to Telnet the NAS for configuring the NAS remotely. To prevent unauthorized access to the NAS, user authentication is required.

The AAA security services make it easy for the network devices to perform line-based Login authentication. No matter which Login authentication method you use, you just need to use the **aaa authentication login** command to define one or more authentication method lists and apply them to the specific line that needs the Login authentication.

To configure the AAA Login authentication, run the following commands in global configuration mode:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa authentication login {default *|list-name} method1 [method2...]*	Defines an accounting method list. To define multiple method lists, repeat this command.
line vty *line-num*	Enters the line to which the AAA authentication applies.
login authentication {default|*list-name*}	Applies the method list to the line.

The keyword **list-name** is a character string used to name the created authentication method list, while **method** means the actual authentication algorithm. Only when the current method returns an ERROR message (no reply), the next authentication method will be attempted. If the current method returns a FAIL message, no authentication method will be used any more. To make sure that users can be authenticated even if no response is received from any method, use the **none** keyword.

In the following example, users can still be authenticated even if the RADIUS server returns TIMEOUT. Use the **aaa authentication login default group radius none** command.


Caution Since the keyword **none** enables every dial-up user to be authenticated even if the security server does not reply, it is used only as a backup authentication method. Normally, the **none** keyword is not recommended.

You can use it as the last authentication method preceded by the local authentication method in the scenario where possible dial-up users are all trustful and their work are susceptible to any delay caused by system faults.

Keyword	Description
local	Uses the local username database for authentication.
none	User authentication is not performed.
group radius	Uses RADIUS to get authentication information.
group tacacs+	Uses TACACS+ to get authentication information.

The preceding table lists the AAA login authentication methods supported by Ruijie products.

Using the Local Database for Login Authentication

To use the local database for Login authentication, configure the local database first. Ruijie product supports authentication based on the local database. To enable the username authentication, run the following commands in global configuration mode:

Command	Function
configure terminal	Enters global configuration mode.
username *name* [**password** *password*]	Creates a local user and sets a password.
end	Returns to privileged mode.
show running-config	Verifies the configuration.

To define and apply the local login authentication method list, use the following commands:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa authentication login {default | *list-name*} **local**	Defines the local authentication method list.
end	Returns to privileged mode.
show aaa method-list	Verifies the configured method list.
configure terminal	Enters global configuration mode.
line vty *line-num*	Enters line configuration mode
login authentication {**default** | *list-name*}	Applies the method list.
end	Returns to privileged mode.
show running-config	Verifies the configuration.

Using Radius for Login Authentication

To use RADIUS for Login authentication, configure the RADIUS server. Ruijie products support the authentication based on the RADIUS server. To configure the RADIUS server, use the following commands in global configuration mode:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.

Command	Function
radius-server host *ip-address* [**auth-port** *port*] [**acct-port** *port*]	Configures the RADIUS server
end	Returns to privileged mode.
show radius server	Shows the RADIUS server.

After the RADIUS server is configured, make sure there is successful communication with the RADIUS server before configuring RADIUS for authentication. For details about the RADIUS server configuration, see the "Configuring RADIUS" section.

Then you can configure the RADIUS server based method list. Use the following commands:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa authentication login {**default** | *list-name*} **group radius**	Defines the local authentication method list.
end	Returns to privileged mode.
show aaa method-list	Verifies the configured method list.
configure terminal	Enters global configuration mode.
line vty *line-num*	Enters line configuration mode
login authentication {default | *list-name*}	Applies the method list.
end	Returns to privileged mode.
show running-config	Verifies the configuration.

Configuring the AAA Enable Authentication

This section describes how to configure the AAA Enable authentication methods supported by our product:

In many cases, the user needs to Telnet the NAS. After being authenticated, the user can access the CLI and is assigned 0–15 privilege levels initially, each having different commands. You can use the **show privilege** command to query the current level. For the details, see the "Using the CLI" section.

After logging in to the CLI, you can use the **enable** command to obtain higher privilege level if you fail to execute some commands. To prevent unauthorized access to the network, authentication needs to be performed when a user applies for a higher privilege level. This authentication type is called Enable authentication.

To configure the AAA Enable authentication, use the following commands in global configuration mode:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa authentication enable default *method1 [method2...]*	Defines an Enable authentication method list, for example RADIUS.

Only one Enable authentication method list can be defined globally, so there is no need to name the method list. The keyword **method** means the actual authentication algorithm. Only when the current method returns an ERROR message (no reply), the next authentication method will be attempted. If the current method returns a FAIL message, no

authentication method will be used any more. To make sure that users can be authenticated even if no response is received from any method, use the **none** keyword.

Once configured, the Enable authentication method takes effect. When using **enable** command in privileged mode, the system prompts a message indicating authentication is required if you want to obtain a higher privilege level. There is no need to authenticate if the privilege level to be set is lower than or equal to the current one.

Caution

The current username will be recorded if the Login authentication(except for **none** method) is done when accessing the CLI. At this time, if the Enable authencation processes, a message indicating that the username must be entered will not be prompted and you can use the same username of Login authentication. Note that the password input must be consistent.

The username information will not be recorded if there is no Login authentication when you access the CLI, or the **none** method is used. At this time, if the Enable authentication is required, you shall enter the username again. This username will not be recorded, so you shall enter in each Enable authentication.

Some authentication methods can bind the security level. Then in the process of authentication, except for the returned response according to the security protocol, it is necessary to verify the bound security level. If the service protocol can bind the security level, the level shall be verified while authenticating. If the binded level is more than or equal to the level to be configured, the enable authentication and level switchover succeed. But if the bound level is less than the level to be configured, the Enable authentication fails, prompting an error message and keeping the current level. If the service protocol fails to be bound to the security level, you can configure the level without verification of the bound level.

Now only RADIUS and Local authentication can be bound to security levels. To this end, security levels need to be checked only for these two methods.

Using the Local Username Database for Enable Authentication

When configuring the local Enable authentication, you can configure the privilege level of local users. By default, the privilege level is 1. To configure the local Enable authentication, configure the local database and privilege levels. To enable the username authentication, use the following commands in global configuration mode:

Command	Function
configure terminal	Enters global configuration mode.
username *name* [**password** *password*]	Creates the local user and sets a password.
username *name* [**privilege** *level*]	Sets the user privilege level. (Optional)
end	Returns to privileged mode.
show running-config	Verifies the configuration.

To define the local Enable authentication method list, run the following commands:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa authentication enable default local	Defines the local authentication method list.
end	Returns to privileged mode.
show aaa method-list	Verifies the configured method list.

Command	Function
show running-config	Verifies the configuration.

Using RADIUS for Enable Authentication

The standard RADIUS server can pass the privilege level bound to the Service-Type attribute (the standard attribute number is 6), can specify the privilege with 1 or 15 level. The extened RADIUS server (for example, SAM) can configure the privilege level of the administrator (the private attribute number is 42), can specify 0-15 privilege level. For the details of the RADIUS server, see the "Specifying the RADIUS Private Attribute Type" section in "Configuring RADIUS".

To configure the RADIUS Enable authentication, configure the RADIUS server and then the RADIUS Enable authentication method list. Use the following commands in global configuration mode:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa authentication enable default group radius	Defines the RADIUS authentication method.
end	Returns to privileged mode.
show aaa method-list	Verifies the configured method list.
show running-config	Verifies the configuration.

Configuring the AAA Authentication for PPP Users

PPP is a link-layer protocol of carrying the network-layer datagram in the point-to-point link. In many circumstances, the user accesses the NAS by means of asynchronous or ISDN dail-up. Once the connection has been set up, the PPP negotiation will be enabled. To prevent the unauthorized access to the network, authentication is required for the dail-up user in the process of PPP negotiation.

This section describes how to configure the AAA Enable authentication methods supported by Ruijie products. To configure the AAA Enable authentication, use the following command in global configuration mode:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa authentication ppp {**default** | *list-name*} *method1 [method2...]*	Defines a PPP authentication method list. RADIUS, TACACS+ remote authentication and using the local database are the supported authentication methods.
interface *interface-type interface-number*	Enters the asynchronous or ISDN interface to which AAA authentication applies.
ppp authentication {chap | pap} {default | ***list-name***}	Applies the method list to the asynchronous or ISDN interface.

For details about PPP configuration, see the related chapter in *Configuring PPP and MP*.

Configuring the AAA Authentication for 802.1x Users

IEEE802.1x is a standard of Port-Based Network Access Control, providing the point-to-point secure access for the LAN, and a means of the authentication of the user connecting to the LAN device.

This section describes how to configure the 802.1x authentication methods supported by Ruijie products. To configure the AAA Enable authentication, use the following command in global configuration mode:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa authentication dot1x {**default** | *list-name*} *method1 [method2...]*	Defines an IEEE802.1x authentication method list. RADIUS remote authentication and using the local database are the supported authentication methods.
dot1x authentication *list-name*	Applies the method list to 802.1x users.

For details about IEEE802.1x configuration, see the related chapter in *Configuring 802.1x*.

Example of Authentication Configuration

The following example illustrates how to apply both RADIUS authentication and local authentication to a network device.

```
Ruijie(config)# aaa new-model
Ruijie(config)# username Ruijie password starnet
Ruijie(config)# radius-server host 192.168.217.64
Ruijie(config)# aaa authentication login test group radius local
Ruijie(config)# line vty 0
Ruijie(config-line)# login authentication test
Ruijie(config-line)# end
Ruijie# show running-config
!
aaa new-model
!
!
aaa authentication login test group radius local
username Ruijie password 0 starnet
!
radius-server host 192.168.217.64
!
line con 0
line vty 0
login authentication test
line vty 1 4
!
!
```

In the preceding example, the access server uses the RADIUS server (IP address: 192.168.217.64) to perform Login authentication for users. If the RADIUS server does not reply, the local database will be used for authentication.

Example of Terminal Service Application Configuration

In the environment of the terminal service application, the terminal first connects to the asynchronous console, then offers the service accessing the network network server. However, if AAA is enabled, the Login authentication is necessary in all

lines. To access the server, the terminal must pass the Login authentication and it influences the terminal service. You can separate two lines by configuration that makes the line using the terminal service directly connecting the server without the Login authentication, and ensures the device security by the Login authentication of the line connecting the device. That is to say, you can configure a login authentication list specific for the terminal service but the authentication method as **none**. Then apply the configured list to the line with terminal service enabled, while other lines connecting the local device is unchanged. In this way, the terminal can skip the local login authentication.

The following example illustrates the configuration steps:

```
Ruijie(config)# aaa new-model
Ruijie(config)# username Ruijie password starnet
Ruijie(config)# radius-server host 192.168.217.64
Ruijie(config)# radius-server key test
Ruijie(config)# aaa authentication login test group radius local
Ruijie(config)# aaa authentication login terms none
Ruijie(config)# line tty 1 4
Ruijie(config-line)# login authentication terms
Ruijie(config-line)# exit
Ruijie(config)# line tty 5 16
Ruijie(config-line)# login authentication test
Ruijie(config-line)# exit
Ruijie(config)# line vty 0 4
Ruijie(config-line)# login authentication test
Ruijie(config-line)# end
Ruijie(config)# show running-config
!
aaa new-model
!
!
aaa authentication login test group radius local
aaa authentication login terms none
username Ruijie password 0 starnet
!
radius-server host 192.168.217.64
radius-server key 7 093b100133
!
line con 0
line aux 0
line tty 1 4
login authentication terms
line tty 5 16
login authentication test
line vty 0 4
login authentication test
!
!
```

In the preceding example, the NAS uses the RADIUS server (IP address: 192.168.217.64) to perform login authentication for users. If the RADIUS server does not reply, the local database will be used for authentication. Login authentication is unnecessary for TTY 1-4 is the used line of the terminal service, while using other TTY and VTY lines needs the login authentication.

Configuring Authorization

The AAA authorization enables the administrator to control the use of services or rights. After the AAA authorization service is enabled, the network device configures the user sessions by using the user configuration file stored locally or in the server. After the authorization is completed, the user can only use the services allowed in the profile or has the assigned rights.

Authorization Types

Ruijie products support the following AAA authorization methods:

- Exec authorization: The user terminal loggs in to the CLI of the NAS and is granted the privilege level (0-15).
- Command authorization: After a user logs in to the CLI of the NAS, the user is specific commands are authorized.
- Network authorization: Grants the available service to the user session in the network.

Note Only TACACS+ supports the command authorization method. For the detailed information, see the "Configuring TACACS+" section.

Preparations for Authorization

The following tasks must be completed before the AAA authorization is configured:

- Enable the AAA server. For details, see the AAA Overview chapter.
- (Optional) Configure the AAA authentication. The authorization is performed after the user is authenticated. But independent authorization can also be performed without authentication. For details of the AAA authentication, see the "Configuring Authentication section.
- (Optional) Configure security protocol parameters. If the security protocol is required for authorization, configure the security protocol parameters. The network authorization only supports RADIUS; the Exec authorization supports RADIUS and TACACS+. For details of the RADIUS, see the "Configuring RADIUS" section. For details of the TACACS+, see the "Configuring TACACS+ section.
- (Optional) If the local authorization is required, use the **username** command to define the user rights.

Configuring Authorization List

To enable AAA authorization, use the following commands in global configuration mode:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa authorization exec network{default | *list-name}* *method1 [method2*|…]	Defines the AAA Exec authorization method.

Command	Function
aaa authorization network network{**default** | *list-name}* *method1 [method2*|…]	Defines the AAA Network authorization method.

Configuring AAA Exec Authorization

The Exec authorization grants the privilege level of command execution for the user terminal logging in to the NAS. You can use the **show privilege** command to display the specific level after the user logs in to the NAS CLI successfully (by telnet, for example).

No matter which Exec authorization method you use, you just need to use the **aaa authorization exec** command to define one or more authorization method lists and apply them to the line that needs the Exec authorization.

To configure the AAA Exec authorization, use the following commands in global configuration mode:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa authorization exec network{**default** | *list-name}* *method1 [method2*|…]	Defines the AAA Exec authorization method. If you need to define multiple methods, execute this command repeatedly.
line vty *line-num*	Enters the line to which the AAA Exec authorization method is applied.
authorization exec {**default** | *list-name*}	Applies the method to the line.

The keyword **list-name** is a character string used to name the created authorization method list, while the keyword **method** means the actual authorization algorithm. Only when the current method returns an ERROR message (no reply), the next authorization method will be attempted. If the current method returns a FAIL message, no authorization method will be used any more. To make sure that users can be authorized successfully even if no response is received from any method, use the **none** keyword.

In the following example, the Exec authorication is still successful even if the RADIUS server returns TIMEOUT:

aaa authorization exec default group radius none

Keyword	Description
local	Uses the local username database for Exec authorization.
none	Exec authorization is not performed.
group radius	Uses RADIUS for Exec authorization.
group tacacs+	Uses TACACS+ for Exec authorization.

The preceding table lists the AAA Exec authorization methods supported by Ruijie products.

Caution The exec authorization is always used together with the login authentication, and they can be applied to the same line at the same time. But note that it is possible to have different results of the authentication and the authorization towards the same user because they can use different methods and servers. If the Exec

authorization fails, a user cannot access the CLI even though the login authentication of the user is successful.

Using the Local Username Database for Exec Authorization

To configure the local Exec authorization, configure the local database first. You can configure the privilege level of local users. By default, the privilege level is 1. Use the following commands in global configuration mode:

Command	Function
configure terminal	Enters global configuration mode.
username *name* [**password** *password*]	Creates a local user and sets a password.
username *name* [**privilege** *level*]	Sets the user privilege level. (Optional)
end	Returns to privileged mode.
show running-config	Verifies the configuration.

To define the local Exec authorization method list, use the following commands:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa authorization exec {**default** | *list-name*} **local**	Defines the local authorization method list.
end	Returns to privileged mode.
show aaa method-list	Verifies the configured method list.
configure terminal	Enters global configuration mode.
line vty *line-num*	Enters line configuration mode.
authorization exec {**default** | *list-name*}	Applies the method list.
end	Returns to privileged mode.
show running-config	Verifies the configuration.

Using RADIUS for Exec Authorization

To configure the RADIUS Exec authorization, onfigure the RADIUS server. For details about the RADIUS server configuration, see the "Configuring RADIUS" section.

After configuring the RADIUS server, the RADIUS authorization method list can be configured. Use the following commands in global configuration mode:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa authentication enable {default | *list-name*} **group radius**	Defines RADIUS authentication method.
end	Returns to privileged mode.
show aaa method-list	Verifies the configured method list.
configure terminal	Enters global configuration mode.
line vty *line-num*	Enters line configuration mode.
authorization exec {**default** | *list-name*}	Applies the method list.

Command	Function
end	Returns to privileged mode.
show running-config	Verifies the configuration.

Example of Configuring Exec Authorization

The following example illustrates how to configure Exec authorization. The local login authentication and the "Radius+local" Exec authorization are used when the user logs in through VTY lines 0-4. The NAS uses the RADIUS server with IP address set to 192.168.217.64 and shared keyword **test**. The local username and password are *Ruijie*, and the privilege level is *6*.

```
Ruijie# configure terminal
Ruijie(config)# aaa new-model
Ruijie(config)# radius-server host 192.168.217.64
Ruijie(config)# radius-server key test
Ruijie(config)# username Ruijie password Ruijie
Ruijie(config)# username Ruijie privilege 6
Ruijie(config)# aaa authentication login mlist1 local
Ruijie(config)# aaa authentication exec mlist2 group radius local
Ruijie(config)# line vty 0 4
Ruijie(config-line)# login authentication mlist1
Ruijie(config-line)# authorization exec mlist2
Ruijie(config-line)# end
Ruijie(config)# show running-config
!
aaa new-model
!
aaa authorization lexec mlist2 group radius local
aaa authentication login mlist1 local
!
username Ruijie password Ruijie
username Ruijie privilege 6
!
Radius-server host 192.168.217.64
radius-server key 7 093b100133
!
line con 0
line vty 0 4
authorization exec mliat2
login authentication mlist1
!
end
```

Configuring AAA Network Authorization

Ruijie product support PPP and SLIP network authorization. The network authorization makes service configuration regarding traffic, bandwidth, and timeout available on the network connection. The network authorization only supports

RADIUS and TACACS+. The authorization information assigned by the server are encapsulated in the RADIUS attribute or TACACS+ attribute. Authorization information may vary with netowrk connections.


Caution Now AAA network configuration does not support 802.1X. For details about the 802.1X authorization, see the "Configuring 802.1X" section.

To configure the AAA network authorization, use the following commands in global configuration mode:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa authorization network{**default** | *list-name} method1 [method2*|…]	Defines an AAA network authorization method. If you need to define multiple methods, use this command repeatedly.

The keyword **list-name** is a character string used to name the created authorization method list, while **method** means the actual authorization algorithm. Only when the current method returns an ERROR message (no reply), the next authorization method will be attempted. If the current method returns a FAIL message, no authorization method will be used any more. To make sure that users can be authenticated even if no response is received from any method, use the **none** keyword.

Using RADIUS for Network Authorization

To configure RADIUS Network authorization, configure the RADIUS server. For details about the RADIUS server configuration, see the "Configuring RADIUS" section.

After configuring the RADIUS server, the RADIUS Network authorization method list can be configured. Use the following commands in global configuration mode:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa authentication network {**default** | *list-name*} **group radius**	Defines a RADIUS Network authorization method.

Example of Configuring Network Authorization

The following example illustrates how to configure Network authorization.

```
Ruijie# configure terminal
Ruijie(config)# aaa new-model
Ruijie(config)# radius-server host 192.168.217.64
Ruijie(config)# radius-server key test
Ruijie(config)# aaa authorization network test group radius local
Ruijie(config-line)# end
Ruijie(config)# show running-config
!
```

```
aaa new-model
!
aaa authorization network test group radius none
!
radius-server host 192.168.217.64
radius-server key 7 093b100133
!
```

Configuring Accounting

The AAA accounting function enables you to trace the services and network resources used by the user. After the accounting function is enabled, the NAS or router sends network access records of users to the RADIUS security server by means of AVP. You may use some analysis software to analyze these data to implement the billing, audit and tracing function for the user's activities.

Accounting Types

Ruijie products currently support the following accounting types:

- Exec accounting -- records the accounting information when users access or exit the CLI of the NAS.
- Command accounting – records the specific commands executed after the user logs in to the CLI of the NAS.
- Network accounting – records the related information on the user session in the network.


Note

The command accounting function supports only TACACS+. For details, see the "Configuring TACACS+" section.

Preparations for Accounting

The following tasks must be completed before the AAA accouting is configured:

- Enable the AAA server. For details, see the "AAA Overview" chapter.
- Define the security protocol parameters. It is required to configure the security protocol parameters for accouting. The network accounting only supports RADIUS; the Exec accounting supports RADIUS and TACACS+; the Command accounting supports TACACS+ only. For details of RADIUS, see the "Configuring RADIUS" section. For details of TACACS+, see the "Configuring TACACS+" section.
- (Optional) Configure the AAA authentication. Certain types of accounting (for example, Exec accounting) are performed after the user is authenticated. In some circumstances, the accouting can also be performed without authentication. For details about AAA authentication, see the "Configuring Authentication" section.

Configuring AAA Exec Accounting

The Exec accounting records the information when users access or exit the CLI of the NAS. When a user logs in and accesses the NAS CLI, it sends the accounting start information to the security server. When the user exits the CLI, it sends the accounting stop information to the server.


Caution

Exec accounting starts only after login authentication of the user is successful. If no login authentication or **none** authentication method has been configured, Exec accounting is not performed. If a user does not send no accounting start information to the security server when logging in, no accounting stop information will be sent when the user logs out.

To configure the AAA Exec accounting, use the following commands in global configuration mode:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa accounting exec {**default** | *list-name}* **start-stop** *method1 [method2*|*…*]	Defines the AAA Exec accounting method list. If you need to define multiple method lists, use this command repeatedly.
line vty *line-num*	Enters the line to which the AAA Exec accounting applies.
accounting exec {**default** | *list-name*}	Applies the method list to the line.

The keyword **list-name** is a character string used to name the created accounting method list, while the keyword **method** means the actual accounting algorithm. Only when the current method returns an ERROR message (no reply), the next accounting method will be attempted. If the current method returns a FAIL message, no accounting method will be used any more. To make sure that users can be authorized successfully even if no response is received from any method, use the **none** keyword.


Note

The keyword **start-stop** is used for the NAS to send the accounting information at the start and end of the network service to the security server.

Using the RADIUS for Exec Accounting

To configure RADIUS Exec acounting, configure the RADIUS server. For details about the RADIUS server configuration, see the "Configuring RADIUS" section.

After configuring the RADIUS server, the RADIUS accounting method list can be configured. Use the following commands in global configuration mode:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa accounting exec {**default** | *list-name*} **start-stop group radius**	Defines a RADIUS accounting method.
end	Returns to privileged mode.
show aaa method-list	Verifies the configured method list.
configure terminal	Enters global configuration mode.
line vty *line-num*	Enters the line configuration mode.
accounting exec {**default** | *list-name*}	Applies the method list.

Command	Function
end	Returns to privileged mode.
show running-config	Verifies the configuration.

Example of Configuring Exec Accounting

The following example illustrates how to configure Exec accounting. The local login authentication and the RADIUS Exec authorization are used when the user logs in through VTY lines 0-4. The IP address and shared key of the RADIUS server are 192.168.217.64 and *test* respectively. The local username and password both are *Ruijie*

```
Ruijie# configure terminal
Ruijie(config)# aaa new-model
Ruijie(config)# radius-server host 192.168.217.64
Ruijie(config)# radius-server key test
Ruijie(config)# username Ruijie password Ruijie
Ruijie(config)# aaa authentication login auth local
Ruijie(config)# aaa accouting exec acct start-stop group radius
Ruijie(config)# line vty 0 4
Ruijie(config-line)# login authentication auth
Ruijie(config-line)# accounting exec acct
Ruijie(config-line)# end
Ruijie(config)# show running-config
!
aaa new-model
!
aaa accounting exec acct start-stop group radius
aaa authentication login auth local
!
username Ruijie password Ruijie
!
radius-server host 192.168.217.64
radius-server key 7 093b100133
!
line con 0
line vty 0 4
accounting exec acct
login authentication auth
!
end
```

Configuring AAA Network Accounting

Network accounting records the accounting information about user sessions, including the numbers of packets and bytes, IP address and username. Now network accounting only supports RADIUS.

Note The format of RADIUS accounting information varies with the RADIUS security server. The contents of the accounting records may also vary with Ruijie product versions.

To configure the AAA network accounting, use the following commands in global configuration mode:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa accounting network{default | *list-name}* start-stop *method1 [method2*|…]	Defines the AAA network accounting method list. If you need to define multiple method lists, use this command repeatedly.

The keyword **list-name** is a character string used to name the created accounting method list, while the keyword **method** means the actual accounting algorithm. Only when the current method returns an ERROR message (no reply), the next accounting method will be attempted. If the current method returns a FAIL message, no accounting method will be used any more. To make sure that users can be authorized successfully even if no response is received from any method, use the **none** keyword.

Using RADIUS for Network Accounting

To configure RADIUS network acounting, configure the RADIUS server. For details about the RADIUS server configuration, see the "Configuring RADIUS" section.

After configuring the RADIUS server, the RADIUS accounting method list can be configured. Use the following commands in global configuration mode:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa accounting network {**default** | *list-name*} **start-stop group radius**	Defines a RADIUS accounting method.

Example of Configuring Network Accounting

The following example illustrates how to configure network authorization using RADIUS.

```
Ruijie# configure terminal
Ruijie(config)# aaa new-model
Ruijie(config)# radius-server host 192.168.217.64
Ruijie(config)# radius-server key test
Ruijie(config)# aaa accounting network acct start-stop group radius
Ruijie(config-line)# end
Ruijie(config)# show running-config
!
aaa new-model
!
```

```
aaa accounting network acct start-stop group radius
!
radius-server host 192.168.217.64
radius-server key 7 093b100133
!
```

Monitoring AAA users

To view the information of the current login users, use the following commands in privileged user mode:

Command	Function
show aaa user { *id* | all }	View the information of the current AAA user.

Configuring VRF-supported AAA Group

Virtual Private Networks (VPNs) provide a secure method for bandwidth share on the backbone networks of ISPs. One VPN is the collection of the shared routes. Users connect to the ISP network through one or multiple interfaces. The VPN routing table is also called VPN routing//forwarding(VRF) table. AAA can specify the VRF for each self-defined server group.

In global configuration mode, use the following commands to configure VRF for the AAA group:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.
aaa group server radius *gs_name*	Configures the RADIUS server group and enters server group configuration mode.
ip vrf forwarding *vrf_name*	Specifies the VRF for the group.
end	Returns to privilege mode.

Note VRF must be supported by Ruijie products.

Configuring Login Lockout for Failed Authentication

To prevent users from cracking passwords, use a command to specify the number of attempts. If the number of login attempts exceeds the limit, the user is locked and cannot log in again in a period.

In global configuration mode, use the following commands to configure login parameters:

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.

Command	Function
aaa local authentication attempts *<1-2147483647>*	Configures the number of login attempt.
aaa local authentication lockout-time*<1-2147483647>*	Configures the time (in hours) in which a user is locked when the number of login attempts of the user exceeds the limit.
show aaa user lockout {all | user-name *<word>*}	Displays the list of locked users.
clear aaa local user lockout {all | user-name *<word>*}	Clears the lockout user list.
End	Returns to privilege mode.

Note By default, the number of login attempts is 3 and the lockout time is 15 hours.

Configuring Domain Name-based AAA Service

This section is organized as follows::

- Overview
- Domain name-based AAA service configuration tasks
- Domain name-based AAA service configuration notes

Caution The domain name-based AAA service is applied to the IEEE802.1x authentication service. For the detailed IEEE802.1x protocol configurations, see the "Configuring 802.1x" section.

Overview

In the multi-domain environment, one NAS can provide the AAA service for users in different domains. Due to the different user attributes (such as the username, password, service type, privilege, ect) in each domain, users need to be distinguished by setting domains and each domain is configured with a unique attribute set including the AAA service method list (RADIUS for example).

Note Ruijie products support the following username formats:

1. userid@domain-name
2. domain-name\userid
3. userid.domain-name
4. userid

Users named in the format of "userid" belong to the default domain.

Basic principles for configuring the domain name-based AAA service are as follows:

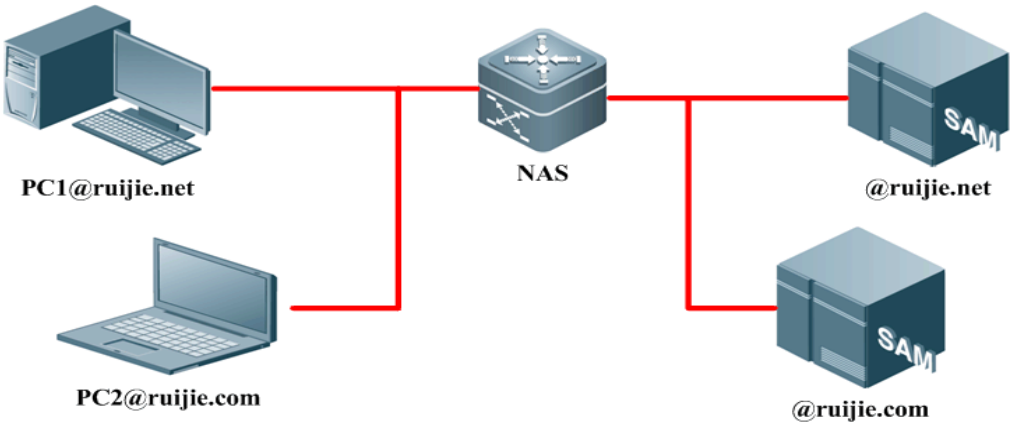
- Parsing the domain name of users
- Searching for the user domain according to the domain name

- Searching for the AAA service method list name according to the domain configurations
- Searching the corresponding method list according to the method list name in the system
- Providing the AAA service by using the method list

Note If one of the abovementioned steps fails, the AAA service cannot be used.

The following is the typical topology of a multi-domain environment:

Figure 26 Typical topology for a multi-domain network



Domain name-based AAA Service Configuration Tasks

Note The system supports up to 32 domains.

Enabling AAA

Command	Function
configure terminal	Enters global configuration mode.
aaa new-model	Enables AAA.

For detailed command descriptions, see the "Enabling AAA" section.

Defining the AAA Service Method List

Command	Function
configure terminal	Enters global configuration mode.
aaa authentication dot1x {**default** | *list-name*} *method1* [*method2*...]	Defines the IEEE802.1x authentication method list.
aaa accounting network {**default** | *list-name*} **start-stop** *method1* [*method2*...]	Defines the Network accounting method list.
aaa authorization network {**default** | *list-name*} *method1* [*method2*...]	Defines the Network authorization method list.

For detailed command descriptions, see the "Configuring authentication", "Configuring Accounting" and "Configuring authorization" sections..

Enabling the Domain Name-based AAA Service

Command	Function
configure terminal	Enters global configuration mode.
aaa domain enable	Enables the domain name-based AAA service.

Creating a Domain

You shall follow the following rules when searching for a domain by username:

52) A single character such as ".", "\", "@" can be used to distinguish between usernames and domain names.
53) The single "@" character is followed by the character string "domain-name". With multiple "@" characters in the username, use the character string following the last "@" characeter as the domain-name. For example, if the username is a@b@c@d, use the a@b@c as the username and use the d as the domain-name.
54) The single "\" character follows the character string "domain-name". With multiple "\" characters in the username, use the character string followed by the first "\" characeter as the domain-name. For example, if the username is a\b\c\d, use the b\c\d as the username and use the a as the domain-name.
55) The single "." character is followed by the character string "domain-name". With multiple "." characters in the username, according to the pre-settings, use the character string following the last "." characeter as the domain-name. For example, if the username is a.b.c.d, use the a.b.c as the username and use the d as the domain-name.
56) If all characters of ".", "\" and "@" exist in the username, when matching the domain-name, use the rules in sequence of the "@", "\" and "." characters.

Command	Function
configure terminal	Enters global configuration mode.
aaa domain *domain-name*	Creates a domain and enters domain configuration mode.

Note The AAA service supports domain names that have a maximum of 64 characters. Domain names are case insensitive.

Configuring the Domain Attribute Set

Use the following commands to select the AAA service method list in domain configuration mode:

Command	Function
authentication dot1x {**default |** *list-name***}**	In domain configuration mode, select the authentication method list.
accounting network {**default |** *list-name*}	In domain configuration mode, select the accounting method list.
authorization network {**default |** *list-name***}**	In domain configuration mode, select the authorization method list.

Use this command to configure the domain state:

Command	Function
state {block | active}	In domain configuration mode, set the domain state.

Use this command to check whether the username carries the domain name:

Command	Function
username-format {without-domain | with-domain}	In domain configuration mode, check whether the username carries the domain name information when the NAS is interacting with the server.

Use this command to set the maximum number of users supported in the domain:

Command	Function
access-limit *num*	In domain configuration mode, set the upper limit of users allowed in the domain. This function applies only to 802.1x users. By default, no upper limit is configured.

Note

1. Only AAA service method lists that have been configured can be selected in domain configuration mode. Otherwise, the system prompts that the AAA service method list you select does not exist.
2. With the domain name-based AAA service enabled, if there is no domain information carried by the username, use the default domain; if there is no configurations for the user domain in the system, the user is determined to be illegitimate and provides no AAA service.
3. In domain configuration mode, the default method list is selected if no other list is available.

Querying the Domain configuration

Use the following command to query the domain name-based AAA service information.

Command	Function
show aaa domain [*domain-name*]	Queries the current domain name-based AAA service information

Domain Name-based AAA Service Configuration Notes

When configuring the domain name-based AAA service, note the following points:

57) If the domain name-based AAA service is enabled, use the method list in the domain. If the service is not enabled, use the method list selected according to the access protocol (such as 802.1x, ect) for the AAA service. For example, if the service is not enabled, use the **dot1x authentication** *authen-list-name,* **dot1x accounting** *acct-list-name authen-list-name* and **dot1x accounting** *acct-list-name acct-list-name* command to provide the AAA service for the authentication and accouting method list name.
58) If the domain name-based AAA service is enabled, the default domain needs to be configured manually by default. The default domain is named "default" and is used to provide AAA services if the username does not contain domain

name. Without the default domain configured, the user whose name does not carry the domain information fails to use the AAA services.

59) If the domain information is carried by the auth-user but the domain is not configured on the device, it fails to provide the AAA service for the user.

60) The AAA service method list selected by the domain must be consistent with the one defined by the AAA service. Or it fails to provide the AAA service for the users in the domain.

61) The domain name carried by the user shall accurately match the one configured on the device. For example, the domain.com and the domain.com.cn have been configured on the device, and the request message carried by the user is aaa@domain.com, the device determines that the user belongs to the domain.com but not the domain.com.cn.

Domain Name-based AAA Service Configuration Example

The following is an example of configuring the domain name-based AAA service:

```
Ruijie(config)# aaa new-model
Ruijie(config)# radius-server host 192.168.197.154
Ruijie(config)# radius-server key test
Ruijie(config)# aaa authentication dot1x default group radius
Ruijie(config)# aaa domain domain.com
Ruijie(config-aaa-domain)# authentication dot1x default
Ruijie(config-aaa-domain)# username-format without-domain
```

After the configuration, with the user a1 in the radius server, use the 802.1x client to login the server for authentication by entering the username a1@domain.com and the correct password. The following shows the related domain name information:

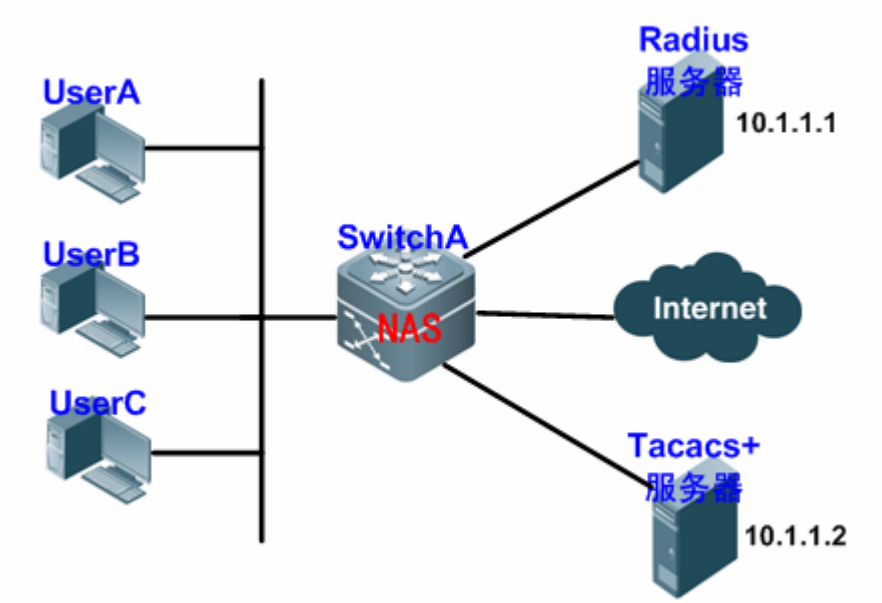
```
Ruijie#show aaa domain domain.com

=============Domain domain.com=============
State: Active
Username format: Without-domain
Access limit: No limit
802.1X Access statistic: 0

Selected method list:
 authentication dot1x default
```

Typical AAA Configuration Example

Typical AAA Aplication

Network Topology

Figure 27 Typical AAA Application Topology



Network Requirements

According to Figure 3, the following requirements must be met for better NAS security management:

62) The administrators shall have their own usernames and passwords, facilitating account management and preventing account leakage.
63) The user authentication methods are divided into local authentication and collection authentication. The method of combining the collection-authentication with the local-authentication shall be adopted, with the collection-authentication mainly-used and the local-authentication as backup. In the process of the collection-authentication, the Radius server authentication shall be passed first, if there is no reply, it will switch to the local authentication.
64) Different users can be configured to access the specified network device during the authentication.
65) Role-based management: Network management users are divided into the superusers and common users. Superusers have rights to query and configure the NAS, while common users only have limited query rights.
66) The user authentication information, the authorization information and the network information are recorded in the server for subsequent query and audit. (This example uses TACACS+ for accounting.)

Configuration Key-points

From the analysis of the part of "*Network Requirements*", deploying the AAA function can address the preceding requirements, which is to dynamically configure the ID authentication, authorization and accounting type for the user (line) or the server. Define the ID authentication, authorization and accounting type by creating the method list, and apply the method list to the specified service or interface. For details, see the "Configuration Steps" section.

Configuration Steps

#Enable AAA:

! Enable the AAA function on the device

```
Ruijie#configure terminal
Ruijie(config)#aaa new-model
```

Configure the security server:

The security server provides the AAA services. Software of the server can record, calculate and analyze the various information in the form of logs.

! Configure the RADIUS server information (the shared key for the communication between the device and the RADIUS server is **ruijie**)

```
Ruijie(config)#radius-server host 10.1.1.1
Ruijie(config)#radius-server key ruijie
```

! Configure TACACS+ server information (the shared key for the communication between the device and the Tacacs+ server is **redgiant**)

```
Ruijie(config)#tacacs-server host 10.1.1.2
Ruijie(config)#tacacs-server key redgiant
```

Configure the local user:

! Configure password encryption (the key information for the local password and the security server are saved and displayed in the simply-encrypted format).

```
Ruijie(config)#service password-encryption
```

! Configure the local user database (Configure the username and the password, and set the user privilege level).

```
Ruijie(config)#username bank privilege 10 password yinhang
Ruijie(config)#username super privilege 15 password star
Ruijie(config)#username normal privilege 2 password normal
Ruijie(config)#username test privilege 1 password test
```

! Configure the local enable password for the local Enable authentication.

```
Ruijie(config)#enable secret w
```

! Configure the line login password (It does not work when the AAA function is enabled. So the line login password configuration is to prevent the login failure with the AAA function disabled).

```
Ruijie(config)#line vty 0 15
Ruijie(config-line)#password w
```

! Configure the line user privilege level (with the Exec authorization disabled, or no Exec authorization method list is applied in the line and no default Exec authorization method list, the configure line user privilege level should be used).

```
Ruijie(config)#line vty 0 15
Ruijie(config-line)#privilege level 10
```

Configure the authentication

1. Login authentication

The Login authentication is used to control the user access. There are two methods to define the authentication method list: 1) Radius; 2) Local.

! Configure login authentication method list and apply it to the corresponding line

```
Ruijie(config)# aaa authentication login hello group radius local
Ruijie(config)# line vty 0 15
Ruijie(config-line)# login authentication hello
```

To prevent the user from using the exhaust algorithm to crack the password during the Login authentication, AAA is used to limit the user Login attempts. When the the number of authentication attempts reaches the configured limit, the user is locked from login in a period (by default, three login authentication attempts are allowed and the lockout time is 15 hours.).

! Configure the number of allowed authentication attempts to 2 and the authentication lockout time to 10 hours

```
Ruijie(config)#aaa local authentication attempts 2
Ruijie(config)#aaa local authentication lockout-time 10
```

2. Enable authentication

The Enable authentication is used to switch the user privilege level. An authentication process is needed before the user switches the privilege level to the superuser using the **enable** command. There are two methods to define the authentication method list: 1) Radius; 2) Local. The Enable authentication can only set the default method list, which will be automatically applied after the configuration.

! Configure the enable authentication method list (RADIUS, TACACS+, and Local in descending order)

```
Ruijie(config)#aaa authentication enable default group radius local
```

Configure the authorization

1. Exec authorization

The Exec authorization is used to control the user command privilege level. For example, level 15 is assigned to the superuser, level 14 is assigned to the configuration user, level 2 is assigned to the common user. The remote Exec authorization takes precedence over the local one.

! Configure the Exec authorization method list (TACACS+ has higher priority over Local) and apply it to the line

```
Ruijie(config)#aaa authorization exec shouquan group tacacs+ local
Ruijie(config)#line vty 0 15
Ruijie(config-line)#authorization exec shouquan
```

! Configure the exec authorization for the console (by default, the Exec authorization is not for the console)

```
Ruijie(config)#aaa authorization console
```

2. Command authorization

The Command authorization is used to offer the execution privilege of the key commands only to the administrators. The Command authorization authorizes the level of the command but not that of the current user. The RADIUS protocol is not supported.

! Configure the Command authorization method list (TACACS+ has higher priority over Local) and apply it to the line.

```
Ruijie(config)#aaa authorization commands 2 abc group tacacs+ local
Ruijie(config)#line vty 0 15
Ruijie(config-line)#authorization commands 2 abc
```

Configure the accounting

1. Exec accounting

The Exec accouting is used to send the information about a user when the user accesses and exits the server for subsequent query, statistics, and audit.

! Configure the Exec accouting method list (TACACS+ accounting) and apply it to the line.

```
Ruijie(config)#aaa accounting exec default start-stop group tacacs+
```

2. Command accounting

The Command accouting is used to send the commands of a specific level executed by the user to the server for subsequent query, statistics and the audit.

! Configure the command accounting method list (TACACS+ only) and apply it to all lines.

```
Ruijie(config)#aaa accounting commands 2 default start-stop group tacacs+
```

Configuration verification

Step 1: Use the **show running-config** command to query the current configurations:

```
Ruijie(config)#show run

Building configuration...
Current configuration : 2337 bytes

!
!
aaa new-model
aaa local authentication attempts 2
aaa local authentication lockout-time 10
!
!
!
aaa authorization exec shouquan group tacacs+ local
aaa authorization commands 2 abc group tacacs+
aaa accounting exec default start-stop group tacacs+
aaa accounting commands 2 default start-stop group tacacs+
aaa authentication login hello group radius local
aaa authentication enable default group radius local
!
!
vlan 1
!
!
username bank password 7 09361c1c2f041c4d
username bank privilege 10
username super password 7 093c011335
username super privilege 15
```

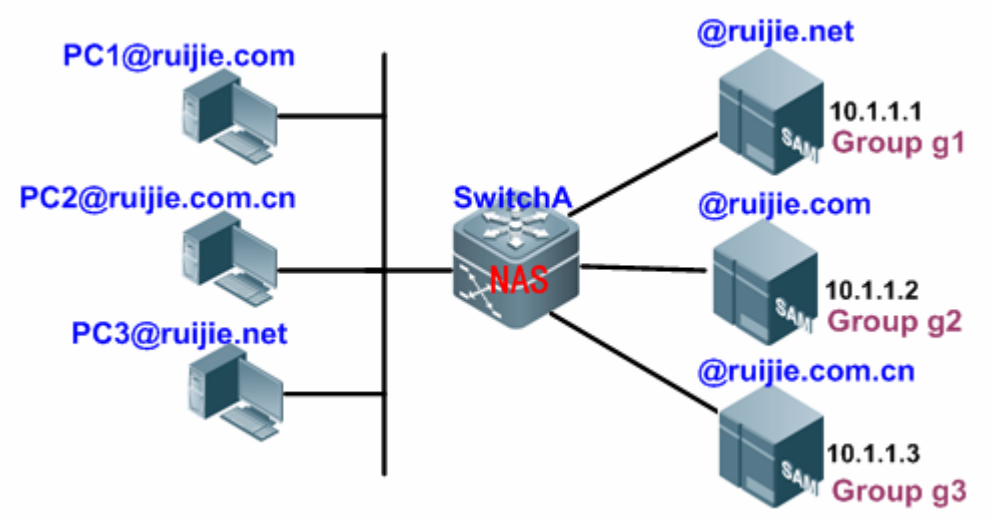
```
username normal password 7 09211a002a041e
username normal privilege 2
username test password 7 093b100133
service password-encryption
!
!
!
!
tacacs-server key 7 072c062b121b260b06
tacacs-server host 10.1.1.2
radius-server host 10.1.1.1
radius-server key 7 072c16261f1b22
enable secret 5 $1$2MjW$xr1t0s1Euvt76xs2
!
!
!
!
!
line con 0
line vty 0 4
 authorization exec shouquan
 authorization commands 2 abc
 privilege level 10
 login authentication hello
 password 7 0938
line vty 5 15
 authorization exec shouquan
 authorization commands 2 abc
 privilege level 10
 login authentication hello
 password 7 005d
!
!
end
```

Step 2: In the actual application, use the **show aaa user {** *id* **| all }** command to query the current AAA user information.

AAA Multi-domain Authentication Application

Network Topology

Figure 28 AAA multi-domain authentication topology



Network Requirements

Configure the NAS device to enable the domain name-based AAA services:

- Use the 802.1x client for the login authentication with the username PC1@ruijie.com or PC2@ruijie.com.cn or PC3@ruijie,.net and the password.
- User network management: classify the users into superusers and common users, wherein the superusers are able to read and write while the common users are able to read only.
- The user authentication, authorization and network behavior are saved in the authentication server for subsequent query and audit.

Configuration Key Points

Configure the domain name-based AAA services to address the preceding network requirements.

The following example describes how to configure AAA multi-domain authentication on a 802.1x client.

Configuration Steps

#Enable AAA:

! Enable the AAA functions on the device

```
Ruijie#configure terminal
Ruijie(config)#aaa new-model
```

Configure the security server:

The security server provides the AAA services. The user information is stored in the server and the software of the server can record, calculate and analyze the various information in the form of logs.

! Configure the RADIUS server information (the shared key for the communication between the device and the Radius server is **ruijie**)

```
Ruijie(config)#aaa group server radius g1
Ruijie(config-gs-radius)#server 10.1.1.1
Ruijie(config-gs-radius)#exit
Ruijie(config)#aaa group server radius g2
Ruijie(config-gs-radius)#server 10.1.1.2
Ruijie(config-gs-radius)#exit
Ruijie(config)#aaa group server radius g3
Ruijie(config-gs-radius)#server 10.1.1.3
Ruijie(config-gs-radius)#exit
Ruijie(config)#radius-server key ruijie
```

Configure the local user:

! Configure the password encryption (the key information for the local password and the security server is saved and displayed in the simply-encrypted format).

```
Ruijie(config)#service password-encryption
```

! Configure the local user database (Configure the username and the password, and set the user privilege level).

```
Ruijie(config)#username bank privilege 10 password yinhang
Ruijie(config)#username super privilege 15 password star
Ruijie(config)#username normal privilege 2 password normal
Ruijie(config)#username test privilege 1 password test
```

! Configure the local Enable password for the local Enable authentication.

```
Ruijie(config)#enable secret w
```

Define the AAA service method list

! Configure dot1x authentication.

```
Ruijie(config)#aaa authentication dot1x renzheng group radius local
```

! Configure network authorization.

```
Ruijie(config)#aaa authorization network shouquan group radius
```

! Configure network accounting.

```
Ruijie(config)#aaa accounting network jizhang start-stop group radius
```

Enable the domain name-based AAA services

```
Ruijie(config)#aaa domain enable
```

Create a domain and configure the domain attribute set

! Create a domain.

```
Ruijie(config)#aaa domain ruijie.com
```

！ Associate the AAA service method list

```
Ruijie(config-aaa-domain)#authentication dot1x renzheng
Ruijie(config-aaa-domain)#authorization network shouquan
Ruijie(config-aaa-domain)#accounting network jizhang
```

！ Configure the domain state.

```
Ruijie(config-aaa-domain)#state active
```

! Exclude the domain name from the username.

```
Ruijie(config-aaa-domain)#username-format without-domain
!
Ruijie(config)#aaa authentication dot1x renzheng group g2
Ruijie(config)#aaa authorization network shouquan group g2

Ruijie(config)#aaa accounting network jizhang start-stop group g2
```

The configurations of the ruijie.com.cn and the ruijie.net are similar.

Configuration Verification

Step 1: Use the **show running-config** command to query the current configurations (take the domain name **ruijie.com** for example):

```
Ruijie#show run

Building configuration...
Current configuration : 2013 bytes

!
aaa new-model
aaa domain enable
!
aaa domain ruijie.com
 authentication dot1x renzheng
 accounting network jizhang
 authorization network shouquan
 username-format without-domain
!
!
aaa group server radius g1
 server 10.1.1.1
!
aaa group server radius g2
 server 10.1.1.2
!
```

```
aaa group server radius g3
 server 10.1.1.3
!
!
aaa accounting network jizhang start-stop group g2
aaa authorization network shouquan group g2
aaa authentication dot1x renzheng group g2
!
!vlan 1
!
!
no service password-encryption
!
!
radius-server key ruijie
!
!
!

Step 2: Query the domain name-based AAA service domain information:
Ruijie#show aaa domain

=============Domain ruijie.com=============
State: Active
Username format: Without-domain
Access limit: No limit
802.1X Access statistic: 0

Selected method list:
 authentication dot1x renzheng
 authorization network shouquan


               accounting network jizhang
```

Configuring RADIUS

Overview of RADIUS

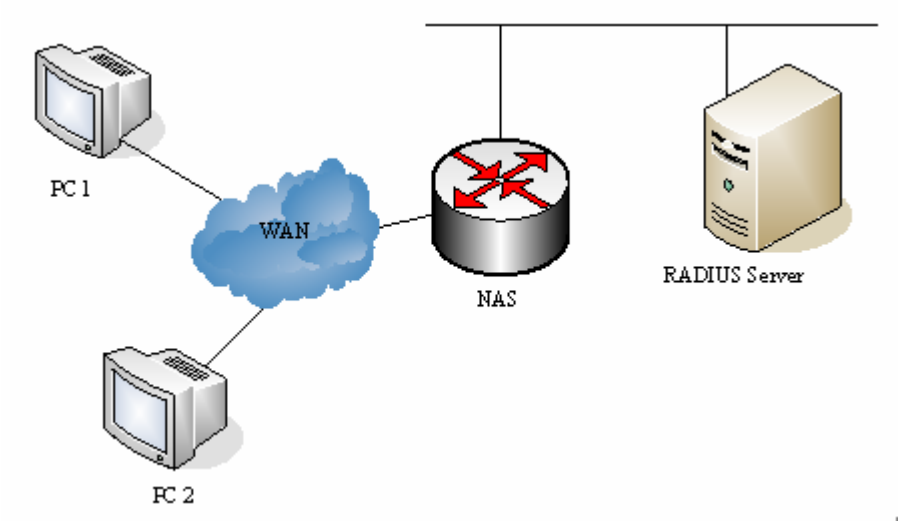
The Remote Authentication Dial-In User Service (Radius) is a distributed client/server system that works with the AAA to perform authentication for the users who are attempting to make connection and prevent unauthorized access. In the RGOS implementation, the RADIUS client runs on the router or the network access server (NAS) to send the authentication requests to the central RADIUS server. The central server stores all information of user authentication and network services.

Since RADIUS is a completely open protocol, it has become a component and been installed in such systems as Unix and Windows 2000, so it is the most popular security protocol for the time being.

The running process of RADIUS is as follows:

- Prompt the user to enter username and password.
- The username and the encrypted password are sent to the RADIUS server via the network.
- The RADIUS returns one of the following responses:
- ACCEPT: indicating that the user is authenticated.
- REJECT: indicating that the user authentication fails and the username and password must be entered again.
- CHALLENGE: indicating that the RADIUS server requests more authentication information from the user.
- The user authorization information is included in the ACCEPT response.

Figure 1 Typical RADIUS network



In addition to the authentication service, the RADIUS server also provides authorization and accounting services.

The RADIUS security protocol, also called the RADIUS method, is configured in the unit of a RADIUS server group. Every RADIUS method corresponds to a RADIUS server group which may consist of one or more RADIUS servers. For details about the RADIUS method, refer to *AAA-SCG.* If a RADIUS server group has multiple RADIUS servers, these RADIUS servers are used in polling mode till there is successful communication or all servers become unreachable.

RADIUS Configuration Tasks

To configure RADIUS on the network device, perform the following tasks first:

- Enable AAA. For the details, see *AAA-SCG*.
- Define a RADIUS authentication method list by using the **aaa authentication** command. For details about usage of the **aaa authentication** command, see the “Configuring Authentication” section.
- Apply the defined authentication method list to the specific line; otherwise the default authentication method list will be used for authentication. For more details, see the “Configuring Authentication” section.

Configuring RADIUS Protocol Parameters

Before configuring RADIUS on the network device, ensure that the RADIUS server is reachable. To configure RADIUS protocol parameters, run the following commands:

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **radius-server host** *ip-address* [**auth-port** *port*] [**acct-port** *port*]	Configures the IP address or hostname of the remote Radius security server and specifies the authentication port and accounting port.
Ruijie(config)# **radius-server key** *string*	Configures the shared key used for the communication between the device and the Radius server.
Ruijie(config)# **radius-server retransmit** *retries*	Specifies the times of sending a request before a RADIUS server is considered unreachable (3 by default).
Ruijie(config)# **radius-server timeout** *seconds*	Specifies the waiting time before the network device resends a request (5 seconds by default).

Caution When configuring RADIUS, you must configure a RADIUS Key. Ensure that the network device and the RADIUS server use the same shared key.

Specifying Radius Authentication

This means defining the authentication method list for the Radius after the After specifying a RADIUS server and a RADIUS shared key, you must define a RADIUS authentication method list. RADIUS authentication is performed via AAA, so you need to run the **aaa authentication** command to define an authentication method list and specify the RADIUS authentication method. For more details, see *AAA-SCG*.

Specifying the Standard Radius Attribute Type

This section describes how to configure types of standard attributes. Now the RADIUS Calling-Station-ID attribute (the attribute value is 31) is supported.

Configuring Calling-Station-ID Format

The RADIUS Calling-Station-ID attribute is used to identify the NAS when the NAS is sending a request to the RADIUS server. The value of the RADIUS Calling-Station-ID is character strings, which can be in multiple formats. The MAC

address for the NAS is usually used as the value of the Calling-Station-ID to solely identify the NAS. The table below describes the formats of the MAC address:

Format	Description
ietf	The standard format specified by IETF (in RFC3580). A hyphen (-) is used as the seperator, for example: 00-D0-F8-33-22-AC.
normal	Normal format of the MAC address (dotted hexadecimal format). A dot (.)is used as the seperator. For example: 00d0.f833.22ac.
unformatted	No format or seperator. By default, unformatted is used. For example: 00d0f83322ac.

To configure the format of the RADIUS Calling-Station-ID MAC-based attribute, run the following commands:

Command	Function
configure terminal	Enters global configuration mode.
radius-server attribute 31 mac format {ietf | normal | unformatted}	Configures the format of the RADIUS Calling-Station-ID MAC-based attribute. The default format is **unformatted**.

Specifying Private Radius Attribute Type

This section describes how to configure private attributes of RADIUS. By default, private RADIUS attributes are classified into Ruijie attributes and extended vendor types:

ID	Function	TYPE	Extended TYPE
1	max-down-rate	1	76
2	port-priority	2	77
3	user-ip	3	3
4	vlan-id	4	4
5	last-supplicant-version	5	5
6	net-ip	6	6
7	user-name	7	7
8	password	8	8
9	file-directory	9	9
10	file-count	10	10
11	file-name-0	11	11
12	file-name-1	12	12
13	file-name-2	13	13
14	file-name-3	14	14
15	file-name-4	15	15
16	max-up-rate	16	16
17	current-supplicant-version	17	17
18	flux-max-high32	18	18

ID	Function	TYPE	Extended TYPE
19	flux-max-low32	19	19
20	proxy-avoid	20	20
21	dailup-avoid	21	21
22	ip-privilege	22	22
23	login-privilege	42	42
26	ipv6-multicast-address	79	79
27	ipv4-multicast-address	87	87
62	sdg-type	62	62
85	sdg-zone-name	85	85
103	sdg-group-name	103	103

Note

Some private attributes are supported only by specific products. You can run the **show radius vendor-specific** command to view private attribute lists supported by products.

Two attributes cannot be configured with the same type number.

The following is an example about private attributes of network devices:

```
Ruijie# show radius vendor-specific
id   vendor-specific   type-value
----- ------------------- ----------
1   max-down-rate     76
2   port-priority     77
3   user-ip       3
4   vlan-id       4
......
Ruijie# configure
Ruijie(config)# radius attribute 4 vendor-type 67
Ruijie(config)# show radius vendor-specific
id   vendor-specific   type-value
----- ------------------- ----------
1   max-down-rate     76
2   port-priority     77
3   user-ip       3
4   vlan-id       67
......

Ruijie(config)#
```

Configuring RADIUS Server Reachability Detection

The device maintains the reachability state of each RADIUS server configured: reachable or unreachable. The device does not send authentication, authorization and accounting requests of users to an unreachable RADIUS server, unless all RADIUS servers in the RADIUS server group are unreachable.

The device can carry out proactive detection of the specified RADIUS server, and this feature is disabled by default. If you enable proactive detection of the specified RADIUS server, the device will periodically send detection requests (authentication requests or accounting requests) to the RADIUS server at an interval of:

- 60 minutes (the default value) for reachable RADIUS servers
- 1 minute (a constant value) for unreachable RADIUS servers

Note

To enable proactive detection of the specified RADIUS server, the following conditions must be met:
1. The test user name for this RADIUS server has been configured on the device.
2. At least one tested port of this RADIUS server (authentication port or accounting port) has been configured on the device.
For a reachable RADIUS server, the device will consider this RADIUS server unreachable if the following two conditions are met:
1. The time configured by using the **radius-server dead-criteria time** *seconds* command has elapsed since the receipt of the last correct response from the RADIUS server.
2. After the receipt of the last correct response from the RADIUS server, the number of requests (including retransmitted requests) without a response reaches the value configured by using the **radius-server dead-criteria tries** *number* command.

For an unreachable RADIUS server, the device will consider this RADIUS server reachable if any of the following conditions is met:

67) A correct response is received from this RADIUS server.
68) The duration that this RADIUS server remains unreachable exceeds the time set by using the **radius-server deadtime** command, and proactive detection of this RADIUS server is not enabled.
69) The authentication port or accounting port of this RADIUS server is updated on the device.

RADIUS server reachability detection allows the user to judge whether a RADIUS server is unreachable and to configure proactive detection.

To configure RADIUS server reachability detection, run the following commands in global configuration mode:

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **radius-server dead-criteria time** *seconds* **tries** *number*	Configures global criteria for judging whether a RADIUS server is reachable. The default value of *seconds* is **60**, and the default value of *number* is **10**.
Ruijie(config)# **radius-server deadtime** *minutes*	Configures the duration for the device to stop sending request packets to the RADIUS server in unreachable state (default value: 0 minutes).

Command	Function
Ruijie(config)# **radius-server host** *ip-address* [**auth-port** *port*] [**acct-port** *port*] [**test username** *name* [**idle-time** *time*] [**ignore-auth-port**] [**ignore-acct-port**]]	Configures the IP address of a remote RADIUS server, specifies the authentication port and accounting port, and specify relevant parameters of proactive detection (testing user name, interval for proactive detection of reachable RADIUS servers, and whether the authentication port or the accounting port shall be neglected).


Caution In the configuration, a special testing user name shall be used. This user name cannot be used by other authorized users, avoiding adverse impact on authentication, authorization or accounting of these users.

Monitoring RADIUS

To monitor RADIUS, run the following command in privileged user mode:

Command	Function
debug radius { **event** | **detail** }	Turns on the Radius debug switch to view the Radius debug information.

Radius Configuration Example

In a typical Radius network configuration diagram, the RADIUS server performs authentication for the users who are attempting to access, enables the accounting function for these users and records the network service usage of them.


Note The RADIUS server can be a component that comes with the Windows 2000/2003 server (IAS) or the Unix system, or special certified server software of some manufacturers.

The following example shows how to configure the Radius on the network device:

```
Ruijie# configure terminal
Ruijie(config)# aaa new-model
Ruijie(config)# radius-server host 192.168.12.219 auth-port 1645 acct-port 1646
Ruijie(config)# radius-server key aaa
Ruijie(config)# aaa authentication login test group radius
Ruijie(config)# end
Ruijie# show radius server
Server IP:   192.168.12.219
Accounting Port: 1646
Authen Port:  1645
Test Username:  <Not Configured>
Test Idle Time:  60 Minutes
Test Ports:   Authen and Accounting
Server State:  Active
```

```
    Current duration 765s, previous duration 0s
  Dead: total time 0s, count 0
  Statistics:
    Authen: request 15, timeouts 1
    Author: request 0, timeouts 0
    Account: request 0, timeouts 0

Ruijie# configure terminal
Ruijie(config)# line vty 0
Ruijie(config-line)# login authentication test
Ruijie(config-line)# end
Ruijie# show running-config
!
aaa new-model
!
!
aaa authentication login test group radius
!
!
!
radius-server host 192.168.12.219 auth-port 1645 acct-port 1646
radius-server key aaa
!
line con 0
line vty 0
login authentication test
line vty 1 4
!
```

RADIUS IPv6 Configuration Example

In the typical RADIUS network configuration diagram, the RADIUS server performs authentication and accounting of users, and records the network service service usage of them.

Note The RADIUS server is deployed on a Windows 2008 Server or special IPv6 capable server software certified by manufacturers.

The following example shows how to configure RADIUS on the network device:

```
Ruijie# configure terminal
Ruijie(config)# aaa new-model
Ruijie(config)# radius-server host 3000::100 auth-port 1645 acct-port 1646
Ruijie(config)# radius-server key aaa
Ruijie(config)# aaa authentication login test group radius
```

```
Ruijie(config)# end
Ruijie# show radius server
Server IP:   3000::100
Accounting Port: 1646
Authen Port:  1645
Test Username:  <Not Configured>
Test Idle Time:  60 Minutes
Test Ports:   Authen and Accounting
Server State:  Active
    Current duration 765s, previous duration 0s
  Dead: total time 0s, count 0
  Statistics:
    Authen: request 15, timeouts 1
    Author: request 0, timeouts 0
    Account: request 0, timeouts 0

Ruijie# configure terminal
Ruijie(config)# line vty 0
Ruijie(config-line)# login authentication test
Ruijie(config-line)# end
Ruijie# show running-config
!
aaa new-model
!
!
aaa authentication login test group radius
!
!
!
radius-server host 3000::100 auth-port 1645 acct-port 1646
radius-server key aaa
!
line con 0
line vty 0
login authentication test
line vty 1 4

!
```

Configuring TACACS+

Overview of TACACS+

TACACS+ is an enhancement of Terminal Access Controller Access Control System (TACACS) defined in RFC 1492. It implements authentication, authorization, and accounting (AAA) functions on multiple types of users by communicating with the TACACS server in client-server mode. Before using the TACACS+ server, you need to configure the related functions of the TACACS+ server.

TACACS+ supports user authentication, authorization and accounting. That is, one server is used for authentication, one for authorization, and another for accounting, which proceed concurrently. Each server has its own user data for authentication, authorization, and accounting.

The following table shows the format of a TACACS+ packet:

Figure 2

4	8	16	24	32 bit
Major	Minor	Packet type	Sequence no.	Flags
Session ID				
Length				

- Major Version —TACACS+ Version;
- Minor Version —TACACS+ release;
- Packet Type — Its values are as follows:
  TAC_PLUS_AUTHEN: = 0x01 (Authentication);
  TAC_PLUS_AUTHOR:= 0x02 (Authorization);
  TAC_PLUS_ACCT:= 0x03 (Accounting).
- Sequence Number — packet sequence number in the current session. The sequence number of the first TACACS+ packet in a session must be 1 and those of subsequent packet increment by one. Therefore, the client sends only the packet with an odd sequence number, while TACACS+ Daemon only sends only the packet with an even sequence number.
- Flags — This field includes flags with various bitmap formats. The Flag value indicates whether a packet is encrypted or not.
- Session ID — ID in a TACACS+ session.
- Length —body length of a TACACS+ packet (excluding the header). All the packets are transmitted in the network after being encrypted.

TACACS+ Application

Typically, TACACS+ is used to manage and control the login of terminal users. Network devices work as TACACS+ clients to send user names and passwords to the TACACS+ server for authentication. After authentication and authorization, you can log in to the switch for operation, as shown in Figure 2:

Figure 3

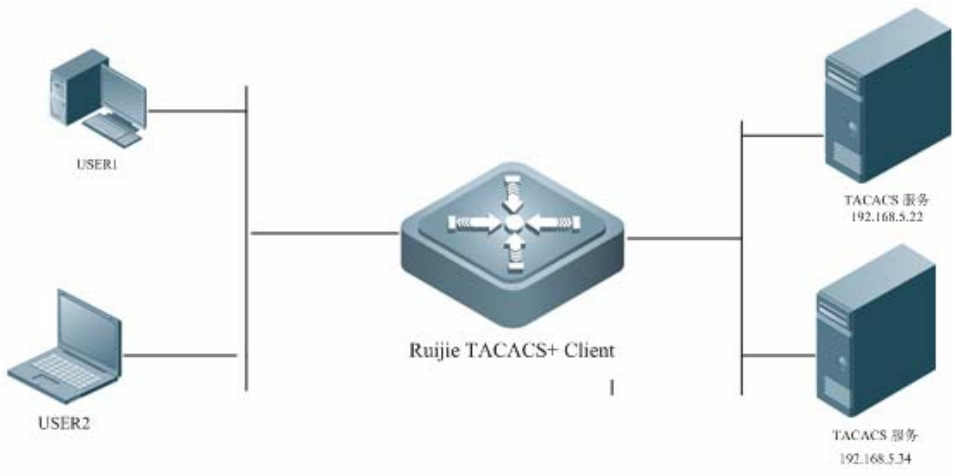
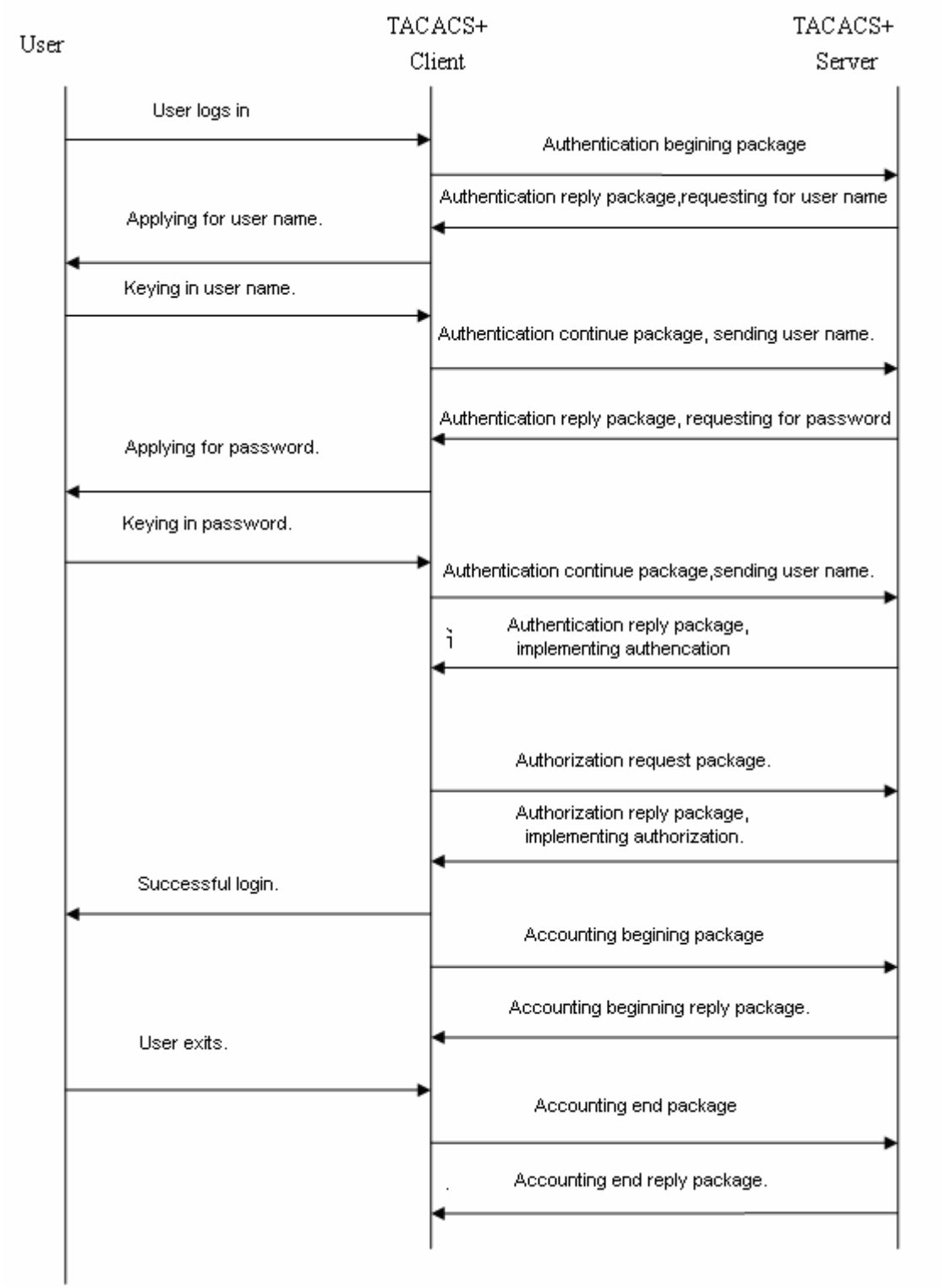

USER1
USER2
Ruijie TACACS+ Client
TACACS 服务
192.168.5.22
TACACS 服务
192.168.5.34

Figure 4 describes the exchange of TACACS+ packets during AAA implementation in a login attempt.

Figure 4



The whole process is divided into three parts:

Authentication:

70) A user sends a login request to the network device;

71) After receiving the request, the TACACS+ client sends a authentication start message to the TACACS+ server;

72) The TACACS+ server sends an authentication reply message, requesting the user name;
73) The TACACS+ client asks the user for the user name.
74) The user enters the login user name;
75) After receiving the user name, the TACACS+ client sends an authentication continue message containing the user name to the TACACS+ server;
76) The TACACS+ server sends an authentication reply message, requesting the login password;
77) The TACACS+ client receives the login password;
78) The user enters the login password;
79) After receiving the login password, the TACACS+ client sends an authentication continue message containing the login password to the TACACS+ server;
80) The TACACS+ server sends an authentication reply message, indicating that the user has been authenticated.

Authorization:

81) The TACACS+ client sends an authorization request message to the TACACS+ server.
82) The TACACS+ server sends an authorization reply message, indicating that the user has been authenticated;
83) The TACACS+ client receives a successful authorization reply message, displaying the interface for configuring the network device.

Accounting:

84) The TACACS+ client sends an accounting start message to the TACACS+ server;
85) The TACACS+ server sends an accounting reply message, indicating that it has received the accounting start message;
86) The user exits;
87) The TACACS+ Client sends an accounting end message to the TACACS+ server;
88) The TACACS+ server sends an accounting end reply message, indicating that it has received the accounting end message.

TACACS+ Configuration Task

The following tasks must be executed before you configure TACACS+ on the network device:

- Use the **aaa new-mode** command to enable AAA. Before using TACACS+, you must enable AAA. For usage of the **aaa new-mode** command, see the “AAA Overview” chapter in *AAA-SCG*.
- Use the **tacacs-server host** command to configure one or multiple TACACS+ servers.
- Use the **tacacs-server key** command to specify the key shared by the server and the network device.
- Use the **tacacs-server timeout** command to specify the timeout time for waiting a reply from the server;
- If authentication is required, use the **aaa authentication** command to define a TACACS+ authentication method list. For details, see the “Configuring Authentication” section in *AAA-SCG*.
- If authorization is required, use the **aaa authorization** command to define a TACACS+ authorization method list. For details, see the “Configuring Authorization” section in *AAA-SCG*.
- If accounting is required, use the **aaa accounting** command to define a TACACS+ accounting method list. For details, see the “Configuring Accounting” section in *AAA-SCG*.
- Apply a specific authentication method list to a specific line. Otherwise, a default method list is used.

Configuring TACACS+ Parameters

Before configuring TACACS+ on a network device, ensure that communication with the TACACS+ server is proper. To configure TACACS+ parameters, run the following commands:

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **tacacs-server host** {*ip-address* | *ipv6-address*} [**port** *integer*] [**timeout** *integer*] [**key** *string*]	Configures the IP address of the remote TACACS+ security server. Different combinations of parameters are used to build parameters of the server. *ip-address*: IP address of the server; *ipv6-address:* IPv6 address of the server; port *intege* [optional]:port used by the server. By default, port 49 is used. The value ranges from 1 to 65535. timeout *integer* [optional]: response timeout time of the server. By default, the timeout time is 5s. The value ranges from 1 to 1000 (in seconds). key *string* [optional]: key shared with the server with the corresponding server.
Ruijie(config)# **tacacs-server key** *string*	Configures the shared key used for communication between the network device and the TACACS+ server. When the corresponding server does not have an independent key, the global configuration is used.
Ruijie(config)# **tacacs-server timeout** *seconds*	Configures the wait time before the network device retransmits a request. It is 5s by default. If no timeout time is specified for a host, the host uses the global configuration.
Ruijie(config)# **ip tacacs source-interface** *interface*	Configures the source IP address used to send a TACACS+ request to the server. By default, the source IP address is not specified.
Ruijie(config)# **aaa group server tacacs+** *group-name*	Configures TACACS+ server groups. Different TACACS+ servers are divided into different groups.
Ruijie(config-gs-tacacs)# **server** {*ip-address* | *ipv6-address*}	Configures IP addresses of servers in a TACACS+ server group.
Ruijie(config-gs-tacacs)# **ip vrf forwarding** *vrf-name*	Configures the VRF instance name used by a TACACS+ server group. This command is available on VRF-capable hosts.

Caution When configuring TACACS+, you must configure the TACACS+ key. The network device and the TACACS+ server must use the same shared key.

The **tacacs-server timeout** is affected by **ip tcp syntime-out,** the real valid timeout value is that of the smaller one between the two.

Using TACACS+ for Implementing AAA Functions

In a typical TACACS+ network, the TACACS+ server implements AAA functions on users. The following example shows how AAA functions are implemented through TACACS+.

Using TACACS+ for Login Authentication

- Enables AAA:

```
Ruijie# configure terminal
Ruijie(config)# aaa new-model
```

- Configures TACACS+ server information:

```
Ruijie(config)# tacacs-server host 192.168.12.219
Ruijie(config)# tacacs-server key aaa
```

- Configures TACACS+ authentication methods:

```
Ruijie(config)# aaa authentication login test group tacacs+
```

- Applies the authentication method to the interface:

```
Ruijie(config)# line vty 0 4
Ruijie (config-line)# login authentication test
```

Through the above configuration, TACACS+ login authentication is implemented. The configuration is as follows:

```
Ruijie#show running-config
!
aaa new-model
!
aaa authentication login test group tacacs+
!
tacacs-server host 192.168.12.219
tacacs-server key aaa
!
line con 0
line vty 0 4
login authentication test
!
```

Using TACACS+ for Enable Authentication

89) Enables AAA:

```
Ruijie# configure terminal
Ruijie(config)# aaa new-model
```

90) Configures TACACS+ server information:

```
Ruijie(config)# tacacs-server host 192.168.12.219
Ruijie(config)# tacacs-server host 192.168.12.218
Ruijie(config)# tacacs-server host 192.168.12.217
Ruijie(config)# tacacs-server key aaa
```

Configures that some servers in a TACACS+ server group are used:

```
Ruijie(config)# aaa group server tacacs+ tacgroup1
Ruijie(config-gs-tacacs)# server 192.168.12.219
Ruijie(config-gs-tacacs)# server 192.168.12.218
```

91) Configures to use authentication methods of TACACS+ server group 1:

```
Ruijie(config)# aaa authentication enable default group tacgroup1
```

Through the above configuration, TACACS+ Enable authentication is implemented on some servers. The configuration is as follows:

```
Ruijie#show running-config
!
aaa new-model
!
!
aaa group server tacacs+ tacgroup1
server 192.168.12.219
server 192.168.12.218
!
aaa authentication enable default group tacgroup1
!
!
tacacs-server host 192.168.12.219
tacacs-server host 192.168.12.218
tacacs-server host 192.168.12.217
tacacs-server key aaa
!
line con 0
line vty 0 4
!
```

Using TACACS+ for Login Authorization

92) Enables AAA:

```
Ruijie# configure terminal
Ruijie(config)# aaa new-model
```

93) Configures TACACS+ server information:

```
Ruijie(config)# tacacs-server host 192.168.12.219
Ruijie(config)# tacacs-server key aaa
```

94) Configures the authorization method of using tacacs+:

```
Ruijie(config)# aaa authorization exec test group tacacs+
```

95) Applies the authorization method to the interface:

```
Ruijie(config)# line vty 0 4
Ruijie (config-line)# authorization exec test
```

Through the above configuration, TACACS+ Enable authorization is implemented. The configuration is as follows:

```
Ruijie#show running-config
!
```

```
aaa new-model
!
!
aaa authorization exec test group tacacs+
!
tacacs-server host 192.168.12.219
tacacs-server key aaa
!
line con 0
line vty 0 4
authorization exec test
!
```

Using TACACS+ for Level 15 Command Audit

- Enables AAA:

```
Ruijie# configure terminal
Ruijie(config)# aaa new-model
```

- Configures TACACS+ server information:

```
Ruijie(config)# tacacs-server host 192.168.12.219
Ruijie(config)# tacacs-server key aaa
```

- Configures to use the accounting method of TACACS+:

```
Ruijie(config)# aaa accounting commands 15 test start-stop group tacacs+
```

- Applies the accounting method to the interface:

```
Ruijie(config)# line vty 0 4
Ruijie (config-line)# accounting commands 15 test
```

Through the above configuration, TACACS+ Enable accounting is implemented. The configuration is as follows:

```
Ruijie# show running-config
!
aaa new-model
!
!
aaa accounting commands 15 default group tacacs+
!
!
tacacs-server host 192.168.12.219
tacacs-server key aaa
!
line con 0
line vty 0 4
accounting commands 15 test
!
```

Port-based Flow Control Configuration

Storm Control

Overview

Too many broadcast, multicast or unknown unicast packets in the LAN will slow the network speed and increase the possibility of packet transmission timeout significantly. This is called LAN storm. Protocol stack implementation errors or wrong network configuration may lead to such storms.

Storm control can be conducted upon the broadcast, multicast and unknown unicast data streams respectively. When the rate of the broadcast, multicast or unknown unicast packets received by the interface exceeds the specified bandwidth throttling, the device only allows the packets within the bandwidth throttling. The packets that exceed the throttle will be discarded until the data stream becomes normal again. This prevents excessive flooding packets from entering the LAN to form a storm.

Configuring Storm Control

In the interface configuration mode, use the following command to configure storm control:

Command	Function
Ruijie(config-if)# **storm-control** {**broadcast** | **multicast** | **unicast**} [{ **level** *percent* | **pps** *packets* | *rate-bps*]	**broadcast**: Enable the broadcast storm control function. **multicast**: Enable the unknown multicast storm control function. **unicast**: Enable the unknown unicast storm control function. *percent:* Set according to the bandwidth percentage, for example, 20 means 20% *packets*: Set according to the pps, which means packets per second *Rate-bps*: rate allowed

In the interface configuration mode, you can disable the storm control on the appropriate interface by using the **no storm-control broadcast**, **no storm-control multicast**, or n**o storm-control unicast** command.

The following example enables the multicast storm control on GigabitEthernet 0/1 and set the allowed rate as 4M.

```
Ruijie# configure terminal
Ruijie(config)# interface GigabitEthernet 0/1
```

```
Ruijie(config-if)# storm-control multicast 4096
Ruijie(config-if)# end
```

Note

1. By default, for S5750, S76, S86 and S12000 series, the storm control function for broadcast, multicast and unknown unicast packets is disabled. For S20, the switching card(NM2-24ESW/NM2-16ESW), S23, S26, S29, S32, S37 series, the storm control function for the multicast packets is disabled and for the broadcast and unknown unicast packets is enabled. The default value of storm control is one percent of the port bandwidth.

2. S8600 and S12000 series do not support **storm-control action.**

3. For S76, S86, S12000 and S96 series, the level-based storm control has certain errors for the packets in the length of more than 64 bytes. The longer the packet length is, the greater the comparable error value is. The error formula is (packet length-64)/84.

4. The reference bandwidth for the level-based storm control is the maximum bandwidth supported by the physical port, but not converted from the bandwidth of the physical port in service.

5. If you enable storm control with the **storm-control broadcast** command, the default setting or 14880PPS is used.

6. For S29 and S5760 series, only the same storm control mode setting(level, pps, kbps) is supported on the switch, and the storm control conflicts with port rate limit. For example, configure the level-based storm control on port1, it prompts error message when configuring the pps-based storm control on port2 and enabling the port rate limit on port3. If the storm control mode for one of the AP member ports is different from the mode for other ports, or the port rate limit is enabled on other ports, the configured storm control function takes no effect when the member port exits from AP.

7. For the S3760 series, the broadcast storm control and the multicast storm control shall be configured in the interface configuration mode, while the unicast storm control shall be configured in the global configuration mode.

8. For S2026 series and the switching card (NM2-24ESW/NM2-16ESW), the configuration of the storm control for the unknown multicast packets is invalid. The configuration of storm control for the unknown unicast packets is valid for the unknown multicast packets.

Viewing the Enable Status of Storm Control

To view the storm control status of the interface, use the following command:

Command	Function

Command	Function
Ruijie# **show storm-control** [*interface-id*]	Show storm control information.

The instance below shows the enabled status of the storm control function of interface Gi1/3:

```
Ruijie# show storm-control gigabitEthernet 0/3
Interface  Broadcast Control  Multicast Control  Unicast Control action
GigabitEthernet 0/3 Disabled  Disabled   Disabled    none
```

You can also view the enabling status of the storm control function of all interfaces at a time:

```
Ruijie# show storm-control
Interface  Broadcast Control  Multicast Control  Unicast Control Action
--------- ----------------- ----------------- ------- ------- ------
GigabitEthernet 0/1   Disabled   Disabled   Disabled   none
GigabitEthernet 0/2   Disabled   Disabled   Disabled   none
GigabitEthernet 0/3   Disabled   Disabled   Disabled   none
GigabitEthernet 0/4   Disabled   Disabled   Disabled   none
GigabitEthernet 0/5   Disabled   Disabled   Disabled   none
GigabitEthernet 0/6   Disabled   Disabled   Disabled   none
GigabitEthernet 0/7   Disabled   Disabled   Disabled   none
GigabitEthernet 0/8   Disabled   Disabled   Disabled   none
GigabitEthernet 0/9   Disabled   Disabled   Disabled   none
GigabitEthernet 0/10  Disabled   Disabled   Disabled   none
GigabitEthernet 0/11  Disabled   Disabled   Disabled   none
GigabitEthernet 0/12  Disabled   Disabled   Disabled   none
GigabitEthernet 0/13  Disabled   Disabled   Disabled   none
GigabitEthernet 0/14  Disabled   Disabled   Disabled   none
GigabitEthernet 0/15  Disabled   Disabled   Disabled   none
GigabitEthernet 0/16  Disabled   Disabled   Disabled   none
GigabitEthernet 0/17  Disabled   Disabled   Disabled   none
GigabitEthernet 0/18  Disabled   Disabled   Disabled   none
GigabitEthernet 0/19  Disabled   Disabled   Disabled   none
GigabitEthernet 0/20  Disabled   Disabled   Disabled   none
GigabitEthernet 0/21  Disabled   Disabled   Disabled   none
GigabitEthernet 0/22  Disabled   Disabled   Disabled   none
GigabitEthernet 0/23  Disabled   Disabled   Disabled   none
GigabitEthernet 0/24  Disabled   Disabled   Disabled   none
```

Protected Port

Overview

In some application environments, some ports are not required to communicate with each other on a device. In such case, frame forwarding is not allowed between the protected ports, no mattter the frames are unicast frames, broadcast frames or multicast frames. To achieve this purpose, you can set some ports as protected ports.

Once ports are set as protected ports, they cannot communicate with each other. However, protected ports can still communicate with unprotected ports.

There are two protected port modes: one is to block layer 2 forwarding between protected ports but allow layer 3 routing; the other is to block layer 2 forwarding and layer 3 routing between protected ports. The first mode is by default when both modes are supported.

When you set two protected ports as a SPAN port pair, the frames transmitted or received by the source port of SPAN are sent to the destination port of SPAN according to the SPAN setting. Therefore, it is not recommended to set the destination port of SPAN as the protected port (and you can also save system resources by doing so).

The device supports setting the Aggregated Port as the protected port. Once you do that, all the member ports of the Aggregated Port will be set as the protected port.

Configuring the Protected Port

Set one port as the protected port:

Command	Function
Ruijie(config-if)**# switchport protected**	Set this interface as a protected port

You can reset a port as unprotected port with the **no switchport protected** command in the interface configuration mode.

The following example describes how to set the Gigabitethernet 0/3 as the protected port.

```
Ruijie# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)# interface gigabitethernet 0/3
Ruijie(config-if)# switchport protected
Ruijie(config-if)# end
```

Caution

For S20, S23 series, the protected port function does not support device stack. That is to say, in the stack environment, if the protected ports are distributed on the different stack member devices, then the protected ports on different devices can communicate with each other, while the protected ports on the same device fail to communicate.

M7600-48GT does not support the protected port configuration.

For S8600 and S12000 series, the destination port of the remote mirroring cannot be configured as the protected port on the RSPAN destination device.

Configuring the Route-deny Between Protected Ports

Command	Function
Ruijie(config)**# protected-ports route-deny**	Set the route-deny between the protected ports.

You can reenable the Layer 3 route between the protected ports using the **no protected-ports route-deny** command in the interface configuration mode.

The following example describes how to disable the Layer 3 route between the protected ports.

```
Ruijie# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)# protected-ports route-deny
Ruijie(config)# end
```

Caution

Only S5750, S8600 and S12000 series support this function.

Showing Protected Port Configuration

Command	Function
Ruijie(config-if)**# show interfaces switchport**	Show the configuration of the switching port

You can use the command of **show interfaces switchport** to view the configuration of protected port.

```
Ruijie# show interfaces gigabitethernet 0/3 switchport
Interface   Switchport  Mode   Access Native Protected   VLAN lists
---------   ----------  ----   ------ ------ ---------   ----
GigabitEthernet 0/3  enabled   Trunk  1   1    Enabled    ALL
```

Port Security

Overview

Port security function allows the packets to enter the switch port by the source MAC address, source MAC+IP address or source IP address. You can control the packets by setting the specific MAC address statically, static IP+MAC binding or IP binding, or dynamically learning limited MAC addresses. The port with port security enabled is named as secure port. Only the packets with the source MAC address in the port security address table, or IP+MAC binding configured, or IP binding configured, or the learned MAC address, can join the switch communication, while other packets are dropped.

Secure port supports Sticky MAC address learning function, which allows the switch to convert the secure dynamic MAC address into a static MAC address. So the device does not need to learn the dynamic MAC address again when the device restarts. However, if the Sticky MAC address function is disabled, the device have to learn the dynamic MAC address again when the device restarts. Use the command **show running-config** to display the configuration.

To enhance security, you can bind the MAC address with the IP address as the secure address. Of course you can also designate the MAC address without binding the IP address.

You can add the secure addresses on the port in the following ways:

- You can manually configure all the secure addresses of the port by using the commands in the interface configuration mode.

- You can also let this port automatically learn these addresses, which will become the secure address on this port till the total number reaches the maximum value. Note that, however, the automatically-learned secure addresses will not be bound with the IP address. On the same port, if you have configured a secure address bound with the IP address, the port cannot be added with any secure address by automatic learning.
- Manually configure some secure addresses, and let the device to learn the rest.

The port security also supports the Sticky MAC address, which can converts the secure addresses learned dynamiclly to the statically configured. You can use the **show running-config** command to display the configuration. With the configuration saved, learning these dynamic secure addresses after restarting the system is unnecessary. If this function is not enabled, then the dynamically learned sercure MAC addresses should be learned again after the reboot.

When a port is configured as a secure port and the maximum number of its secure addresses is reached, a security violation occurs if the port receives a packet whose source address is not one of the secure addresses on the port. When security violations occur, you can set the following methods to handle:

- **protect:** When the maximum number of secure addresses is reached, the secure port discards the packet of unknown addresses (none of which are among the secure addresses of the port).This is the default method for handling exceptions.
- **restrict:** In the case of violation, a Trap notification is sent
- **shutdown:** In the case of violation, the port is shut down and a Trap notification is sent.

Configuring Port Security

Default Configuration of Port Security

The table below shows the default configuration of port security:

Item	Default Configuration
Port security switch	The port security function is disabled for all the ports.
Maximum number of secure addresses	128
Secure address	None
Handling mode for violations	Protect
Secure address binding mode	None
Sticky MAC address learning	Disabled

Caution

For S26 series, without IP binding configured, up to 1024 secure addresses are supported globally; while with IP binding configured, 1000 secure addresses are supported globally. The secure address can also be configured even if the port security is disabled, but it is valid only after the port security is enabled. Besides, once the number of the secure addresses exceeds the maximum value, the excceeding addresses will be invalid.

Port Security Configuration Guide

The following restrictions apply to port security configuration:

- A secure port is not an Aggregate Port.
- A secure port is not the destination port of SPAN.
- A secure port is and can only be an Access Port.

The 802.1x authentication and port security are mutually exclusive in enabling. The 802.1x authentication and port security can ensure the validity of the network users. You can enable either of them to control port access.

At the same time, the secure addresses of the IP+MAC addresses and IP addresses share with the ACLs the hardware resources of the system. Therefore, when you apply the ACLs on one secure port, the IP+MAC addresses and IP addresses on the port can be configured with less secure addresses.

The secure addresses for the same secure port must have the same format, namely either all or none of them are bound with IP addresses. If a security port includes these two types of security addresses at the same time, the secure address not bound with the IP address will fail (the secure address bound with the IP address has a high priority).

Configuration of Secure Ports and Violation Handling Modes

In the interface configuration mode, configure secure ports and violation handling modes by using the following commands:

Command	Function
Ruijie(config-if)# **switchport port-security**	Enable the port security function of this interface.
Ruijie(config-if)# **switchport port-security maximum** *value*	Set the maximum number of secure addresses on the interface. The range is between 1 and 1000 and the default value is 128.
Ruijie(config-if)# **switchport port-security violation**{**protect** | **restrict** | **shutdown**}	Set the violation handling mode: **protect**: Protected port. When the number of secure addresses if full, the security port will discard the packets from unknown address (that is, not any among the secure addresses of the port).

Command	Function
	restrict: In the case of violation, a Trap notification is sent **shutdown**: In the case of violation, the port is shut down and a Trap notification is sent. When a port is closed because of violation, you can recover it from the error status by using the **errdisable recovery** command in the global configuration mode.
Ruijie(config-if)# **switchport port-security mac-address sticky**	Enable the Sticky MAC address learning.

In the interface configuration mode, you can disable the port security function of an interface with the command **no switchport port-security**. Use the command **no switchport port-security maximum** to recover to the default maximum value. Use the command **no switchport port-security violation** to set violation handling to the default mode. Use the command **no switchport port-security mac-address sticky** to set the Sticky MAC address learning to the default mode.

The instance below describes how to enable the port security function on interface gigabitethernet 0/3. The maximum number of addresses to be set is 8 and the violation handling mode is set as protect.

```
Ruijie# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)# interface gigabitethernet 0/3
Ruijie(config-if)# switchport mode access
Ruijie(config-if)# switchport port-security
Ruijie(config-if)# switchport port-security maximum 8
Ruijie(config-if)# switchport port-security violation protect
Ruijie(config-if)# switchport port-security mac-address sticky
Ruijie(config-if)# end
```

Note

1. If the violation mode is modified on the interface, the new violation mode takes effect only after the security port restores to the non-violation state.

Configuration of Secure Addresses on the Secure Port

In the global configuration mode, add secure addresses for secure ports by using the following commands:

Command	Function
Ruijie(config)# **switch portport-security interface** *interface-id* **mac-address** *mac-address*〕**vlan** [*vlan_id*]	In the global configuration mode, manually configure the secure addresses on the port.

In the interface configuration mode, add secure addresses for secure ports by using the following commands:

Command	Function
Ruijie(config-if)# **switchportport-security** ［**mac-address** *mac-address*］ **vlan** [*vlan_id*]	In the interface configuration mode, manually configure the secure addresses on the port.
Ruijie(config-if)# **switchportport-security** ［**mac-address sticky** *mac-address*］ **vlan** [*vlan_id*]	In the interface configuration mode, manually configure the Sticky secure addresses on the port.

In the interface configuration mode, you can use the command **no switchport port-security mac-address** *mac-address* to delete the secure address of this interface. Use the command **no switchport port security sticky mac-address** *mac-address* to delete the Sticky secure address of this interface.

The example below describes how to configure a secure address for interface gigabitethernet 0/3: 00d0.f800.073c and bind it with an IP address: 192.168.12.202.

```
Ruijie# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)# interface gigabitethernet 0/3
Ruijie(config-if)# switchport mode access
Ruijie(config-if)# switchport port-security
Ruijie(config-if)# switchport port-security mac-address 00d0.f800.073c  ip-address
192.168.12.202
Ruijie(config-if)# end
```

The example below describes how to configure a secure address for the Sticky-MAC-learning-enabled interface gigabitethernet 0/3: 00d0.f800.073c.

```
Ruijie# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)# interface gigabitethernet 0/3
Ruijie(config-if)# switchport mode access
Ruijie(config-if)# switchport port-security
Ruijie(config-if)# switchport port-security mac-address sticky
Ruijie(config-if)# switchport port-security mac-address sticky 00d0.f800.073c  vlan 1
Ruijie(config-if)# end
```

Configuration of Secure Address Binding on the Secure Port

In the global configuration mode, add secure address binding for secure ports by using the following commands:

Command	Function
Ruijie(config)# **switchport port-security interface** *interface-id* binding [*mac-address* vlan *vlan_id*] [*ipv4-address*]| [*ipv6-address*]	In the global configuration mode, manually configure the secure addresses binding on the port.

In the interface configuration mode, add secure addresses for secure ports by using the following commands:

Command	Function
Ruijie(config-if)# **switchport port-security binding** [*mac-address* vlan *vlan_id*] [*ipv4-address*]|[*ipv6-address*]	In the interface configuration mode, manually configure the secure addresses binding on the port.

The example below describes how to configure a secure address for interface gigabitethernet 0/3 and bind it with an IP address: 192.168.12.202.

```
Ruijie# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)# interface gigabitethernet 0/3
Ruijie(config-if)# switchport mode access
Ruijie(config-if)# switchport port-security
Ruijie(config-if)# switchport port-security binding 192.168.12.202
Ruijie(config-if)# end
```

The example below describes how to configure a secure address for interface gigabitethernet 0/3 and bind it with an source IP+MAC address: 192.168.12.202, : 00d0.f800.073c.

```
Ruijie# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)# interface gigabitethernet 0/3
Ruijie(config-if)# switchport mode access
Ruijie(config-if)# switchport port-security
Ruijie(config-if)# switchport port-security binding 00d0.f800.073c vlan 1  192.168.12.202
Ruijie(config-if)# end
```

Note

For the packets that correspond to the IP+MAC binding and IP binding, they can be forwarded on the condition that the source MAC address must be the secure address at the same time. For the dynamic secure address, before adding the secure address to the secure address table, any packets that correspond to the secure address binding or IP binding can not be forwarded.

Configuration of Aging Time for Secure Addresses

You can configure the aging time for all the secure addresses on an interface. To enable this function, you need to set the maximum number of secure addresses. In this way, you can make the device automatically add/remove the secure addresses to/from the interface.

In the interface configuration mode, configure the aging time for secure addresses by using the following command:

Command	Function
Ruijie(config-if)**#switchport port-security aging**{**static**	**time** *time* }	**static**: When this keyword is added, the aging time will be applied to both the manually configured secure address and automatically

Command	Function
	learnt addresses. Otherwise, it is applied only to the automatically learnt addresses. **time**: indicates the aging time for the secure address on this port. Its range is 0-1440 and unit is Minute. If you set it to be 0, the aging function actually is disabled. The aging time is the absolute time, which means that an address will be deleted automatically after the *Time* specified expires after the address becomes the secure address of the port. The default value of *Time* is 0.

In the interface configuration mode, use **no switchport port-security aging time** to disable the port security aging. Use the **no switchport port-security aging static** to apply the aging time only to dynamically learned security address.

The example below describes how to configure the port security aging time on interface Gigabitethernet 0/3. The aging time is set to 8 minutes and it is applicable to statically-configured secure addresses:

```
Ruijie# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)# interface gigabitthernet 0/3
Ruijie(config-if)# switchport port-security aging time 8
Ruijie(config-if)# switchport port-security aging static
Ruijie(config-if)# end
```

Caution

The Sticky MAC address is a special MAC address, which is not affected by the aging mechanism. No matter whether the dynamic aging or static aging is configured, the Sticky MAC address will not be aged.

Viewing Port Security Information

In the privileged EXEC mode, you can view the security information of a port by using the following commands.

Command	Function
Ruijie#**show port-security interface** [*interface-id*]	View the port security configuration of an interface.
Ruijie#**show port-security address**	View the secure address information.
Ruijie# **show port-security address** [*interface-id*]	Show the secure address information on an interface.

Command	Function
Ruijie# **show port-security**	Show the statistics of all the security ports, including the maximum number of secure addresses, the number of current addresses, and violation handling mode.

The example below shows the port security configuration on interface **gigabitethernet 0/3**:

```
Ruijie# show port-security interface gigabitethernet 0/3
Interface Gi0/3
Port Security: Enabled
Port status : down
Violation mode:Shutdown
Maximum MAC Addresses:8
Total MAC Addresses:0
Configured MAC Addresses:0
Aging time : 8 mins
SecureStatic address aging : Enabled
```

The instance below shows all the secure addresses in the system.

```
Ruijie# show port-security address
Vlan Mac Address IP Address Type Port Remaining Age(mins)
---------------------------------------- ------------------
1  00d0.f800.073c   192.168.12.202    Configured   Gi0/3    8
1  00d0.f800.3cc9   192.168.12.5     Configured   Gi0/1    7
```

You can also only show the secure address on one interface. The instance below shows the secure address on interface gigabitsethernet 0/3.

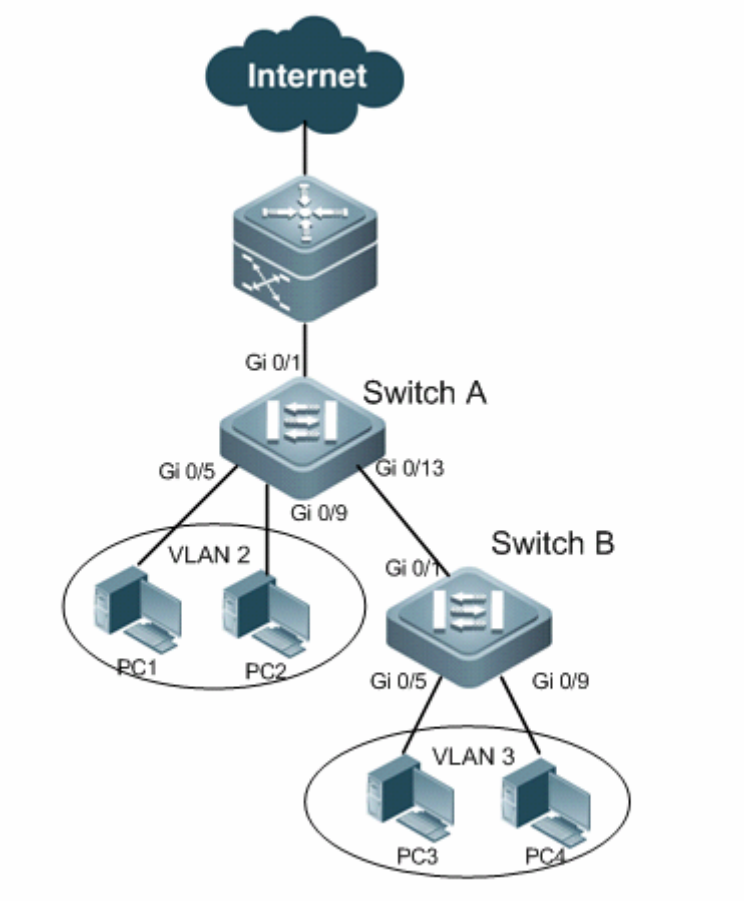
```
Ruijie# show port-security address interface gigabitethernet 0/3
Vlan Mac Address IP Address Type Port Remaining Age(mins)
---- -------------- ---------- ------ ------------------
1   00d0.f800.073c  192.168.12.202 Configured Gi0/3    8
```

The example below shows the statistic information of the secure port.

```
Ruijie# show port-security
Secure Port MaxSecureAddr(count) CurrentAddr(count) Security Action
------- ----------------  ----------------  ------------
Gi0/1      128                1              Restrict
Gi0/2      128                0              Restrict
Gi0/3      8                  1             Protect
```

Example of Port-based Flow Control Combination

Topological Diagram



Network topology

Application Requirements

The above diagram shows the simplified topology of an typical Intranet. The following requirements must be met:

1. Prevent the devices form being attacked by broadcast, multicast and unknown unicast packets.
2. Allow directly connected users (users directly connected to Switch A) to access Internet with the specified IP/MAC address; packets with source address different from the specified IP/MAC address will be discarded to avoid source IP/MAC spoofing.
3. Access users (users accessing Switch B) are not allowed to carry out layer-2 packet communication, so as avoid the mutual interference between access users (such as ARP spoofing or DOS attack).

Configuration Tips

Configuration tips:

1. Enable storm control on the ports of all access devices (Switch A and Switch B).
2. Configure port security feature on the ports (Gi 0/5 and Gi 0/9) of access device (Switch A) to meet the second requirement.
3. Configure port protection on the access device (Switch B) to meet the third requirement.

Note:

After enabling port security and configuring IP/MAC entries, ARP Check will be enabled automatically to check the source address of ARP packets according to the configured IP/MAC address.

Configuration Steps

Configure Switch A

Step 1: Create the VLAN to which the switch belongs and configure port attributes.

! Create VLAN 2

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#vlan 2
Ruijie(config-vlan)#exit
```

! Configure port attributes

```
Ruijie(config)#interface gigabitEthernet 0/5
Ruijie(config-if-GigabitEthernet 0/5)#switchport access vlan 2
Ruijie(config-if-GigabitEthernet 0/5)#exit
Ruijie(config)#interface gigabitEthernet 0/9
Ruijie(config-if-GigabitEthernet 0/9)#switchport access vlan 2
Ruijie(config-if-GigabitEthernet 0/9)#exit
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)#switchport mode trunk
Ruijie(config-if-GigabitEthernet 0/1)#exit
Ruijie(config)#interface gigabitEthernet 0/13
Ruijie(config-if-GigabitEthernet 0/13)#switchport mode trunk
Ruijie(config-if-GigabitEthernet 0/13)#exit
```

Step 2: Enable storm control on all access ports.

```
Ruijie(config)#interface range gigabitEthernet 0/1,0/5,0/9,0/13
Ruijie(config-if-range)#storm-control broadcast
Ruijie(config-if-range)#storm-control multicast
Ruijie(config-if-range)#storm-control unicast
Ruijie(config-if-range)#exit
```

Step 3: Enable port security on the port directly connecting with users and bind the IP address and MAC address

! Bind the access user: IP (1.1.1.1)/MAC (0000.0000.0001)

```
Ruijie(config)#interface gigabitEthernet 0/5
Ruijie(config-if-GigabitEthernet 0/5)#switchport port-security
Ruijie(config-if-GigabitEthernet 0/5)#switchport port-security mac-address 0000.0000.0001
ip-address 1.1.1.1
Ruijie(config-if-GigabitEthernet 0/5)#exit
```

! Bind the access user: IP (1.1.1.2)/MAC (0000.0000.0002)

```
Ruijie(config)#interface gigabitEthernet 0/9
Ruijie(config-if-GigabitEthernet 0/9)#switchport port-security
Ruijie(config-if-GigabitEthernet 0/9)#switchport port-security mac-address 0000.0000.0002
ip-address 1.1.1.2
Ruijie(config-if-GigabitEthernet 0/9)#exit
```

Configure Switch B

Step 1: Create the VLAN to which the switch belongs and configure port attributes.

! Create VLAN 3

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#vlan 3
Ruijie(config-vlan)#exit
Ruijie(config)#interface gigabitEthernet 0/5
Ruijie(config-if-GigabitEthernet 0/5)#switchport access vlan 3
Ruijie(config-if-GigabitEthernet 0/5)#exit
Ruijie(config)#interface gigabitEthernet 0/9
Ruijie(config-if-GigabitEthernet 0/9)#switchport access vlan 3
Ruijie(config-if-GigabitEthernet 0/9)#exit
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)#switchport mode trunk
Ruijie(config-if-GigabitEthernet 0/1)#exit
```

Step 2: Enable storm control on all access ports.

```
Ruijie(config)#interface range gigabitEthernet 0/1,0/5,0/9
Ruijie(config-if-range)#storm-control broadcast
Ruijie(config-if-range)#storm-control multicast
Ruijie(config-if-range)#storm-control unicast
Ruijie(config-if-range)#exit
```

Step 3: Enable port protection on all access ports.

```
Ruijie(config)#interface gigabitEthernet 0/5
Ruijie(config-if-GigabitEthernet 0/5)#switchport protected
```

```
Ruijie(config-if-GigabitEthernet 0/5)#exit
Ruijie(config)#interface gigabitEthernet 0/9
Ruijie(config-if-GigabitEthernet 0/9)#switchport protected
Ruijie(config-if-GigabitEthernet 0/9)#exit
```

Verification

Step 1: Check the configurations of Switch A. Key points: whether storm control has been enabled on respective ports, whether port security has been enabled on the port directly connecting with users and whether IP+MAC addresses have been bound statically.

```
Ruijie#show running-config
vlan 2
!
interface GigabitEthernet 0/1
 switchport mode trunk
 storm-control broadcast
 storm-control multicast
 storm-control unicast
!
interface GigabitEthernet 0/5
 switchport access vlan 2
 switchport port-security mac-address 0000.0000.0001 ip-address 1.1.1.1
 switchport port-security
 storm-control broadcast
 storm-control multicast
 storm-control unicast
!
interface GigabitEthernet 0/9
 switchport access vlan 2
 switchport port-security mac-address 0000.0000.0002 ip-address 1.1.1.2
 switchport port-security
 storm-control broadcast
 storm-control multicast
 storm-control unicast
!
interface GigabitEthernet 0/13
 switchport mode trunk
 storm-control broadcast
 storm-control multicast
 storm-control unicast
```

Step 2: Check the configurations of Switch B. Key points: whether storm control has been enabled on respective ports, and whether port protection has been enabled on the port directly connecting with users.

```
Ruijie#show running-config
```

```
vlan 3
!
interface GigabitEthernet 0/1
 switchport mode trunk
 storm-control broadcast
 storm-control multicast
 storm-control unicast
!
interface GigabitEthernet 0/5
 switchport access vlan 3
 switchport protected
 storm-control broadcast
 storm-control multicast
 storm-control unicast
!
interface GigabitEthernet 0/9
 switchport access vlan 3
 switchport protected
 storm-control broadcast
 storm-control multicast
 storm-control unicast
```

Step 3: View address bindings on the ports of Switch A and ARP check enabling state.

```
Ruijie#show port-security all
Vlan Port  Arp-Check  Mac Address IP Address  Type remaining Age (mins)
---- -------- ---------- -------------- --------------
2    Gi0/5 Enabled  0000.0000.0001 1.1.1.1   Configured      -
2    Gi0/9 Enabled  0000.0000.0002 1.1.1.2   Configured     -
```

Step 4: View port security configurations on GigabitEthernet 0/5 of Switch B. Port security configurations on other ports won't be further introduced.

```
Ruijie#show interfaces gigabitEthernet 0/5 switchport
Interface   Switchport Mode    Access Native Protected VLAN lists
----------------------- ---------- --------- ------ ------
GigabitEthernet0/5 enabled ACCESS   3   1    Enabled   ALL
```

Limiting the Number of Access IPs on the Port

- Overview
- Default configurations to limit the number of access IPs on the port
- Configure the maximum number of access IPs on the port
- Display the number of access IPs on the port

Overview

Ruijie switches support multiple access control applications (such as: IP Source Guard, port security, global IP+MAC binding and etc). These port access applications implement access control through the source IP address of the user in order to filter IP packets and prevent invalid users from using network resources.

The feature of limiting the number of access IPs on the port is intended to limit the number of access IPs bound by these secure access applications on the port, so as to limit the number of users sharing the port bandwidth of switch.

You can configure the number of IP addresses allowed to access network for each port. If the number of IP addresses bound by respective access applications on the port hasn't reached the configured threshold, the access applications shall be able to further bind and add valid users; if the number of IP addresses has reached the configured threshold, the access applications won't be able to further bind valid users.

If the number of IP addresses under the port has exceeded the configured threshold, the excessive IP addresses won't be allowed to pass through.

Caution

1. Limiting the number of access IPs on the port will take effect only if IP+MAC bindings or IP bindings of access control applications have taken effect. If no access application has been configured on the port (or if the port is the excluded port of global IP+MAC bindings), the limiting won't take effect.
2. When a same IP address is bound by IP+MAC binding and IP binding, it will be treated as two user IPs.
3. The access IP limiting only applies to IPv4 packets.
4. Except for the excluded port of global IP+MAC binding, the users added via global IP+MAC binding will be included into the number of IP addresses limited on each port.

Default Configurations to Limit the Number of Access IPs on the Port

The following table shows the default configurations to limit the number of access IPs on the port

Function	Default Setting
Limiting the number of access IPs on the port	This feature is disabled on all ports. The default value is 0.

Configuring the Maximum Number of Access IPs on the Port

In privileged EXEC mode, configure the maximum number of access IPs on the port:

Command	Function

Command	Function
Ruijie# configure	Enter configuration mode
Ruijie(config)#interface interface-id	Enter interface mode
Ruijie(config-if)#nac-author-user maximum value	Configure the maximum number of access IPs on the port
Ruijie(config-if)**#no nac-author-user maximum**	Disable the maximum number of access IPs on the port

Displaying the Number of Access IPs on the Port

You can view the maximum number of access IPs configured on the port and the number of IP address bindings:

Command	Function
Ruijie**#show nac-author-user**	Display the maximum number of access IPs on the port and the number of IP address bindings.

As shown below:

```
Ruijie#show nac-author-user
 Port     Cur_num  Max_num
 --------  -------  -------
 Fa0/1    2        50
 Fa0/2    0        0
 Fa0/3    2        100
 Fa0/4    0        0
 Fa0/5    0        200
 Fa0/6    0        0
 Fa0/7    0        0
 Fa0/8    0        0
```

Configuring NAT

NAT Overview

Before Network Address Translation (NAT) configuration, it is necessary to understand the allocation of internal local addresses and internal global addresses. Perform the following configuration tasks according to different requirements.

Configuring Static NAT for Internal Source Addresses

To enable an internal network to communicate with an external network, you need to configure NAT to translate internal private IP addresses into a globally unique IP address. In this case, you can choose to configure static NAT or dynamic NAT or even both of them.

Static NAT is to establish a one-to-one permanent mapping between internal local addresses and internal global addresses. It is necessary when an external network uses a fixed global address to access hosts on an internal network. To configure static NAT, run the following commands in global configuration mode:

Command	Function
Ruijie(config)# **ip nat inside source static** *local-address global-address* [**permit-inside**] [**vrf** vrf_*name*]	Defines the static translation relationship of internal source addresses.
Ruijie(config)# **interface** *interface-type interface-number*	Enters interface configuration mode.
Ruijie(config-if)# **ip nat inside**	Defines the internal network the interface connects to.
Ruijie(config)# **interface** *interface-type interface-number*	Enters interface configuration mode.
Ruijie(config-if)# **ip nat outside**	Defines the external network the interface connects to.

The above configuration is the simplest one. You may configure several inside and outside interfaces.

Dynamic NAT is to establish a temporary mapping between internal local addresses and the internal global address pool, which will be deleted after a while. To configure dynamic NAT, run the following commands in global configuration mode:

Command	Function
Ruijie(config)# **ip nat pool** *address-pool start-address end-address* {**netmask** *mask* | **prefix-length** *prefix-length*}	Defines a global IP address pool.
Ruijie(config)# **access-list** *access-list-number* **permit** *ip-address wildcard*	Defines an ACL. Only the IP addresses that match the ACL are translated.
Ruijie(config)# **ip nat inside source list** *access-list-number* **pool** *address-pool* [**vrf** vrf_*name*]	Defines the dynamic translation relationship of internal source addresses.
Ruijie(config)# **interface** *interface-type interface-number*	Enters interface configuration mode.
Ruijie(config-if)# **ip nat inside**	Defines the internal network the interface connects to.

Command	Function
Ruijie(config)# **interface** *interface-type interface-number*	Enters interface configuration mode.
Ruijie(config-if)# **ip nat outside**	Defines the external network the interface connects to.

Note

Only source addresses that match the ACL are translated. Note that the last rule of the ACL contains a deny any statement. The ACL should not permit a wide range of IP addresses to be translated; otherwise, unexpected results will be received.

Configuring NAPT for Internal Source Addresses

Traditional NAT generally defines a one-to-one mapping and cannot enable all hosts on an internal network to communicate with an external network. NAPT allows multiple internal local addresses to be mapped to an internal global address.

NAPT is classified into static NAPT and dynamic NAPT. Static NAPT maps the designated port of a designated internal host to a designated global port, whereas static NAT maps an internal address to a global address.

To configure static NAPT, run the following commands in global configuration mode:

Command	Function
Ruijie(config)# **ip nat inside source static** {**UDP** | **TCP**} *local-address port global-address port* [**permit-inside**] [**vrf** vrf_*name*]	Defines the static translation relationship of internal source addresses.
Ruijie(config)# **interface** *interface-type interface-number*	Enters interface configuration mode.
Ruijie(config-if)# **ip nat inside**	Defines the internal network the interface connects to.
Ruijie(config)# **interface** *interface-type interface-number*	Enters interface configuration mode.
Ruijie(config-if)# **ip nat outside**	Defines the external network the interface connects to

Dynamic internal source address translation mentioned in previous section has automatically completed the internal source address dynamic NAPT and the configuration is to run the following command in global configuration mode.

Command	Function
Ruijie(config)# **ip nat pool** *address-pool start-address end-address* {**netmask** *mask* | **prefix-length** *prefix-length*}	Defines a global IP address pool. For NAPT, only one IP address is defined.
Ruijie(config)# **access-list** *ccess-list-number* **permit** *ip-address* **wildcard**	Defines an ACL. Only the IP addresses that match the ACL are translated.

Command	Function
Ruijie(config)# **ip nat inside source list** *access-list-number* {[**pool** *address-pool*] | [**interface** *interface-type interface-number*]} **overload** [**vrf** vrf_*name*]	Defines the dynamic translation relationship of source address. The translation effect is the same with or without overload, which is only for compatibility with mainstream manufacturers.
Ruijie(config)# **interface** *interface-type interface-number*	Enters interface configuration mode.
Ruijie(config-if)# **ip nat inside**	Defines the internal network the interface connects to.
Ruijie(config)# **interface** *interface-type interface-number*	Enters interface configuration mode.
Ruijie(config-if)# **ip nat outside**	Defines the external network the interface connects to.

NAPT may use the IP addresses in the address pool or directly uses the IP address of the interface. Generally, one address is enough to meet the address translation need of a network and can be translated into up to 64,512 addresses. In case of insufficient addresses, you can add IP addresses to the address pool.

Configuring NAT Overlap

Address Overlapping refers to the fact that two private networks in need of interconnection are allocated the same IP address or one private network and public network are allocated the same global IP address. Communication is impossible between two network hosts with overlapping addresses since they deem their counterparts are in the local network. NAT overlap is configured to solve this problem by presenting the address of external network host as that of another network host and vice versa.

NAT Overlap configuration is actually divided into two parts: 1) Internal source address translation configuration; and 2) External source address translation configuration, which is only needed by an external network that has addresses overlapped with the inner network. Static NAT or dynamic NAT may be adopted for external source address translation.

To configure static NAT for external source addresses, run the following command in global configuration mode:

Command	Function
Ruijie(config)# **ip nat outside source static** *global-address local-address* [vrf vrf_*name*]	Defines the static translation relationship of external source addresses.
Ruijie(config)# **interface** *interface-type interface-number*	Enters interface configuration mode.
Ruijie(config-if)# **ip nat inside**	Defines the internal network the interface connects to.
Ruijie(config)# **interface** *interface-type interface-number*	Enters interface configuration mode.
Ruijie(config-if)# **ip nat outside**	Defines the external network the interface connects to.

☑ NPE80 does not support NAT overlap.

Configuring TCP Load Balancing

When TCP traffic overload is detected on an internal host, more hosts can be deployed to balance the TCP traffic. In this case, you may use NAT for TCP traffic load balancing. NAT creates a virtual host, which corresponds to several real hosts,

to provide TCP services, so that destination addresses are polled for load balancing. To configure destination address polling, run the following commands in global configuration mode:

Command	Function
Ruijie(config)# **ip nat pool** *address-pool start-address end-address* {**netmask** *mask* | **prefix-length** *prefix-length*}	Defines an IP address pool. The IP addresses of all real hosts are included in the pool.
Ruijie(config)# **access-list** *access-list-number permit ip-address* **wildcard**	Defines an ACL to match the IP address of a virtual host. The ACL should be an extended ACL used to match destination IP addresses.
Ruijie(config)# **ip nat inside destination list** *access-list-number* **pool** *address-pool* [**vrf** vrf_*name*]	Defines the dynamic translation relationship of internal destination addresses.
Ruijie(config)# **interface** *interface-type* *interface-number*	Enters interface configuration mode.
Ruijie(config-if)# **ip nat inside**	Defines the internal network the interface connects to.
Ruijie(config)# **interface** *interface-type interface-number*	Enters interface configuration mode.
Ruijie(config-if)# **ip nat outside**	Defines the external network the interface connects to.

☑ NPE80 does not support TCP load balancing.

NAT Configuration Examples

Dynamic translation of internal source addresses

In the following configuration, local and global addresses are allocated from the NAT address pool of Net200, which defines the address range from 200.168.12.2 to 200.168.12.100. A NAT entry is created only when a packet whose internal source address matches ACL 1.

```
!
interface FastEthernet 0/0
ip address 192.168.12.1 255.255.255.0
ip nat inside
!
interface FastEthernet 1/0
ip address 200.168.12.1 255.255.255.0
ip nat outside
!
ip nat pool net200 200.168.12.2 200.168.12.100 netmask 255.255.255.0
ip nat inside source list 1 pool net200
!
access-list 1 permit 192.168.12.0 0.0.0.255
```

Reuse of internal global addresses

Reuse of internal global address is equivalent to NAPT actually. RGOS 8.1 and later versions automatically implement NAPT for dynamic NAT. In the following configuration, local and global addresses are allocated from NAT address pool—Net200, which only defines one IP address 200.168.12.200 that can be reused. A NAT entry is created only when a packet whose internal source address matches ACL 1.

```
!
interface FastEthernet 0/0
ip address 192.168.12.1 255.255.255.0
ip nat inside
!
interface FastEthernet 1/0
ip address 200.168.12.200 255.255.255.0
ip nat outside
!
ip nat pool net200 200.168.12.200 200.168.12.200 netmask 255.255.255.0
ip nat inside source list 1 pool net200
access-list 1 permit 192.168.12.0 0.0.0.255
Whether correct NAT entries can be created can be checked by looking up the NAT mapping table.
Ruijie# show ip nat translations
Pro Inside global  Inside local  Outside local  Outside global
tcp 200.168.12.200:2063 192.168.12.65:2063 168.168.12.1:23 168.168.12.1:23
```

Static NAPT for Internal Source Addresses

Static NAPT may be used for creating a virtual server.Creating a virtual server here refers to setting up a server and mapping it to an external network through static NAPT. Thus, access to the virtual server with a global address is diverted to an internal server.

The following example describes how to map IP address 192.168.12.3 of an internal web server to a global IP address 200.198.12.1 of port 80. The configuration script is as follows:

```
!
interface FastEthernet 0/0
ip address 192.168.12.1 255.255.255.0
ip nat inside
!
interface FastEthernet 1/0
ip address 200.198.12.1 255.255.255.0
ip nat outside
!
ip nat inside source static tcp 192.168.12.3 80 200.198.12.1 80
```

For details, see the “Configuring a local server” section.

TCP Load Balancing

A virtual host address is defined in the following configuration so that all TCP connections to this virtual host from external networks will be processed by multiple real hosts for load balancing. **Realhosts** defines a real host address pool, while ACL 1 defines the IP address of the virtual host. Traffic from hosts on an external network must be routed to this virtual host. The following configuration applies only to TCP traffic. Note that an extended ACL must be configured to match destination IP addresses.

```
!
interface FastEthernet 0/0
ip address 10.10.10.1 255.255.255.0
ip nat inside
!
interface FastEthernet 1/0
ip address 200.198.12.1 255.255.255.0
ip nat outside
!
ip nat pool realhosts 10.10.10.2 10.10.10.3 netmask 255.255.255.0 type rotary
ip nat inside destination list 100 pool realhosts
!
access-list 100 permit ip any host 10.10.10.100
!
```

Whether correct NAT entries can be created can be checked by looking up the NAT mapping table.

```
Ruijie# sh ip nat translations
Pro Inside global Inside local Outside local  Outside global
tcp 10.10.10.100:23 10.10.10.2:23 100.100.100.100:1178 100.100.100.100:1178
tcp 10.10.10.100:23 10.10.10.3:23 200.200.200.200:1024 200.200.200.200:1024
```

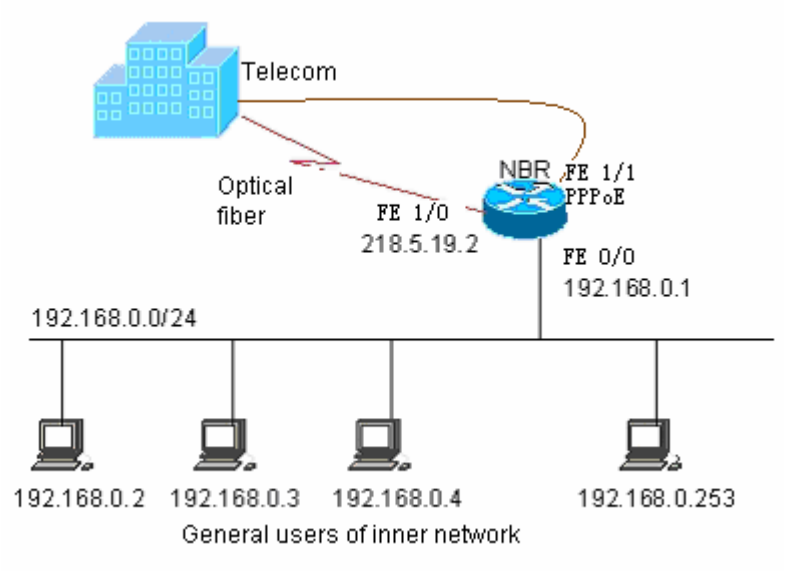
Load balancing among multiple outside interfaces

If several WAN ports of a device are used as outside interfaces, load is balanced among these WAN ports by bandwidth. When one WAN port is faulty, the load will be automatically routed to other normal ports. By default, the load is distributed according to global destination addresses of NAT. In the following example, load is balanced between two WAN ports of a RSR series router.

96) Interface GigabitEthernet 0/0 connects to a telecom network.
97) Interface GigabitEthernet 0/1 connects to the education network.

The topology is as follows:

Figure 5



The configuration is as follows:

```
!
```

Configure an ACL to allow internal network users to access internet.

```
access-list 99 permit 192.168.0.0 0.0.0.255
```

Configure GigabitEthernet 0/2 to connect to the internal network..

```
interface GigabitEthernet 0/2
ip nat inside
ip address 10.29.0.253 255.255.255.0
!
```

Configure a static IP address for WAN port 0 which connects to the telecom network.

```
interface GigabitEthernet 0/0
ip nat outside
ip address 218.4.53.238 255.255.255.0
!
```

WAN port 1 connects to the education network.

```
interface GigabitEthernet 0/1
ip nat outside
ip address 172.16.253.18 255.255.255.0
!
```

Configure a NAT address pool. NAT provides multiple Outside ports. If GigabitEthernet 0/0 is configured as the Outside port, the IP address of the port is set to 218.4.53.238; if GigabitEthernet 0/1 is configured as the Outside port, the IP address of the port is set to 172.16.253.18.

```
ip nat pool setup_build_pool prefix-length 24
address 61.155.18.17 61.155.18.18 match interface GigabitEthernet 0/0
```

```
address 210.28.160.100 210.28.160.110 match interface GigabitEthernet 0/1
```

Enable internal source address translation of NAT

```
ip nat inside source list 99 pool nbr_setup_build_pool
```

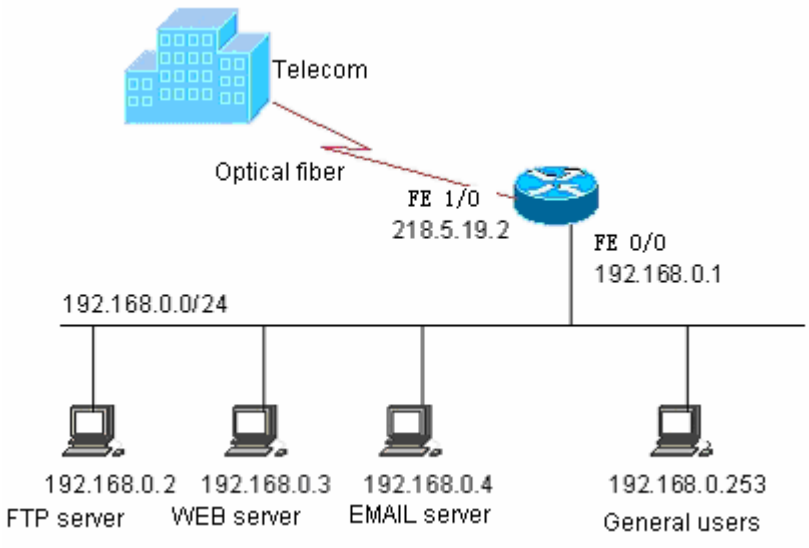
Configure that traffic is routed to two WAN ports by default.

```
ip route 0.0.0.0 0.0.0.0 FastEthernet 1/0 202.101.98.1
ip route 0.0.0.0 0.0.0.0 dialer 1
!
```

Configuring a local server

To configure a local server means to map one or more hosts to a network access server (NAS), so that users on the WAN can access desired services. As shown in Figure 6, three servers (an FTP server, a web server, and an E-mail server) are deployed on the internal network. It is expected that hosts on the WAN can access the three servers and common users of the internal network can access Internet by using the gateway as a NAS. For Ruijie products, static NAT is used for server access and dynamic NAT is used for Internet access.

Figure 6 Configuring a local server



To realize these functions, static NAT needs to be configured.

Enter privileged user mode

```
Ruijie> enable
```

Enter global configuration mode

```
Ruijie# config terminal
Enter configuration commands, one per line. End with CNTL/Z.
```

Enter WAN port 0 configuration mode

```
Ruijie(config)#interface fastethernet 1/0
```

Configure the IP address of the WAN port

```
Ruijie(config-if)# ip address 218.5.19.2 255.255.255.0
```

Configure the WAN port as the connection-sharing Internet access port

```
Ruijie(config-if)# ip nat outside
```

Enable the WAN port

```
Ruijie(config-if)# no shut
```

Return to common user mode

```
Ruijie(config-if)# end
Ruijie#
```

The system prompts that the link to the WAN port is Up.

```
%LINK CHANGED: Interface FastEthernet 1/0, changed state to up
%LINE PROTOCOL CHANGE: Interface FastEthernet 1/0, changed state to UP
Ruijie# config terminal
Enter configuration commands, one per line. End with CNTL/Z.
```

Enter LAN port configuration mode

```
Ruijie(config)# interface fastethernet 0/0
```

Configure the IP address of the LAN port

```
Ruijie(config-if)# ip address 192.168.0.1 255.255.255.0
```

Configure the LAN port as the connection-sharing internet access port

```
Ruijie(config-if)# ip nat inside
```

Enable the LAN port

```
Ruijie(config-if)# no shut
Ruijie(config-if)# end
Ruijie#
%LINK CHANGED: Interface FastEthernet 0/0, changed state to up
%LINE PROTOCOL CHANGE: Interface FastEthernet 0/0, changed state to UP
Ruijie# config terminal
Enter configuration commands, one per line. End with CNTL/Z.
```

Configure default route to access to internet

```
Ruijie(config)# ip route 0.0.0.0 0.0.0.0 fastethernet 1/0 218.5.19.1
```

Configure a default route for Internet access

```
Ruijie(config)# ip route 0.0.0.0 0.0.0.0 fastethernet 1/0 218.5.19.1
```

Configure an ACL for NAT application

```
Ruijie(config)# access-list 1 permit any
```

Configure a connection sharing rule to allow common internal users to access Internet over a device

```
Ruijie(config)#ip nat inside source list 1 interface fastethernet 1/0
```

Configure static mapping of the FTP server

```
Ruijie(config)# ip nat inside source static tcp 192.168.0.2 20 218.5.19.2 20
Ruijie(config)# ip nat inside source static tcp 192.168.0.2 21 218.5.19.2 21
```

Configure static mapping of the web server

```
Ruijie(config)# ip nat inside source static tcp 192.168.0.3 80 218.5.19.2 80
```

Configure static mapping of the E-mail server

```
Ruijie(config)# ip nat inside source static tcp 192.168.0.4 25 218.5.19.2 25
Ruijie(config)# ip nat inside source static tcp 192.168.0.4 110 218.5.19.2 110
Ruijie(config)# end
Ruijie#
Ruijie# config terminal
Enter configuration commands, one per line. End with CNTL/Z.
```

Configure a password for Telnet access

```
Ruijie(config)# line vty 0 4
Ruijie(config-line)# password remoteuser
Ruijie(config-line)# end
Ruijie#
Ruijie# config terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)# enable secret private
```

Configure a device name

```
Ruijie(config)# host RUIJIE
RUIJIE(config)# end
RUIJIE#
```

Save the configuration

```
RUIJIE# write
Building configuration...
[OK]
RUIJIE#
```

Verify the configuration

```
RUIJIE# show running-config
Building configuration...
Current configuration:
!
!
hostname NBR
!
```

```
!
!
access-list 1 permit any
!
!
interface FastEthernet 0/0
ip address 192.168.0.1 255.255.255.0
ip nat inside
!
interface FastEthernet 1/0
ip address 218.5.19.2 255.255.255.0
ip nat outside
!
ip nat inside source list 1 interface FastEthernet 1/0
ip nat inside source static tcp 192.168.0.4 110 218.5.19.2 110
ip nat inside source static tcp 192.168.0.4 25 218.5.19.2 25
ip nat inside source static tcp 192.168.0.3 80 218.5.19.2 80
ip nat inside source static tcp 192.168.0.2 21 218.5.19.2 21
ip nat inside source static tcp 192.168.0.2 20 218.5.19.2 20
!
ip route 0.0.0.0 0.0.0.0 FastEthernet 1/0 218.5.19.1
!
line con 0
line vty 0 4
password remoteuser
login
!
end
RUIJIE#
```

NAT Configuration in case of multiple VRF instances

The following example shows the NAT implementation when there are multiple VRF instances. An IP address may be found in different VRF instances and needs to be translated into different source IP addresses during NAT. In this case, you must specify the target VRF domain of NAT.

```
access-list 1 permit 192.168.12.0 0.0.0.255

ip vrf 1

ip vrf 2

interface FastEthernet 0/0
ip vrf forward 1
ip address 192.168.12.1 255.255.255.0
ip nat inside
```

```
!
interface FastEthernet 0/1
ip vrf forward 1
ip address 100.168.12.200 255.255.255.0
ip nat outside
!
interface FastEthernet 1/0
ip vrf forward 2
ip address 192.168.12.1 255.255.255.0
ip nat inside
!
interface FastEthernet 1/1
ip vrf forward 2
ip address 200.168.12.200 255.255.255.0
ip nat outside
!
ip nat pool net100 100.168.12.200 100.168.12.200 netmask 255.255.255.0
ip nat pool net200 200.168.12.200 200.168.12.200 netmask 255.255.255.0

ip nat inside source list 1 pool net100 vrf 1
ip nat inside source list 1 pool net200 vrf 2
```

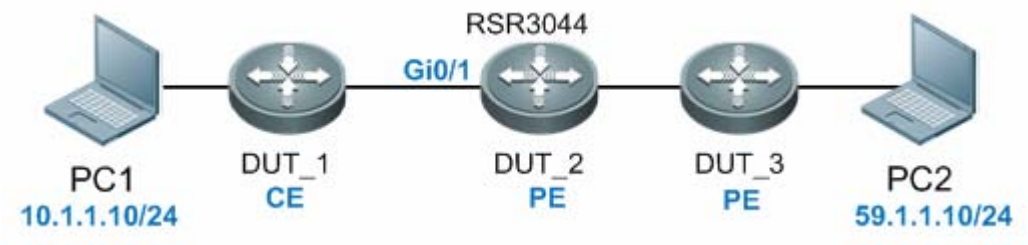
Whether correct NAT entries can be created can be checked by looking up the NAT mapping table.

```
Ruijie# show ip nat translations vrf 1
Pro Inside global  Inside local  Outside local  Outside global
tcp 100.168.12.200:2063 192.168.12.65:2063 168.168.12.1:23 168.168.12.1:23
Ruijie# show ip nat translations vrf 2
Pro Inside global  Inside local  Outside local  Outside global
tcp 200.168.12.200:2063 192.168.12.65:2063 168.168.12.1:23 168.168.12.1:23
```

VPN NAT configuration example

On a MPLS network, NAT can be used to implement VRF traversal.

Figure 7



Configure MPLS

```
mpls ip
```

Configure PBR

```
route-map vrfdata permit 10
 match ip address 150
 set vrf data
```

Specify an ACL

```
ip access-list extended 100
 10 permit ip 10.0.0.0 0.255.255.255 any
ip access-list extended 150
 10 permit ip any 20.1.1.0 0.0.0.255
```

Configure VRF domains

```
ip vrf data
 rd 200:1
 route-target both 200:1
ip vrf v1
 rd 100:1
 route-target export 100:1
ip vrf v2
 rd 100:2
 route-target export 100:2
```

Deploy MPLS on a public network interface

```
interface GigabitEthernet 0/0
 ip nat outside
 ip ref
 ip address 10.3.1.3 255.255.255.0
 label-switching
 mpls ip
 duplex auto
 speed auto
```

Configure PBR on a private network interface for NAT deployment

```
interface GigabitEthernet 0/1
 ip vrf forwarding v1
 ip nat inside
 ip policy route-map vrfdata
 ip ref
 ip address 10.1.1.1 255.255.255.0
 duplex auto
 speed auto
interface GigabitEthernet 0/1.1
 encapsulation dot1Q 100
 ip vrf forwarding v2
 ip nat inside
```

```
 ip policy route-map vrfdata
 ip address 10.1.1.1 255.255.255.0
```

Configure the loopback interface for advertising routes

```
interface Loopback 0
 ip ref
 ip address 3.3.3.3 255.255.255.255
router bgp 100
 bgp router-id 3.3.3.3
 bgp log-neighbor-changes
 neighbor 4.4.4.4 remote-as 100
 neighbor 4.4.4.4 update-source Loopback 0
address-family ipv4
 neighbor 4.4.4.4 activate
 exit-address-family
address-family vpnv4 unicast
 neighbor 4.4.4.4 activate
 neighbor 4.4.4.4 send-community both
 neighbor 4.4.4.4 route-map hzb out
 exit-address-family
address-family ipv4 vrf data
 maximum-prefix 10000
 network 0.0.0.0
 redistribute connected
 redistribute static
 exit-address-family
address-family ipv4 vrf v1
 maximum-prefix 10000
 redistribute static
 exit-address-family
address-family ipv4 vrf v2
 maximum-prefix 10000
 exit-address-family
router ospf 1
 router-id 3.3.3.3
 network 0.0.0.0 255.255.255.255 area 0
mpls router ldp
 ldp router-id interface Loopback 0 force
```

Configure NAT to take effect on VRF data packets

```
ip nat pool abc 100.1.1.1 100.1.1.1 netmask 255.255.255.0
ip nat inside source static 10.1.1.2 100.1.1.1 vrf data
```

Specify a blackhole route

```
ip route vrf data 100.1.1.1 255.255.255.255 Null 0
```

Configuring SSH Terminal Service

Overview of SSH

A Secure Shell (SSH) connection functions like a Telnet connection, except that all transmissions based on the connection are encrypted. When a user logs in to the device from an insecure network, the SSH feature provides information security guarantee and powerful authentication function to protect the devices from IP spoofing, plain password interception and other kinds of attacks.

Ruijie SSH service supports both the IPv4 and IPv6 protocols.

SSH Algorithms Supported by Ruijie Products

Supported Algorithm	SSH1	SSH2
Signature authentication algorithm	RSA	RSA, DSA
Key exchange algorithm	RSA public key encryption based key exchange algorithm	KEX_DH_GEX_SHA1 KEX_DH_GRP1_SHA1 KEX_DH_GRP14_SHA1
Encryption algorithm	DES, 3DES, Blowfish	DES, 3DES, AES-128, AES-192, AES-256
User authentication algorithm	User password based authentication method	User password based authentication method
Message authentication algorithm	Not supported	MD5, SHA1, SHA1-96, MD5-96
Compression algorithm	NONE	NONE

SSH Configuration

Default SSH Configurations

Item	Default Value
SSH server status	Off
SSH version	Compatible mode (supporting versions 1 and 2)
SSH user authentication timeout period	120s
SSH user re-authentication times	3

Configuring User Authentication

- Considering the SSH connection security, the login without authentication is forbidden. Therefore, in the login authentication of the users, the login authentication mode must have password configured (authentication-free login allowed for telnet).
- The username and password entered every time must be set. If the current authentication mode does not need the username, the username can be entered randomly but the length must be greater than zero.

Enabling SSH Server

The SSH Server is disabled by default. To enable the SSH Server, run the **enable service ssh-server** command in global configuration mode while generating a SSH key.

Command	Description
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **enable service ssh-server**	Enables the SSH Server.
Ruijie(config)# **crypto key generate** {**rsa**|**dsa**}	Generates a key

Caution To delete a key, use the crypto key zeroize command rather than the [no] crypto key generate command. The SSH module does not support hot standby. For products supporting management module hot standby, after the management module is switched over, if the current primary board has no SSH key file, the crypto key generate command must be used to regenerate a key in order to use SSH.

Shutting Down the SSH Server

To disable the SSH Server, run the **no enable service ssh-server** command in global configuration mode:

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **no enable service ssh-server**	Disables the SSH Server.

Configuring the Supported SSH Server Version

By default, the SSHv1 and SSHv2 are compatible. Run the following commands to configure the SSH version.

Command	Function
Ruijie# **configure terminal**	Enters configuration mode.
Ruijie(config)# **ip ssh version** {**1	2**}	Configures the supported SSH version.
Ruijie(config)# **no ip ssh version**	Restore the default SSH version. By default, SSHv1 and SSHv2 are supported.

Configuring SSH User Authentication Timeout Period

By default, the user authentication timeout period of the SSH server is 120 seconds. Run the following commands to configure the SSH user authentication timeout period.

Command	Function
Ruijie# **configure terminal**	Enters configuration mode.
Ruijie(config)# **ip ssh time-out** *time*	Configures the SSH timeout period (ranging from 1 to 120 seconds).
Ruijie(config)# **no ip ssh time-out**	Restores the default SSH user authentication timeout period to 120 seconds.

Configuring SSH Re-authentication Times

This command is used to set the authentication attempts for SSH users requesting connections to prevent illegal actions such as malicious guesswork. By default, three authentication attempts can be made for the SSH Server. In other words, it allows the user to enter the username and password for three times to attempt the authentication. Run the following commands to configure the SSH re-authentication times:

Command	Function
Ruijie# **configure terminal**	Enters configuration mode.
Ruijie(config)# **ip ssh authentication-retries** *retry times*	Configures SSH re-authentication times (ranging from 0 to 5).
Ruijie(config)# **no ip ssh authentication-retries**	Restores the default SSH re-authentication times to 3.

Caution For details of the preceding commands, see SSH Command Reference Manual.

Configuring SSH Public Key Based Authentication

Only the version 2 of the SSH protocol supports public key based authentication. The following commands associate a public key file with a username. When processing client authentication, the sever use a designated public key file according to the username of the client.

Command	Function
Ruijie# configure terminal	Enters configuration mode.
Ruijie(config)# **ip ssh peer** *test* **public-key rsa flash**:*rsa.pub*	Configures the RSA public key file that associated with the username *test*.
Ruijie(config)# ip ssh peer *test* **public-key dsa flash**:*dsa.pub*	Configures the DSA public key file that associated with the username *test*.

Configuring the SCP Server Function

With the SCP server enabled on a network device, the user can directly download files from the network device and upload local files to the network device. Meanwhile, the user can transfer all interactive data in encrypted text manner, featuring authentication and security.

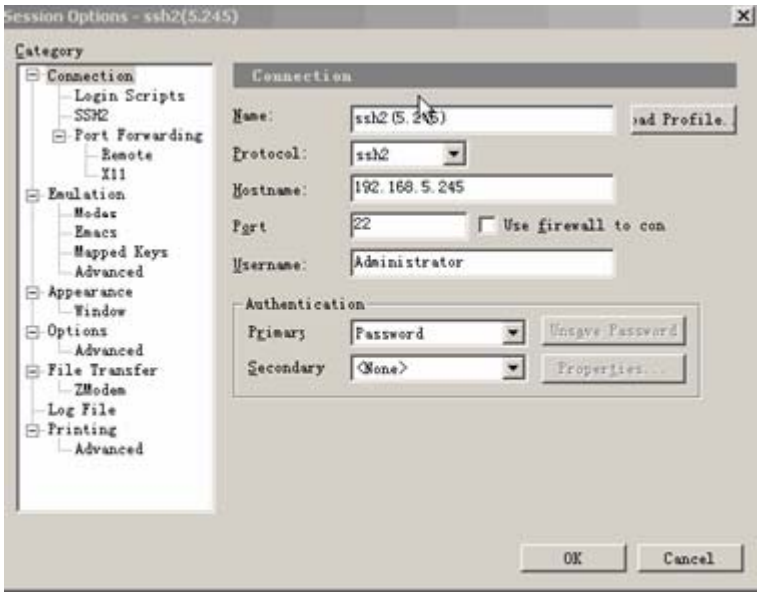
Command	Function
Ruijie# **configure terminal**	Enters configuration mode..
Ruijie(config)#**ip scp server enable**	Enable the SCP server function.
Ruijie(config)# **no ip scp server enable**	Disable the SCP server function.

Note For details of the above commands, see *SSH Command Reference Manual*.

Using SSH for Device Management

You may use SSH for device management after enabling the SSH Server function that is disabled by default. Since Telnet that comes with the Windows does not support SSH, third-party client software must be used. Currently, the clients with sound forward compatibility include Putty, Linux and SecureCRT. With the client software SecureCRT as an example, the SSH client configuration is described as follows (see the UI below):

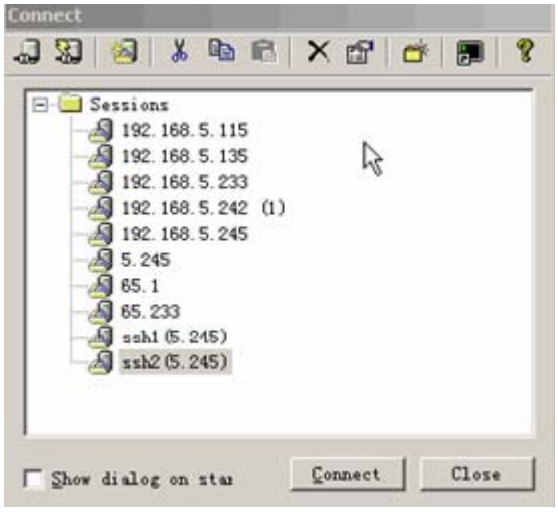
Figure 8



As shown in Figure 8, protocol 2 is used for login, so **SSH2** is selected for **Protocol**. **Hostname** indicates the IP address of the host the user will log in, 192.168.5.245. Port 22 is the default port listened by SSH. **Username** indicates the username, and does not take effect when the device only requires a password. **Authentication** indicates the authentication mode, and the username/password authentication is supported here. The used password is the same as the password used for Telnet.

Click **OK**. The following dialog box pops up:

Figure 9



Click **Connect** to log in to the host, as shown below:

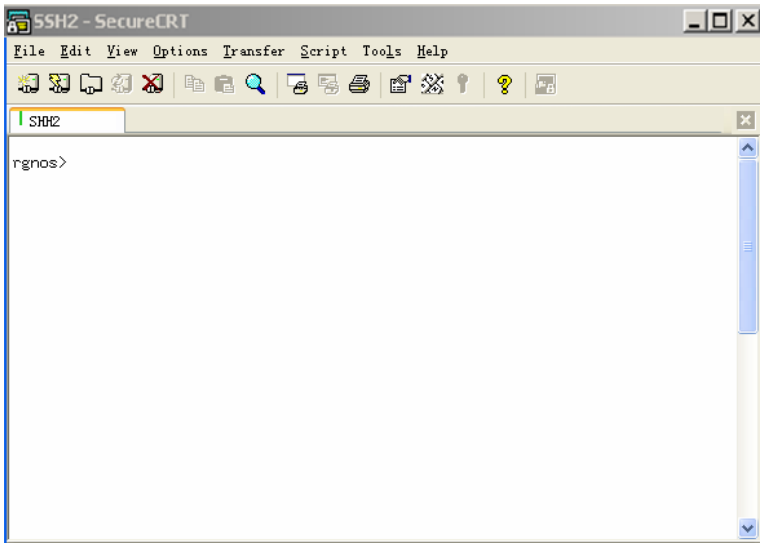
Figure 10

Ask the user whose is logging in to the host 192.168.5.245 whether to receive the key from the server. Select **Accept & Save** or **Accept Once**. A dialog box, prompting you to enter a password, pops up as follows:

Figure 11

Enter the Telnet login password. A window pops up as follows:

Figure 12

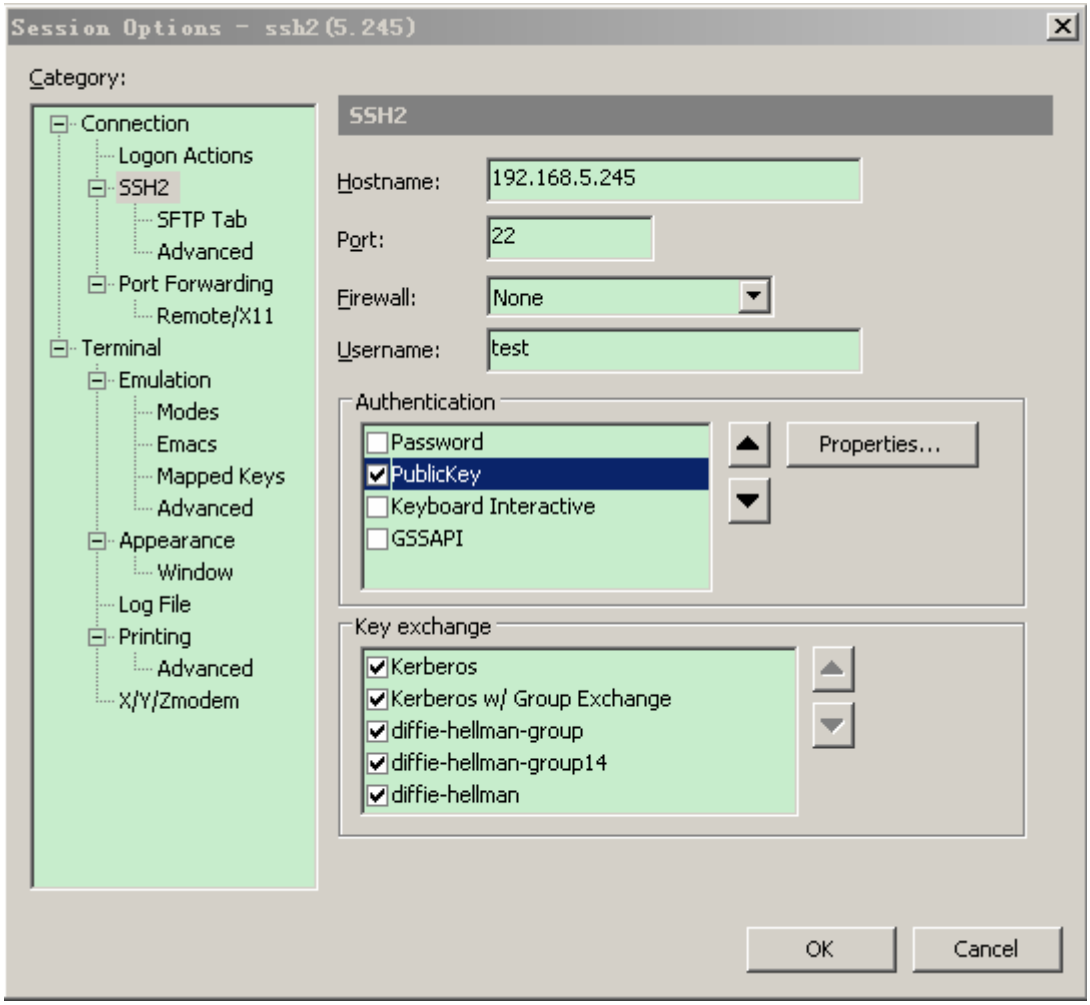


Enabling SSH public key based authentication

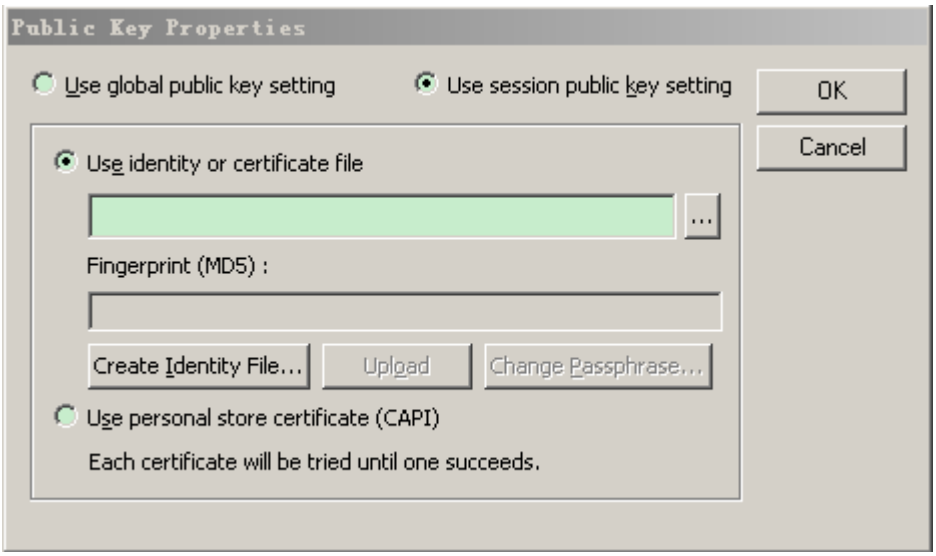
Operations on the SSH Client:

To enable SSH public key authentication, generate a key pair (RSA or DSA) on the SSH client and put the public key on the SSH server. And then enabling SSH public key based authentication on SSH server. The following section takes client software SecureCRT for an instance to demonstrate how to generate key pair on SSH client.

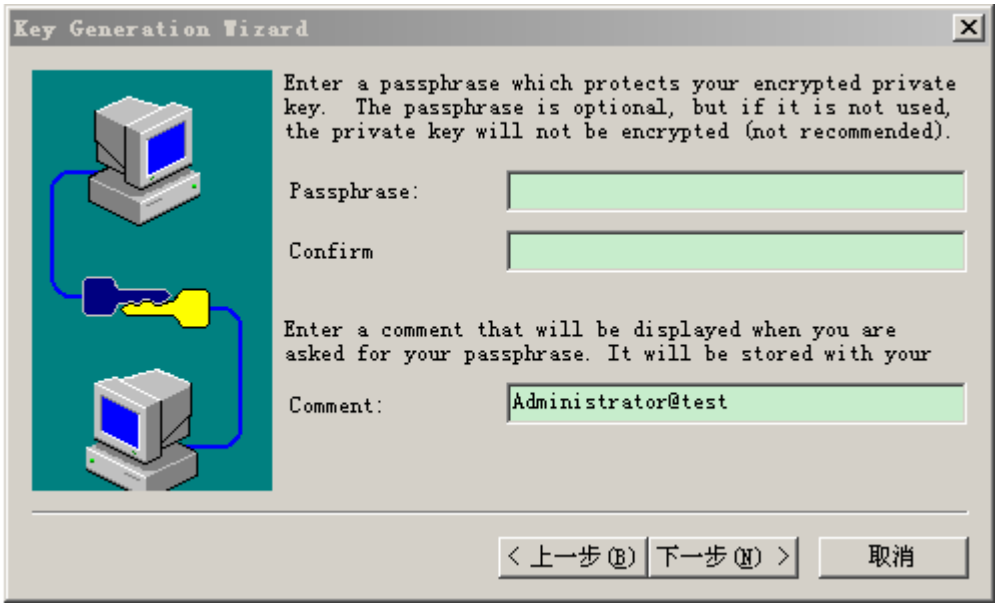
Firstly, click PublicKey in Authentication on Session Option, and then click Properties. as Shown below.



If the key pair is generated before, use the private key （Use identity or certificate file）. Note that this private key must be paired with the public key on the SSH server, otherwise the authentication fails. As shown below.



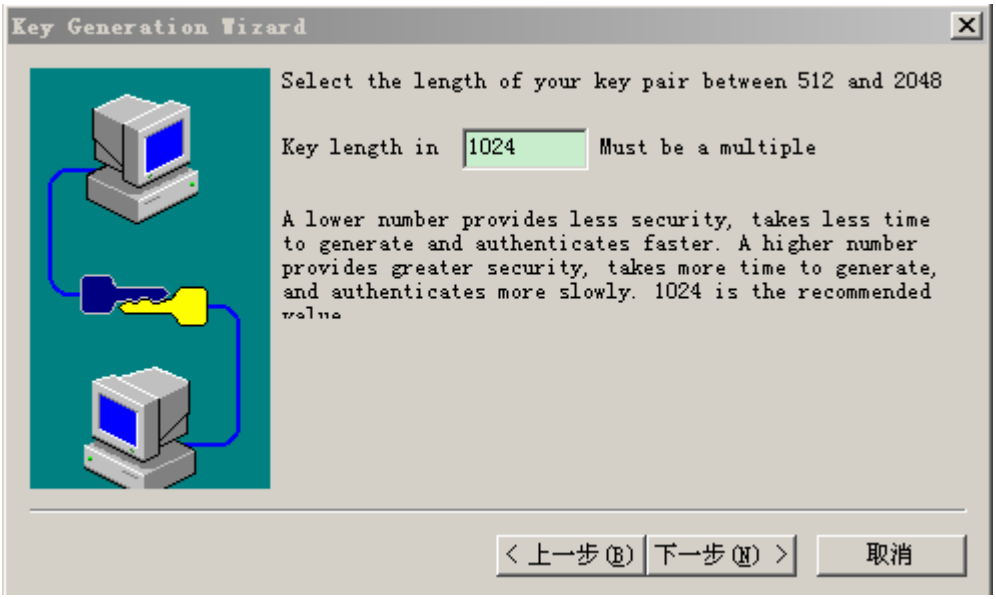
If no key pair is generated before, generate a new key pair. (Optional) set a passphrase for the private key. Once the passphrase is set, you should key in this passphrase for authentication. As shown below.



Note

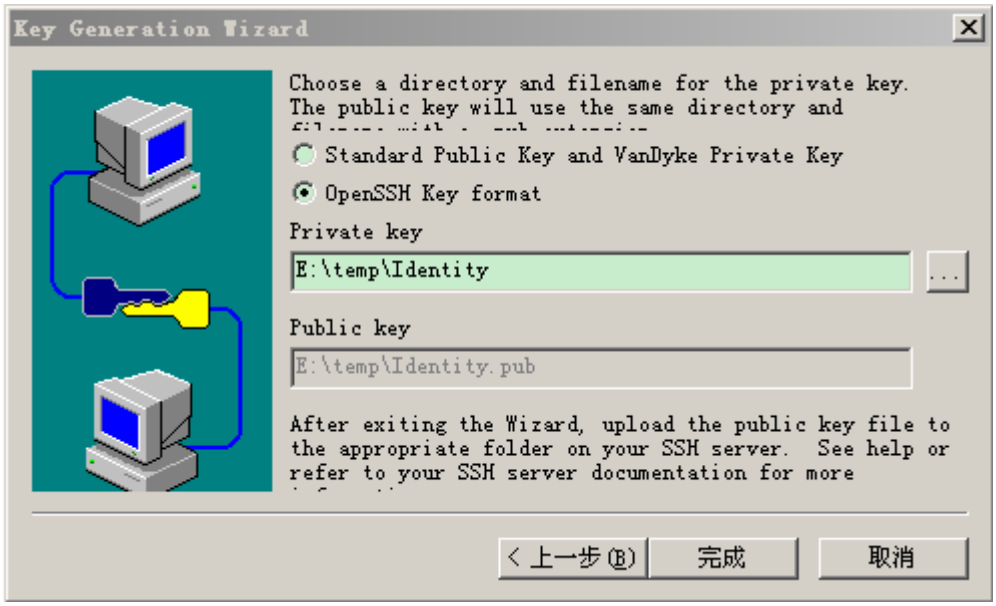
Shaking the mouse when the SSH client is generating the key pair, otherwise the generating rate will be slow.

The key files must be stored in OpenSSH key format, otherwise the files cannot be used. If the Putty is adopted as the client software, still the private key is required to turn into the Putty format by puttygen.exe.(Puttygen.exe can generate key pair in OpenSHH format, but Putty cannot use key pair in OpenSHH format directly). However, the public key files generated in OpenSSH format do not need transformation.



Note

To guarantee the security of RSA public key based authentication, make sure the key length is longer or equivalent to 768.



Operations on the SSH server

When the key pair is generated on the SSH client, the SSH server (network device) copies the public key files into flash, and associated these public key files with SSH clients' username. Each username can be associated with one RSA public key and one DSA public key. As shown below:

```
Ruijie# configure terminal
Ruijie(config)# ip ssh peer test public-key rsa flash:rsa.pub
Ruijie(config)# ip ssh peer test public-key dsa flash:dsa.pub
```

By doing so, SSH clients can log into network devices through public key based authentication.

Transferring files through SSH

Operation on the SSH server:

SSH transfers files by means of the SCP protocol (Secure Copy). The client can upload files to the network device or download files from the network device through SCP. To realize such function, enable the SCP server function, as shown below.

```
Ruijie# configure terminal
Ruijie(config)# ip scp server enable
```

By doing so, client can connect server and transfer files through SCP. SCP server use SSH thread. So when a client connects the network device transferring files through SCP, it will takes up a VTY line. (when using the command show user, you can see the user type is SSH).

Operation on the SSH server:

Both Unix and Linux platform carries SCP command. Taking Ubuntu Linux as an example to demonstrate the use of SCP command, as shown below:

```
Grammar of SCP command:
    scp [-1246BCpqrv] [-c cipher] [-F ssh_config] [-i identity_file]
       [-l limit] [-o ssh_option] [-P port] [-S program]
       [[user@]host1:]file1 [...] [[user@]host2:]file2
Explanation for some options:
-1 : Use SSH version 1 (by default, use SSH version 2);
-2 :  Use SSH version 2 (by default);
-C :  Specify compressed transmission;
-c :  Specify encryption algorithm;
-r :  Transmit all files under this content;
-i :  Specify key pair;
-l :  Limit the transmission rate (measured by Kbits);
For other detailed parameters, see als the scp.0.
```

Take Ubuntu 7.10 as an example to demonstrate file transferring.

The designated user named *test copies config.text* file from a network device with an IP address 192.168.195.188 to the local */root*. As shown below:

```
root@dhcpd:~# scp test@192.168.195.188:/config.text /root/config.text
test@192.168.195.188's password:
config.text                100% 1506    1.5KB/s   00:00
Read from remote host 192.168.195.188: Connection reset by peer
```

Note

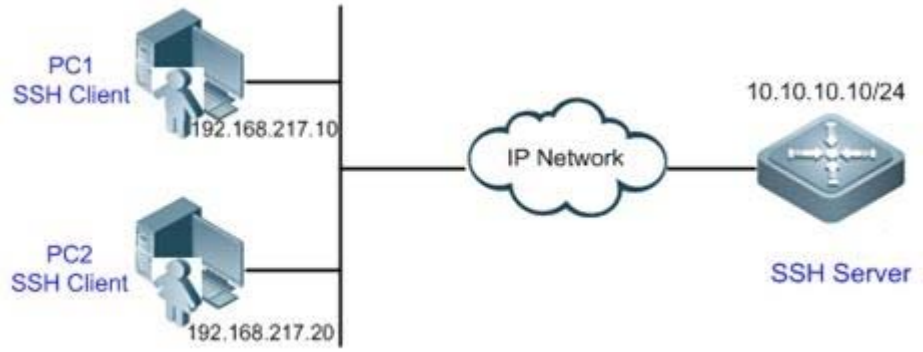
Most options are client related only. And few of these options require support from both clent and server. The SCP server on Ruijie Networks' devices do not support -d -p –q –r options. So when user configuring these options, the device indicates unsupported message.

If no rate limitation (-l option) is configured in advance, the CPU usage will rise when the client downloading files from server, and recover after the downloading. The console remains available but other application tasks will be affected.

Typical SSH Configuration Examples

Configuring SSH Local Authentication

Figure 13 Networking diagram for SSH local password protection



Application Requirements

As shown in Figure 13, to ensure the security of information exchange, PC1 and PC2 serve as SSH clients from which users will log in to the SSH Server through SSH. The specific requirements are shown below:

- SSH users adopt line password authentication.
- Lines 0 to 4 are activated at the same time. The login password for line 0 is "passzero", and the login password for other four lines is "pass". Any user name can be used.

Notes

- Notes on SSH Server configuration are as follows:

98) Globally enable SSH Server. By default, SSH Server supports SSHv1 and SSHv2.

99) Configure a key. The SSH server will use this key to decrypt the encrypted passwords received from the SSH clients, and compare the plain text with the password stored on the server before returning a message that indicates a successful or failed authentication. SSHv1 uses RSA key, while SSHv2 uses RSA or DSA key.

100) Configure the IP address of the Gi 1/1 interface of the SSH server. SSH clients connect to the SSH server through this interface. The routes from SSH clients to the SSH server are reachable.

- Configurations on SSH Clients:

There are many SSH client software, such as Putty, Linux, OpenSSH and etc. In this example, SecureCRT is used as the SSH client software. For configuration details, see the "Configuration Steps" section.

Configuration Steps

- Configure the SSH Server

Before configuring relevant SSH features, make sure the routes from SSH clients to the SSH server are reachable. The IP addresses of respective interfaces are shown in Figure 6, and the IP address and route configuration are omitted herein.

Step 1: Enable SSH Server

```
Ruijie(config)# enable service ssh-server
```

Step 2: Generate an RSA key

```
Ruijie(config)#crypto key generate rsa
% You already have RSA keys.
% Do you really want to replace them? [yes/no]:
Choose the size of the key modulus in the range of 360 to 2048 for your
Signature Keys. Choosing a key modulus greater than 512 may take
a few minutes.

How many bits in the modulus [512]:
% Generating 512 bit RSA1 keys ...[ok]
% Generating 512 bit RSA keys ...[ok]
```

Step 3: Configure the IP address of Gi 1/1 interface. The client will use this IP address to connect to the SSH server.

```
Ruijie(config)#interface gigabitEthernet 1/1
Ruijie(config-if- gigabitEthernet 1/1)#ip address 10.10.10.10 255.255.255.0
Ruijie(config-if- gigabitEthernet 1/1)#exit
```

Step 4: Configure login passwords for lines

! Configure the login password for line 0 as "passzero"

```
Ruijie(config)#line vty 0
Ruijie(config-line)#password passzero
Ruijie(config-line)#privilege level 15
Ruijie(config-line)#exit
```

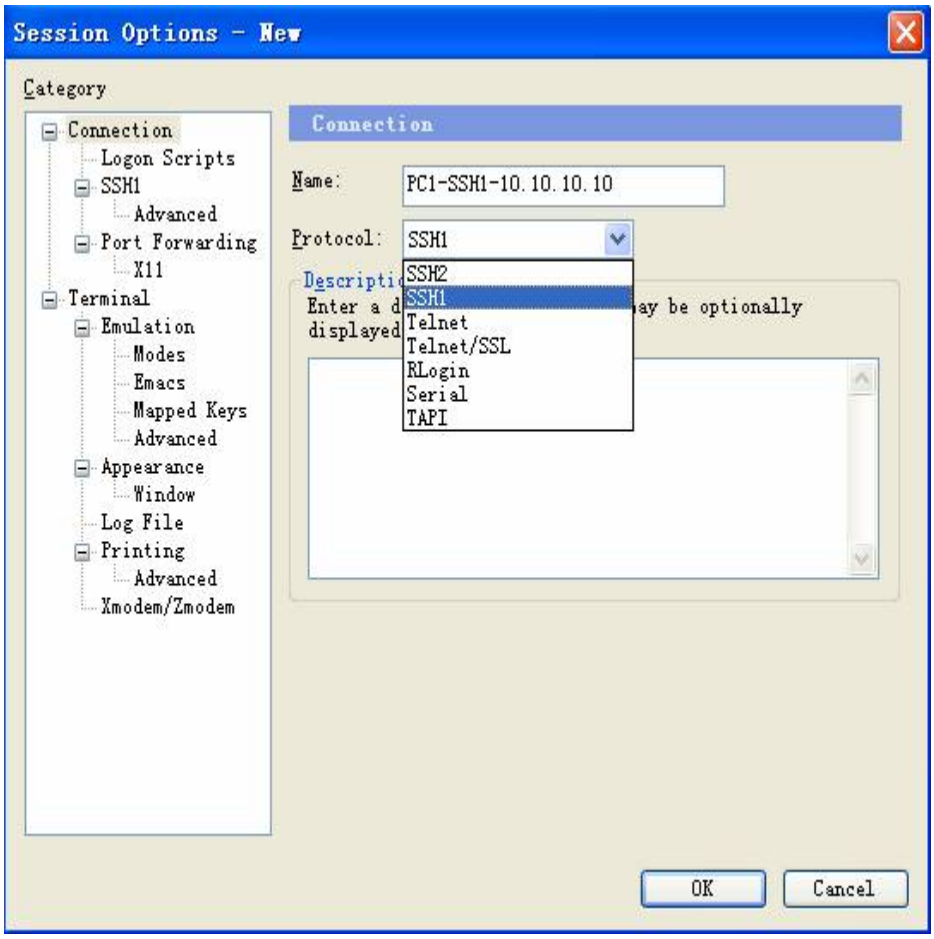
! Configure the login password for lines 1 to 4 as "pass"

```
Ruijie(config)#line vty 1 4
Ruijie(config-line)#password pass
Ruijie(config-line)#privilege level 15
Ruijie(config-line)#exit
```

- Configure SSH Clients (PC1 and PC2)

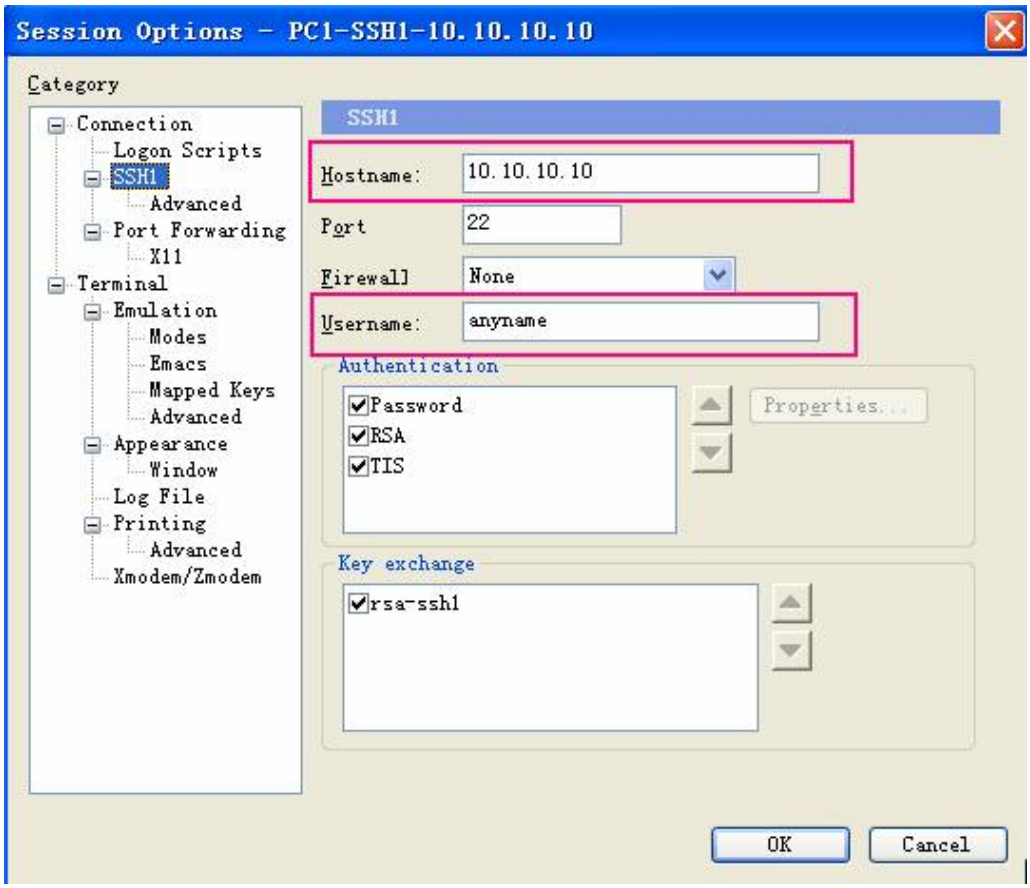
Start SecureCRT, as shown in Figure 7. Use SSH1 for login authentication. Any session name can be specified (here the session name is configured as PC1-SSH1-10.10.10.10).

Figure 14



Configure SSH attributes. The host name is the IP address of the SSH server (10.10.10.10 in this example). Since user name is not required, you can type in any user name in the **User Name** field, but this field cannot be left blank (the user name is **anyname** in this example).

Figure 15



Verifying the Configuration

- Verify the SSH Server configuration

Step 1: Run the **show running-config** command to verify the current configuration:

```
Ruijie#show running-config

Building configuration...
!
enable secret 5 $1$eyy2$xs28FDw4s2q0tx97
enable service ssh-server
!
interface gigabitEthernet 1/1
 ip address 10.10.10.10 255.255.255.0
line vty 0
privilege level 15
 login
 password passzero
line vty 1 4
privilege level 15
 login
```

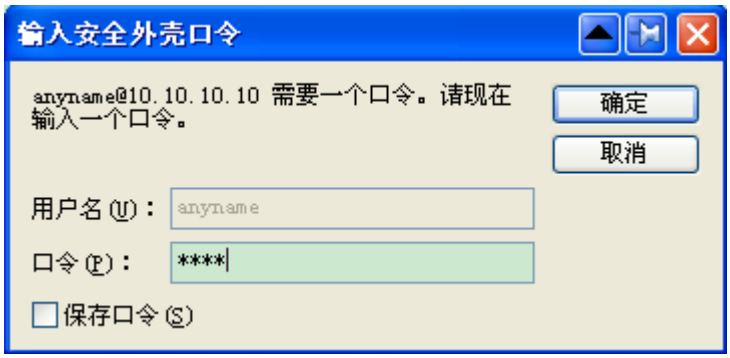
```
 password pass
!
end
```

■ Verify the configuration of SSH clients

Step 1: Establish a remote connection.

Establish a connection and type in the correct password in order to enter the interface of the SSH Server. The login password for line 0 is "passzero", and the login password for other four lines is "pass".

Figure 16

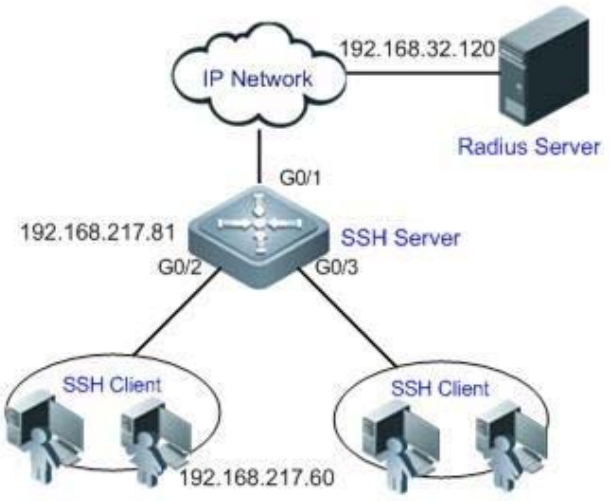


Step 2: Query the online user.

```
Ruijie#show users
    Line       User       Host(s)           Idle      Location
   0 con 0                 idle             00:03:16
   1 vty 0                 idle             00:02:16   192.168.217.10
*  2 vty 1                 idle             00:00:00   192.168.217.20
```

Example of Configuring SSH AAA Authentication

Figure 17 Networking diagram for SSH AAA authentication



Application Requirements

As shown in Figure 10, to ensure the security of information exchange, PCs serve as SSH clients from which users will log in to the SSH Server through SSH.

To better implement security management, SSH clients adopt AAA authentication. Meanwhile, for stability consideration, two authentication methods are configured in the AAA authentication method list: Radius server authentication and local authentication. Radius server authentication has a higher priority than local authentication unless no response is received during Radius server authentication.

Notes

- The routes from SSH clients to the SSH server and the route from the SSH server to the Radius server shall be reachable.
- SSH Server related configuration is complete on the network device. The configuration tips have been described in the previous example, and are not further described herein.
- AAA authentication related configuration is complete on the network device. AAA defines identity authentication and type by creating a method list, which is then applied to the specific service or interface. For details, see the "Configuration Steps" section.

Configuration Steps

The routes from SSH clients to the SSH server and the route from the SSH server to the Radius server shall be reachable. Route configuration will not be further described. For details, see the section about route configuration in this manual.

- Configure relevant SSH features on the network device

Step 1: Enable SSH Server

```
Ruijie(config)# enable service ssh-server
```

Step 2: Generate a key

! Generate an RSA key

```
Ruijie(config)#crypto key generate rsa
% You already have RSA keys.
% Do you really want to replace them? [yes/no]:
Choose the size of the key modulus in the range of 360 to 2048 for your
Signature Keys. Choosing a key modulus greater than 512 may take
a few minutes.
How many bits in the modulus [512]:
% Generating 512 bit RSA1 keys ...[ok]
% Generating 512 bit RSA keys ...[ok]
```

! Generate a DSA key

```
Ruijie(config)#crypto key generate dsa
Choose the size of the key modulus in the range of 360 to 2048 for your
Signature Keys. Choosing a key modulus greater than 512 may take
a few minutes.
```

```
How many bits in the modulus [512]:
% Generating 512 bit DSA keys ...[ok]
```

Step 3: Configure the IP address of the device. The clients will use this address to connect to the SSH server.

```
Ruijie(config)#interface gigabitEthernet 1/1
Ruijie(config-if-gigabitEthernet 1/1)#ip address 192.168.217.81 255.255.255.0
Ruijie(config-if-gigabitEthernet 1/1)#exit
```

- Configure AAA authentication on the network device

Step 1: Enable AAA on the device

```
Ruijie#configure terminal
Ruijie(config)#aaa new-model
```

Step 2: Configure information about the Radius server (the shared key used by the SSH server for communicating with the Radius server is "aaaradius"

```
Ruijie(config)#radius-server host 192.168.32.120
Ruijie(config)#radius-server key aaaradius
```

Step 3: Configure an AAA authentication method list

! Configure a login authentication method list (Radius server authentication followed by local authentication), and the name of the method list is "method".

```
Ruijie(config)#aaa authentication login method group radius local
```

Step 4: Apply this method list to the lines

```
Ruijie(config)#line vty 0 4
Ruijie(config-line)#login authentication method
Ruijie(config-line)#exit
```

Step 5: Configure a local user database

! Configure a local user database (configure the user name and password, and bind the user to a privilege level)

```
Ruijie(config)#username user1 privilege 1 password 111
Ruijie(config)#username user2 privilege 10 password 222
Ruijie(config)#username user3 privilege 15 password 333
```

! Configure a password for local Enable authentication

```
Ruijie(config)#enable secret w
```

Verifying the Configuration

Step 1: Run the **show running-config** command to verify the current configuration:

```
Ruijie#show run

aaa new-model
!
```

```
aaa authentication login method group radius local
!
username user1 password 111
username user2 password 222
username user2 privilege 10
username user3 password 333
username user3 privilege 15

no service password-encryption
!
radius-server host 192.168.32.120
radius-server key aaaradius
enable secret 5 $1$hbgz$ArCsyqty6yyzzp03
enable service ssh-server
!
interface gigabitEthernet 1/1
 no ip proxy-arp
 ip address 192.168.217.81 255.255.255.0
!
ip route 0.0.0.0 0.0.0.0 192.168.217.1
!
line con 0
line vty 0 4
 login authentication method
!
end
```

Step 2: Configure the Radius Server. This example describes how to configure the SAM server.

Choose **System Management** > **Device Management**, and type in 192.168.217.81 as the IP address of the device and the device key **aaaradius**;

Choose **Security Management** > **Device Management Privilege**, and configure a privilege level for the login user;

Choose **Security Management** > **Device Administrator**, and type in **user** as the user name and **pass** as the password.

Step 3: Establish a remote SSH connection on the PC.

For details about how to set SSH client software and establish a connection, see the previous example.

Type in **user** as the SSH user and **pass** as the password. The user will log in successfully.

Step 4: Query the online user.

```
Ruijie#show users
    Line       User       Host(s)           Idle      Location
   0 con 0                idle             00:00:31
 * 1 vty 0    user        idle              00:00:33   192.168.217.60
```

Configuring IP Accounting

Understanding IP Accounting

Overview

IP accounting, an easy-to-use traffic management tool, classifies and collects statistics on the traffic passing routers by source IP address and destination IP address. The collected statistics include the number of packets and number of bytes. Traffic accounting and traffic analysis can be implemented on the basis of IP accounting statistics.

Configuring IP Accounting

Enabling IP Accounting

IP accounting is enabled on the inbound or outbound interface. You need to specify an interface and the direction when enabling IP accounting. In addition, you can configure a traffic classification rule while enabling IP accounting. The system will collect statistics on traffic based on the configured rule.

Use the following commands to enable IP accounting.

Command	Function
Ruijie> **enable**	Enters privileged EXEC mode.
Ruijie**# config terminall**	Enters global configuration mode.
Ruijie(config)**# interface** *interface-type interface-number*	Enters interface configuration mode.
Ruijie(config-if)**# ip accounting** { **ingress** | **egress**} **list** { *acl_list_num* | *acl_list_name* }	Enables IP accounting on the interface.
Ruijie(config-if)**# end**	Returns to privileged EXEC mode.
Ruijie**# copy running-config startup-config**	Saves the configuration.

To disable IP accounting on the interface, use the **no ip accounting** { **ingress** | **egress** } command in interface configuration mode.

Configuration example

```
Ruijie# config terminal
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if)# ip accounting ingress list 20 //Enable IP Accounting on the 0/1 interface
to classify and collect statistics on incoming traffic based on ACL 20.
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitEthernet 0/2
```

```
Ruijie(config-if)# ip accounting egress list 10 //Enable IP Accounting on the 0/2 interface
to classify and collect statistics on outgoing traffic based on ACL 10.
Ruijie(config-if)# exit
Ruijie(config)#
```

Displaying IP Accounting Configuration

Use the **show ip accounting config** command to query IP accounting configuration on an interface. For exampe:

```
Ruijie# show ip accounting config
GigabitEthernet 0/1
ip accounting ingress list 20
GigabitEthernet 0/1
ip accounting egress list 10
```

Displaying IP Accounting Statistics

Use the **show ip accounting interface** *interface-type interface-number* { **ingress** | **egress** } { **interior** | **exterior** } command to query IP accounting statistics on the inbound or outbound interface in priveledged, global, or interface mode, with **interior** indicating the statistics matching an ACL rule and **exterior** indicating the statistics not matching the ACL rule.

Command	Function
Ruijie> **enable**	Enters privileged EXEC mode.
Ruijie**# config terminal**	Enters global configuration mode.
Ruijie(config)**# interface** *interface-type interface-number*	Enters interface configuration mode.
Ruijie(config-if)**# show ip accounting** *interface interface-type interface-number* { **ingress** | **egress** } { **interior** | **exterior** }	Displays IP accounting statistics on the interface.
Ruijie(config-if)**# end**	Returns to privileged EXEC mode.

Configuration example

```
Ruijie# config terminal
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if)# show ip accounting interface gigabitEthernet 0/1 ingress interior
```

Clearing IP Accounting Statistics

Use the **clear ip accounting interface** *interface-type interface-number* { **ingress** | **egress** } command to clear the IP accounting statistics on the specified inteface in priveledge EXEC mode.

The following example clears IP accounting statistics on the outbound interface.

```
Ruijie# clear ip accounting interface gigabitEthernet 0/1 egress
```

Configuring SDG

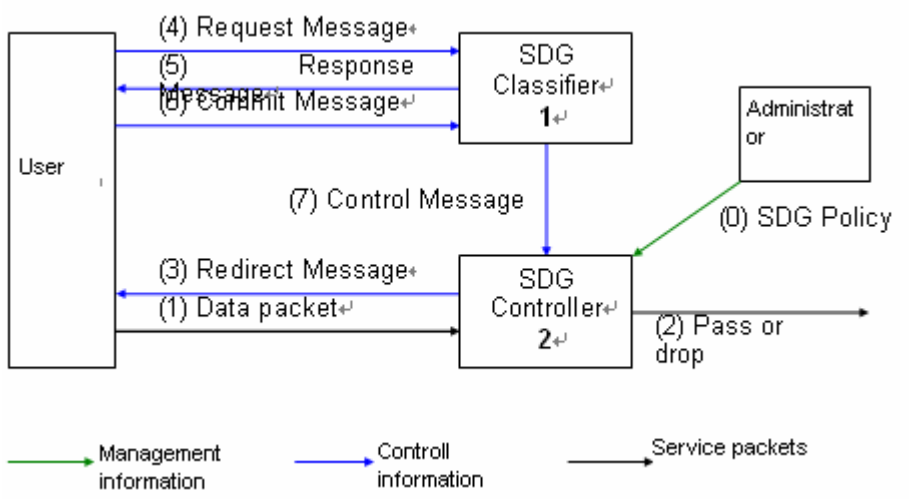
Understanding SDG

Overview of SDG

To be simple, Security Domain Gateway (SDG) achieves the logical isolation between different security domains. By limiting the user to access only the specified security domain at a time, users can be prevented from accessing different security domains and hence viruses will not spread to other protected domains, or important information will not leak to the insecure domains. SDG has two operating modes: local mode and linked mode.

Working Principle

Working principle of SDG in local mode:



As shown above, the SDG system consists of two parts:

Classifier: Through the interaction with users, the classifier determines the current role of each user, and sends this message to the controller. The classifier is realized by means of Web, so that the user does not need to install the client software.

Controller: The controller is mainly responsible for receiving the user role message sent by the classifier and applying access control to the traffic sent by the user as per the access permission assigned to such role. In addition, the controller is also responsible for triggering a message prompting the user to reselect a role while accessing an unauthorized domain.

User: During the interaction with SDG, the user sends traffic to the controller on one hand and negotiates with the Classifier for role selection on the other hand.

Administrator: It is responsible for establishing SDG policies on the controller. Such a policy determines the access permissions of different user roles, implementing "logical isolation". The policy is generally configured through CLI.

The working procedures of SDG are shown below:

(0): The administrator establishes a SDG policy according to actual needs, covering the user role, isolated domain and the access control rules applied between user roles and isolated domains.

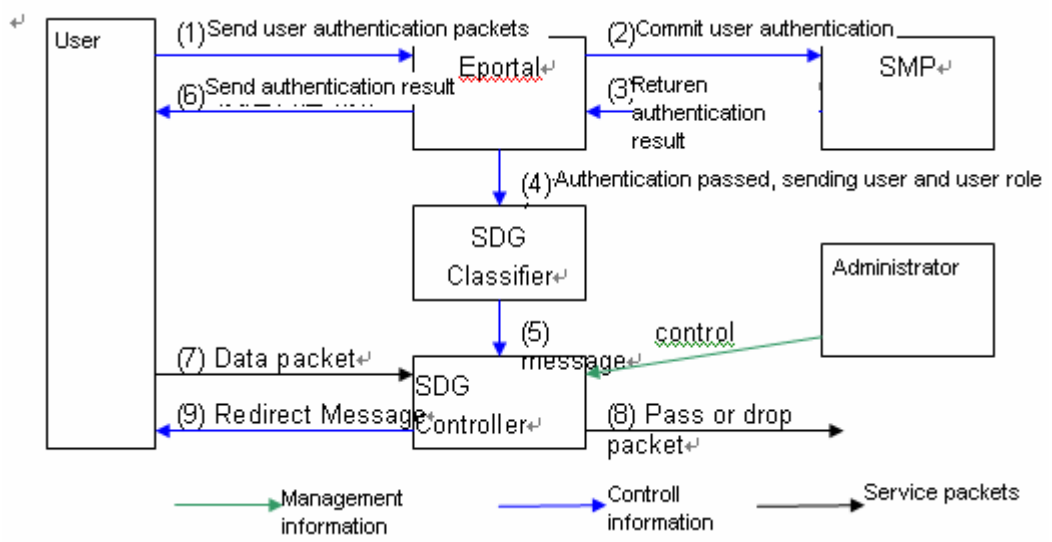
(1) → (2): The Controller receives the traffic sent by the user and applies the access control, so that valid packets can pass and invalid packets failing to trigger "user role selection" will be discarded. A criterion for identifying valid packet depends on an SDG policy: the user role sending this packet is allowed to access the isolated domain.

(1) → (3) → (4): As for the invalid packets sent by the user, if such packets are capable of triggering "role selection", then the controller will send an Http redirection packet to the user and redirect the user request to the "user role selection" page on the Classifier. One condition for triggering "user role selection" is that the packet must be a valid http request packet.

(4) → (5) → (6): The user proactively (or through Controller redirection) sends the "user role selection" request to the Classifier, which will reply to the user (browser) with this page. No matter which role is selected by the user on the page, the selection result will be submitted to the Classifier.

(7): The Classifier forwards the user role selection result to the Controller, which will record and use such information as the reference for security check of this user during future access.

Working principle of SDG in linked mode



Eportal: Eportal server

SMP: security authentication server

Other flows are the same as local mode.

The working procedures of SDG are shown below:

(0): The administrator establishes an SDG policy according to actual needs, covering the user role, isolated domain and access control rules applied between user roles and isolated domains.

(1)→(2): The user sends authentication packet to Eportal, which will forward the user authentication packet to SMP.

(3) MP verifies user information and sends the authentication result to Eportal.

(4)→(5): In case of successful authentication, Eportal will send the user and user role to the SDG Classifier, which will update the user role and forward the user role selection result to the Controller. The Controller will record and use such information as the reference for security check of this user during future access.

(6): Eportal will send the authentication result to the user, which will reselect the role or send traffic according to the authentication result.

(7)→(8)→(9): The SDG Controller matches the user role. If the user role does not match and the redirection condition is met, it will send a redirection packet. The user will reselect the role and send a user authentication packet to the Eportal, or else it will discard the packet. If matched, SDG check is passed.

Protocol Specification

N/A

Default Configurations

N/A

Configuring SDG

Configuring SDG Mode

While deploying SDG, you can select different SDG operating modes according to users' security needs. The SDG working in local mode is easy to deploy and will be ready to operate after the router is configured. To deploy SDG working in linked mode, you need to add an SMP server. This mode, however, supports user authentication and hence provides higher security.

To configure SDG mode, run the following commands:

Command	Function
Ruijie> **enable**	Enters privileged command mode.
Ruijie**# config terminal**	Enters global configuration mode.
Ruijie(config)**# ip sdg mode** *link*	Enables SDG linked mode.

Configuring the IP Address of the SMP Server

In linked mode, you need to configure the IP address of the SMP server for redirection. The user can also use an SMP URL for redirection.

To configure the IP address of the SMP server, run the following commands:

Command	Function
Ruijie> **enable**	Enters privileged command mode.
Ruijie**# config terminal**	Enters global configuration mode.
Ruijie(config)**# ip sdg portal** *ip* [url]	Configures the IP address for connecting to the Eport, namely the IP address of the Eportal server .

Configuring Aging Time for Offline Users

In linked mode, you need to configure aging time for users. A user is considered offline if the user does not initiate a connection request within the aging time.

To configure aging time for offline users, run the following commands:

Command	Function
Ruijie> **enable**	Enters privileged command mode.
Ruijie**# config terminal**	Enters global configuration mode.
Ruijie(config)**# ip sdg user-timeout** *time*	Configures aging time for offline users.

Configure the Default User

In local mode, add the default user into the specified user group. Upon the first access, the user has the permission to access the specified user group.

To configure the default user, run the following commands:

Command	Function
Ruijie> **enable**	Enters privileged command mode.
Ruijie**# config terminal**	Enters global configuration mode.
Ruijie(config)**#ip sdg permit-user** *user-ip user-mask* **user-group** *group-name*	Adds the default user.
Ruijie(config)**#no ip sdg permit-user** *user-ip user-mask* **user-group** *group-name*	Removes the default user.

Configuring SDG Classifiers

To control SDG, you must define SDG classifiers. Each SDG classifier defines a series of user groups (user roles). One user belongs to only one user group at the same time.

The SDG classifier created is applied to SDG policies. When user access violates the SDG policy, the user selection page will be displayed to prompt the user to select a user group.

The user can also take the initiative to access the user selection page to select a user group. The URL of the user selection page is:

"http://" + *device interface address* + "/sdg" + *classifier ID* + ".htm?ruijie_query_id=sdg". For example, if the interface address is 192.168.52.52 and the classifier ID is 1, then the corresponding URL is:

http://192.168.52.52/sdg001.htm

To configure SDG classifiers, run the following commands:

Command	Function
Ruijie> **enable**	Enters privileged command mode.
Ruijie**# config terminal**	Enters global configuration mode.
Ruijie(config)**# ip sdg classifier** *classifier-id*	Configures SDG classifiers and enters SDG classifier command mode.

Caution Web server must be enabled in order to generate the user role selection page.

```
Ruijie(config)# enable service web-server
```

Configuring User Groups

After creating SDG classifiers, run the **user-group** command to configure user groups to be included in this classifier.

To configure user groups, run the following command:

Command	Function
Ruijie> **enable**	Enters privileged command mode.
Ruijie**# config terminal**	Enters global configuration mode.
Ruijie(config)**# ip sdg classifier** *classifier-id*	Configures SDG classifiers and enters SDG classifier command mode.
Ruijie(config)**# user-group** *group-name*	Configures the user group included in an SDG classifier.

Configuring Static Users

In local mode, add users into the specified user group. The statically configured user will not be changed while the user is selecting a role.

Command	Function
Ruijie> **enable**	Enters privileged command mode.
Ruijie**# config terminal**	Enters global configuration mode.
Ruijie(config)**# user-group** *group-name*	Configures user groups to be included in an SDG classifier.
Ruijie (config-user-group)**# user** ip	Adds a static user.
Ruijie (config-user-group)**#no user** ip	Removes a static user.

Clearing Users in a User Group

In local mode, remove non-static users from a user group; in linked mode, remove all users from a user group.

Command	Function
Ruijie> **enable**	Enters privileged command mode.
Ruijie**# clear user-group** *group-name*	Removes users from a user group.

Configuring SDG Control Policies

A SDG policy can be configured in either inbound or outbound direction of an interface. It consists of one ACL and one SDG classifier. The ACL is used to define the isolation policy, which must be based on the user groups included in the SDG classifier. When user access violates the isolation policy, the user selection page defined in SDG classifier will be displayed to prompt the user to select an appropriate user group.

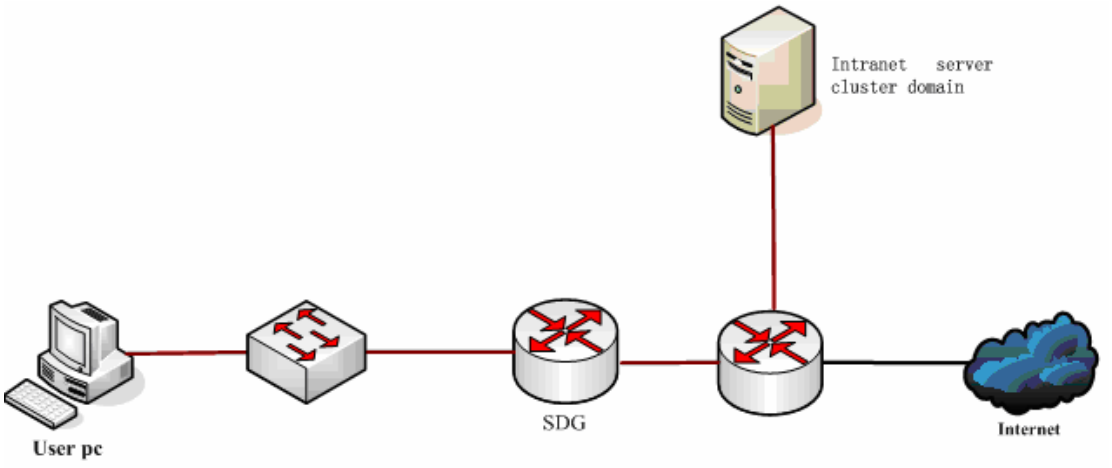
To configure SDG control policies, run the following commands:

Command	Function
Ruijie> **enable**	Enters privileged command mode.
Ruijie**# config terminal**	Enters global configuration mode.

Ruijie(config)#**interface** *gigabitEthernet 0/0*	Enters interface configuration mode.
Ruijie(config-if-gigabitEthernet 0/0)#**ip sdg in|out access-group** *acl-no* **trigger** *classifier-id*	Configures an SDG control policy.

Configuration Examples

Local mode



As shown above, after transparent bridge mode is enabled on the SDG device, SDG functions can be realized without changing the network structure.

Configuration:

101) Configure SDG to work in local mode

Command	Function
Ruijie(config)# **ip sdg mode local**	Configures SDG to work in local mode.

102) Configure the SMP address for SDG in linked mode

Command	Function
Ruijie(config)# **ip sdg portal** 10.1.1.2 http:// *xxx.xxx.xxx/eportal*	Configure the IP address for connecting to the Eport, namely the IP address of the Eportal server.

103) Create a user group

Define a user group for each user role, including intranet user group (intranet_user) and internet user group (internet_user).

Command	Function
Ruijie(config)# **user-group** *intranet_user*	Configures the intranet user group.
Ruijie(config)# **user-group** *internet_user*	Configures the internet user group.

104) Configure a static user

In local mode, add a user into the user group

Command	Function

Ruijie(config-user-group)#**user** 192.168.50.18	Adds a user.
Ruijie(config-user-group)# **no user** 192.168.50.18	Removes a user.

105) Create a domain

An intranet server cluster domain (intranet_site) needs to be defined.

Command	Function
Ruijie(config)# **network-region** *intranet _site*	Configures an intranet server cluster domain.
Ruijie(config-network-region)# **network** *192.168.0.0 255.255.0.0* **.....**	Configures all network segments included in the intranet server cluster domain.

106) Configure an SDG classifier

Define an SDG classifier, which shall include intranet user group (intranet_user) and internet user group (internet_user).

Command	Function
Ruijie(config)# **ip sdg classifier** *1*	Defines SDG classifier 1.
Ruijie(config-sdg-classifier)# **user-group** *intranet_user*	Adds intranet_user into the classifier.
Ruijie(config-sdg-classifier)# **user-group** *internet_user*	Adds internet_user into the classifier.

107) Configure an isolated access policy

Use an ACL to define an isolation policy.

Command	Function
Ruijie(config)# **ip access-list extend** *100*	Configures extended ACL 100.
Ruijie(config-ext-acl)# **permit ip user-group** *intranet_user* **network-region** *intranet_site*	Allows intranet users to access intranet servers.
Ruijie(config-ext-acl)# **deny ip user-group** *intranet_user* **any**	Prohibits intranet users from accessing other sites.
Ruijie(config-ext-acl)# **deny ip user-group** *internet_user* **network-region** *intranet_site*	Prohibits Internet users from accessing intranet servers.
Ruijie(config-ext-acl)# **permit ip user-group** *internet_user* **any**	Allows Internet users to access other sites.

Note: DNS traffic must not be confined. You can create ACEs at the beginning of the ACL to permit DNS traffic.

108) Configure an SDG policy

Configure an SDG policy on the interface. The SDG policy is associated with one ACL and one SDG trigger. HTTP requests violating this ACL will be redirected to the page configured by the SDG trigger.

Command	Function
Ruijie(config)# **Interface** *gi 0/0*	# Enters Gi 0/0 interface.
Ruijie(config-interface)# **ip sdg in access-group** *100* **trigge**r *1*	Configures an SDG policy in the inbound direction and associates the policy with ACL 100 and SDG classifier 1.

109) Enable web-server

Command	Function
Ruijie(config)# **enable service web-server**	The SDG user selection page will only be generated only after web-server is enabled.

110) Enable transparent bridge mode

Command	Function
Ruijie(config)# transparent	Enables transparent bridge mode.

Note: Only fast forwarding supports transparent bridge mode

111) Authenticating a user

You can directly type the URL of the SMP server in the address box of a Internet Explorer for authentication, or makes SDG trigger authentication upon denial of access.

(The following page is for reference only.)

Configuring Anti-attack Features on Devices

Overview of Device Anti-attack

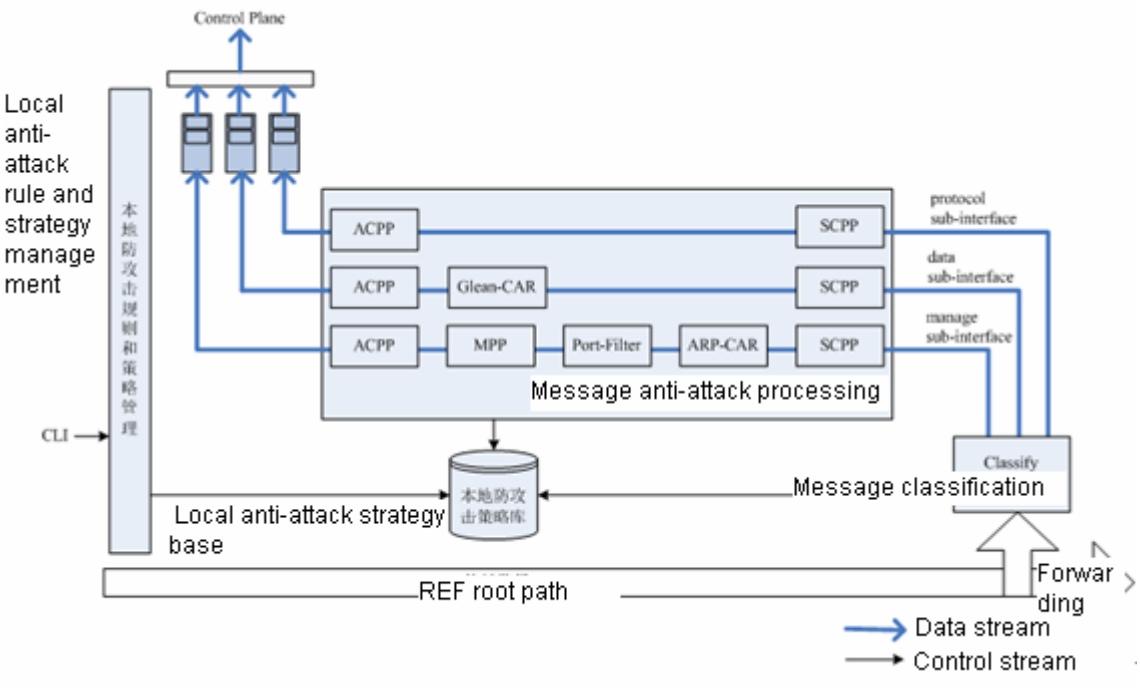
When encountering a network attack or heavy traffic, the device on a complex network may report the following exceptions:

112) Extremely high CPU usage;
113) Slow response or no response of CLI;
114) Loss of link or network control protocol messages, consequently leading to link or network delay variation;
115) Unauthorized occupation of bandwidth, resulting in the failure to process important protocol messages.

Such phenomena are due to the difference in processing capacity of control and forwarding planes on one hand and the lack of protection of the control plane on the other hand. The anti-attack module is to classify, filter and rate-limit the data messages that need to be forwarded to the control layer for processing, protecting the key resources of the control plane.

The following figure illustrates the principle and process of device anti-attack:

Figure 18



As shown in the figure, device anti-attack consists of numerous sub-modules:

Classify: Identify and classify the data traffic destined for the control plane. There are three categories of traffic including protocol, manage and data. The sub-module sets a base for subsequent rate limiting and filtering.

Sub-interface: The three traffic categories correspond to the following three sub-interfaces. The three sub-interfaces and streams through these interfaces are defined as follows:

Protocol sub-interface: All protocol control streams sent to the local device, such as link layer protocol messages, routing protocol messages, etc.

Manage sub-interface: All management protocol streams sent to the local device, such as FTP, TELNET, SNMP streams, etc. In addition, ARP and ICMP traffic also falls into this category.

Data sub-interface: All data streams that cannot be processed by any REF plane.

Note The sub-interface in this manual is different from what is usually regarded. It only represents an internal path through which a type of traffic is sent to the control plane, helping you configure anti-attack and process traffic.

SCPP: protects the control plane by subdividing traffic. SCPP delivers more delicate rate limiting and protection according to user-defined policies.

Glean-CAR: limits the rate of the traffic to the REF plane matching REF Glean adjacency (traffic with a direct route but without a host route matching the destination IP address is diverted to the control plane for destination IP address resolution).

ARP-CAR: Since the REF plane cannot complete processing ARP messages, these messages must be forwarded to the control plane. ARP-CAR can limit the rate of ARP messages from each neighbor.

Port-Filter: checks whether ports have been enabled for local TCP and UDP messages and filters network traffic for which no local network service is enabled.

MPP: Management Plane Protection (MPP) allows administrators to specify one or more interfaces as in-band management interfaces (receiving management messages and forwarding normal service messages). After the MPP function is enabled, only specified in-band management interfaces are allowed to receive the management messages of specified protocol. However, service messages, protocol messages, ARP messages, etc are not affected.

ACPP: Aggregate Control Plane Protection (ACPP) limits, on the basis of classification result by Classify, the rate of traffic on protocol sub-interface, manage sub-interface and data sub-interface with default or users' custom-made rate in order to ensure the traffic does not exceed the processing capacity of the control plane and the control planed is protected as a result.

Configuring Device Anti-attack

Device Anti-attack Configuration Tasks

Note Sub-functions, such as SCPP, Glean-CAR, ARP-CAR, Port-Filter, MPP, and ACPP, are independent from each other. Users may combine and configure them according to their needs and strategies. But it should be noticed that some sub-functions can be applied only to specified sub-interfaces.

Entering Control-plane Configuration Mode

All device anti-attack functions are configured in control-plane configuration mode. To enter control-plane configuration mode, run the following command:

Command	Function
Ruijie(config)# **control-plane** {**protocol** | **manage** | **data**}	Enters control-plane configuration mode and accesses corresponding sub-interfaces.

To exit control-plane configuration mode, run the **exit** command.

Configuring SCPP

SCPP can be used to distinguish and limit the rate of traffic in sub-interfaces according to user-defined policies. Rate limiting is classified into connection limiting and traffic bandwidth limiting. To configure SCPP, run the following commands:

Command	Function
Ruijie(config-cp)# **scpp list** *acl_no* {**bw-rate** bw-rate **bw-burst-rate** *bw-burst-rate* | **conn-total** *conn-num* | **conn-create-rate** conn-*create-rate* **conn-create-burst-rate** *conn-create-burst-rate*}	Configures a SCPP traffic bandwidth limit (unit: pps), a connection limit, etc for the traffic that complies with **acl_no** strategy on the sub-interface. *Acl_no*: ACL rule used to select the traffic in need of SCPP processing. *Bw-rate*: rate limit (unit: pps) *Bw- burst-rate*: burst rate limit (unit: pps) *Conn-num*: limit on the total number of connections *Conn-create-rate*: limit on the rate of connection establishment (unit: connection/s) *Conn-create-burst-rate*: limit on the burst rate of connection establishment (unit: connection/s)
Ruijie(config-cp)# **no scpp list** acl_no	Deletes configured SCPP rules.

SCPP processing can be applied to traffic on all sub-interfaces.

SCPP is disabled by default and will not be enabled until users configure SCPP rules explicitly.

Configuring Glean-CAR

For traffic that has a direct route but does not have its destination IP address resolved, configure Glean-CAR to limit the rate by using the following commands:

Command	Function
Ruijie(config-cp)# **glean-car** *packet_rate_per_group*	Configures a rate limit on Glean adjacency traffic initiated by users hashed to the same group *Packet_rate_per_group:* rate limit (unit: pps)
Ruijie(config-cp)# **no glean-car**	Deletes Glean-CAR rules.

The Glean-CAR function can only be configured on the data sub-interface.

Currently, the hash algorithm extracts the least significant *n* bits (*n* is determined by products) of source address.

It should be noticed that Glean-CAR can limit the rate of Glean adjacency matching traffic initiated by users hashed to the same group. For example, both user of A (192.168.52.57) and user B (192.168.60.57) (with the same hashed result) send traffic to destination host C (172.16.0.5) directly connected to the device. Before ARP messages of host C has been successfully resolved, only a maximum of five messages can be sent by users A and B to the control plane every second for destination IP ARP resolution if glean-car 5 is configured.

Glean-CAR is enabled by default and the rate limit of Glean adjacency matching traffic initiated by users (source) hashed to the same group is configured at 5 pps.

Configuring ARP-CAR

Run the following commands to configure ARP-CAR on ARP traffic reaching the local device.

Command	Function
Ruijie(config-cp)# **arp-car** *packet_rate_per_group*	Configures a rate limit of the ARP traffic initiated by users hashed to the same group. *Packet_rate_per_group:* rate limit (unit: pps)
Ruijie(config-cp)# **no arp-car**	Deletes ARP-CAR rules.

The ARP-CAR function can only be configured on the manage sub-interface.

Currently, the hash algorithm extracts the least significant *n* bits (*n* is determined by products) of source address.

It should be noticed that ARP-CAR can limit the rate of ARP traffic initiated by users hashed to the same group. For example, both user A (192.168.52.57) and user B (192.168.60.57) (with the same hashed result) initiate ARP requests of 192.168.52.1 to the device. If ARP-CAR 5 is configured, only a maximum of five messages can be sent by users A and B to the control plane every second for ARP response.

ARP-CAR is enabled by default and the rate limit of the ARP traffic initiated by users (source) hashed to the same group is configured at 5 pps.

Configuring ARP-Filter

Run the following commands to filter the ARP packets that reach the local device.

Command	Function
Ruijie(config-cp)# **arp-filter** *mac ip* [log]	Enables ARP-Filter.
Ruijie(config-cp)# **no port-filter**	Disables ARP-Filter.

The ARP-Filter function can only be configured on the manage sub-interface.

The ARP-Filter function is disabled by default and will not be enabled until users configure ARP-Filter rules explicitly..

Configuring Port-Filter

Run the following commands to configure Port-Filter to filter the transport layer messages that reach the local device yet have no services enabled:

Command	Function
Ruijie(config-cp)# **port-filter** [log]	Enables Port-Filter.
Ruijie(config-cp)# **no port-filter**	Disables Port-Filter.

The Port-Filter function can only be configured on the manage sub-interface.

Port-Filter is disabled by default and will not be enabled until users configure Port-Filter rules explicitly..

Configuring MPP

Run the following commands to configure the in-band management interface and the management protocol messages the interface is allowed to receive:

Command	Function
Ruijie(config-cp)# **management-interface** *interface* **allow** {**ftp** | **http** | **https** | **ssh** | **snmp** | **telnet** | **tftp**} [log]	Specifies the in-band management interface and configures the management protocol messages supported by the interface *Interface:* in-band management interface
Ruijie(config-cp)# **no management-interface** *interface*	Deletes the specified in-band management interface. The MPP function will be disabled if all in-band management interfaces are deleted.

The MPP sub-function can only be configured on the manage sub-interface.

A maximum of 16 in-band management interfaces can be configured and each of them can receive several or all management protocol messages.

After the MPP function is enabled, in-band management interfaces can receive specified management protocol messages and other interfaces do not receive management protocol messages.

MPP is disabled by default and will not be enabled until users configure MPP rules explicitly.

Configuring ACPP

Run the following commands to configure ACPP for the classisified traffic reaching the control plane:

Command	Function
Ruijie(config-cp)# **acpp bw-rate** *rate* **bw-burst-rate** *burst-rate* [log]	Configures ACPP rules for the traffic on sub-interfaces. *Rate:* rate limit (unit: pps) *Burst-rate:* burst rate limit (unit: pps)
Ruijie(config-cp)# **no acpp**	Deletes ACPP rules.

ACPP can be applied to all sub-interfaces.

ACPP is disabled by default and will not be enabled until users configure ACPP rules explicitly.

Enabling Device Anti-attack with Default Rules

Run the following commands in control-plane configuration mode to configure device anti-attack with default rules:

Command	Function
Ruijie(config-cp)# **ef-rnfp enable**	Enables device anti-attack with default rules.
Ruijie(config-cp)# **ef-rnfp disable**	Disables device anti-attack.

Default device anti-attack rules and strategies are configured according to different products and platforms.

Maintaining Device Anti-attack

Maintenance of device anti-attack

To query configurations and statistics of device anti-attack, run the following command:

Command	Function
Ruijie# **show ef-rnfp** { **acpp** {**data** | **manage** | **protocol**}| **scpp** {**data** | **manage** | **protocol**}| **glean-car** | **arp-car** | **port-filter** | **mpp** | **all** }	Views configurations and statistics of device anti-attack.

You can use the **show ef-rnfp { acpp {data | manage | protocol}| scpp {data | manage | protocol}| glean-car | arp-car | port-filter | mpp | all }** command to query configurations and statistics of sub-functions, or the **show ef-rnfp all** command to query the configurations and statistics of available anti-attack functions.

Typical Device Anti-Attack Configuration Example

The following example shows the typical configuration of device anti-attack:

```
Ruijie# config
```

//Enter control-plane configuration mode and protocol sub-interface

```
Ruijie(config)# control-plane protocol
```

// Configure ACPP to set the traffic rate to 500 pps and burst traffic rate to 600 pps on the protocol sub-interface

```
Ruijie(config-cp)# acpp bw-rate 500 bw-burst-rate 600
```

//Enter control-plane configuration mode and data sub-interface

```
Ruijie(config)# control-plane data
```

// Configure ACPP to set the traffic rate to 500 pps and burst traffic rate to 600 pps on the data sub-interface

```
Ruijie(config-cp)# acpp bw-rate 500 bw-burst-rate 600
```

// Configure Glean-CAR, allowing 10 messages from a source to match Glean adjacency per second

```
Ruijie(config-cp)# glean-car 10
```

//Enter control-plane configuration mode and manage sub-interface

```
Ruijie(config)# control-plane manage
```

// Configuring ACPP to set the traffic rate to 500 pps and burst traffic rate to 600 pps on the manage sub-interface

```
Ruijie(config-cp)# acpp bw-rate 500 bw-burst-rate 600
```

// Configure ARP-CAR allowing 10 messages from a source to match Glean adjacency per second

```
Ruijie(config-cp)# arp-car 10
```

// Enable Port-Filter

```
Ruijie(config-cp)# port-filter
```

//Configure MPP rules by specifying gi0/0 interface as the in-band management interface and only allowing it to receive Telnet and SNMP messages

```
Ruijie(config-cp)# management-interface gi0/0 allow telnet snmp
```

Configuring RPL

Understanding RPL

Overview

Reverse path limited (RPL) enables packets to be sent and returned along the same path, ensuring that these packets are not discarded by firewalls that do not allow one-way connection.

When establishing a flow table, a router buffers the inbound port No. of the first packet. Reply packets of a data flow are matched to the flow table preferentially and are forwarded through the inbound port. (Both the routing table and policy-based routing table are not used preferentially, which is similar to the state-based forwarding mechanism of firewalls.)

Basic Concept

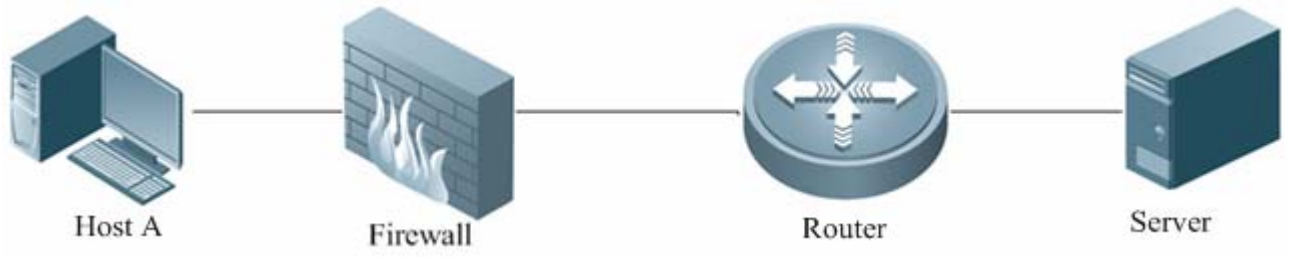
RPL

Work Principle

The source port for obtaining a packet is used as the outbound port for replying to the packet.

Typical Application

Figure 19 Networking topology for a terminal to access the server by traversing the firewall



Configuring RPL

Default Configuration

The following table describes the default configuration of RPL.

Feature	Default Setting
RPL	Disabled.

Configuring RPL

Command	Function
Ruijie(config-GigabitEthernet 0/0)**#ip reverse-path** [**access-list**] [*acl_id*]	Enables RPL. The value range of acl_id is as follows: 1 to 99 (IP standard access list) 100 to 199 (IP extended access list) 1300 to 1999 (IP standard access list, expanded range) 2000 to 2699 (IP extended access list, expanded range)
Ruijie(config-GigabitEthernet 0/0)**#no ip reverse-path**	Disables RPL.

Caution Before enabling RPL on a subinterface, ensure that the subinterface and its peer subinterface are interconnected and the MAC address of the peer subinterface is learnt by this subinterface. If not, the one-way audio failure will occur. You can ping the IP address of the peer subinterface, or use the **shutdown** command to disable the primary interface of the subinterface and then use the **no shutdown** command to enable the primary interface.The preceding restriction does not apply when RPL is configured on other interfaces.

☑ This command is supported by routers only.

Configuration example`# Enable RPL.`

This example shows how to enable RPL on an interface.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface gigabitethernet 0/0/0
Ruijie(config-if)# ip reverse-path
Ruijie(config-if)#exit
Ruijie(config)#end
```

Displaying Device Configurations

Use the following command to show device configurations.

Command	Function
show running-config	Displays device configurations.

Configuration Examples

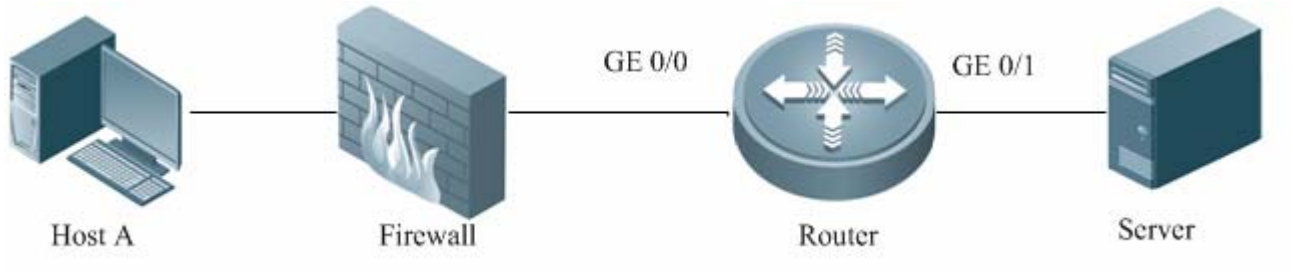
RPL Configuration Example

Networking requirements

Terminals of a network need to traverse the firewall to access the server.

Networking topology

Figure 20 Networking topology for a terminal to access the server through the router and firewall



Configuration Tips

- The router and host A is interconnected.
- IP forwarding is enabled on GE 0/0 and GE 0/1.
- Routes to host A are not required on the router.

Configuration Steps

Enter configuration commands in interface mode to configure RPL.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface gigabitethernet 0/0/0
Ruijie(config-if)# ip reverse-path
Ruijie(config-if)#exit
Ruijie(config)#end
```

Verification

Run the **show running-config** command on the router. **ip reverse-path** is displayed for GE 0/0. Ping the IP address of the server from host A. The server can be successfully pinged.

MAC Address Configuration

Using the information in the MAC address table, the Ethernet switch rapidly searches for the address to which the messages in the data link layer are forwarded. This chapter describes the MAC address configuration, including the following sections:

- Understanding the MAC Address Table
- Default Configuration
- Configuring the Dynamic Address
- Configuring the Dynamic Address Aging Time
- Configuring the Management Learning mode of Dynamic Address
- Configuring the Limit of Dynamic Addresses for a VLAN
- Configuring the Static Address
- Configuring the Filtering Address
- Configuring the MAC Addres Change Notification Function
- Configuring IP address and MAC address binding
- Configuration Examples

Understanding the MAC Address Table

Overview

Layer-2 forwarding, a major function of the Ethernet Switch, is to forward the messages by identifying the data link layer information. The switch forwards the messages to the corresponding interface through the destination MAC addresses carried by the messages, and stores the information about the relationship between the destination MAC address and the interface in the MAC address table.

All the MAC addresses in the MAC address table are associated with the VLAN. Different MAC addresses are allowed to be in the same VLAN. Each VLAN maintains a MAC address table logically. It is possible that a MAC address learned by a VLAN is unknown to other VLANs and shall be learned again.

The MAC address contains the following information:

State	VLAN	MAC address	Interface

Figure-1 MAC Address Entry

- State: Dynamic,static or filtering address.
- VLAN: VLAN to which the MAC address belongs;
- MAC address: the MAC address information in the entry;
- Interface: the information of the interface with which the MAC address is correspondent.

The MAC address entries are updated and maintained by the following two ways:

- Learning the Dynamic Address
- Configuring the Dynamic Address Manually

The switch searches for the corresponding outgoing forward interface according to the destination MAC address and the VLAN ID for the message in the MAC address table, and then forwards the messages in unicast, multicast and broadcast way.

- Unicast forwarding: if the switch searches for the corresponding entry of the packet destination MAC address and VLAN ID in the MAC address table and the outgoing forward interface is sole, the packets are forwarded through this interface.
- Multicast forwarding: if the switch searches for the corresponding entry of the packet destination MAC address and VLAN ID in the MAC address table and this entry is correspondent with a group of outgoing forward interfaces, the packets are forwarded through the interfaces directly.
- Broadcast forwarding: if the switch receives the packets destined to ffff.ffff.ffff, or it can not search for the corresponding entry in the MAC address table, the packets are sent to the VLAN to which belongs and forwarded through the outgoing interfaces except for the incoming interface.

Note

■ This chapter describes management of dynamic, static and filtering addresses. For the management of multicast address, please refer to *IGMP Snooping Configurations*.

Learning the Dynamic Address

Dynamic Address

A dynamic address is the MAC address learnt automatically from the packets received by the switch. Only the dynamic address be removed by the aging mechanism of the address table.

Address Learning Process

In general, it maintains the MAC address table by learning the dynamic address. The operation principle is:

The MAC address table in the switch is null and User A shall communicate with User B. User A sends the packet to interface GigabitEthernet 0/2 and the MAC address for User A is learnt in the MAC address table.

There is no source MAC address for User B in MAC address table. Therefore, the switch sends the packets to all ports except for the ports of User A in broadcast form. User C can receive the packets sent from User A and don't belong to User A.

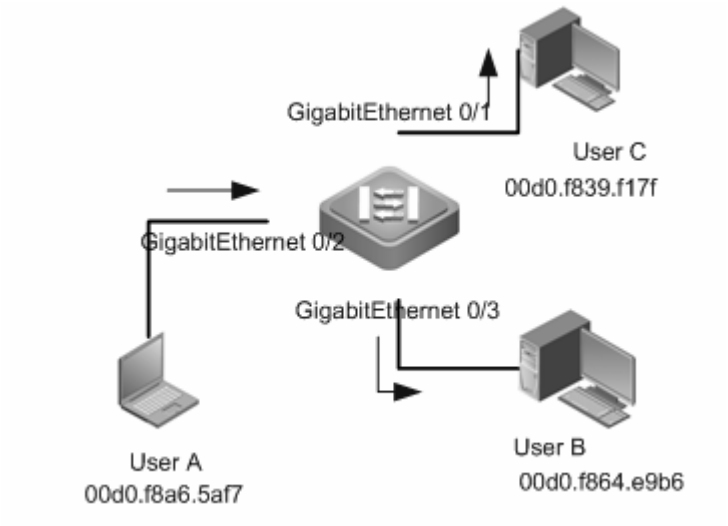


Figure2 Dynamic Address Learn (Step 1)

Status	VLAN	MAC address	Interface
Dynamic	1	00d0.f8a6.5af7	GigabitEthernet 0/2

Figure3 MAC Address Table1

Upon receiving the packets, UserB will send them to UserA through interface GigabitEthernet 0/3. The MAC address for UserA exits in the MAC address table. Therefore, the packets are forwarded to interface GigabitEthernet 0/2 in the unicast form and the switch learns the MAC address for UserB at the same time. The difference from the step one is that UserC can not receive the packets sent from UserB to UserA.

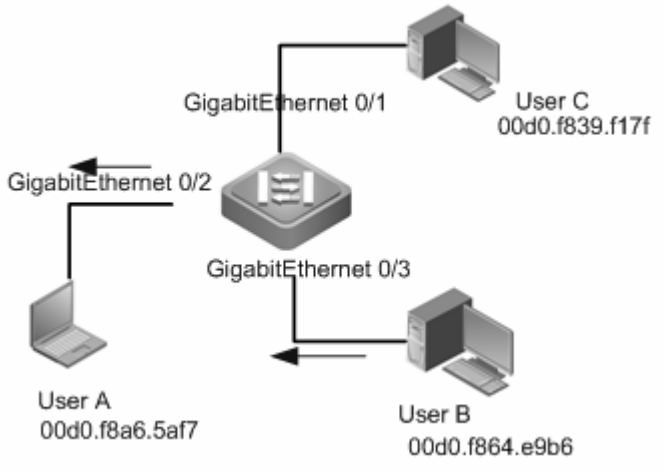


Figure4 Dynamic Address Learn (Step 2)

Status	VLAN	MAC address	Interface

Dynamic	1	00d0.f8a6.5af7	GigabitEthernet 0/2
Dynamic	1	00d0.f8a4.e9b6	GigabitEthernet 0/3

Figure5 MAC Address Table 2

After the communication between UserA and UserB, the switch learns the source MAC addresses for UserA and UserB. The mutual packets between UserA and UserB are forwarded in the unicast form and UserC can not receive them again.

Caution

- In the stack system, the address tables of each member device are asynchronous. For example:
- Suppose the device A and device B stack and the device A is the host, send the broadcast packets to the device A, the port receiving the frames on the device A will learn the MAC1 address, which will be recorded in the address table. Since the packets are broadcasted to the device B through the stack port, the stack port on the device B will also learn this MAC1 address but not record it in the address table.
- Removing the MAC address learned from the frame-receiving port on the device A, the MAC1 address in the address table will also be removed. However, the stack port of the device B still learn this MAC address, the inconsistency of the hardware address table of the master and slave devices occurs. Send the packets destined to MAC1 address to other ports of the device A, those packets can not be broadcasted to the device B for the reason that the MAC1 address has already been learned by the stack port of the device B. After this MAC address ages out, the packets are broadcasted to the port of the device B.
- For the line cards of S7600 series, the MAC address learning is not asynchronous, either.
- For S20, S2300 series, if a packet is destined to the MAC address from 0x 0180c2000000 to 0x0180c200002f, the source MAC address for this packet can not be learned from the switch.
- For S20, S2300, S2600, S3200, S3750 and S5750 series, it is possible that the MAC addresses or the addresses learning collision may occur, which cause the MAC address can not be learned even if the MAC address table is not full.
- The internal mechanism is simply introduced as follows:

To improve the efficiency, the hardware address table runs through the hush bucket mechanism. The address table is divided into several buckets, each bucket has 1 MAC address(for S20, S2300 series) or 8 MAC addresses(for S2600, S3200, S3750 and

	S5750 series). When learning the MAC addresses, the bucket index value is calculated through the Hash algorithm with the combination of MAC+VID, and is added to this bucket. It will collide if the bucket index values calculted for different combinations of MAC+VID are the same. For S2600, S3200, S3750 and S5750 series, the bucket size is 8 MAC addresses, then it will be allowed to collide for 8 times. When all the addresses in the bucket are learned, the bucket overflows and the corresponding MAC address can not be added to the bucket and will be dropped. For S20, S2300 series, the bucket size is 1 MAC addres, and the bucket overflow possibility is much greater. To this end, in the actual application environment, the possibility of MAC address learning deny is much greater. While in this circumstance, it does not influence the normal working for the user.

Address Aging

The capacity of MAC address is restricted. The switch updates the MAC address list by learning new addresses and aging out unused addresses.

For an address in the MAC address table, if the switch has not received any packet from the MAC address for a long time (depending on the aging time), the address will be aged out and removed from the MAC address table.

Management Learning mode of the Dynamic Address

Product Support	Only S8600, S12000 and S9600 series support the management learning mode configuration of the dynamic address.

Ruijie high-density modular Ethernet switches support the management learning mode of the dynamic address, including:

- Uniform MAC address learning mode
- Dispersive MAC address learning mode

Uniform MAC address learning mode

A. Operation Mechanism

In this mode, multiple line cards in the switch learn the MAC addresses, with each line card learning the MAC address independently. The MAC address learn process is described as follows:

The UserA under the Line Card1 sends the packets to the UserB. For the MAC address for the UserB does not exist on the switch, the packets will be sent to all line cards on the switch in broadcast form.

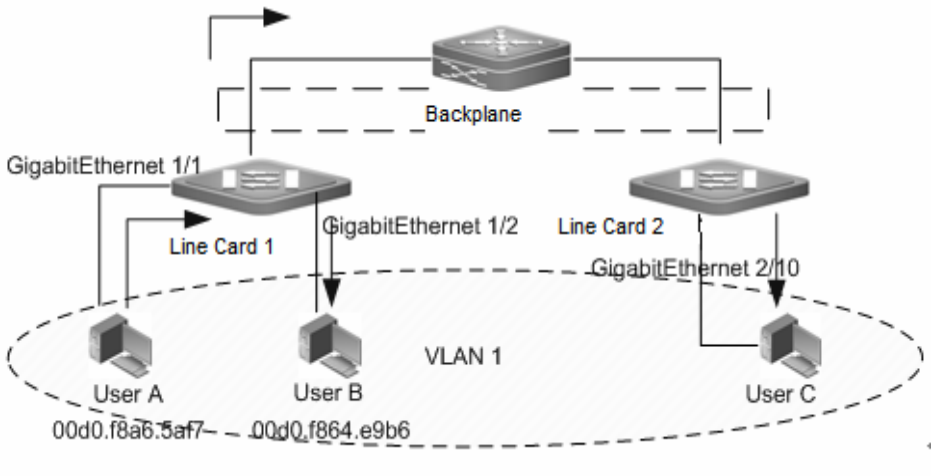


Figure-6 Uniform MAC Address Forward Process 1

The User A under the Line Card1 sends the packets to the User B. For the MAC address for the User B does not exist on the switch, the packets will be sent to all line cards on the switch in broadcast form. The switch learns the address after receiving the packets from the User A. At this time, Line Card 1 and Line Card 2 both receive the packets from the User A, so they learn the MAC address for the User A simultaneously.

MAC address table(Line card 1)			
Status	VLAN	MAC address	Interface
Dynamic	1	00d0.f8a6.5af7	GigabitEthernet 1/1

MAC address table(Line card 2)			
Status	VLAN	MAC address	Interface
Dynamic	1	00d0.f8a6.5af7	GigabitEthernet 1/1

Figure-7 Uniform MAC address Learning: MAC address table

After receiving the packets from the User A, the User B sends the reply packets to the Line Card1. Since the Line Card 1 has learned the MAC address for the User A, the packets will be sent to the port of User A in the unicast form and will not be sent to the Line Card 2.

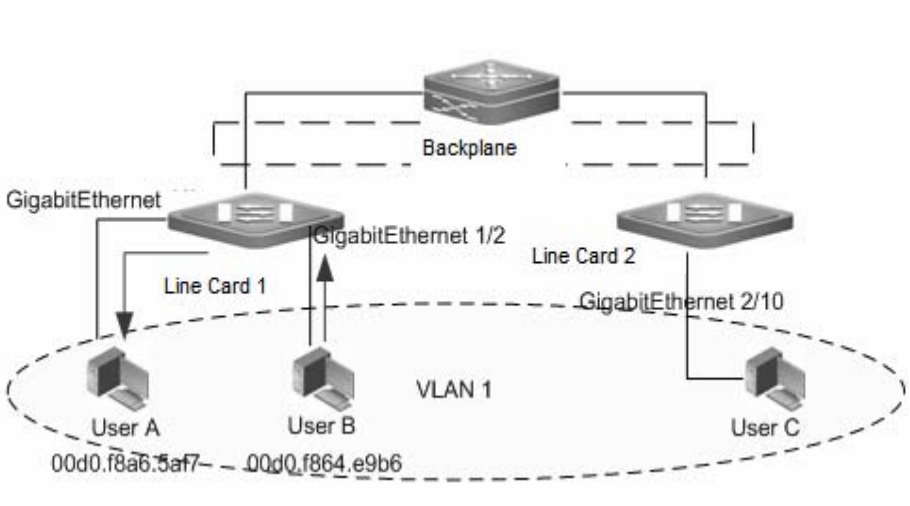


Figure-8 Uniform MAC Address Forward Process 2

For the reply packets sent by the UserB are forwarded to the port of UserA through the Line Card 1, the switch only learn the Mac addresses on the Line Card 1 and the MAC addres for UserB can not be learned on the Line Card 2.

MAC address table(Line card 1)			
Status	VLAN	MAC address	Interface
Dynamic	1	00d0.f8a6.5af7	GigabitEthernet 1/1
Dynamic	1	00d0.f864.c9b6	GigabitEthernet 1/2

MAC address table(Line card 2)			
Status	VLAN	MAC address	Interface
Dynamic	1	00d0.f8a6.5af7	GigabitEthernet 1/1

Figure-9 Uniform MAC address Learning: MAC address table 2

The advantages of the uniform MAC address learning:

- ✧ The capacity of the address table for all linecards in the switch is allocated on demand: If two users exchange the packets on the same line card, only the MAC address space of the line card 1 is occupied.
- ✧ High System Performance: Small system expenditure since the internal system adopts the dispersive MAC address learning mode.

The disadvantages of the uniform MAC address learning: since the address tables for all line cards in the switch are asynchronous, the packets are sent in the unicast form for Line Card 1 while in the broadcast form for Line Card 2.

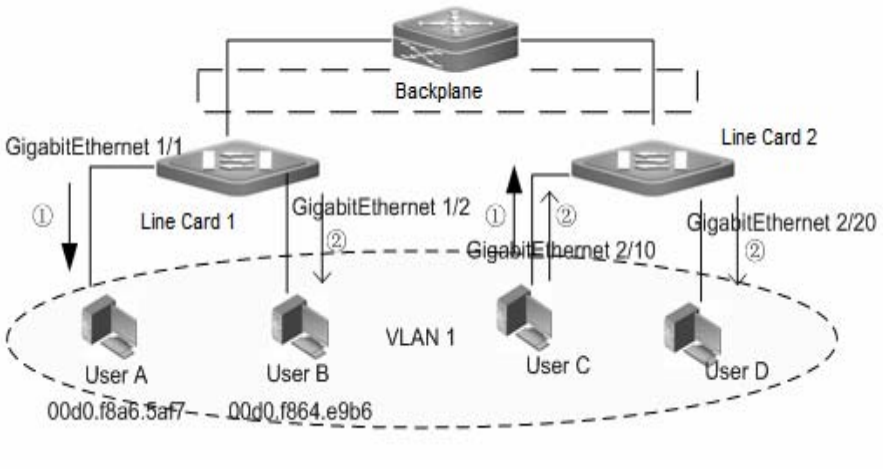


Figure-10 Uniform MAC address Learning: Unicast and Multicast Packets Forward

When the UserC under the Line Card 2 sends a packet to the UserA, since the Line Card 2 has learned the MAC address for the UserA, the packet will be forwarded to the UserA in the unicast form.

When the UserC under the Line Card 2 sends a packet to the UserB, since the Line Card 2 has learned the MAC address for the UserB, the packet will be forwarded in the broadcast form. At this time, the UserD that is in the same VLAN of UserC also receives the packet. The packet will be forwarded in the unicast form to the UserB after being sent to the Line Card 1.

B. MAC Address Synchronization

In the uniform MAC address learning mode, the Ethernet switch supports the MAC address synchronization function. All line cards in the switch no longer learn the MAC address in the dispersive MAC address learning mode and synchronize the new MAC address learned by any line card.

The advantages of the MAC address synchronization: the MAC addresses within the switch are synchronous. It helps prevent the packets in the network from being forwarded in the broadcast form if the number of users connecting to the switch exceeds the MAC address table limit.

The disadvantages of the MAC address synchronization:

- ✧ Occupy the large space of the MAC address table: Even though two users exchange the packets on the same line card, the MAC address space of other line cards will also be occupied.
- ✧ Decrease the System Performance: The system performance is decreased and it needs the extra synchronous expenditure because the line card adopts the non-dispersive MAC address learning mode.

Caution

■ With the dynamic MAC address synchronization enabled, every time the address learning or address aging occurs, the corresponding operation is executed by the switch. Frequent address learning or address aging in a short time consumes a lot of CPU resources, which results in the high utilization of CPU. The administrator shall enable this function prudently.

Dispersive MAC address learning mode

In the uniform mode, all line cards join the address learning in all VLANs. Even though a port in a specified VLAN is only distributed on one line card, other line cards still learns the address when receiving the packet from this specified VLAN.

In the dispersive mode, the line card is responsible for learning the address only in the VLAN where the port that is on this line card is in, not learning the address in other VLANs.

In the VLAN 1, all ports are on the line card 1. In the VLAN 2, all ports are on the line card 2. In the VLAN 3, all ports are on the line card 3.

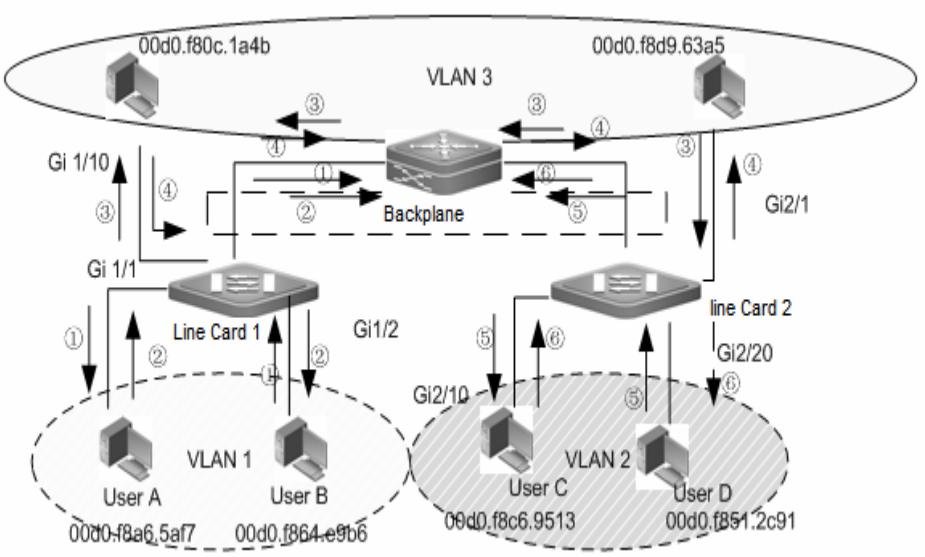


Figure-11 Separated MAC address Learning Forward

If the address tables of the line card 1 and line card 2 are null, the UserA and the UserB exchanges the packets in VLAN1, the UserC and the UserD exchanges the packets in VLAN2, the UserE and the UserF exchanges the packets in VLAN3. The following shows the MAC address table learned by the switch:

MAC address table(Line card 1)			
Status	VLAN	MAC address	Interface
Dynamic	1	00d0.f8a6.5af7	GigabitEthernet 1/1
Dynamic	1	00d0.f864.c9b6	GigabitEthernet 1/2

Dynamic	3	00d0.f8d9.63a5	GigabitEthernet 2/1
Dynamic	3	00d0.f80c.1a4b	GigabitEthernet 1/10

MAC address table(Line card 2)			
Status	VLAN	MAC address	Interface
Dynamic	2	00d0.f8c6.9513	GigabitEthernet 2/10
Dynamic	2	00d0.f851.2c91	GigabitEthernet 2/20
Dynamic	3	00d0.f8d9.63a5	GigabitEthernet 2/1
Dynamic	3	00d0.f80c.1a4b	GigabitEthernet 1/10

Figure-12 Separated MAC address Learning: MAC address table

In the dispersive mode, the line card learns the neccesary address information only. To this end, it maximizes the resources of the MAC address table in the system.

Caution

1. In the dispersive mode, theoretically, when the line cards in different models are mix-inserted, the total capacity of the address table equals to the sum of the capacity of the address table of all line cards. In the uniform mode, when the line cards in different models are mix-inserted, the minimum capacity of the address table of the line card determines the maximum total capacity of the address table. For example, in the dispersive mode, seven line cards of M8600P-48GT/4SFP-A and one line card of M8600-24SFP/12GT are mix-inserted, the total capacity of the address table equals to 32K*7+16K; while in the uniform mode, the total capacity of the address table is 16K.
2. In the dispersive mode, for M8600-4XFP, M9600-4XFP, and M12000-4XFP to reach the limited capacity, the port 1 and 2, 3 and 4 on this line card can not be configured in the same VLAN. For M8600-8XFP, M9600-8XFP and M12000-8XFP to reach the limited capacity, the port 1 and 2, 3 and 4, 5 and 6, 7 and 8 on this line card can not be configured in the same VLAN.

Limit of Dynamic Addresses for a VLAN

The capacity of the MAC address table on the Ethernet switch is limited and shared by all VLANs. To prevent large amout of dynamic addresses in a VLAN from occupying the whole MAC address table and disabling other VLANs to learn the dynamic addresses which leads the packets in other VLANs to be forwarded in the broadcast way, the switch provides the limit of dynamic addresses for

a VLAN. The user can specify the number of dynamic addresses learned in each VLAN and configure the upper limit of dynamic addresses for each VLAN.

For the VLAN with the limit of dynamic addresses configured, only the specified MAC addresses can be learned. The MAC addresses that exceeds the upper limit are not learned and the packets destined to those MAC addresses are forwarded in the broadcast form.

Caution

- 1. If the upper limit of the dynamic addresses for a VLAN is less than the number of the learned dynamic addresses in the current VLAN, the Ethernet switch no longer learns the address in the VLAN and learns again untill the number of the addresses is less than the upper limit due to the address aging and deletion.
- 2. The MAC address duplication which duplicates the MAC address to the MAC address entry of the specified VLAN is not limited by the number of dynamic MAC addresses learnt in this VLAN.

Product Support

For S8600 series switches, only EB/EC line cards support this function.

For S12000 series switches, only EA line cards support this function.

This function will take no effect if non-aforementioned line cards are installed in the switch.

Static Address

A static address is a manually configured MAC address. A static address is the same as a dynamic address in terms of funciton. However, you can only manually add and delete a static address rather than learn and age out a static address. A static address is stored in the configuration file and will not be lost even if the device restarts.

By configuring the static address manually, you can bind the MAC address for the network device with the interface in the MAC address table.

Filtering Address

A filtering address is a manually configured MAC address When the device receives the packets from a filtering address, it will directly discard them. You can only manually add and delete a filtering address rather than age it out. A filtering address is stored in the configuration file and will not be lost even if the device restarts.

If you want the device to filter some invalid users, you can specify their source MAC addresses as filtering addresses. Consequently, these invalid users cannot communicate with outside through the device.

Caution

■ A filtering address is invalid for the packets sent to the CPU. For example, the L2 source MAC address for an ARP packet is a filtering address, this ARP packet can still be sent to the CPU, but can not be forwarded.

Product Support

S20 , S23 and rsr1002e-rsr2004e series only support filtering the packets destined to the filtering addresses.

MAC Address Change Notification

The MAC address notification function is an effective way to let you know user changes for the devices in a network.

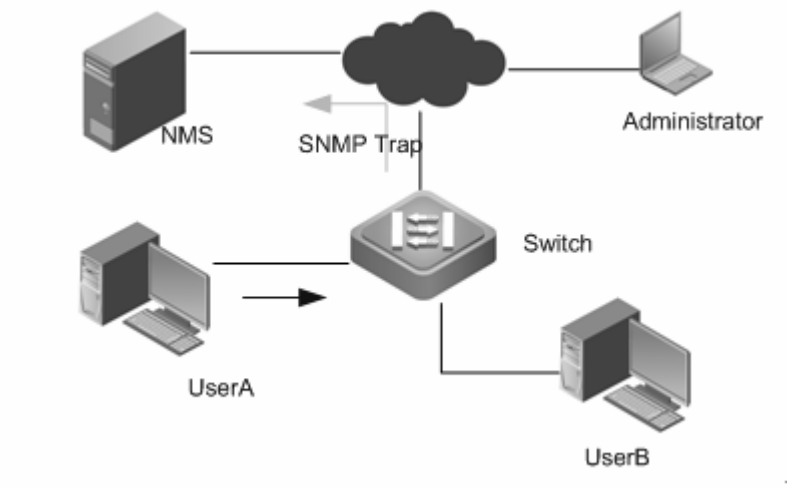


Figure-13 MAC address Change Notification

After the MAC address change notification is enabled, the MAC address change notification information is generated and sent in the SNMP Trap message form to the specified NMS when the switch learns a new MAC address or ages out a learned MAC address.

The notification about adding a MAC address lets you know a newcomer (identified by the MAC address) is using the device. The notification about deleting a MAC address (in the case of that the user did not communicate with the device within the aging time) lets you know that a user does not use the device any more.

When many users use the device, lots of MAC address changes may occur in a short period of time (for example, when the device is powered on), incurring additional network traffic. In order to release network burden, you can set the time interval of sending MAC address notifications. All the notification messages within the interval time will be bundled in one SNMP Trap message. So one notification message includes multiple MAC address changes, reducing netowrk traffic significantly.

When a MAC address change notification is generated, it will be recorded in the MAC address notification history list. Then even though the NMS has not been specified to receive the SNMP

Trap message, the administrator can view the information about address change by checking the MAC address notification history list.

Caution

■ MAC address change notification is effective only for dynamic addresses, not for static addresses and filtering addresses.

IP address and MAC address Binding

Overview

IP address and MAC address binding lets you filter pakcets. After you bind an IP address and a MAC address, the switch will only receive the IP packets whose source IP address and MAC address match the binding address ;or it will be discarded.

Taking advantages of IP address and MAC address binding, you can check the legality of the input sources. Note that this funciton takes precedence over 802.1X, port-based security and ACL effectiveness.

Address Binding Mode

The address binding mode divides into 3 modes: compatible, loose and strict. By default, the address binding mode is strict. The following table lists the corresponding forwarding rules:

Mode	IPv4 packet forward rule	IPv6 packet forward rule
Strict	Packets with IPV4+MAC are forwarded.	No IPV6 packet is forwarded.
Loose	Packets with IPV4+MAC are forwarded.	All IPV6 packets are forwarded.
Compatible	Packets with IPV4+MAC are forwarded.	The IPV6 packets binded with the source MAC addresses are forwarded.

Exceptional Ports for the Address Binding

By default, the IP address and MAC address binding function is effective on all ports. You can configure the exceptional ports to make this address binding function ineffective on some ports.

Note

■ Because the binding relationship on the uplink port is uncertain, generally the uplink port is configured as the exceptional port. It is not necessary to check the IP address and MAC address binding on the uplink port.

Caution

■ For S5750 and S8600 series, the ARP Check function takes no effect on the IP+MAC binding exceptional port.

Related Protocols

《IEEE Std 802.3™ Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications》

《IEEE Std 802.1Q™ Virtual Bridged Local Area Networks》

Default MAC Address Table Configuration

Function	Default
Dynamic address aging time	300s
Dynamic address learning mode	dispersive
Dynamic address synchronization	disabled
Limit of VLAN dynamic address	disabled
MAC address change notification	disabled
Address-bind mode	compatible
Bridge Protocol Frame Forwarding Action	BPDU: not forward 802.1x: forward GVRP: not forward

Setting Dynamic Addresses

Clearing Dynamic Addresses

Command	Function
Ruijie**#clear mac-address-table dynamic**	Clear all dynamic addresses.
Ruijie**#clear mac-address-table dynamic address** *mac-address* **vlan** *vlan-id*	Clear the specified MAC address. *mac-address*：the specified MAC address to be cleared. *vlan-id*：the specified VLAN to which the MAC address to be cleared belongs.

Ruijie#**clear mac-address-table dynamic interface** *interface-id* [**vlan** *vlan-id*]	Clear all dynamic addresses on the specified port or Aggregate Port, or clear all dynamic addresses on all interfaces. *Interface-id:* the specified port or Aggregate Port; *vlan-id*：the specified VLAN to which the dynamic address to be cleared belongs.
Ruijie#**clear mac-address-table dynamic vlan** *vlan-id*	Clear all dynamic addresses in the specified VLAN. *vlan-id*：the specified VLAN to which the dynamic address to be cleared belongs.

The following example shows how to clear all dynamic addresses in VLAN 1 on interface GigabitEthernet 0/1:

```
Ruijie#clear mac-address-table dynamic interface GigabitEthernet 0/1 vlan 1
```

Viewing Configurations

Command	Function
Ruijie# **show mac-address-table dynamic**	Show all dynamic addresses.
Ruijie# **show mac-address-table dynamic address** *mac-address* [**vlan** *vlan-id*]	Show the specified dynamic MAC address. *mac-address*：the specified MAC address. *vlan-id*：the specified VLAN to which the MAC address belongs.
Ruijie# **show mac-address-table dynamic interface** *interface-id* [**vlan** *vlan-id*]	Show all dynamic addresses on the specified port or Aggregate Port. *Interface-id:* the specified port or Aggregate Port; *vlan-id*：the specified VLAN to which the dynamic address belongs.
Ruijie# **show mac-address-table dynamic vlan** *vlan-id*	Show all dynamic addresses in the specified VLAN. *vlan-id*：the specified VLAN to which the dynamic address belongs.

Ruijie# **show mac-address-table count**	Show the statistics in the mac address table.

The following example shows all dynamic MAC addresses in VLAN 1 on interface GigabitEthernet 0/1:

```
Ruijie#show mac-address-table dynamic interface gigabitEthernet 0/1 vlan 1
Vlan        MAC Address         Type     Interface
----------  ------------------- -------- ------------------
 1        0000.5e00.010c       DYNAMIC  GigabitEthernet 0/1
 1        00d0.f822.33aa       DYNAMIC  GigabitEthernet 0/1
 1        00d0.f822.a219       DYNAMIC  GigabitEthernet 0/1
 1        00d0.f8a6.5af7       DYNAMIC  GigabitEthernet 0/1
```

Caution

- For S20, S2300 series, when removing the MAC addresses manually, the notification of address removing-adding-removing again is generated and the MAC address will be removed finally. For S2300 series, removing the address learned from the Private VLAN manually leads to the turbulance of the address table in a short period.
- For R2700 switching card (NM2-24ESW/NM2-16ESW), the displaying MAC address table of execution of the command **show mac-address-table dynamic** may not be complete, but it will not influence the normal message switching. Meanwhile, for the addresses learned from the AP of S20 series and switching card, if the member port learning the address from the AP is down, the MAC address for the AP will be removed, yet it will not influence the normal message switching.

The following example shows the statistics in the MAC address table:

```
Ruijie# show mac-address-table count
Dynamic Address Count  : 30
Static  Address Count  : 0
Filtering Address Count: 0
Total Mac Addresses    : 30
Total Mac Address Space Available: 8159
```

Caution

- For S57 series, the total available MAC address space is 16384.

Setting the Address Aging Time

Setting the Aging Time

The following table shows how to set the aging time of address:

Command	Function
Ruijie(config)# **mac-address-table aging-time** [*0* |*10-1000000*]	Set the time for an address to be stored in the dynamic MAC address table after it has been learned. It is in the range of 10 to 1000000 seconds, 300 seconds by default. When you set the aging time as 0, the address aging function is disabled and the learned addresses will not be aged.
Ruijie(config)# **no mac-address-table aging-time**	Restore the aging time to the default value.

The following example shows how to set the address aging time to 180s:

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#mac-address-tabsle aging-time 180
```

Viewing Configurations

Command	Function
Ruijie)**#show mac-address-table aging-time**	Show the aging time of all addresses.

The following example shows how to view the address aging time configurations:

```
Ruijie#show mac-address-table aging-time
Aging time   : 180 seconds
```

Caution

- The actual aging time may be different from the setting value for the MAC address table. However, it will not be 2 times than the setting value.
- For S2900, S3760 and S5760 series, the range of aging time is 10-630s.

Setting the Management Learning Mode of Dynamic Addresses

Setting the Dynamic Address Learning Mode

Command	Function

Command	Function
Ruijie(config)# **mac-manage-learning dispersive**	Set the management learning mode of the dynamic address as the dispersive mode.
Ruijie(config)# **mac-manage-learning uniform**	Set the management learning mode of the dynamic address as the uniform mode.

The following example shows how to set the dispersive address learning mode:

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#mac-manage-learning dispersive
```

Setting the Uniform Address Learning-Sync

Command	Function
Ruijie(config)# **mac-manage-learning uniform learning-synchronization**	In the uniform address learning mode, enable dynamic address synchronization.
Ruijie(config)# **no mac-manage-learning uniform learning-synchronization**	In the uniform address learning mode, disable dynamic address synchronization.
Ruijie(config)# **mac-manage-learning uniform**	Set the management learning mode of the dynamic address as the uniform mode.

The following example shows how to enable dynamic address synchronization:

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#mac-manage-learning uniform learning-synchronization
```

Viewing Configurations

```
Ruijie #show mac-address-table mac-manage-learning
MAC manage-learning
running mode: dispersive.
configuration mode: dispersive.
dynamic address learning-synchronization: off.
```

Setting the Limit of Dynamic Addresses for a VLAN

Setting the Limit of Dynamic Addresses for a VLAN

You can set the limit of dynamic MAC addresses that a VLAN can learn.

The table below sets the limit of the dynamic addresses for a VLAN.

Command	Function
Ruijie**# configure terminal**	Enter the global configuration mode.
Ruijie(config)**# vlan** [*1-4094*]	Enter the VLAN configuration mode.
Ruijie(config-vlan)# **max-dynamic-mac-count** [*1-32768*]	Set the maximum number of dynamic MAC addresses that the VLAN can learn.

To disable the limit of the dynamic addresses for a VLAN, use the **no max-dynamic-mac-count** command.

The following example shows how to set the maximum dynamic address number to 160:

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#vlan 1
Ruijie(config-vlan)#max-dynamic-mac-count 160
```

Caution

For S8600 series switches, only EB/EC line cards support this function.

For S12000 series switches, only EA line cards support this function.

- This function will take no effect if non-aforementioned line cards are installed in the switch.

Viewing Configurations

Show the maximum number of dynamic addresses for a specified VLAN:

```
Ruijie#show mac-address-table max-dynamic-mac-count vlan 1
vlan limit   mac count learning
---- ------- --------- --------
 1    160       6        YES
```

Show the maximum number of dynamic addresses for all VLANs:

```
Ruijie#show mac-address-table max-dynamic-mac-count
vlan limit   mac count learning
---- ------- --------- --------
 1    160     6        YES

  3    500     124      YES
```

Caution

For S8600 series switches, only EB/EC line cards support this function.

For S12000 series switches, only EA line cards support this function.

- This function will take no effect if non-aforementioned line cards are installed in the switch.

Setting the Static MAC Addresses

Adding and Removing the Static MAC Addresses

You can add a static address to the MAC address table by specifying the destination MAC address, the VLAN (the static address will be added to the address table of this VLAN), and the interface (the packets to the destination MAC address are forwarded to this interface).

To add a static address, execute the following commands:

Command	Function
Ruijie(config)# **mac-address-table static** *mac-address* **vlan** *vlan-id* **interface** *interface-id*	*mac-addr*: Specify the destination MAC address to which the entry corresponds. *vlan-id*: Specify the VLAN to which this address belongs. *interface-id:* specify the interface (physical port or aggregate port) to which the packet is forwarded. Upon receiving the packets to the destination MAC address in the VLAN, the switch will forward them to the interface.
Ruijie(config)# **no mac-address-table static** *mac-address* **vlan** *vlan-id* **interface** *interface-id*	Remove the static MAC address entries.

The following example shows how to configure the static address 00d0.f800.073c. When a packet to this address is received in VLAN 4, it is forwarded to Gigabitethernet 0/3.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mac-address-table static 00d0.f800.073c vlan 4 interface gigabitethernet
0/3
```

The following example shows how to remove the static address 00d0.f800.073c.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
```

```
Ruijie(config)#no mac-address-table static 00d0.f800.073c vlan 4 interface gigabitethernet
0/3
```

Viewing Configurations

Command	Function
Ruijie# **show mac-address-table static**	Show the information of all the static MAC addresses.

The following example shows how to view the information of all the static MAC addresses:

```
Vlan        MAC Address         Type      Interface
----------  ------------------- -------- ------------------
          4       00d0.f800.073c       STATIC    GigabitEthernet 0/3
```

Setting the Filtering MAC Addresses

Adding and Removing the Filtering Addresses

To add a filtering address, specify the MAC address to be filtered and the VLAN that the MAC address belongs to. The device will directly discard the packets from the MAC address in the VLAN.

To add a filtering address, execute the following command:

Command	Function
Ruijie(config)# **mac-address-table filtering** *mac-addr* **vlan** *vlan-id*	mac-addr: Specify the MAC address to be filtered by the device. vlan-id: Specify the VLAN to which this address belongs.
Ruijie(config)# **no mac-address-table filtering** *mac-addr* **vlan** *vlan-id*	Remove the filtering MAC address entries.

The following example shows how to configure the filtering address 00d0.f800.073c. When a packet to or from this address is received in VLAN 4, it will be discarded.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mac-address-table filtering 00d0.f800.073c vlan 4
```

The following example shows how to remove the filtering address 00d0.f800.073c.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#no mac-address-table filtering 00d0.f800.073c vlan 4
```

Viewing Configurations

Command	Function

Command	Function
Ruijie# **show mac-address-table filtering**	Show the information of all the filtering MAC addresses.

The following example shows how to view the information of all the filtering MAC addresses:

```
Vlan        MAC Address         Type      Interface
----------  ------------------- --------  ------------------
          4       00d0.f800.073c       FILTER    GigabitEthernet 0/3
```

Setting MAC Address Change Notification

Setting MAC Address Change Notification

By default, the global switch of MAC addresses is turned off, so the MAC address change notification function is disabled on all interfaces.

To configure the MAC address change notification function, execute the following command:

Command	Function
Ruijie(config)# **snmp-server host** *host-addr* **traps** [**version** {**1 | 2c |3 [auth | noauth | priv**]}] *community-string*	Configure the NMS to receive the MAC address change notification. *host-add*: IP address of the receiver. *version:* Specify the version of the SNMP Trap message to be sent. *community-string*: Specify the authentication name carried with the SNMP Trap message.
Ruijie (config)**#snmp-server enable traps**	Allow the switch to send the SNMP Trap message.
Ruijie(config)# **mac-address-table notification**	Turn on the global switch of the MAC address change notification function.
Ruijie(config)# **mac-address-table notification** {**interval** *value* | **history-size** *value*}	*interval value* :Interval of generating the MAC address change notification (optional), in the range of 1 to 3600 seconds, 1 second by default. *history-size value*: Maximum number of the records in the MAC notification history list, in the range of 1 to 200, 50 by default.

Command	Function
Ruijie(config-if)# **snmp trap mac-notification** {**added	removed**}	Enable the MAC address change notification on the interface. added: Send a MAC address change notification when a MAC address is **added** on this interface. Removed: Send a MAC address change notification when an address is deleted.

To disable the MAC address change notification function, use the **no snmp-server enable traps** command in the global configuration mode. To turn off the global switch of the MAC address change notification function, use the **no mac-address-table notification** command. To disable the MAC address change notification funciton on a specified interface, use the **no snmp trap mac-notification** {**added** | **removed**} command in the interface configuration mode.

This example shows how to enable the MAC address change notification funciton, use public as the authentication name to send a MAC address change notification to the NMS whose IP address is 192.168.12.54 at the interval of 40 seconds, set the size of the MAC address change history list to 100, and enable the MAC address change notification funciton on gigabitethernet 0/1 when a MAC address is added or removed.

```
Ruijie(config)# snmp-server host 192.168.12.54 traps public
Ruijie(config)# snmp-server enable traps
Ruijie(config)# mac-address-table notification
Ruijie(config)# mac-address-table notification interval 40
Ruijie(config)# mac-address-table notification  history-size 100
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# snmp trap mac-notification added
Ruijie(config-if)# snmp trap mac-notification removed
```

Viewing the MAC Address change Notification Information

In the privileged EXEC mode, you can view the information on the MAC address table of the device by using the commands listed in the following table:

Command	Function
Ruijie**# show mac-address-table notification**	Show the global configuration of the MAC address change notification function.
Ruijie**# show mac-address-table notification interface**	Show the configuration of the MAC address change notification on the interface.
Ruijie**# show mac-address-table notification history**	Show the history list of the MAC address change notification.

The following examples show how to view the MAC address change notification.

View the global configuration of the MAC address change notification:

```
Ruijie# show mac-address-table notification
MAC Notification Feature : Enabled
Interval(Sec): 2
Maximum History Size : 154
Current History Size : 2
Ruijie# show mac-address-table notification interface
Interface          MAC Added Trap MAC Removed Trap
---------------- -------------- ----------------
Gi0/1              Disabled      Enabled
Gi0/2              Disabled      Disabled
Gi0/3              Enabled       Enabled
Gi0/4              Disabled      Disabled
Gi0/5              Disabled      Disabled
Gi0/6              Disabled      Disabled
Ruijie# show mac-address-table notification history
History Index:1
Entry Timestamp: 15091
MAC Changed Message :
Operation   VLAN MAC Address    Interface
---------- ---- -------------- --------------------
Added       1    00d0.f808.3cc9 Gi0/1
Removed     1    00d0.f808.0c0c Gi0/1
History Index:2
Entry Timestamp: 21891
MAC Changed Message :
Operation   VLAN  MAC Address    Interface
----------- ---- ------------- --------------------
Added       1    00d0.f80d.1083 Gi0/1
```

Setting IP Address and MAC Address Binding

Setting IP Address and MAC address Binding

In the global mode, to configure IP address and MAC address binding, execute the following commands.

Command	Function
Ruijie(config)# **address-bind** *ip-address mac-address*	Configure IP address and MAC address binding.
Ruijie(config)# **address-bind install**	Enable the address binding function.

To cancel the IP address and MAC address binding, use the **no address-bind** *ip-address mac-address* command in the global configuration mode.

To disable the address binding function, execute the **no address-bind install** command.

The following example shows how to bind the IP address and MAC address:

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
```

```
Ruijie(config)#address-bind 192.168.5.1 00d0.f800.0001
Ruijie(config)#address-bind install
```

Problem: In the stack environment, if one switch learns the MAC address when receiving the IP packets not correspond to the address binding, this MAC address can only be learned by the chip of that switch and cannot be learned by the chips of other switches in the stack environment.

Phenomenon: In the stack environment, if one switch learns the MAC address when receiving the IP packets not correspond to the address binding, this address entry is displayed using the **show mac** command and the IP packets can still be broadcasted to other stack switches. The MAC address learning is normal when receiving the non-IP packets or the IP packets correspond to the address binding.

Caution

Influence: For S23, S26, S57 series, in the stack environment, the switch can nornally learn the MAC address when receiving the IP packets without the secure addresses on the port with address binding enabled. Other stack switches cannot learn the address. This problem neither influence the non-IP packets nor the actual application.

The source MAC address learning for S76 series when the IP+MAC violation packets are received on the line card is similar to the above description.

Workaround: N/A.

After executing the **address-bind install** command but the IP+MAC binding is not configured, then allow all packets to be transmitted on the interface.

Note

■ 1. For S29/S3760/S5760 series, when the global IP+MAC binding and user-based DOT1X user authentication are co-used and the security channel is enabled, all global binding or DOT1X users can communicate with each other.

■ 2. For S26/S26E/S3250E/S3760E/S5760/S8600/S12000 series, when the global IP+MAC binding, port security and DOT1X are co-used and no matter whether the security channel is enabled or not, all secure users can communicate with each other.

Setting the Address Binding Mode

In the global mode, to configure the address binding mode, execute the following commands.

Command	Function
Ruijie(config)# **address-bind ipv6-mode** { **compatible**| **loose** | **strict** }	Configure the address binding mode.
Ruijie(config)# **no adress-bind ipv6-mode**	Restore to the default address binding mode.

The following example shows how to set the address binding mode to strict:

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#address-bind ipv6-mode strict
```

Caution

■ In the IPV6 mode, DHCP Snooping address binding, port security MAC+IP address binding functions are enabled at the same time.

Mode	IPv4 packet forward rule	IPv6 packet forward rule
Strict	Only packets with IPV4+MAC are forwarded.	Only IPV6 packets with IPv6 security address configured are allowed to be forwarded.
Loose	Only packets with IPV4+MAC are forwarded.	All IPV6 packets are allowed to be forwarded.
Compatible	Only packets with IPV4+MAC are forwarded.	Only IPV6 packets bound with the source MAC address or the security address configured are allowed to be forwarded. ForS26/S26E/S3250E/S3760E/S5750/S8600/S12000 series, when the IPv6 compatible mode, port security and DOT1X authentication are co-used, all IPv6 packets bound with the MAC address can be transmitted on the interface. For S29/S3760/S5750 series, when the IPv6 compatible mode, port security and DOT1X authentication are co-used, and the secure channel is enabled, all IPv6 packets with the IP+MAC binding address can be transmitted on the interface.

■

■ For S2900/S3760/S5760 series, if the binding mode is set to be loose, the maximum capacity of the port security IPv4+MAC address binding/802.1x user authorization is reduced to the half of the original one.

Setting the Exceptional Ports for the IP Address and MAC Address Binding

To make the IP address and MAC address binding not to take effect on some ports, you can set these ports as exceptional ports. To configure an exceptional port, execute the following command in the global configuration mode.

Command	Function
Ruijie(config)#address-bind uplink *interface-id*	Configure the exceptional port for the IP address and MAC address binding. *Interface-id:* port or Aggregate port

Use the **no address-bind uplink** *interface-id* command to cancel the configuration of the specified exceptional port.

The following example shows how to set the interface GigabitEthenet 0/1 to the exceptional port:

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# address-bind uplink GigabitEthernet 0/1
```

Viewing the IP Address and MAC Address Binding Table

To show the IP address and MAC address binding table, use the **show address-bind** command in the privileged EXEC mode:

Command	Function
Ruijie(config)#show address-bind	View the IP address and MAC address binding table.

The following example shows how to view the IP address and MAC address binding table :

```
Ruijie#show address-bind
Total Bind Addresses in System : 1

IP Address        Binding MAC Addr
---------------    ----------------
    192.168.5.1    00d0.f800.0001
```

Typical Configuration Examples of MAC Address Table Management

Configuring Static MAC Addresses

Topological Diagram

As Figure-14 shows, the database server connects to the Ethernet switch through the interface GigabitEthernet 0/11, the web server connects to the Ethernet switch through the interface GigabitEthernet 0/10, and the server administrator connects to the switch through the interface GigabitEthernet 0/12. Other users access the web server through the interface GigabitEthernet 0/5. All data are forwarded in VLAN 10.

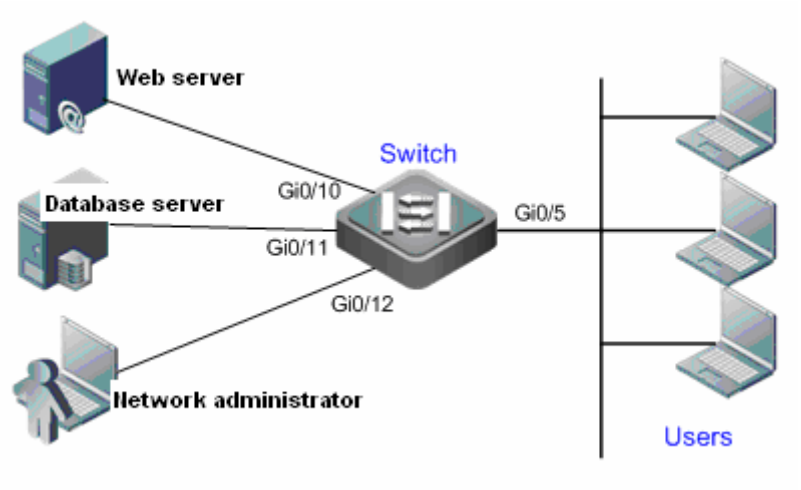


Figure 14 Typical Configuration Topology

Application Requirements

The static MAC address configuration enables the data exchanged between the web server and the database server, the administrator and the server to be forwarded in the unicast form, preventing these data from being forwarded in the broadcast form in the user network and ensuring the security of the information exchanged between the web server and the database server, the administrator and the server .

Configuration Tips

The following three keypoints shall be ensured when configuring the static MAC address entries:

1. Specify the destination MAC address in the entry.

2. Specify the Vlan to which this address belongs.

3. Interface ID.

Upon receiving the packets to the destination MAC address in the VLAN, the switch will forward them to the specified interface.

The following table shows the corresponding relationship among the MAC address, VLAN ID and interface ID in this configuration example.

Role	MAC Address	VLAN ID	Interface ID
Web server	00d0.3232.0001	VLAN2	Gi 0/10
Database server	00d0.3232.0002	VLAN2	Gi 0/11
Network administrator	00d0.3232.1000	VLAN2	Gi 0/12

Configuration Steps

! Enter global configuration mode.

```
Ruijie>en
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
```

! Add the static MAC addresses (Specify the VLAN and interface to which this address belongs).

```
Ruijie(config)#mac-address-table static 00d0.f8003232.0001 vlan 110 interface
GigabitEthernetgigabitEthernet 0/10
Ruijie(config)#mac-address-table static 00d0.f8003232.0002 vlan 110 interface
GigabitEthernetgigabitEthernet 0/211
Ruijie(config)#mac-address-table static 00d0.f800.00033232.1000 vlan 110 interface
GigabitEthernetgigabitEthernet 0/312
```

! Display the device configurations.

Verifications

Display the configured static MAC addresses.

```
Ruijie#show mac-address-table static
Vlan       MAC Address         Type    Interface
----------  -------------------- -------- -------------------
   110       00d0.f8003232.0001      STATIC   GigabitEthernet 0/10
   110       00d0.f8003232.0002      STATIC   GigabitEthernet 0/211
   110       00d0.f800.00033232.1000      STATIC   GigabitEthernet 0/312
```

Configuring Dynamic MAC Addresses Change Notification

Topological Diagram

As Figure-15 shows, the users connect to the switch through the interface GigabitEthernet 0/2.

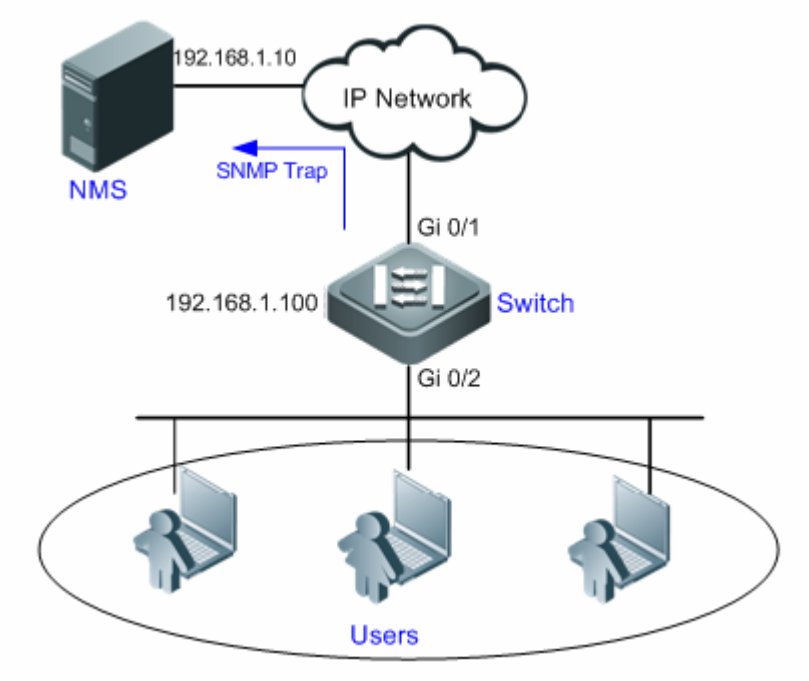


Figure 15 Typical Configuration Topology

Application Requirements

In order to facilitate network access management for an administrator, the following requirements are expected through the configuration:

1. Upon receiving a new MAC address or aging a leart MAC address on the interface connected to the user, the switch will record the address change information in the MAC address notification history list, so that the administrator could view the information about address change by checking the MAC address notification history list.

2. Meanwhile, the MAC address change notification will be sent in SNMP Trap message form to the specified NMS.

3. When many users use the device, avoid generating lots of MAC address changes in a short period of time to reduce network burden.

Configuration Tips

1. Enable the MAC address change notification function globally, and configure the MAC address change notification on the interface Gi 0/2.

2. Configure the NMS host address, and enable the switch to actively send the SNMP Trap notification. The route from the switch to the NMS (Network Management Station) should be reachable.

3. Set the interval of sending the MAC address change notification to 300 seconds (the default interval is 1 second). All the notification messages within the interval time will be bundled in one SNMP Trap message. So one notification message includes multiple MAC address changes, reducing netowrk traffic significantly.

Configuration Steps

The IP address of the device is shown in above figure.

Step1: Enable the global MAC address change notification function on the switch.

```
Ruijie>enable
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#mac-address-table notification
```

Step2: Set the interval of sending MAC address change notification to 30 seconds.

```
Ruijie(config)#mac-address-table notification! Display the device configurations.
```

Step3: Enable the MAC address change notification function on the interface Gi 0/2.

```
Ruijie(config)#mac-address-table notification interval 30
```

! Enter Gi 0/2 interface configuration mode.

```
Ruijie(config)#interface gigabitEthernet 0/2
```

! Enable the device to send notification when an address is added on this interface.

```
Ruijie(config-if-GigabitEthernet 0/2)# snmp trap mac-notification added
```

! Enable the device to send notification when an address is deleted on this interface.

```
Ruijie(config-if-GigabitEthernet 0/2)# snmp trap mac-notification removed
Ruijie(config-if-GigabitEthernet 0/2)#exit
```

Step4: Configure the NMS which receives the MAC address change notifiction, with IP address being 192.168.1.10, messge format being Version 2c and authentication name being comefrom2.

```
Ruijie(config)#snmp-server host 192.168.1.10 traps version 2c comefrom2
```

Step5: Enable the device to actively send the Trap message.

```
Ruijie(config)# snmp-server enable traps
```

Verifications

Step1: Display the global configuration of MAC address change notification.

```
Ruijie#show mac-address-table notification
MAC Notification Feature : Enabled
Interval(Sec): 300
Maximum History Size : 50
Current History Size : 0
```

Step2: Display the status of MAC address change notification function on the interface.

```
Ruijie#show mac-address-table notification interface gigabitEthernet 0/2
Interface             MAC Added Trap    MAC Removed Trap
-----------           --------------    --------------
```

```
GigabitEthernet 0/2    Enabled          Enabled
```

Step3: Display the MAC address table of the interface.

```
Ruijie#show mac-address-table interface gigabitEthernet 0/2
Vlan       MAC Address        Type    Interface
----------  ------------------- -------- ------------------
   1       00d0.3232.0001      DYNAMIC  GigabitEthernet 0/2
   1       00d0.3232.0002      DYNAMIC  GigabitEthernet 0/2
   1       00d0.3232.0003      DYNAMIC  GigabitEthernet 0/2
```

Step4: Verify the configuration.

Use the **clear mac-address-table dynamic address** *00d0.3232.0003* command to simulate the address aging.

! Display the global configuration of MAC address change notification function.

```
Ruijie#show mac-address-table notification
MAC Notification Feature : Enabled
Interval (Sec): 30
Maximum History Size: 50
Current History Size: 1
```

! Display the MAC address change notification history list.

```
Ruijie#show mac-address-table notification history
History Index : 0
Entry Timestamp: 221683
MAC Changed Message :
Operation:DEL Vlan:1 MAC Addr: 00d0.3232.0003 GigabitEthernet 0/2
```

Configuring Global IP Address and MAC Binding

Topological Diagram

As Figure-16 shows, in order to facilitate management, each host is assigned a fixed IP address

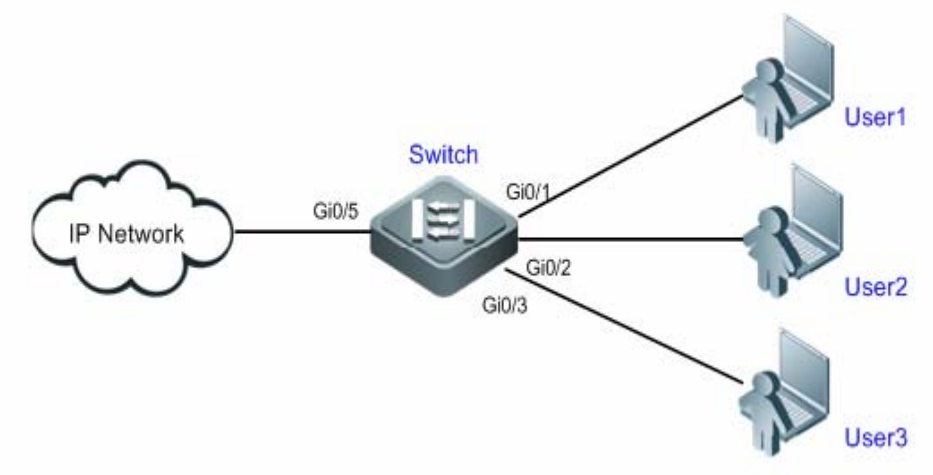


Figure 16 Typical Configuration Topology

Application Requirements

1. Prevent the employee from embezzling IP addresses. For example, some employ may embezzle the IP address of higher perssion to obtain the additional information over his permission.

2. Mobile officing can be achieved in the department.

Configuration Tips

Manually configuring the global IP address and MAC address binding can meet the aforementioned requirements. The configuration keypoints are shown below:

1. Manually configure the global IP address and MAC address binding. (This example lists 3 users.)

User	MAC Address	IP Address
User1	00d0.3232.0001	192.168.1.10
User2	00d0.3232.0002	192.168.1.20
User3	00d0.3232.1000	192.168.1.30

2. Enable the IP address and MAC address binding function globally.

3. Configure the uplink port of the switch (Gi 0/5) as an exceptional port.

Note

■ Because the binding relationship of the IP packets on the uplink port is uncertain, the uplink port is generally configured as the exceptional port. It is not necessary to check the IP address and MAC address binding on the uplink port.

Configuration Steps

Step1: Configure the global IP address and MAC address binding.

```
Ruijie#configure terminal
```

! Configure the IP address and MAC address binding for the User1.

```
Ruijie(config)#address-bind 192.168.1.10 00d0.3232.0001
```

! Configure the IP address and MAC address binding for the User2.

```
Ruijie(config)#address-bind 192.168.1.20 00d0.3232.0002
```

! Configure the IP address and MAC address binding for the User3.

```
Ruijie(config)#address-bind 192.168.1.30 00d0.3232.0003
```

Step2: Enable the global IP address and MAC address binding.

```
Ruijie(config)#address-bind install
```

Step3: Configure the uplink port Gi 0/5 as an exceptional port.

```
Ruijie(config)#address-bind uplink gigabitEthernet 0/5
```

Verifications

Step1: Display the configuration of IP address and MAC address binding on the switch. Keypoint: whether the binding relationship is correct.

```
Ruijie#show address-bind
IP Address        Binding MAC Addr
---------------    ----------------
   192.168.1.10    00d0.3232.0001
   192.168.1.20    00d0.3232.0002
   192.168.1.30    00d0.3232.0003
```

Step2: Display the configuration of the exceptional port.

```
Ruijie#show address-bind uplink
Ports       State
------------ ------
Gi0/5       Enabled
```

Step3: Verify the configuration.

The switch (except for the interface Gi 0/5) will only receive the IP packets whose sourcr IP address and MAC address match the binding address; or the packets will be discarded.

Configuring MAC Authentication

Overview

In an IEEE 802 LAN where no authentication or authorization is required, a user can access the network as long as the user can connect to a network device. So does the unauthorized user. With the wide application of WLAN and the growth of ISP, the requirement of a secure authentication has been put on the agenda. How to develop an authentication on the simple and cheap Ethernet becomes the focus. The IEEE 802.1x is put forward under this circumstance.

IEEE802.1x（Port-Based Network Access Control）is an IEEE Standard for Port-based Network Access Control, providing secure point-to-point communications over LAN. IEEE802.1x defines a “Client-Server” based mode to restrict the unauthorized user to access the network. Every client has to pass the authentication provided by server before accessing the network.

In the 802.1x authentication mode, users require a client to perform the authentication interaction with the server by entering the user name and password. However, some users want to perform the authentication without any client. So the MAC address authentication is developed.

MAC address authentication is a port and MAC address based authentication applied for network access control. The network device will perform the authentication at the first time when the user MAC address is detected. Neither the client nor the user name and password are required during the authentication.

Ruijie devices support MAC address authentication provided by RADIUS (Remote Authentication Dial-In User Service) server via a channel similar to that of 802.1x. When performing MAC address authentication, the MAC address of user device is sent to the RADIUS functioning as the user name and password.

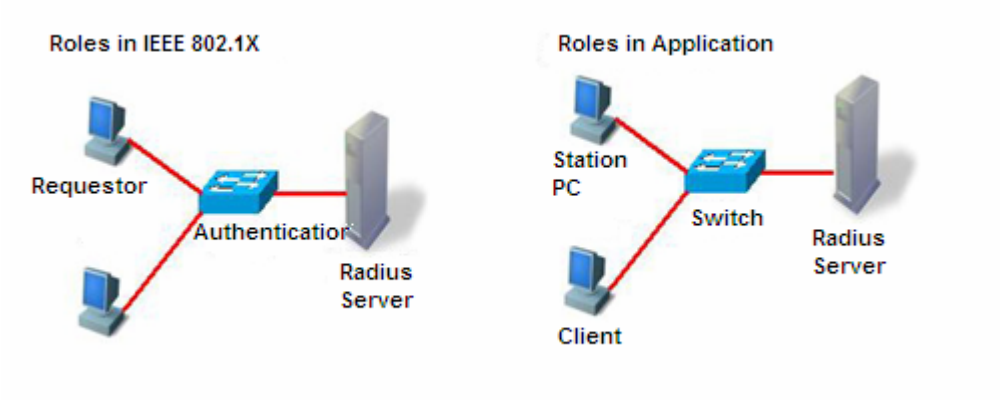
The instruction of MAC address authentication contains the following aspects:

- Device Role
- Topology of typical application

Device Role

The three roles in the MAC authentication system are requestor, authenticator and RADIUS server. They respectively match Station(Client), Device(network access server，NAS) and RADIUS-Server.

The following figure shows the device roles.



- Requestor

The requestor is a user device, generally a PC. It requests the access of network service.

- Authenticator

The authenticator usually is an access device, like a switch. The authenticator's responsibility is to control the network access status according to the client authentication status. The authenticator is an agent. It obtains the MAC address from a user device and then sends the MAC address as the user name and password to the RADIUS server to perform the authentication. The requestor does not need to participate in this process.

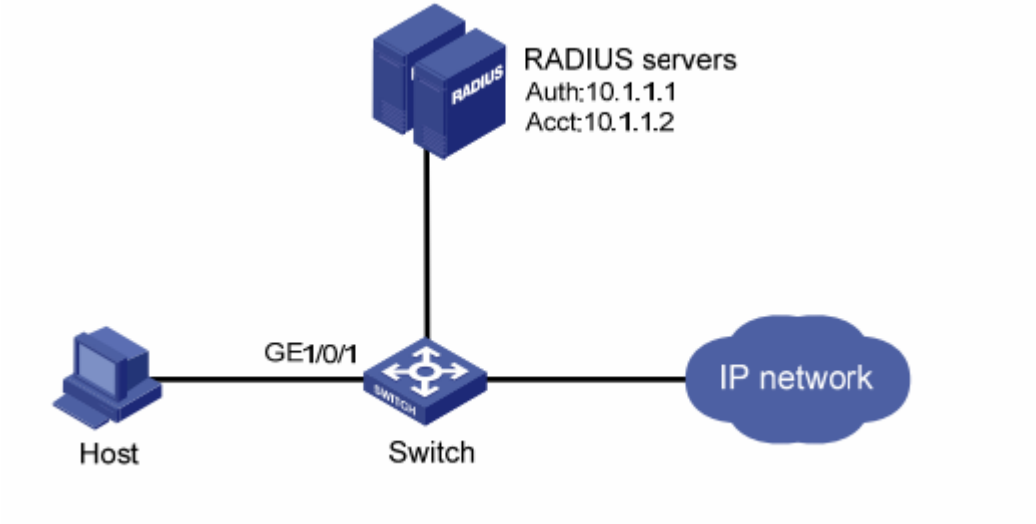
The two types of ports on the device which functions as an authenticator are controlled Port and uncontrolled Port. The user device which is connected to the controlled port has to pass the authentication before accessing the network. But the user device which is connected to the uncontrolled port can bypass the authentication and access the network directly. To realize the user control, the user devices should be connected to controlled ports. To ensure the communication between the device and authentication server, the authentication server should be connected to the uncontrolled port.

- RADIUS server

The RADIUS server usually is a RADIUS server. It works with the authenticator to support the authentication for users. The RADIUS server stores the user name and password (The MAC address of the requestor). A RADIUS server can cooperate with many access devices to realize the centralized user management. The RADIUS server is also in charge of the accounting data sent by the authenticator. Ruijie has developed the RADIUS Server that is compatible with 802.1x, which is similar to the RADIUS Server on MicroSoft win2000 Server and the Free RADIUS Server in Linux.

Topology of Typical Application

The following figure shows the typical application of MAC authentication



Description of above application:

The user Host wants to access the IP network via a switch. And the administrator does not want to bother the user to install any client. To ensure the security of the network, the MAC authentication is deployed. Then the user Host can perform the MAC authentication on a remote server.

Configuring MAC Authentication

Tips of configuring MAC authentication

- Only products that support MAC authentication can have the following configurations.
- MAC authentication is deployed at layer two.
- Only when the RADIUS server IP address is configured, can the radius-server authentication mode functions.
- MAC authentication is incompatible with the 802.1x. So only one authentication mode can be enabled
- After the MAC authentication is enabled, all static MAC addresses on the device must be configured again.

Configuring Communications between Devices and the RADIUS Server

RADIUS Server maintains all users' information, including: user name, password, authorities and accounting. So the administrator can perform centralized user management.

To ensure the communications between devices and the RADIUS server, the following configuration should be done:

At the RADIUS Server end: Registry a RADIUS Client. Specify the IP address of the RADIUS Server, authentication UDP port (Specify a UDP for accounting if required), and RADIUS Key. Select the EAP supported by the client. The way of registering a RADIUS Client on RADIUS server varies according to the software. Refer to the relative files for the settings.

At the authenticator end: To ensure the communications between devices and the RADIUS server, the IP address of the RADIUS Server, authentication (accounting) UDP port, and RADIUS Key should be specified.

Follow the steps shown below to build up the communications between the device and the authentication server in the privileged configuration mode:

Command	Description
Ruijie(config)# **aaa new-model**	Enables AAA
Ruijie(config)**#radius-server host** *ip-address [auth-port port] [acct-port port]*	Configures the RADIUS Server.
Ruijie(config)# **radius-server key** *string*	Configures the RADIUS Key.
Ruijie(config)# **show radius server**	Displays the RADIUS Server.

Use the command **no radius-server host** *ip-address auth-port* to restore the authentication UDP port on the RADIUS server to the default value. Use the command **no radius-server key** to remove RADIUS Key on the RADIUS server.

Example：The following example specifies the server IP as 192.168.4.12; Sets the UDP port number as 600; configures the RADIUS Key to be transmitted in plaintext:

```
Ruijie# configure terminal
Ruijie(config)# radius-server host 192.168.4.12
Ruijie(config)# radius-server host 192.168.4.12 auth-port 600
Ruijie(config)# radius-server key MsdadShaAdasdj878dajL6g6ga
Ruijie(config)# end
```

The official designated authentication UDP port number is 1812.

The official designated accounting UDP port number is 1813.

The RADIUS Key should contain at least 16 characters.

Set the port on the RADIUS Server which connects to the RADIUS server as an uncontrolled port.

Configuring MAC authentication

When the MAC authentication is enabled, the authenticator will listen to the MAC address learned from the authentication port, and send this MAC address as the user name and password to initiate authentication to RADIUS server. The RADIUS server will return an outcome to decide whether the device with such MAC address is allowed to access the network.

Take the following steps to configure MAC authentication

Command	Description
Ruijie(config)# **interface** *interface-type interface-number*	Enters a layer two interface.
Ruijie(config-if)# **mac-auth port-control**	Enables MAC authentication on an interface.

Example：The following example demonstrates how to configure MAC authentication:

```
Ruijie# configure terminal
Ruijie(config)# interface fa 0/1
Ruijie(config-if)# mac-auth port-control
```

Configuring MAC Authentication MAC Move

When MAC authentication is enabled on a interface, MAC move is not allowed on the device by default. Because MAC address moving from one interface into another may lead to the instability of network. To enhance network adjustment and user control, the administrator can enable/disable MAC move.

Take the following steps to configure MAC move for MAC authentication users:

Command	Description
Ruijie(config)**#mac-auth mac-move**	When MAC authentication is enabled, use this command to enable the MAC move between interfaces.

Example：The following example enables the MAC move for MAC authentication users:

```
Ruijie# configure terminal
Ruijie(config)# mac-auth mac-move
```

Configuring MAC authentication Aging Time

User can specify an aging time for MAC authentication. User can remove the user from the authentication list with the aging time. By default, this function is enabled.

Take the following steps to configure MAC authentication aging time. The aging time can be disabled by setting the value as 0:

Command	Description
Ruijie# configure terminal	Enters global configuration mode.
Ruijie(config)**#mac-address-table aging-time** *time*	Specifies the aging time by seconds.

Example：The following example sets the aging time as 1000 seconds:

```
Ruijie# configure terminal
Ruijie(config)# mac-address-table aging-time 1000
Ruijie(config)#end
Ruijie#
```

Configuring the Fixed User Name and Password Mode for MAC authentication

Under the circumstance where network reliability requirement is low, the administrator may specify a fixed user name and password for all users on a port for the convenience concern. So no matter how many users are under this port, all can perform the authentication with the same username and password to access the network.

Take the following steps to specify the fixed user name and password in MAC authentication:

Command	Description
Ruijie(config)# **interface** *interface-type interface-number*	Enters a layer two interface.
Ruijie(config-if)**#mac-auth user-name** *name-list* **password** *key*	Configures a fixed user name and password.

Example：The following example configures the user name as “abc”, the password as “123456”:

```
Ruijie# configure terminal
```

```
Ruijie(config)# interface fa 0/0
Ruijie(config-if)# mac-auth user-name abc password 123456
```

Displaying MAC Authentication Configurations

Command	Description
Ruijie(config)**#show mac-auth**	Displays the number of MAC authentication users and the number of authenticated users.

Example：Use the command **show mac-auth** check the MAC authentication configuration:

```
Ruijie# show mac-auth
Mac-move permit: Disabled
Interface Fastethernet 0/0:  Enabled
fixed user-name abc password 123456
Current timeout-activity :       1000(s)
Interface Fastethernet 0/1:  Disabled
Interface Fastethernet 0/2:  Enabled
Interface Fastethernet 0/3:  Enabled
Interface Fastethernet 0/4:  Disabled
Interface Fastethernet 0/5:  Enabled
Interface Fastethernet 0/6:  Enabled
Interface Fastethernet 0/7:  Enabled
```

Displaying MAC Authentication List

Use the command **show mac-auth list** in the privileged configuration mode to check the number of MAC authentication users and the number of authenticated users.

Command	Description
Ruijie(config)**#show mac-auth list**	查看当前 MAC 认证用户数及已认证用户数。

Example：The following example displays the detail information on the MAC authentication port:

```
Ruijie# show mac-auth list
MAC-addr        auth-state   auth-interface      fixed-user
0012.1234.1254   PASS       Fastethernet 0/0     abc
0012.AA34.1254   FAIL       Fastethernet 0/5     NULL
```

Note: When the interface is shutdown or MAC authentication is disabled, the user information may still be displayed after running the command **show mac-auth list**. Because MAC authentication users will not be removed until AAA communicates with the server.

Configuring Web Authentication

Overview

Web authentication controls the network access of users based on interfaces. Instead of dedicated client applications, users can use common browsers for web authentication. Users that are not authenticated can access only the portal and resources specified by the administrator. Users have to pass web authentication before accessing other network resources.

If users attempt to access restricted network resources by using the Hypertext Transfer Protocol (HTTP), they are forced to access the portal and start the web authentication process (forced authentication).

Web authentication simplifies portal management. Therefore, users can implement advertisements, community services, and personalized services on portals.

Basic Concept

Basic concepts of web authentication include HTTP interception and HTTP redirection.

HTTP Interception

HTTP interception refers to the interception of the to-be-forwarded HTTP packets by the access device. These HTTP packets are sent by users connected to the interfaces of the access device, but are not directed to the access device. For example, if a user uses Internet Explorer to access the Internet, the access device needs to forward HTTP request packets. However, if the HTTP interception is enabled, these packets are not forwarded.

After HTTP packets are intercepted, the access device uses the HTTP redirection function to redirect HTTP requests to the page configured by the administrator. The page can be the authentication page or the page that containing links for downloading software.

In web authentication, only HTTP request packets sent by authenticated users are forwarded. Based on HTTP interception, web authentication is automatically triggered if interception occurs.

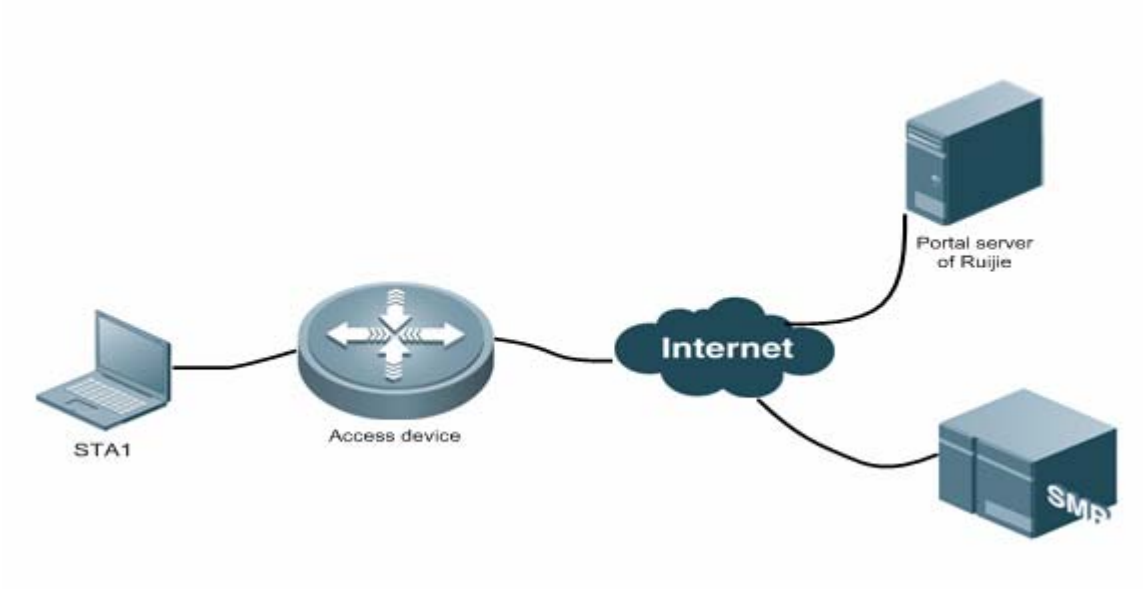
HTTP Redirection

According to HTTP, the 200 response packet is used to respond to HTTP GET or HEAD request packets sent by browsers. The path to a new site is included in the 200 response packet. After receiving the packet, users can send HTTP GET or HEAD packets to the new site for resources.

Working Principle

Figure 21 shows the typical networking topology of web authentication. Web authentication involves three basic roles: authentication client, access device, and Portal server.

Figure 21 Web authentication topology



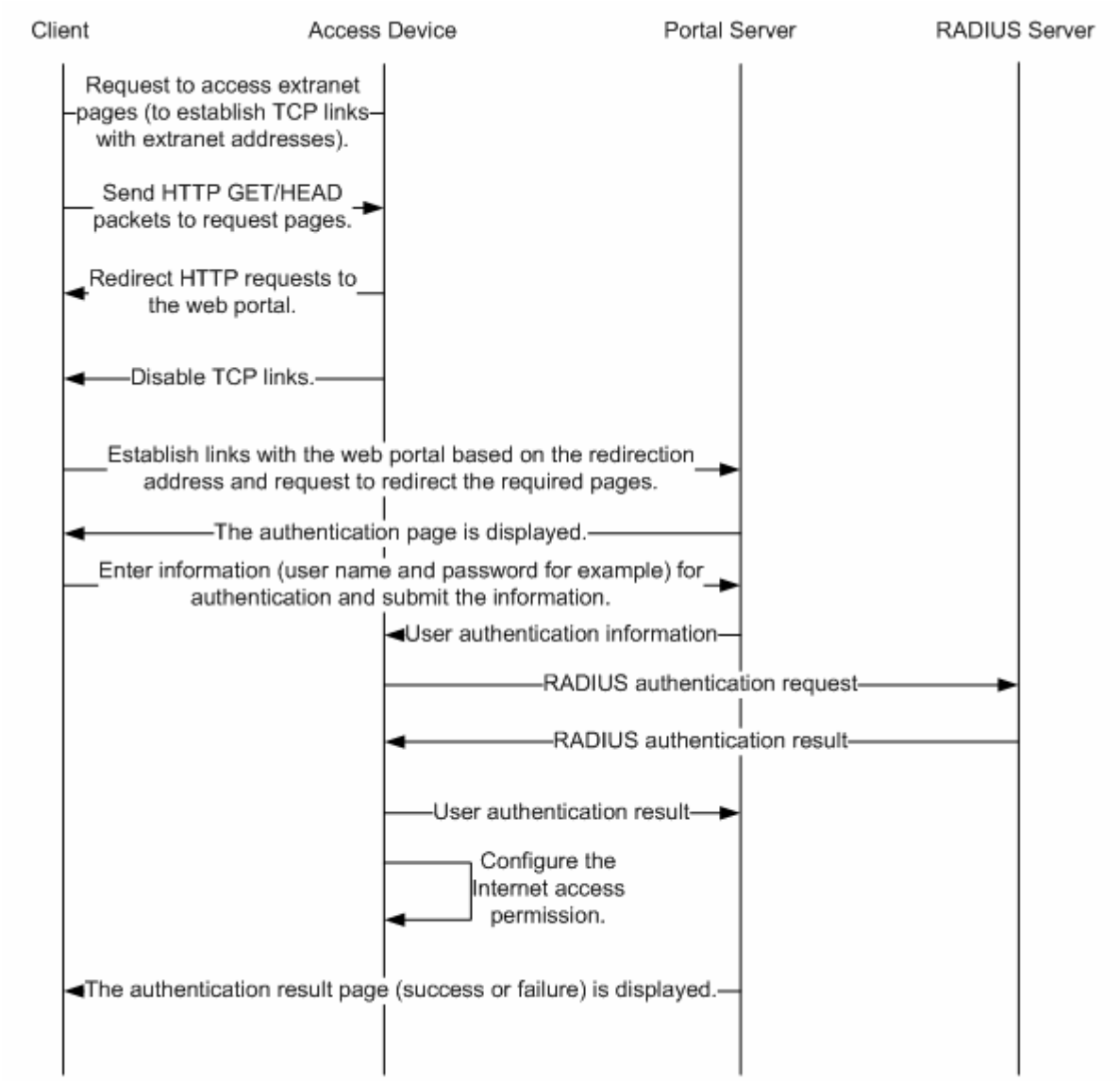
116) Roles involved in web authentication:

- Authentication client: is the client system, that is, the HTTP-based browser. It sends out HTTP requests when a user accesses the network.
- Access device: is directly connected to user terminals. Web authentication must be enabled on the access device. The access device receives user authentication information from the Portal server, initiates authentication requests to the Remote Authentication Dial-In User Service (RADIUS) server, determines whether the user can access the Internet based on the authentication result, and reports the authentication result to the Portal server.
- Portal server: provides the interface and related operations for web authentication. After receiving an HTTP-based authentication request from the authentication client, the Portal server extracts account information from the request, sends the information to the access device, and displays the authentication result from the access device on a page to the user.
- SAM/SMP: provides the RADIUS-based remote user authentication.

117) Web authentication process:

- Before authentication, the access device intercepts all HTTP requests from the user and redirects these requests to the Portal server. An authentication page is displayed on the browser for the user.
- During authentication, the user enters information, for example, user name, password, and check code, on the authentication page to interact with the Portal server.
- The Portal server sends the user authentication information to the access device.
- The access device initiates authentication to the RADIUS server and returns the authentication result to the Portal server.
- The Portal server displays a page containing the authentication result (success or failure) to the user.

Figure 22 Web authentication flowchart



118) Process for going offline:

After detecting that the user is offline, the Portal server uses the Portal protocol to notify the access device. The Portal server then returns a page indicating that the user is offline to the user. Meanwhile, the access device initiates the end-of-charging request to the RADIUS server to notify that the user is offline.

Protocol Specification

- For functions related to HTTP redirection, see the HTTP 1.1 protocol (RFC 1945).
- For functions related to RADIUS authentication, see RFC 2865 and RFC 2866.
- The private Portal protocol is used between the access device and the Portal server.

Configuring Web Authentication

Default Configuration

The following table describes the default configuration of web authentication.

Feature	Default Setting
Configuring the Portal server	The Portal server is not configured.
Configuring the Authentication, Authorization and Accounting (AAA) authentication list for web authentication	The authentication list is not configured.
Configuring the AAA accounting list for web authentication	The accounting list is not configured.
Configuring the key for communication between the access device and the Portal server	The communication key is not configured.
Configuring the NAS IP address for the communication between the access device and the Portal server	The NAS IP address is not configured.
Configuring the global authentication list	The global authentication list is not configured.
Configuring the global accounting list	The global accounting list is not configured.
Enabling multiple users to use the same account for web authentication	An account is configured for a user for web authentication.
Enabling web authentication on an interface	Web authentication is not enabled.
Configuring the range of network resources free from web authentication	The range is not specified.
Configuring the IP address range of users free from web authentication	The range is not specified.
Configuring traffic detection	The detection period is 15 minutes and the traffic threshold is 1024 bytes.
Configuring the accounting update interval for web authentication	The update interval is 5 minutes.

Configuration Guide

- The **ip ref** command must be enabled on interfaces where web authentication is enabled.
- The SDG function cannot be configured on interfaces where web authentication is enabled.

Configuring the Portal ServerUse the following command to configure the Portal server.

Command	Function
Ruijie(config)**#portal-server** *portal-name* **ip** *ip-address* [**url** *url-string*] [**port** *port-num*] [vrf *vrf-name*]	Configures the Portal server for web authentication, including the name, IP address, and authentication page URL of the Portal server.

To remove configurations of the Portal server, run the **no portal-server** *portal-name* command in global configuration mode.

Configuration example

Configure the Portal server.

This example shows how to configure a Portal server named edu-server with the IP address of 172.20.1.10. The URL of the authentication page is http://172.20.1.10:7080/index.php.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#portal-server edu-server ip 172.20.1.10 url http://172.20.1.10:7080/index.php
```

Caution Before removing configurations of the Portal server, cancel the Portal server on the interface. If not, errors will occur when web authenticated users get online or offline.
Ensure that the Portal server is correctly configured before using it.

Configuring the AAA Authentication List for Web Authentication

Use the following command to configure the authentication list for web authentication.

Command	Function
Ruijie(config)**#aaa authentication web-auth** { **default** | *list-name* } *method1* [*method2*...]	Configures the AAA authentication list for web authentication.

Configuration example

Configure the AAA authentication list for web authentication.

This example shows how to configure an AAA authentication list named **default** for web authentication with the default RADIUS group **radius**.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#aaa new-model
Ruijie(config)#aaa authentication web-auth default group radius
```

Note For details about AAA and RADIUS configurations, see the *Configuring AAA* and *Configuring RADIUS*.

Configuring the AAA Accounting List for Web Authentication

Use the following command to configure the accounting list.

Command	Function
Ruijie(config)**#aaa accounting network** { **default** | *list-name* } **start-stop** *method1* [*method2*...]	Configures the network accounting list.

Configuration example

Configure the accounting list.

This example shows how to configure a network AAA accounting list named **default** with the default RADIUS group **radius**.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#aaa new-model
Ruijie(config)#aaa accounting network default start-stop group radius
```

Note To enable devices to use the RADIUS group for user accounting, configure the accounting RADIUS server for the RADIUS group. For details, see the *Configuring AAA* and *Configuring RADIUS*.

Configuring the Key for Communication Between the Access Device and the Portal Server

Use the following command to configure the communication key between the access device and Portal server.

Command	Function
Ruijie(config)# **web-auth portal key** *key-string*	Configures the key for communication between the access device and the Portal server. The maximum length of the key is 255 bytes.

To remove the key, run the **no web-auth portal key** command in global configuration mode.

Configuration example

Configure the key between the access device and Portal server.

This example shows how to set the key for communication between the access device and the Portal server to web-auth.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#web-auth portal key web-auth
```

Configuring the NAS IP Address for Communication Between the Access Device and the Portal Server

Use the following command to configure the NAS IP address for the communication between the access device and the Portal server.

Command	Function
Ruijie(config)# **web-auth nas-ip** *ip-address*	Sets the NAS IP address for communication between the access device and Portal server.

To remove the NAS IP address, run the **no web-auth nas-ip** command in global configuration mode.

Configuration example# Configure the NAS IP address for the communication between the access device and the Portal server.

This example shows how to set the NAS IP address for communication between the access device and the Portal server to 192.168.1.2.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#web-auth nas-ip 192.168.1.2
```

Configuring the Global Authentication List

Use the following command to configure the name of the global authentication list for web authentication.

Command	Function
Ruijie(config)**#web-auth authentication** { **default** | *list-name* }	Configures the name of the global authentication list for web authentication.

To delete the global authentication list, run the **no web-auth authentication** command in global configuration mode.

Configuration example

Configure the global authentication list for web authentication.

This example shows how to configure edu-web as the global authentication list for web authentication.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#web-auth authentication edu-web
```

Caution Before configuring the authentication list, ensure that the authentication list is configured for AAA.

Configuring the Global Accounting List

Use the following command to configure the global accounting list.

Command	Function
Ruijie(config)**#web-auth accounting** { **default** | *list-name* }	Configures the global accounting list for web authentication.

To delete the global accounting list, run the **no web-auth accounting** command in global configuration mode.

Configuration example

Configure the global accounting list for web authentication.

This example shows how to configure edu-acct as the global accounting list for web authentication.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#web-auth accounting edu-acct
```

Enabling Multiple Users to Use the Same Account for Web Authentication

Use the following command to enable multiple users to use the same account for web authentication.

Command	Function
Ruijie(config)# web-auth multi-account enable	Enables multiple users to use the same account for web authentication.

To disable multiple users from using the same account for web authentication, run the **no web-auth multi-account enable** command in global configuration mode.

Configuration example

Enable multiple users to use the same account for web authentication.

This example shows how to enable multiple users to use the same account for web authentication.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# web-auth multi-account enable
```

Enabling Web Authentication on an Interface

Use the following command to enable web authentication on an interface.

Command	Function
Ruijie(config-if)**#web-auth control** *portal-name*	Enables web authentication on an interface.

To resume to the default Portal server, run the **web-auth control** *portal-name* command in interface configuration mode.

Configuration example

Enable web authentication on an interface.

This example shows how to enable web authentication on FastEthernet 0/1.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface FastEthernet 0/1
Ruijie(config-if-FastEthernet 0/1)#web-auth control edu-server
```

Configuring the Range of Network Resources Free From Web Authentication

Use the following command to configure the range of network resources free from web authentication.

Command	Function
Ruijie(config)# **web-auth direct-site** *ip-address ip-mask*	Configures network resources that are free from web authentication.

To cancel network resources that are free from web authentication, run the **no web-auth direct-site** *ip-address ip-mask* command in global configuration mode.

Configuration example

Configure network resources that are free from web authentication.

This example shows how to set the free 172.16.*x.x* on a campus network free from web authentication.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#web-auth direct-site 172.16.0.0 255.255.0.0
```

Configuring the IP Address Range of Users Free From Web Authentication

Use the following command to specify the IP address range of users free from web authentication.

Command	Function
Ruijie(config)# **web-auth direct-host** *ip-address* i*p-mask*	Configures the range of users free from web authentication.

To cancel users that are free from web authentication, run the **no web-auth direct-host** *ip-address ip-mask* command in global configuration mode.

Configuration example

Configure users free from web authentication.

This example shows how to set the user with the IP address of 172.10.0.1 free from web authentication.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#web-auth direct-host 176.10.0.1 255.255.255.255
```

Configuring Traffic Detection

Web authentication provides the low-traffic forced offline function, allowing devices to detect traffic generated within a specified time length by an authenticated user. If the value of detected traffic is lower than the specified threshold, the user is considered in the low-traffic state (idle state for example) and is forced offline.

Use the following command to configure traffic detection.

Command	Function
web-auth offline-detect idle-timeout *minutes* **threshold** *bytes*	Configures the traffic detection parameters.

To resume to the default value of traffic detection, run the **no web-auth offline-detect** command in global configuration mode.

Configuration example

Configure traffic detection.

This example shows how to configure the traffic detection function, and set the traffic detection period to 3 minutes and the smaller traffic threshold to 1024 bytes.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
```

```
Ruijie(config)# web-auth offline-detect idle-timeout 3 threshold 1024
```

Configuring the Accounting Update Interval for Web Authentication

Use the following command to configure the accounting update interval.

Command	Function
Ruijie(config)# **web-auth acct-update-interval** *minutes*	Configures the accounting update interval.

To resume to the default value of accounting update interval for web authentication, run the **no web-auth acct-update-interval** command in global configuration mode.

Configuration example

Configure the accounting update interval for web authentication.

This example shows how to set the accounting update interval for web authentication to 3 minutes.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# web-auth acct-update-interval 3
```

Displaying Configurations of the Portal Server

Use the following command to display configurations of the Portal server.

Command	Function
Ruijie**#show web-auth portal**	Displays configurations of the Portal server.

Configuration example

Display configurations of the Portal server.

```
Ruijie#sho web-auth portal
Portal Server: edu-server
   IPv4 Address: 172.20.1.10
   Redirect-URL: http://172.20.1.10:7080/index.php
   UDP Port: 50100
```

Displaying the Range of Users Free From Web Authentication

Use the following command to display the range of users that are free from web authentication.

Command	Function
Ruijie**# show web-auth direct-host**	Displays the range of users that are free from web authentication.

Configuration example

Display the range of users that are free from web authentication.

```
Ruijie#show web-auth direct-host
Direct-hosts(3):
```

```
 Address         Mask
 --------------- ----------------
 176.10.0.1      255.255.255.255
 192.168.4.11    255.255.255.255
 192.168.5.0     255.255.255.0
```

Displaying the Range of Network Resources Free From Web Authentication

Use the following command to display the range of network resources that are free from web authentication.

Command	Function
Ruijie**#show web-auth direct-site**	Displays the range of network resources that are free from web authentication.

Configuration example

Display the range of network resources that are free from web authentication.

```
Ruijie#show web-auth direct-site
Direct-sites(1):
 Address         Mask
 --------------- ----------------
 172.16.0.0     255.255.0.0
```

Displaying Configurations of Web Authentication

Use the following command to display configurations of web authentication.

Command	Function
Ruijie**#show web-auth control**	Displays configurations of web authentication.

Configuration example

Display configurations of web authentication on an interface.

```
Ruijie#show web-auth control
  Interface        Control   Server Name
  ----------------  ---------  --------------
  FastEthernet 0/1   On       edu-server
  FastEthernet 0/2   On       edu-server
  FastEthernet 0/3   Off      --
```

Displaying Information about Web Authenticated Users

Use the following command to display online information about all users or specified users.

Command	Function
Ruijie**#show web-auth user** *ip-address*	Displays online information about all users or specified users.

Configuration example

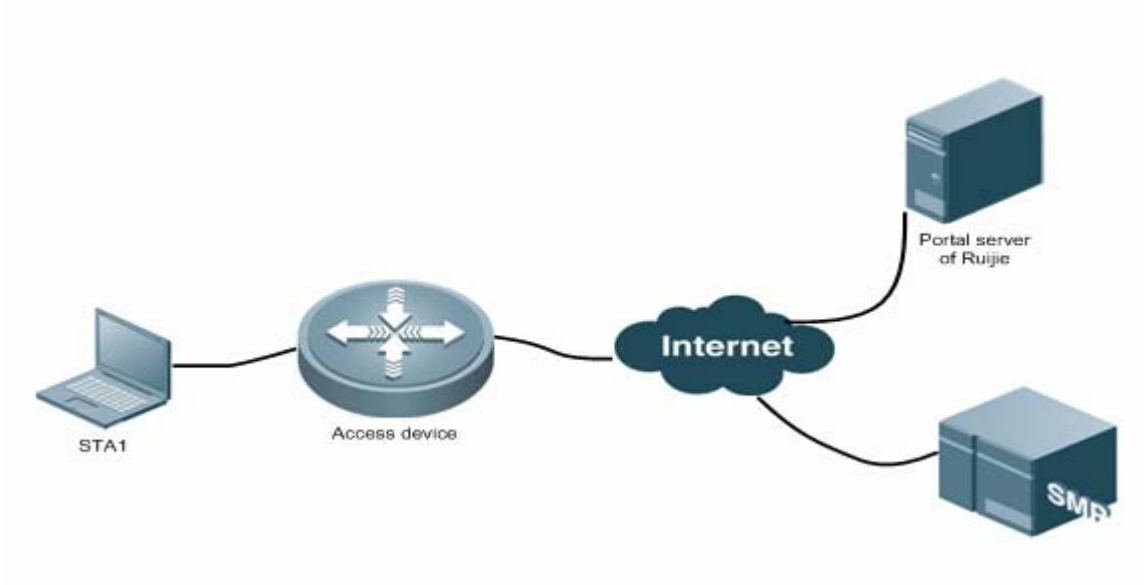
Display online information about all users or specified users.

```
Ruijie#sho web-auth user
Current user num  :  3
Address         State          Time Used
---------------  ---------------  -------------
192.1.1.69       AUTHENTICATED    0d 18:27:47
192.1.1.155      AUTHENTICATED    0d 01:10:51
192.1.1.174      AUTHENTICATED    0d 18:25:10
Ruijie#sho web-auth user 192.1.1.69
Name       :  xxxx
IP         :  192.1.1.69
Mac        :  0023aea7bf48
Vrf name    :  --
State      :  AUTHENTICATED
Time used   :  0d 18:28:43
Input bytes  :  19527
Intf name   :  Gi0/0
Acct interval:  2
```

Configuration Examples

Networking Topology

Figure 23 Web authentication topology



Networking Requirements

119) Use the Portal server of Ruijie as the Portal server for web authentication.

120) Use the SAM/SMP server of Ruijie as the authentication/charging server.
121) Hosts of users can access only the Portal server before being authenticated and can access all network resources after authentication.

Configuration Steps

122) Configure the Portal server.

Set the name of the Portal server to eportal, the IP address to 172.20.1.10, and the URL of the authentication page to http://172.20.1.10:7080/index.php.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#portal-server eportal ip 172.20.1.10 url http://172.20.1.10:7080/index.php
```

123) Configure the shared key and the NAS IP address.

Set the shared key between the access device and the Portal server to ruijie and the NAS IP address to 192.168.1.2.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# web-auth portal key ruijie
Ruijie(config)# web-auth nas-ip 192.168.1.2
```

124) Configure AAA.

Enable the AAA function.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#aaa new-model
```

Configure the RADIUS server in the default RADIUS group **radius** as the server for authentication and accounting.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#radius-server host 172.20.1.20 key 88----89
```

Configure the AAA authentication list for web authentication with the default RADIUS group.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#aaa authentication web-auth default group radius
```

Configure the AAA accounting list with the default RADIUS group.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#aaa accounting network default start-stop group radius
```

125) Use the AAA authentication list for web authentication.

Use the authentication list named **default**.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# web-auth authentication default
```

126) Use the AAA accounting list for web authentication.

Use the accounting list named **default**.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# web-auth accounting default
```

127) Enable web authentication on an interface.

Enable web authentication on the specified interface.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface FastEthernet 0/1
Ruijie(config-if-FastEthernet 0/1)#web-auth control eportal
```

Verification

128) Query configurations of AAA.

```
Ruijie#show aaa method-list
Authentication method-list
aaa authentication web-auth default group radius

Accounting method-list
aaa accounting network default start-stop group radius

Authorization method-list
```

129) Query configurations of the Portal server for web authentication.

```
Ruijie#sho web-auth portal
Portal Server: edu-server
    IPv4 Address: 172.20.1.10
    Redirect-URL: http://172.20.1.10:7080/index.php
    UDP Port: 50100
```

130) Query the control condition of the interface where web authentication is enabled.

```
Ruijie#show web-auth control
  Interface        Control   Server Name
  ----------------  --------- ---------------
  FastEthernet 0/1   On      eportal
  FastEthernet 0/2   Off     --
  FastEthernet 0/3   Off     --
```

Configuring 802.1x

Overview

In an IEEE 802 LAN, users can access the network device without authorization and authorization as long as they are connected to the network device. Therefore, an unauthorized user can access the network unobstructed by connecting the LAN. As the wide application of LAN technology, particularly the appearance of the operating network, it is necessary to address the safety authentication needs of the network. It has become the focus of concerns in the industry that how to provide user with the authentication on the legality of network or device access on the basis of simple and cheap Ethernet technologies. The IEEE 802.1x protocol is developed under such a context.

As a Port-Based Network Access Control standard, the IEEE802.1x provides LAN access point-to-point security access. Specially designed by the IEEE Standardization Commission to tackle the safety defects of Ethernet, this standard can provide a means to authenticate the devices and users connected to the LAN by utilizing the advantages of IEEE 802 LAN.

The IEEE 802.1x defines a mode based on Client-Server to restrict unauthorized users from accessing the network. Before a client can access the network, it must first pass the authentication of the authentication server.

Before the client passes the authentication, only the EAPOL (Extensible Authentication Protocol over LAN) packets can be transmitted over the network. After successful authentication, normal data streams can be transmitted over the network.

By using 802.1x, our routers provide Authentication, Authorization, and Accounting (AAA).

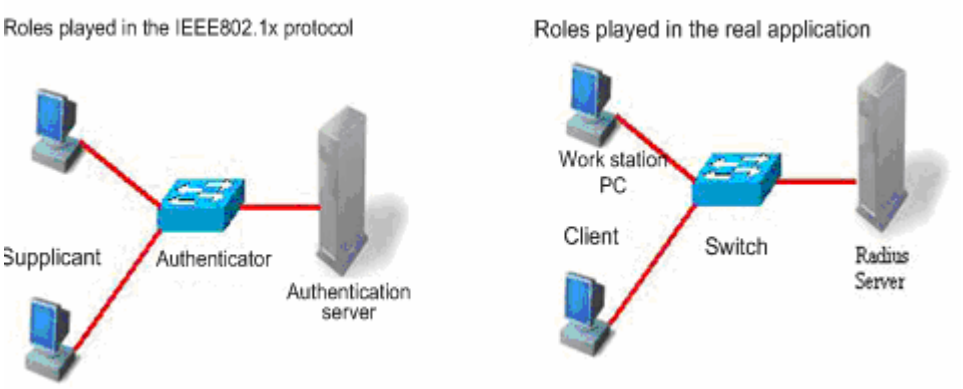
Authentication: It is used to determine whether a user has the access, restricting illegal users.
Authorization: It authorizes the services available to users, controlling the rights of valid users.
Accounting: It records users' use of network resources, providing the supporting data for charging.

The 802.1x is described in the following aspects as below:

Device Roles
Authentication Initiation and Packet Interaction During Authentication
States of Authorized Users and Unauthorized Users
Topologies of Typical Applications

Device Roles

In the IEEE802.1x standard, there are three roles: **supplicant, authenticator, and authentication server.** In practice, they are the Client, network access server (NAS) and Radius-Server.



Supplicant:

The **supplicant** is a role played by the end user, usually a PC. It requests for the access to network services and acknowledges the request packets from the authenticator. The supplicant must run the IEEE 802.1x client. Currently, the most popular one is the IEEE802.1x client carried by Windows XP. In addition, we have also launched the STAR Supplicant software compliant of this standard.

Authenticator:

The **authenticator** is usually an access device like the router. The responsibility of the device is to control the connection status between client and the network according to the current authentication status of that client. Between the client and server, this device plays the role of a mediator, which requests the client for username, verifies the authentication information from the server, and forwards it to the client. Therefore, the router acts as both the IEEE802.1x authenticator and the RADIUS Client, so it is referred to as the network access server (NAS). It encapsulates the acknowledgement received from the client into the RADIUS format packets and forwards them to the RADIUS Server, while resolving the information received from the RADIUS Server and forwards the information to the client.

The device acting as the authenticator has two types of ports: controlled Port and uncontrolled Port. The users connected to a controlled port can only access network resources after passing the authentication, while those connected to a uncontrolled port can directly access network resources without authentication. We can control users by simply connecting them to an controlled port. On the other hand, the uncontrolled port is used to connect the authentication server, for ensuring normal communication between the server and router.

Authentication server:

The **authentication server** is usually an **RADIUS** server, which works with the authenticator to provide users with authentication services. The authentication server saves the user name and password and related authorization information. One server can provide authentication services for multiple authenticators, thus allowing centralized management of users. The authentication server also manages the accounting data from the authenticator. Our 802.1x device is fully compatible with the standard Radius Server, for example, the Radius Server carried on Microsoft Win2000 Server and the Free Radius Server on Linux.

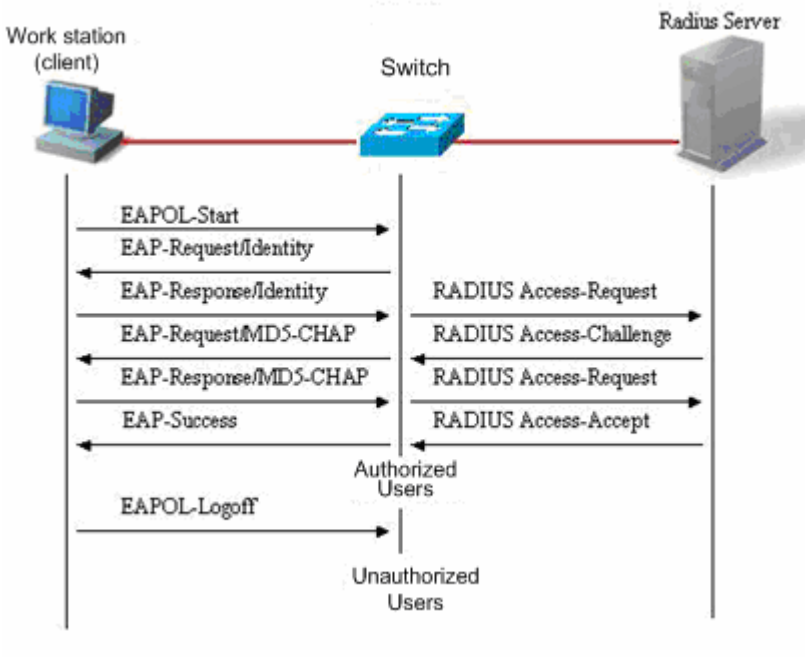
Authentication Initiation and Packet Interaction During Authentication

The supplicant and the authenticator exchange information by EAPOL protocol, while the authenticator and authentication server exchange information by RADIUS protocol, completing the authentication process with such a conversion. The EAPOL protocol is encapsulated on the MAC layer, with the type number of 0x888E. In addition, the standard has

required for an MAC address (01-80-C2-00-00-03) for the protocol for packet exchange during the initial authentication process.

The following diagram shows a typical authentication process, during which the three role devices exchange packets with one another.

Figure 0-1



This is a typical authentication process initiated by users (in some special cases, the router can actively initiate authentication request, whose process is the same as that shown in the diagram, except that it does not contain the step where the user actively initiates the request).

States of Authorized Users and Unauthorized Users

The 802.1x determines whether the users on the port are allowed to access the network according to the authentication status of the port. Since we expand the 802.1X based on users, we determine whether a user is allowed to access network resources according to the authentication status of that user under a port. All users under an uncontrolled port can use network resources, while those under a controlled port can access network resources only if they are authorized. When a user just initiates an authentication request, its status is unauthorized, in which case it cannot access the network. When it passes the authentication, its status changes to be authorized, in which case it can use the network resources.

If the workstation does not support 802.1x while the machine is connected with the controlled port, when the equipment requests the username of the user, the workstation will not respond to the request due to no support. This means that the user is still unauthorized and cannot access the network resources.

On the contrary, if the client supports 802.1x, while the connected router does not: The EAPOL-START frames from the user are not responded, and the user deems it connected port as an uncontrolled port and directly uses network resources, when the user fails to receive any response after it sends the specified number of EAPOL-START frames.

On a 802.1x-enabled device, all ports are uncontrolled ports by default. We can set a port as a controlled port, to impose authentication over all the users under that port.

When a user has passed authentication (the router has received success packets from the RADIUS Server), the user is authorized and therefore can freely use network resources.If the user fails in the authentication and remains in the unauthenticated status, it is possible to initiate authentication once again. If the communication between the router and the RADIUS server is faulty, the user is still unauthorized and therefore still cannot use the network.

When the user sends the EAPOL-LOGOFF packets, its status changes from authorized to unauthorized.

When a port of the router changes to the LINK-DOWN status, all the users on the port change to be in the unauthorized status.

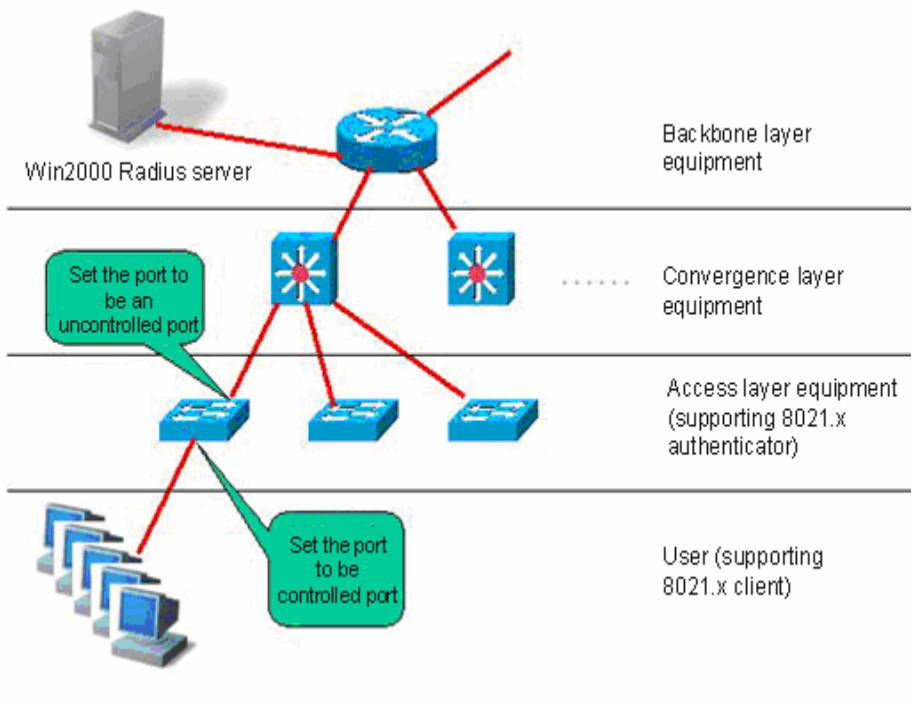
When the device restarts, all users on the device turn into the unauthorized status.

To force a user to pass the authentication, you can add a static MAC address.

Topologies of Typical Applications

Scheme 1: The 802.1x-enabled device is used as the access layer device

Figure 0-3



This solution is described as below:

Requirements of this solution:

- The user supports 802.1x. That is, it is installed with the 802.1x client (Windows XP carried, Star-supplicant or other IEEE802.1x compliant client software).
- The access layer device supports IEEE 802.1x.
- One or multiple RADIUS compliant servers are available as the authentication server.

Key points for configuration of this solution:

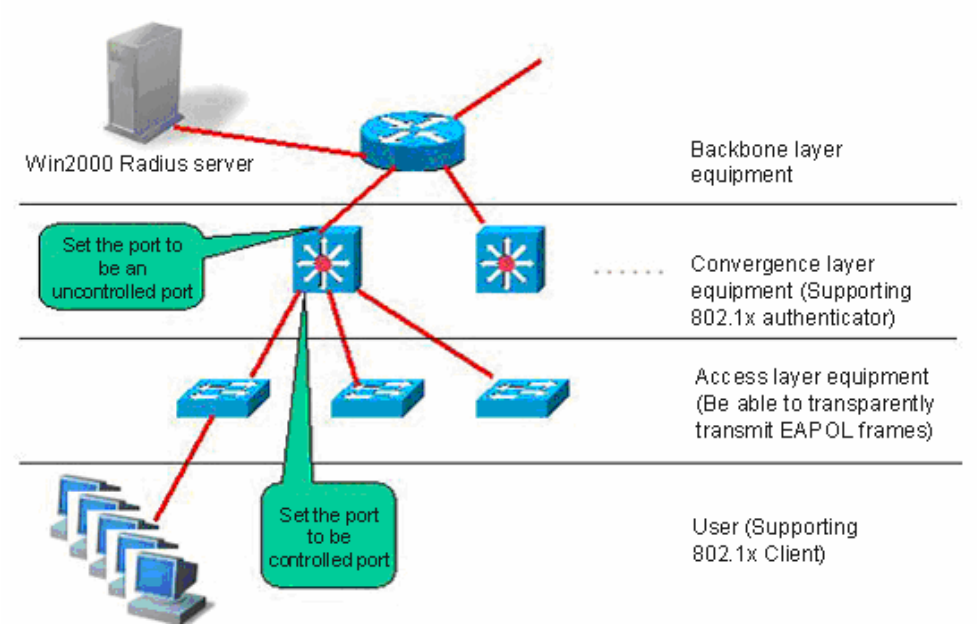
- The ports connected to the Radius Server and the uplink ports are configured as **uncontrolled ports**, so that the router can normally communicate with the server and the authorized users can access network resources through the uplink interface.
- The ports connected to the user must be set as **controlled ports** to control the accessed users, and the users cannot access network resources unless they first pass the authentication.

Characteristics of this solution:

- Each 802.1x-enabled router is responsible for a small number of clients, thus offering higher speed.The devices are mutually independent, and the restart operation of the device does not affect the users connected with other devices.
- User management is performed on the Radius Server in a centralized manner. The administrator does not have to know which router a user is connected to, making management much easier.
- The administrator can manage the device on the access layer through the network.

Scheme 2: The 802.1x-enabled device is used as the convergence layer device

Figure 0-4



This solution is described as below:

Requirements of this solution:

- The user supports 802.1x. That is, it is installed with the 802.1x client (Windows XP carried, Star-supplicant or other IEEE802.1x compliant client software).
- The access layer device should be able to transparently transmit IEEE 802.1x. frames (EAPOL)
- The convergence layer device supports 802.1x (playing the role of the authenticator)
- One or multiple RADIUS compliant servers are available as the authentication server.

Key points for configuration of this solution:

- The ports connected to the Radius Server and the uplink ports are configured as uncontrolled ports, so that the router can normally communicate with the server and the authorized users can access network resources through the uplink interface.

- The ports connected to the access layer routers must be set as controlled ports to control the accessed users, and the users cannot access network resources unless they first pass the authentication.

Characteristics of this solution:

- The convergence layer device must be of high quality since the network is large and numerous users are connected, since any of its fault may cause the failures of many users to normally access the network.
- User management is performed on the Radius Server in a centralized manner. The administrator does not have to know which router a user is connected to, making management much easier.
- The access layer device can be the less expensive non-NM routers (as long as they support transparent transmission of EAPOL frames).
- The administrator cannot manage the device on the access layer through the network.

Configuring 802.1x

Default Configuration of 802.1x

The following table lists some defaults of the 802.1x

Item	Default
Authentication	DISABLE
Accounting	DISABLE
Radius Server *ServerIp *Authentication UDP port *Key	*No default *1812 *No default
Accounting Server *ServerIp *Accounting UDP port	*No default *1813
All port types	Uncontrolled port (all ports can perform communication directly without authentication)
Timed re-authentication	Off
Timed reauth_period	3,600 seconds
Interval between two authentication requests	10 seconds
Retransmission interval	3 seconds
Maximum retransmissions	3
Client timeout period	3 seconds, if within which no response is received from the client, the communication is deemed as a failure
Server timeout period	5 seconds, if within which no response is received from the server, the communication is deemed as a failure
Lists of authenticable hosts under a port	No default

Precautions for Configuring 802.1x

- You can perform the following configuration only to the products that support 802.1x.
- The 802.1x can run on both L2 device and L3 device.
- It is required to configure the IP address of the authentication server before the Radius-server authentication mode can operate normally.
- If the 1x function is enabled on only one port of a router, all the port will send the 1x protocol packets to the CPU.
- If the dot1x function is enabled on the port and the number of authenticated users is larger than the maximum number of users of port security, port security cannot be enabled.
- With both the port security and dot1x function enabled, if the secure address ages, the users corresponding to the dot1x must be re-authenticated to continue communication.
- Security addresses of static ports can access the Internet without authentication. If there is authorization, the addresses must comply with authorization binding to access the Internet.
- When the port-based transferable authentication mode and port security are used concurrently, the learned addresses become security addresses and cannot be transferred.
- When the port-based transferable authentication mode and port security are used concurrently, if an authenticated address is aged securely by a port, the port must be re-authenticated to communicate.
- After the port-based transferable authentication mode passes the authentication, and port security is enabled, the port must be re-authenticated to communicate.
- If there is IP and MAC binding, the authentication mode cannot be switched between the port-based one and user-based one.

Configuring the communication between the device and Radius server

The Radius Server maintains the information of all users: user name, password, authorization information and accounting information. All users are managed on the Radius Server in a centralized manner, without being distributed over various routers, making easier management for the administrator.

In order for the router to normally communicate with the RADIUS SERVER, you must set the following parameters:

Radius Server end: You must register a Radius Client. At registration, you must supply the Radius Server router's IP address, authentication UDP port (add the accounting UDP port, if needed), and the agreed key for communication between the router and Radius Server, and select EAP support for the Client. The procedure for registering one Radius Client on the Radius Server varies with different software settings. Please refer to the appropriate document.

Device end: The following settings are necessary at the device end to ensure the communication between the device and the server: Configure the IP address of the Radius Server, authentication (accounting) UDP port and the agreed password for the communication with the server.

In the privileged EXEC mode, you can set the communication between the router and the Radius Server via the following steps:

Command	Function
Ruijie (config)**#aaa new-model**	Enable AAA.
Ruijie (config)**#radius-server host** *ip-address* [**auth-port** *port*] [**acct-port** *port*]	Configure the RADIUS server.
Ruijie (config)**#radius-server key** *string*	Configure RADIUS key.
Ruijie**#show radius server**	Show the RADIUS server.

You can use the **no radius-server host** *ip-address* **auth-port** command to restore the authentication UDP port of the Radius Server to its default. You can use the **no radius-server key** command to delete the authentication key of the Radius Server. The following example sets the Server IP as 192.168.4.12, authentication UDP port as 600, and the key as agreed password:

```
Ruijie# configure terminal
Ruijie(config)# radius-server host 192.168.4.12
Ruijie(config)# radius-server host 192.168.4.12 auth-port 600
Ruijie(config)# radius-server key MsdadShaAdasdj878dajL6g6ga
Ruijie(config)# end
```

The officially agreed authentication UDP port is 1812.
The officially agreed accounting UDP port is 1813.
No less than 16 characters are recommended for the agreed password between the device and the Radius Server.
The port of the device to connect the Radius Server shall be configured as uncontrolled port.

Setting the 802.1X Authentication Router

When the 802.1x authentication is enabled, the router will impose authentication over the host connected to the controlled port, and the hosts that fail the authentication are not allowed to access the network.

In the privileged EXEC mode, you can enable the 1x authentication by performing the following steps:

Command	Function
Ruijie (config)**#aaa new-model**	Enable AAA.
Ruijie (config)**#radius-server host** *ip-address* [**auth-port** *port*] [**acct-port** *port*]	Configure the RADIUS server.
Ruijie (config)**#radius-server key** *string*	Configure RADIUS Key.
Ruijie (config)**#aaa authentication dot1x** ***auth*** **group radius**	Configure the dot1x authentication method list.
Ruijie (config)**#dot1x authentication** *auth*	dot1x applies authentication method list
Ruijie**#show running-config**	Show the configuration.

Note In case of the domain-name-based AAA service router is enabled, that is when the **aaa domain enable** command is configured, the authentication method list chosen by the **dot1x authentication** command will not be used. Instead, the authentication method list configured by the domain where the user locates will be used. For detailed configuration, see Configuring the AAA Service Based on Domain Names.

The following example enables 802.1x authentication:

```
Ruijie# configure terminal
Ruijie(config)# aaa new-model
Ruijie(config)# radius-server host 192.168.217.64
Ruijie(config)# radius-server key starnet
Ruijie(config)# aaa authentication dot1x authen group radius
```

```
Ruijie(config)# dot1x authentication authen
Ruijie(config)# end
Ruijie# show running-config
!
aaa new-model
!
aaa authentication dot1x authen group radius
!
username Ruijie password 0 starnet
!
radius-server host 192.168.217.64
radius-server key 7 072d172e071c2211
!
!
!
dot1x authentication authen
!
interface VLAN 1
 ip address 192.168.217.222 255.255.255.0
 no shutdown
!
!
line con 0
line vty 0 4
!
end
```

To apply the RADIUS authentication method in the 802.1x, configure the IP address of the Radius Server and make sure normal communication between the device and the Radius Server. Without the coordination of the Radius Server, the router cannot perform authentication. For setting the communication between the Radius Server and the router, please see the previous section.

Enabling/Disabling the Authentication of a Port

If you enable authentication for a port when the 802.1x is enabled, the port becomes a controlled port, and the users under the port must first pass authentication before they can access the network. However, the users under the uncontrolled port can directly access the network.

In the privileged EXEC mode, you can set authentication for a port by performing the following steps:

Command	Function
Ruijie (config)**#interface** *interface*	Enter global configuration mode.
Ruijie (config-if-*type ID*)**#dot1x port-control auto**	Enter interface configuration mode and specify the Interface to configure.
Ruijie**#show dot1x port-control**	Set the port to be a controlled port (enable interface authentication). You can use the no option of the command to disable the authentication of the interface.

You can use the **no dot1x port-control** command to disable the authentication of the interface. The following example sets Ethernet interface 1/1 to be a controlled interface:

```
Ruijie# configure terminal
Ruijie ( config )# interface f 1/1
Ruijie ( config-if )# dot1x port-control auto
Ruijie ( config )# end
```

When a port is set as a controlled port, only the EAP packets are allowed to pass; the packets to the CPU are also under control.

Note If you hope that cpu can not receive non-EAP packet from any controlled port, you can separate management VLAN from user VLAN.

Enabling Timed Re-authentication

The 802.1x can ask users for re-authentication at periodical intervals, to prevent authorized users from being used by other users. This can also detect disconnection, making more accurate charging. In addition to the re-authentication switch, you can also define the re-authentication interval, which is 3600 seconds by default. In the case of charging based on duration, you should determine the re-authentication interval according to the specific network size, which should be sufficient while as accurate as possible.

In the privileged EXEC mode, you can enable/disable re-authentication and set the re-authentication interval by performing the following steps.

Command	Function
Ruijie (config)**#dot1x re-authentication**	Enable timed re-authentication.
Ruijie (config)**#dot1x timeout re-authperiod** *seconds*	Set the re-authentication interval.
Ruijie**#show dot1x**	Show the dot1x configurations.

You can use the **no dot1x re-authentication** command to disable timed re-authentication, and use the **no dot1x timeout re-authperiod** command to restore the re-authentication interval to the default.

The following example enables re-authentication and sets the re-authentication interval as 1000 seconds.

```
Ruijie# configure terminal
```

```
Ruijie(config)# dot1x re-authentication
Ruijie(config)# dot1x timeout re-authperiod 1000
Ruijie(config)# end
Ruijie# show dot1x
802.1X Status:          Disabled
Authentication Mode:    EAP-MD5
Authed User Number:     0
Re-authen Enabled:      Enabled
Re-authen Period:       1000 sec
Quiet Timer Period:     10 sec
Tx Timer Period:        3 sec
Supplicant Timeout:     3 sec
Server Timeout:         5 sec
Re-authen Max:          3 times
Maximum Request:        3 times
Filter Non-RG Supp:     Disabled
Client Online Probe:    Disabled
Eapol Tag Enable:       Disabled
Authorization Mode:     Disabled
```

If re-authentication is enabled, please pay attention to the reasonableness of the re-authentication interval, which must be set according to the specific network size.

Enabling/Disabling the Filtering of Non-Ruijie Supplicant

When the Ruijie supplicant product is used as the 802.1x authentication client, authentication may fail if you use some other 802.1x authentication clients at the same time (for example, Windows XP 802.1x authentication function is enabled).

In this case, you can enable this function to filter the 802.1x packets from non-Ruijie supplicants so that supplicant authentication is not affected by other 802.1x clients. The function is enabled by default.

In the privileged EXEC mode, you can enable/disable the filtering by performing the following steps:

Command	Function
Ruijie (config)**#dot1x private-supplicant-only**	Enable the filtering function.
Ruijie**#show dot1x**	Show the dot1x configurations.

Following example is the configuration to enable the supplicant function provided by us.

```
Ruijie# configure terminal
Ruijie(config)# dot1x private-supplicant-only
Ruijie(config)# end
Ruijie# show dot1x
802.1X Status:          enable
Authentication Mode:    eap-md5
Total User Number:      0(exclude dynamic user)
Authed User Number:     0(exclude dynamic user)
```

```
Dynamic User Number:    0
Re-authen Enabled:      enable
Re-authen Period:       2 sec
Quiet Timer Period:     10 sec
Tx Timer Period:        3 sec
Supplicant Timeout:     3 sec
Server Timeout:         5 sec
Re-authen Max:      3 times
Maximum Request:        3 times
Private supplicant only:    enable
Client Online Probe:    disable
Eapol Tag Enable:       disable
Authorization Mode:     disable
```

Use the **no dot1x private-supplicant-only** command to disable this function.

Changing the QUIET Time

When the user authentication fails, the router does not allow that user to re-authenticate until a specified period, which is referred to as Quiet Period.This value functions to protect the device from malicious attacks. The default interval for Quiet Period is 10 seconds. A shorter Quiet Period may speed up re-authentication for the users.

In the privileged EXEC mode, you can set the Quiet Period by performing the following steps:

Command	Function
dot1x timeout quiet-period seconds	Set the Quiet Period.
show dot1x	Show the dot1x configurations.

You can use the **no dot1x timeout quiet-period command to** restore the Quiet Period to its default. In the example below the QuietPeriod value is set as 500 seconds:

```
Ruijie# configure terminal
Ruijie (config)# dot1x timeout quiet-period 500
Ruijie(config)# end
```

Setting the Packet Retransmission Interval

After the device sends the EAP-request/identity, it resends that message if no response is received from the user within a certain period. By default, this value is 3 seconds. You should modify this value to suit the specific network size.

In the privileged EXEC mode, you can set the packet retransmission interval by performing the following steps:

Command	Function
Ruijie(config)**#dot1x timeout tx-period** *seconds*	Setting the Packet Retransmission Interval
Ruijie**#show dot1x**	Show the dot1x configurations.

You can use the **no dot1x timeout tx-period** to restore the packet re-transmission interval to its default. The following example sets the packet retransmission interval as 100 seconds:

```
Ruijie# configure terminal
```

```
Ruijie(config)# dot1x timeout tx-period 100
Ruijie(config)# end
```

Setting the Maximum Number of Requests

If the router does not receive response within the ServerTimeout after it sends an authentication request to the RadiusServer, it will retransmit the packets.The maximum number of requests are the maximum retransmission requests of the device, and the authentication fails if this number is exceeded. By default, this value is 3. You should modify this value to suit the specific network size.

In the privileged EXEC mode, you can set the maximum number of retransmissions by performing the following steps:

Command	Function
Ruijie(config)**#dot1x max-req** *count*	Set the maximum number of packet re-transmissions.
Ruijie**#show dot1x**	Show the dot1x configurations.

You can use the **no dot1x max-req** command to restore the maximum number of packet re-transmissions to its default. The following example sets the maximum number of packet retransmissions to 5:

```
Ruijie# configure terminal
Ruijie(config)# dot1x max-req 5
Ruijie(config)# end
```

Setting the Maximum Number of Re-authentications

When the user authentication fails, the device attempts to perform authentication for the user once again. When the number of attempts exceeds the maximum number of authentications, the router believes that this user is already disconnected, and ends the authentication process accordingly. By default, the number is 3. However, you can modify this value.

In the privileged EXEC mode, you can set the maximum number of re-authentications by performing the following steps:

Command	Function
Ruijie (config)**#dot1x reauth-max** *count*	Setting the Maximum Number of Re-authentications
Ruijie**#show dot1x**	Show the dot1x configurations.

You can use the **no dot1x reauth-max** command to restore the maximum number of re-authentications to its default. The following example sets the maximum number of re-authentications to 3:

```
Ruijie# configure terminal
Ruijie(config)# dot1x reauth-max 3
Ruijie(config)# end
```

Setting the Server-timeout

This value indicates the maximum response time of the Radius Server. If the router does not receive the response from the Radius Server within this period, it deems the authentication as a failure.

In the privileged EXEC mode, you can set the Server-timeout and restore its default by performing the following steps:

Command	Function
Ruijie (config)**#dot1x timeout server-timeout** *seconds*	Set the maximum response time of the Radius Server. You can use the no option of the command to restore its default.
Ruijie**#show dot1x**	Show the dot1x configurations.

Configuring the device to initiate the 802.1x authentication proactively

The 802.1x is secure access authentication based on port. Users must first undergo authentication before they can access the network. In most cases, authentication is initiated by the user end through EAPOL-START packets. For the information about packet interaction during the authentication process, please see “Authentication Initiation and Packet Interaction During Authentication”.

However, authentication needs to be initiated by the router in some cases. For example, when the router is reset and the status of the authentication port changes from linkdown to linkup, the router needs to automatically initiate authentication to ensure that the authenticated users can continue to use the network. In addition, if you use a 802.1x client that does not actively initiate authentication requests (for example, the Windows XP 802.1x client), the router should be able to actively initiate authentication. The router forcedly asks all the users under the authentication port to authenticate by sending the EAP-request/identity multicast packets.

The following section describes how to configure the router to actively initiate 802.1x authentication and how you should configure appropriately in different application environments.

Turn on/off the router for the proactive authentication initiation of the device

When this function is disabled, the router can only initiate an authentication request at resetting or when the status of the authentication port is changed. This ensures that the on-line users can continue to use the network. The router will not actively initiate an authentication request in any other cases. When this function is enabled, you can configure the times of automatic authentication initiation, authentication request interval, and whether to stop sending requests when the users pass the authentication.

In the privileged EXEC mode, you can enable automatic authentication by performing the following steps:

Command	Function
Ruijie (config)**#dot1x auto-req**	Enable automatic authentication. It is enabled by default.
Ruijie**#show dot1x**	Show the dot1x configurations.

The **no** option of the command turns off the function. Only when the function is enabled, the following settings take effect. The user can set the number of proactive authentication requests initiated by the device, which can be determined according to the actual network environment.

In the privileged EXEC mode, you can set the number of automatic authentication requests by performing the following steps:

Command	Function
Ruijie (config)**#dot1x auto-req packet-num** *num*	The device proactively initiates num 802.1x authentication request messages. If num is equal to 0, the device will continually send that message. The default is 0 (infinite).
Ruijie**#show dot1x auto-req**	Show the configuration.

The **no** option of the command restores the value to its default. The following contents introduce how to configure the message sending interval.

In the privileged EXEC mode, you can set the packet sending interval by performing the following steps:

Command	Function
Ruijie (config)**#dot1x auto-req req-interval** *interval*	Setting the Packet Sending Interval
Ruijie**#show dot1x auto-req**	Show the configuration.

The **no** option of the command restores the value to its default. Since sending the authentication request multicast message will cause re-authentication for all users under the authentication interface, the sending interval shall not be too small lest the authentication efficiency is affected.

It is possible to set whether to stop sending the request messages when the user authentication passes. In some applications (only one user under a port, for example), we can stop sending authentication requests to the related port when the device finds the user authentication passes. If the user gets offline, the request is sent continually.

In the privileged EXEC mode, you can set this function by performing the following steps:

Command	Function
Ruijie (config)**#dot1x auto-req user-detect**	Stop sending the messages when there is some authentication user under the port. This function is enabled by default.
Ruijie**#show dot1x auto-req**	Show the configuration.

The **no** option of the command disables the function. Before setting this function, take careful considerations on the current network application environment.

The above three commands provide you with flexible application strategies. You can select the appropriate configuration command according to the specific network application environment. To help you configure easily, the following configuration table is provided for your reference:

	Solution 1	Solution 2	Solution 3
User environment	One port for any user	One port for one user	One port for multiple users
Whether the Ruijie supplicant should be used as the authentication client	Yes	No	No
Configuration command recommended	Not necessary to enable the dot1x auto-req function	**dot1x auto-req** **dot1x auto-req packet-num** *num*	**dot1x auto-req** **dot1x auto-req packet-num** *0*

		dot1x auto-req req-interval *interval* **dot1x auto-req user-detect**	**dot1x auto-req req-interval** *interval* **no dot1x auto-req user-detect**

Configuring 802.1x Accounting

Our 802.1x has implemented the accounting function. Accounting is based on interval. In other words, the 802.1x records the length of the period between the first successful authentication of the user and the user's logoff or when the router detects user disconnection.

After the first successful user authentication, the router sends an accounting start request to the server. When the user gets off-line or the router finds that the user has got off line or when the physical connection of the user is broken, the router sends an accounting end request to the server. The server group records this information in the database of the server group. Based on such information, the NMS can provide the basis for accounting.

Our 802.1x stresses the reliability of accounting, and it specially supports the backup accounting server to avoid failures of the accounting server. When a server can no longer provide the accounting service due to various reasons, the router will automatically forward the accounting information to another backup server. This greatly improves the reliability of accounting.

When a user exits by itself, the accounting duration is accurate. When the connection of the user is broken by accident, the accounting accuracy depends on the re-authentication interval (the router detects the disconnection of a user by using the re-authentication mechanism).

To enable the accounting function of the device, the following settings are necessary on the device:

On the Radius Server, register the router as a Radius Client, like the authentication operation.
Set the IP address of the accounting server.
Set the accounting UDP port.
Enable the accounting service on the precondition that the 802.1x has been enabled.

In the privileged EXEC mode, you can set the accounting service by performing the following steps:

Command	Function
Ruijie (config)**#aaa new-model**	Enable the AAA function
Ruijie (config)**#aaa group server radius** *gs*	Configure the accounting server group.
Ruijie (config-gs-radius)**#server** *address* **acct-port** *port-id*	Add a server to the server group.
aaa accounting network *acct* **start-stop group** *gs*	Configure the accounting method list.
Ruijie (config-gs-radius)**# dot1x accounting** *acct*	Apply the accounting method list for the 802.1X.
Ruijie**#show running-config**	Show the configuration.

The **no aaa accounting network** command deletes the accounting method list. The **no dot1x accounting** command restores the default dot1x accounting method. The following example sets the IP address of the accounting server to 192.1.1.1, that of the backup accounting server to 192.1.1.2, and the UDP port of the accounting server to 1200, and enables 802.1x accounting:

```
Ruijie# configure terminal
Ruijie(config)# aaa new-model
Ruijie(config)# aaa group server radius acct-use
Ruijie(config-gs-radius)# server 192.168.4.12 acct-port 1200
Ruijie(config-gs-radius)# server 192.168.4.13 acct-port 1200
Ruijie(config-gs-radius)# exit
Ruijie(config)# aaa accounting network acct-list start-stop group acct-use
Ruijie(config)# dot1x accounting acct-list
Ruijie(config)# end
Ruijie# write memory
Ruijie# show running-config
```


Note The agreed accounting key must be the same as that of the Radius Server and authentication.


Note The accounting function cannot be enabled unless the AAA is enabled.


Note The accounting is impossible unless the 802.1X authentication passes.


Note By default, the accounting function of the 802.1x is disabled.


Note For the database format of accounting, see the related Radius Server documentation.


Note In case of the domain-name-based AAA service router is enabled, that is when the **aaa domain enable** command is configured, the accounting method list chosen by the **dot1x accounting** command will not be used. Instead, the accounting method list configured by the domain where the user locates will be used. For detailed configuration, see Configuring the AAA Service Based on Domain Names.

Also, the account update is supported. After the account update interval is set on the NAS device, the NAS device will send account update packets to the Radius Server at periodical intervals. On the Radius Server, you can define the number of periods before which the account update packet of a user is not received from the NAS device, the NAS or user will be regarded as off-line. Then, the Radius Server can stop the accounting of the user, and delete the user from the on-line user table.

In the privileged EXEC mode, you can set the account update function by performing the following steps:

Command	Function
Ruijie (config)**#aaa new-model**	Enable the AAA function
Ruijie (config)**#aaa accounting update**	Set the account update function.
Ruijie**#show running-config**	Show the configuration.

You can disable the account update service by using the **no aaa accounting update** command.

```
Ruijie# configure terminal
Ruijie(config)# aaa accounting update
Ruijie(config)# end
Ruijie# write memory
Ruijie# show running-config
```

The following chapters introduce the propriety features of Ruijie's network products:

To make it easy for broadband operators and to accommodate use in special environments, our 802.1x has been expanded on the basis of the account (such expansion is completely based on the standard, and has totally compatible with IEEE 802.1x).

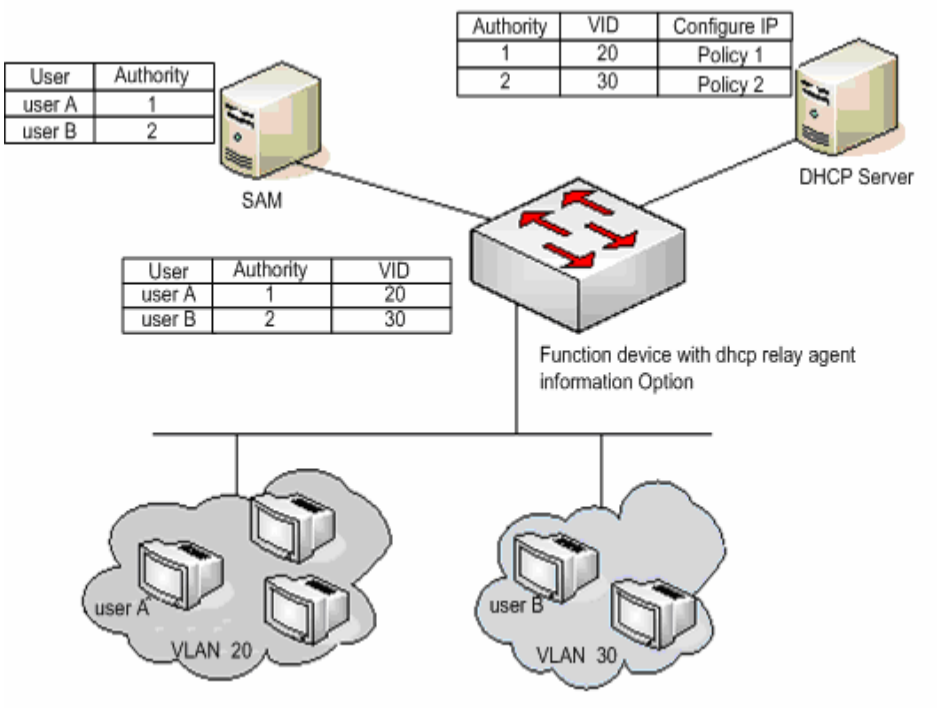
Configuring the IP authorization mode

The 802.1x implemented by Ruijie Network can force the authenticated users to use fixed IP. By configuring the IP authorization mode, the administrator can limit the way the user gets IP address. There are four IP authorization modes: DISABLE, DHCP SERVER, RADIUS SERVER and SUPPLICANT. They are detailed below respectively:

DISABLE mode (default): The device has no limitation for the user IP, and the user only needs to pass the authentication to be able to access the network.

DHCP SERVER mode: The user IP is obtained via specified DHCP SERVER, and only the IP allocated by the specified DHCP SERVER is considered legal. For the DHCP mode, it is possible to use DHCP relay option82 to implement a more flexible IP allocation policy with the 802.1X. Here is a typical diagram for the plan:

Figure 0-2



The user initiates IP requests via the DHCP Client. The network device with dhcp relay option82 converges the user authority on the SAM server to construct the option82 field and encapsulate it in the DHCP request message. That option82 field consists of “vid + permission”. The DHCP Server chooses different allocation policies by using the option82 field.

In this mode, it is required to configure the DHCP Relay and the related option82. If the DHCP relay function is enabled and the option82 policy is selected, see the DHCP Relay Configuration Guide and Command References for the configurations.

RADIUS SERVER mode: The user IP is specified by the RADIUS SERVER. The user can only use the IP specified by the RADIUS SERVER to be able to access the network.

SUPPLICANT mode: The IP bound to the user is the IP of the PC during the SUPPLICANT’s authentication. After the authentication, the user can only use that IP to be able to access the network.

The application models in the four modes are as follows:

- DISABLE mode: Suitable for the environment with no limits for the users. The user can access the network once he/she passes the authentication.
- DHCP SERVER mode: The user PC gets the IP address via DHCP. The administrator configures the DHCP RELAY of the device to limit the DHCP SERVER that the users can access. In this way, only the IPs allocated by the specified DHCP SERVER are legal.
- RADIUS SERVER mode: The user PC uses fixed IP. The RADIUS SERVER is configured with <user-IP> mapping relations that are notified to the device via the Framed-IP-Address attributes of the device. The user has to use that IP to be able to access the network.
- SUPPLICANT mode: The user PC uses fixed IP. The SUPPLICANT notifies the information to the device. The user has to use the IP at authentication to be able to access the network.

Note When the user switches modes, it will cause all authenticated users to get offline. So, it is recommended to configure the authentication mode before the use.

In the privileged EXEC mode, configure the IP authorization mode as follows:

Command	Function
Ruijie (config)**#aaa new-model**	Enable the AAA function
Ruijie (config)**#aaa authorization ip-auth-mode {disabled | dhcp-server | radius-server | supplicant }**	Configure the IP authorization mode
show running-config	Show the configuration.

The example below configures the IP authorization mode as the RADIUS-SERVER mode:

```
Ruijie# configure terminal
Ruijie(config)# aaa authorization ip-auth-mode radius-server
Ruijie(config)# end
Ruijie# show running-config
!
aaa new-model
!
aaa authorization ip-auth-mode radius-server
!
Ruijie# write memory
```

Releasing Advertisement

Our 802.1x allows you to configure the Reply-Message field on the Radius Server. When authentication succeeds, the information of the field is shown on our 802.1x client of Star-Supplicant, by which the operators can release some information.

Such information is shown at the first user authorization, but not at re-authentication. This avoids frequently disturbing the user.

The window for showing the advertisement information supports html, which converts the http://XXX.XXX.XX in the message into links capable of direct switching, for easier browsing.

Releasing of the advertising information:

- The operator configures the Reply Message attribute on the Radius Server end.
- Only our Star-supplicant client supports such information (free for the users of our router), while other clients cannot see the information, which however does not affect their normal use.
- No setting is required at the device end.

List of Authenticable Hosts under a Port

For enhanced security of the 802.1x, we have made expansion without affecting the IEEE 802.1x, allowing the NM to restrict the list of hosts authenticated of a port. If the list of hosts authenticated of a port is empty, any user can be authenticated. If the list is not empty, only the hosts in the list can be authenticated. The hosts that can be authenticated are identified by using the MAC addresses.

The following example adds/deletes the hosts that can be authenticated under a port.

Command	Function
configure terminal	Enter global configuration mode.
dot1x auth-address-table address *mac-addr* **interface** *interface*	Set the list of the hosts that can be authenticated.
end	Return to the privileged EXEC mode.
write	Save the configuration.
show running-config	Show the configuration.

Note If the list of the host is empty, the port allows any host to be authenticated.

Authorization

To make it easier for operators, our products can provide services of different qualities for different types of services, for example, offering different maximum bandwidths. Such information is all stored on the Radius Server, and the administrator does not need to configure every router.

Since the Radius has no standard attribute to represent the maximum data rate, we can only transfer the authorization information by the manufacturer customized attribute.

The general format of the definition is as follows:

Figure 0-3

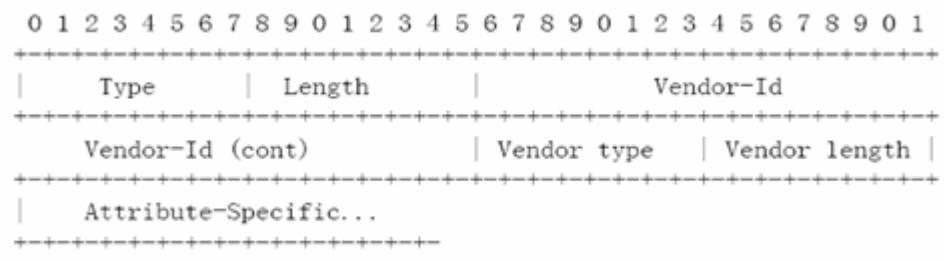
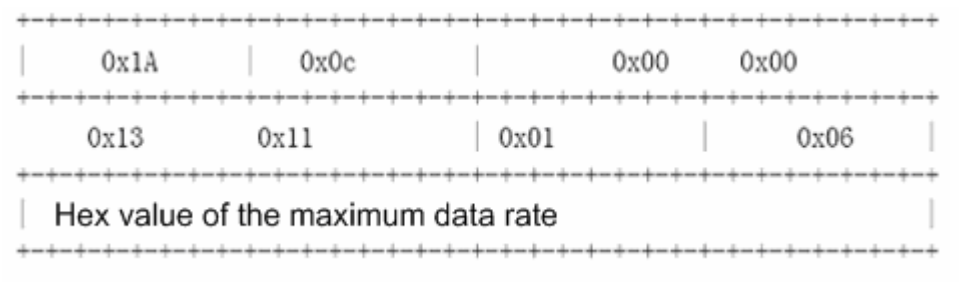


Figure 0-4

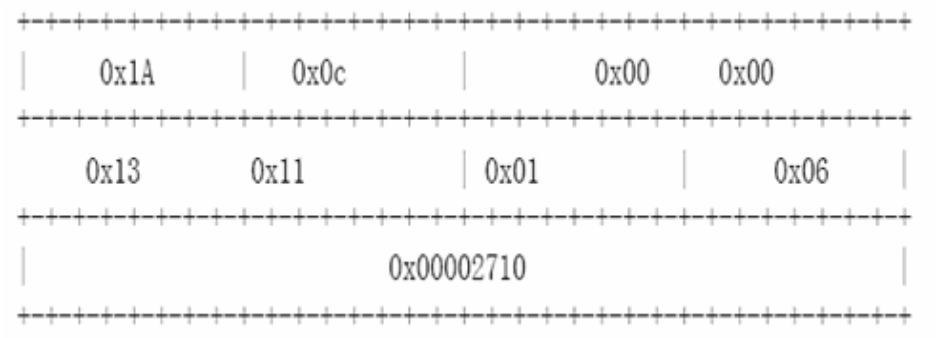
For the maximum data rate, you need to fill in the following values:



The unit of the maximum data rate is kbps.

For users with the maximum data rate of 10M, you need to fill in the following values:

Figure 0-5



For the customized header, follow those provided above. The maximum data rate is 10M, that is, 10000kbsp, and makes 0x00002710 in the Hex system. You only need to fill in the corresponding field.

This function calls for no settings on the device end, and works as long as the device end supports authorization.

Configuring the Authentication Mode

In the standard, the 802.1x implements authentication through the EAP-MD5. The 802.1X designed by Ruijie can perform authentication through both the EAP-MD5 (default) mode and the CHAP and PAP mode. The advantage of the CHAP is that it reduces the communication between the router and the RADIUS SERVER, thus alleviating the pressure on the RADIUS SERVER. Same as the CHAP mode, the communication between the PAP and RADIUS SERVER occurs only once. Although the PAP mode is not recommended for its poor security, it can meet the special needs of the user in some cases. For example, when the security server used only supports the PAP authentication mode, this mode can be selected to fully exploit the existing resources, protecting the existing investment.

In the privileged EXEC mode, you can set the authentication mode of the 802.1x by performing the following steps:

Command	Function
Ruijie (config)**#dot1x auth-mode** *mode*	Configure the authentication mode
Ruijie**#show dot1x**	Show the configuration.

The following example configures the authentication mode to the CHAP mode:

```
Ruijie# configure terminal
Ruijie(config)# dot1x auth-mode CHAP
Ruijie(config)# end
```

```
Ruijie# show dot1x
802.1X Status:          Disabled
Authentication Mode:    CHAP
Authed User Number:     0
Re-authen Enabled:      Disabled
Re-authen Period:       3600 sec
Quiet Timer Period:     10 sec
Tx Timer Period:        3 sec
Supplicant Timeout:     3 sec
Server Timeout:         5 sec
Re-authen Max:          3 times
Maximum Request:        3 times
Filter Non-RG Supp:     Disabled
Client Oline Probe:     Disabled
Eapol Tag Enable:       Disabled
Authorization Mode:     Group Server
```

Configuring the backup authentication server

Our 802.1x-based authentication system can support the backup server.When the master server is down due to various reasons, the device automatically issues a server submission authentication request to the method list server group.

In the privileged EXEC mode, you can set the backup authentication server by performing the following steps:

Command	Function
Ruijie (config)**#aaa new-model**	Enable AAA.
Ruijie (config)**#aaa group server radius** *gs-name*	Configure the server group.
Ruijie (config-gs-radius)**#server** *sever*	Configure the server.
Ruijie (config-gs-radius)**#server** *server-backup*	Configure the backup server.
Ruijie**#show dot1x**	Show the configuration.

The following example configures 192.168.4.12 to be the backup server:

```
Ruijie# configure terminal
Ruijie# aaa new-model
Ruijie(config)# aaa group server radius auth-ll
Ruijie(config-gs-radius)# server 192.168.4.1
Ruijie(config-gs-radius)# server 192.168.4.12
Ruijie(config-gs-radius)# end
Ruijie#
```

Configuring and Managing Online Users

Ruijie’s devices provide management for authenticated users via SNMP. The administrator can view the information of the authorized users via SNMP, and forcedly log off a user. The user forcedly logged off must pass the authentication again before it can use network resources.

This function calls for no configuration on the device.

Implementing User-IP Binding

With our clients and by correctly configuring the Radius Server, you can implement unique user-IP binding. A user must undergo authentication by using the IP address allocated by the administrator. Otherwise, authentication will fail.

For this function, you do not need to configure the router. The user needs to use our client and the administrator needs to configure the Radius Server.

Port-based Traffic Charging

In addition to the duration-based billing, Ruijie's network devices provide the traffic-based billing function in case each port of the equipment has only one user access.

This function calls for no configuration on the device but need the support of the Radius server.

Implementing Automatic Switching and Control of VLAN

To implement the auto-switching of the dynamic VLAN, the user VLAN shall be assigned and configured by the remote RADIUS server. The remote RADIUS server encapsulates the VLAN assignment information through the defined RADIUS attributes. After receiving those information and the user authentication, the access device automatically adds the port where the user is to the VLAN assigned by the RADIUS server. It is unnecessary of the manual configurations for the administrator.

You shall use the **show dot1x summary** command to on the access device to view the actual VLAN where the user is. Use the **show dot1x user id** command to view the VLAN assigned by the RADIUS server.

The access device is able to receive the VLAN assigned by the RADIUS server in two ways of the extension RADIUS attributes and the standard RADIUS attributes.

The RADIUS server assigns the VLAN to the access device using the standard-extension attributes. The server encapsulates the extension attributes into the No.26 RADIUS standard attributes. The extension manufacturing ID is in hex 0x00001311. By default, the extension attribute type is 4, you can use the **radius attribute 4 vendor-type** *type* command to set the extension attribute type number to assign the VLAN. For the configuration command, see *RADIUS Configuration*.

The access device supports the RADIUS server to use the standard RADIUS attributes to assign the VLAN, including the following attribute combinations:

- No.64 Attribute Tunnel-Type
- No.65 Attribute Tunnel-Medium-Type
- No.81 Attribute Tunnel-Private-Group-ID
- And for the auto-switching of the dynamic VLAN application, the valid range is:
- Tunnel-Type=VLAN(13)
- Tunnel-Medium-Type=802(6)
- Tunnel-Private-Group-ID=VLAN ID or VLAN Name
- For the details, see the RFC2868 and the RFC3580.

The processing steps of receiving the assigned VLAN for the access device are: 1. use the assigned VLAN attribute as the VLAN name and view that whether there is the same VLAN name on the access device; 2. if there is the same VLAN name, the port where the user is switches to the VLAN automatically; if there is no same VLAN name, then the assigned

VLAN attribute will be used as the VLAN ID; 3. if the VLAN ID is valid(within the VLAN ID range of the system supported), the port where the user is auto-switches to this VLAN; if the VLAN ID is 0, no VLAN assignment information exist; 4. except for those conditions mentioned above, the user authentication is faulty.

Only the ACCESS port and the TRUNK port are supported by the access device for the 802.1x authentication. In other port modes, it fails to enable the auto-switching function of the dynamic VLAN. The following describes the conditions of the VLAN auto-switching function on the ACCESS and TRUNK ports:

VLAN auto-switching function on the ACCESS port

Without the assigned VLAN configured on the device, if the assigned VLAN is identified as the VLAN ID by the device, the device will create the VLAN with the corresponding VLAN ID and switch the auth-port to the newly- created VLAN; while if the assigned VLAN is identified as the VLAN name by the device, the user authentication will be faulty.

With the assigned VLAN configured on the device, if the assigned VLAN is set as the VLAN not supporting the auto-switching on the ACCESS port, the user authentication will be faulty; while if the assigned VLAN is set as the VLAN supporting the auto-switching on the ACCESS port, the user authentication and the auto-switching implementation of the assigned VLAN will be successful.

The following lists the VLANs not supporting the auto-switching on the ACCESS port:

- Private VLAN
- Remote VLAN
- Super VLAN, including Sub VLAN

Native VLAN configuration on the TRUNK port

For the TRUNK port with the authentication enabled, set the assigned VLAN as the Native VLAN for the port to be authenticated.

Without the assigned VLAN configured on the device, if the assigned VLAN is identified as the VLAN ID by the device, the Native VLAN for the port to be authenticated will be set as the assigned VLAN; while if the assigned VLAN is identified as the VLAN name by the device, the user authentication will be faulty.

With the settings of the assigned VLAN configured on the device, if the assigned VLAN is set as the VLAN not supporting the auto-switching on the TRUNK port, the user authentication will be faulty; while if the assigned VLAN is set as the VLAN supporting the auto-switching on the TRUNK port, the user authentication will be successful and the Native VLAN for the port to be authenticated will be set as the assigned VLAN.

The following lists the VLANs not supporting the auto-switching on the TRUNK port:

- Private VLAN
- Remote VLAN
- Super VLAN, including Sub VLAN

Native VLAN configuration on the HYBRID port

For the HYBRID port with the MAC VLAN disabled, handling methods for the assigned VLAN are as below:

Without the assigned VLAN configured on the device, if the assigned VLAN is identified as the VLAN ID, the device will automatically create the corresponding VLAN and allows the assigned VLAN to pass current HYBRID port without TAG, and changes the Native VLAN of the port to the assigned VLAN. In such case, the user authentication will be successful.

While if the assigned VLAN is identified as the VLAN name and the corresponding VLAN ID cannot be found by the device, the user authentication will be faulty.

With the settings of the assigned VLAN configured on the device, if the assigned VLAN is set as the VLAN not supporting the auto-switching on the HYBRID port, or the designated VLAN has existed in the TAG VLAN list carried by the HYBRID port, the user authentication will be faulty; or else, the assigned VLAN can pass the current HYBRID port without TAG and the Native VLAN of the port is changed to the assigned VLAN. In such case, the user authentication will be successful.

With the MAC VLAN enabled on the HYBRID port, handling methods for the assigned VLAN are as blow:

If the VLAN assigned by the authentication server is not existent in the device (MAC VLAN requires that the corresponding VLAN must be statically configured and existent), or the assigned VLAN has been added to the HYBRID port with TAG carried, or the VLAN type is not supported by MAC VLAN (see the description in MAC-VLAN-SCG.doc), the user authentication will be faulty; or else, the device creates the MAC VLAN entry dynamically according to the authentication server assigned VLAN and user MAC address, the user authentication will be successful.

When the user goes offline, the MAC VLAN entry is deleted dynamically.

The following lists the VLANs not supporting the auto-switching on the HYBRID port:

- Private VLAN
- Remote VLAN
- Super VLAN, including Sub VLAN

Note When the MAC VLAN is not enabled on the port, VLAN assignment changes the Native VLAN of this port, but the Native VLAN configured by commands is not changed. The priority of the assigned VLAN is higher than the VLA configured by commands. That is, the Native VLAN that takes effect after the authentication is assigned VLAN, and the Native VLAN configured by commands takes effect after the user goes offline.

Note When the MAC VLAN is enabled on the port and the authentication mode is based on MAC, VLAN assignment is implemented through dynamically generating MAC VLAN entry without changing the Native VLAN of this port.

Note For the HYBRID port with MAC VLAN enabled or disabled, VLAN assignment will fail if the assigned VLAN has been added to the port with TAG carried.

Note If the MAC VLAN is enabled on the port, VLAN assignment will create the MAC VLAN entry with the network mask being all Fs. For example, the MAC address of the authenticated user is 00d0.f800.0001, the entry with VLAN: vlan-radius (the VLAN delivered under the server), MAC address: 00d0.f800.0001 and mask: FFFF.FFFF.FFFF will be created. If the MAC address of 802.1x user is overridden by the statically configured MAC address in the MAC VLAN entry with the network mask being not all Fs, For example, if the following entry with VLAN: vlan-static (manually configured VLAN), MAC address: 00d0.f800.0001, and

mask: FFFF.FFFF.0000 is configured manually, the two MAC addresses must be same, that is vlan-radius and vlan-static must be the same; otherwise, the following abnormities about 802.1x users of VLAN assignment will occur: (The following listed do not cover all abnormities)

Note 802.1x users can be authenticated successfully, but the legal data packets will be dropped after the authentication, resulting in network access failure.

Note After the user sends EAPOL-LOGOFF message to goes offline, the authentication server still shows that user is online as the 802.1x authentication entry is still in the device.

To enable the dynamic VLAN auto-switching function on an interface, run the following commands:

enable the AAA function

Command	Function
Ruijie (config)**#aaa new-model**	Enable the AAA function

For the details, see *AAA Configuration*.

set the RADIUS server

Command	Function
Ruijie (config)**#radius-server host** *host-ip*	Configure the RADIUS server.
Ruijie (config)**#radius-server key** *text*	Configure the RADIUS server shared key.

For the details, see *RADIUS Configuration*.

enable the method list

Command	Function
Ruijie (config)**#aaa authentication dot1x** *list1* **group radius**	Configure the authentication method list1.
Ruijie (config)**#aaa accounting network** *list2* **start-stop group radius**	Configure the accounting method list2.

For the details, see *AAA Configuration*.

802.1x method list

Command	Function
Ruijie (config)**#dot1x authentication** *list1*	Select list1 as the authentication method list, which is configured in step 3.
Ruijie (config)**#dot1x accounting** *list2*	Select list2 sd the authentication method list, which is configured in step 3.

enable the 802.1x authentication on the interface

Command	Function
Ruijie (config)**#interface** *interface_id*	Enter the interface mode to be configured. *interface_id* is the interface to be entered.
Ruijie (config-if-*type ID*)**#dot1x port-control auto**	Enable the 802.1x authentication on the interface.

enable the VLAN auto-switching on the interface

Command	Function
Ruijie (config)**#interface** *interface_id*	Enter interface configuration mode.
Ruijie (config-if-*type ID*)**#dot1x dynamic-vlan enable**	Enable the VLAN auto-switching on the interface.

Note For the VLAN auto-switching function, the dynamic switching must be enabled on the interface. That is, use the **dot1x dynamic-vlan enable** command in tinterface configuration mode. Or the RADIUS attributes of the encapsulted assigned VLAN will be ignored.

Note In interface configuration mode, the **dot1x dynamic-vlan enable** command must be configured after the **dot1x port-control auto** command has been configured. With the **dot1x port-control auto** command configured, the VLAN auto-switching function is disabled.

View the dynamic VLAN auto-switching settings

Command	Function
show dot1x user id *session_id*	View the user information in *session-id,* including the dynamic VLAN auto-switching information.
show dot1x summary	View the actual VLAN where the user is.

The VLAN auto-switching function is configured on access devices. For the related precautions, see the chapter of *Other Precautions of 802.1x Configuration*.

Implementing GUEST VLAN Function

With the GUEST VLAN function enabled on the port, this port will be added to the guest vlan if any of the following conditions is met:

- The port will successively send out authentication packets for three times. No EAPOL response packet is received within auto-req req-interval*3.
- No EAPOL response packet is received within 90 seconds.
- Failed MAC address authentication in MAC mode.

Use **show runninng-config** to view the configuration and **show vlan** to check whether the port jumps to guest vlan or not .

Follow these steps to configure a port whether to be allowed to jump to **GUEST VLAN** or not:

Command	Function
Ruijie (config-if-*type ID*)**#interface** *interface*	Enter interface configuration mode.
Ruijie (config-if-*type ID*)**#dot1x dynamic-vlan enable**	Allow Vlan jump on the interface.
Ruijie (config-if-*type ID*)# [**no**] **dot1x guest-vlan** *vid*	Configure whether to enable guest vlan, which is disabled by default.
show running-config	Show the configuration.


Note Guest vlan takes effect unless you configure dot1x dynamic-vlan enable.


Note It is better not to configure L2 attributes when configuring guest vlan, especially not to set vlan on the port manually.


Note After the port is added to guest vlan, if there is eapol packet received on this port or the port state is switched from linkup to linkdown, the port will exit guest vlan.


Note If you configure guest vlan on the port, it will check whether the port is added to guest vlan when the port state is switched from linkdown to linkup.

Shielding Proxy Server and Dial-up

The two major potential threats to network security are: The user sets its own proxy server and the user makes dial-up to access the network after authentication. Star routers provide the function to shield proxy servers and dial-up connections.

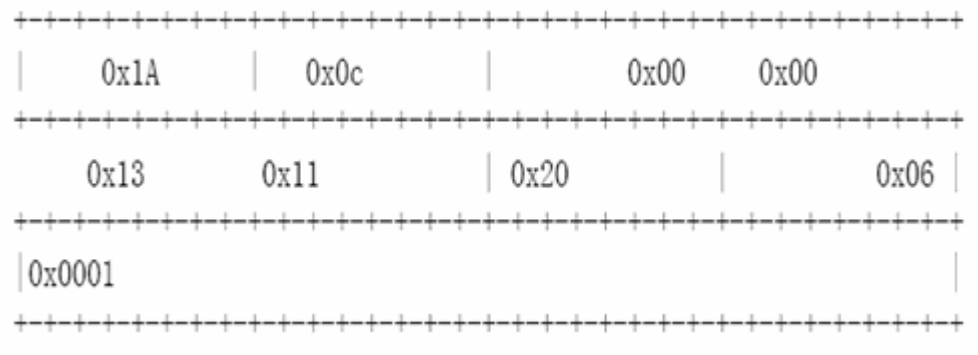
To implement this function needs no settings on the device end and needs only the corresponding attributes configured on the Radius server end. Since the Radius has no standard attributes to indicate the maximum data rate, we can transfer the authorization information only through the manufacturer custom attributes. For the general format defined, see the Authorization section.

The proxy server shielding function defines the Vendor type of 0x20, and the dial-up shielding function defines the Vendor type of 0x21.

The Attribute-Specific field is a 4-byte manufacturer defined attribute, which defines the actions taken against proxy server access and dial-up access. 0x0000 means normal connection, without shielding detection. 0x0001 means shielding detection.

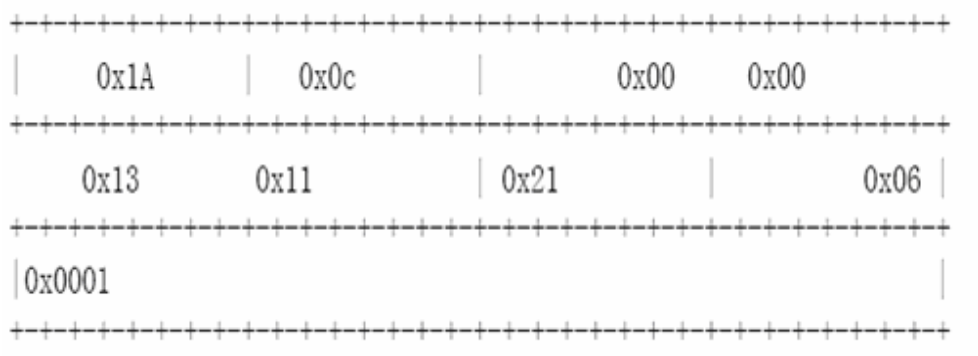
To shield the access via the proxy server, you should fill in the following information:

Figure 0-6



To shield the access via the dial-up connection, you should fill in the following information:

Figure 0-7



Configuring On-line Probe on Client End

To ensure accurate charging, an on-line probe mechanism is needed to detect whether a user is on-line within a short period. The re-authentication mechanism specified in the standard can meet such needs, but it needs the participation of the RADIUS server. Accurate user probe will occupy enormous resources of the router and RADIUS server. To meet the need to implement accurate charging with few resources occupied, we use a new client on-line probe mechanism. Such mechanism only needs interaction between the router and client and occupies little network traffic, and it implements minute-level charging accuracy (you can set the charging accuracy).

Note To implement on-line client monitoring, the client software must support this function.

The following two timers affect the performance and accuracy of on-line probe:

- Hello Interval: It is the interval at which the client sends advertisement.
- Alive Interval: Client online interval. If the device has not received the client advertisement during this interval, it actively disconnects the client and notifies the billing server. The interval must be greater than the Hello Interval.

In the privileged EXEC mode, you can configure the on-line probe function of the client by performing the following steps:

Command	Function
Ruijie (config)**#dot1x client-probe enable**	Enable the on-line probe function of the client
Ruijie (config)**#dot1x probe-timer interval** *interval*	Configure the Hello Interval
Ruijie (config)**#dot1x probe-timer alive** *interval*	Configure the Alive Interval of the device.
Ruijie**#show dot1x**	Show the configuration.

Configuring the Option Flag for EAPOL Frames to Carry TAG

In accordance with IEEE 802.1x, the EAPOL packets cannot be added with vlan TAG. However, based on the possible application requirements, the selection flag is provided. When the flag is turned on, tags can be outputted according to the related output rule of the trunk ports.

The typical application environment is to enable 802.1x authentication on the convergence layer. For more information, see “Topologies of Typical Applications”.

In the privileged EXEC mode, you can configure the flag for EAPOL frames to carry TAG by performing the following steps:

Command	Function
Ruijie (config)**#dot1x eapol-tag**	Enable the flag for EAPOL frames to carry TAG. By default, the function is disabled.
Ruijie**#show dot1x**	Show the configuration.

You can disable this function by using the **no dot1x eapol-tag** command.

Configuring Port-based Authentication

The 802.1x controls users on the basis of their MAC addresses by default. Only the authenticated user can use the network. With port-based authentication, the port is authenticated as long as a user is authenticated on a port. Consequently, all users connecting to this port can access the network.

To configure port-based control mode, execute the following commands in the privileged EXEC mode.

Command	Function
Ruijie (config)**#interface** *interface-id*	Enter the interface mode
Ruijie (config-if-*type ID*)**#dot1x port-control auto**	Enable the function being controlled.
Ruijie (config-if-*type ID*)**#dot1x port-control-mode** ***{ mac-based|port-based }***	Select the controlled mode.
Ruijie**#show dot1x port-control**	Show the configuration of port 802.1X.

You can run **no dot1x port-control-mode** to restore the settings to the default control mode.

Following example shows how to configure the authentication mode of a port.

```
Ruijie# configure terminal
```

```
Ruijie(config)# interface interface-id
Ruijie(config-if)# dot1x port-control-mode port-base
```

Note In the port-based authentication mode, if one user is authenticated on a port, other users can access the network without authentication through this interface.

Port-based authentication mode can enable or disable dynamic users to migrate among multiple authenticated ports. By default, the migration is allowed. To prohibit the migration, run the following commands one by one in the privileged EXEC mode.

Command	Function
Ruijie (config)**#dot1x stationarity enable**	Disable the migration among ports.

Configuring Port-based Single-user Authentication

By default, 802.1x controls on the basis of user MAC. Only the authenticated users can use the network, while other users connected to the same port is not able to use the network. In the port-based control mode, the port is authenticated when there is an authenticated user on the port. All the users connected to the authenticated port are able to use the network normally.

However, in the port-based control mode, the port-based single-user authentication controls only one authenticated user. The port is authenticated when it allows only one authenticated user who is enable to use the network normally. Then, if you find other users on the port, you should clear all the users on the port and reauthenticate.

From the privileged EXEC mode, follow the steps below to configure port-based single-user control mode on the port.

Command	Function
Ruijie (config)**#interface** *interface-id*	Enter interface configuration mode.
Ruijie (config-if-*type ID*)**#dot1x port-control auto**	Enable control function.
Ruijie (config-if-*type ID*)**#dot1x port-control-mode port-based single-host**	Port-based single-user control mode.
Ruijie**#show dot1x port-control**	Show 802.1x configuration.

You can run no dot1x port-control-mode to restore the settings to the default control mode.

Following example shows how to configure the authentication mode of a port.

```
Ruijie(config)#interface interface-idRuijie(config)#interface interface-id
Ruijie(config-if)#dot1x port-control-mode port-base single-host
```


Note In the port-based authentication mode, if one user is authenticated on a port, other users can access the network without authentication through this interface.


Note Single-host is port-based single-user 802.1x access control. Use **show dot1x port-control** to display port-based and use **show running-config** to **display dot1x port-control-mode port-based single-host**.


Note Since **single-host** only supports the single-user form, setting **default-user-limit** on the port manually does not take effect in **single-host** mode. If you set default-user-limit on the port after setting **single-host**, only one user can be permitted to use the network still.

In the port-based authentication mode, you can permit or deny dynamic users to migrate among multiple authentication ports, which is permitted by default. If you want to deny the migration of dynamic users, follow the steps below from the privileged EXEC mode.

Command	Function
Ruijie (config) **dot1x stationarity enable**	Prohibits migration between ports.

Configuring Dynamic Acl Assignment

802.1x supports ACL assignment from server and dynamic installation of the assigned ACL. Our product support installing acl by default. They will install acl dynamically on condition that the allowed acl is set on the server and is assigned after the successful user authentication.

To implement dynamic acl assignment, you need to set the port as mac-based authentication mode or port-based single-user authentication mode. For the configuration, please refer to the related command configuration manual.


Note In single-host authentication mode, it supports to renew acl when reauthenticating. That is, acl takes effect when the authenticated user sets acl on the server and reauthenticates.


Note The mac-based authentication mode does not support ACL update when re-authenticating. That is to say, ACL of the authenticated user can only be assigned once. The new acl is ignored and the original acl remains if the acl changes when re-authenticating.


Note Supported acl type: extension type which can explain acl function on our router.

Execute the following command if you need to support dynamic acl assignment on the server which is not authenticated by our company.

```
Ruijie#configure terminal
```

```
Ruijie(config)# radius vendor-specific extend
```

Configuring Dot1x MAC Authentication Bypass

GUEST VLAN provides a method of network accessing without the 802.1x authentication client, but this technology is unable to determine whether the access device is secure or insecure. In some conditions, for the network management and security, although there is no 802.1x authentication client, the administrator still needs to control the validity of the access device. MAB (MAC Authentication Bypass) provides a solution for this application.

With the MAB function enabled on the 802.1x authentication port, the authentication request packets are sent continuously to the port and the client response is expected. If there is no client response within the time of “tx-period*reauth-max”, the MAC address learned on the 802.1x authentication port will be monitored, and the authentication will be initiated by sending the username (the learned MAC address) and keyword to the server. It determines whether the learned MAC address is accessible to the network or not according to the returned authentication result from the server.

To configure the MAB function, run the following commands:

Command	Function
Ruijie (config)**#interface** *interface-id*	Enter interface configuration mode.
Ruijie (config-if-*type ID*)**#dot1x mac-auth-bypass**	Set the dot1x MAC authentication bypass.
Ruijie**#show running-config**	Show all configurations.

Following example shows how to configure the MAB function.

```
Ruijie# configure terminal
Ruijie(config)# interface fa 0/1
Ruijie(config-if)# dot1x port-control auto
Ruijie(config-if)# dot1x mac-auth-bypass
```

Note Use the format XXXXXXXXXXXX when setting the username and keyword for the MAC address on the server. Other formats such as xx:xx:xx:xx:xx:xx, xx-xx-xx-xx-xx-xx and xxxx.xxxx.xxxx are not allowed.

Note With the port in the MAB mode, only one MAC address that firstly found by the device can be used for the authentication.

Note One port for one MAC address authentication is supported in both the port mode and the MAC mode.

Note Anytime when the client responses the 802.1x authentication, the MAB on the port takes no effect unless the link state down/up change occurs or the 802.1x function on the port is re-enabled.


Note The client online probe function takes no effect for the MAC authentication in the MAB mode.


Note With MAB port configured, an authentication request packet is sent at the interval of tx-period. After sending the packets for reauth-max times, if there is no client response, the port enters to the MAB mode. The port in the MAB mode can learn the MAC address and use the learned MAC address as the username for the authentication.


Note MAB supports the PAP, CHAP, EAP-MD5 authentication methods. For how to configure the authentication method, see the chapter in *Authentication Method Configuration*.


Note In the MAB mode, after the MAC address authentication failure, if the guest vlan has been configured, the authentication port will enter the guest vlan; if the guest vlan has not been configured, the port stays in the original vlan. The MAB does not support auth-fail VLAN, that is, even though the MAB authentication fails and the auth-fail VLAN has been configured, the port will not enter the auth-fail VLAN.


Note MAB supports server deployment functions such as dynamic VLAN delivery and ACL delivery.


Note If one MAC address has passed the MAB authentication for one port and it appears on other ports, the MAB violation will be set for the latter port.


Note The MAB authentication offers the access-auth service for the device without the auth-client software. Those devices generally cannot recognize the 802.1Q TAG labels. To this end, it is recommended that the MAB-auth function shall be set on the ACCESS port. Otherwise, even though it passes the authentication, the communication between the devices fails.


Note If one address of a port passes MAB authentication, other addresses of this port don’t need authentication.

Configuring Dot1x MAC Authentication Bypass Timeout

After a MAC address authentication in the MAB mode is online, this MAC address will always be online unless the re-auth fails, the port is Down or it is forcibly offline due to the administration policy.

The user can configure the allowed online time of those authentication MAC address. 0 is the default value, indicating that the MAC address is always online.

To configure the MAB timeout, run the following commands:

Command	Function
Ruijie (config)**#interface** *interface-id*	Enter interface configuration mode.
Ruijie (config-if-*type ID*)**#dot1x mac-auth-bypass timeout-activity** *value*	Set the MAB timeout time, in seconds. No default value and the valid range is 1-65535.
Ruijie**#show running-config**	Show all configurations.

Following example shows how to configure the MAB timeout time.

```
Ruijie# configure terminal
Ruijie(config)# interface fa 0/1
Ruijie(config-if)# dot1x mac-auth-bypass  timeout-activity 3600
```

Note If the online time for the MAC address authentication is also assigned by the server, this online time is independent from the timeout-activity.

Note After it times out, with guest vlan configured on the port, the port switches to the guest vlan. However, during the authentication, the response timeout for the server will not cause the MAB port in the guest vlan.

Configuring Dot1x MAC Authentication Bypass Violation

By default, with one MAC address authenticated in the MAB mode, data of all devices under the port are allowed to be forwarded. However, in some safe applications, if only one MAC address is allowed for the MAB port by the administrator, configure the MAB violation. With the MAB violation configured, once the port enters the MAB mode, the violation occurs if there is more than one 1 Mac address for the port.

To configure the MAB violation on the interface, run the following commands:

Command	Function
Ruijie (config)**#interface** *interface-id*	Enter interface configuration mode.
Ruijie (config-if-*type ID*)**#dot1x mac-auth-bypass violation**	Set the MAB violation.
Ruijie**#show running-config**	Show all configurations.

Following example shows how to configure the MAB violation.

```
Ruijie# configure terminal
Ruijie(config)# interface fa 0/1
Ruijie(config-if)# dot1x mac-auth-bypass violation
```

Note Use the **erridisable recover** command to restore the MAB violation port.


Note The same MAC address for the port in the private vlan appears in the primary and the secondary VLAN simultaneously, so the MAB authentication violation shall not be configured on the port in the private vlan. Or it will lead to the MAB violation judgment error and influence the normal use.

Configuring Dot1x Auth-Fail VLAN

With the auth-fail vlan configured on the router, when the user authentication on the port fails, the port enters to the auth-fail vlan pre-configured.

To configure the auth-fail VLAN in interface configuration mode, run the following commands:

Command	Function
Ruijie (config)**#interface** *interface-id*	Enter interface configuration mode.
Ruijie (config-if-*type ID*)**#dot1x auth-fail vlan** *vid*	Set the auth-fail VLAN on the interface.
Ruijie**#show run**	Show configurations.

Following example shows how to configure the auth-fail VLAN.

```
Ruijie# configure terminal
Ruijie(config)# interface fa 0/1
Ruijie(config-if)# dot1x auth-fail vlan 2
```


Note If the configured vlan is inexistent, the vlan will be created dynamically when the port enters the auth-fail vlan, and will be auto-removed when the port exits from the auth-fail vlan.


Note If the port is down, it will exit from the auth-fail vlan automatically.


Note It allows setting the auth-fail vlan and the guest vlan in the same VLAN.


Note In the port mode and in the auth-fail vlan, it only allows the last-auth-fail user for the re-auth, and the auth-requests of other users are dropped. This restriction is not applicable for the MAC mode.


Note The auth-fail vlan does not support private vlan. That is, the private vlan cannot be set as the dot1x auth-fail vlan.


Note When the GSN address binding function is enabled on the port, the auth-fail user cannot access the network.

Configuring Dot1x Auth-Fail Max-Attempt

Fail-VLAN is entered only after the client fails to pass authentication for certain times. To configure the auth-fail max-attempt times, run the following commands:

Command	Function
Ruijie (config)**#dot1x auth-fail max-attempt** *value*	Set the auth-fail max-attempt times, the default value is 3 and the valid range is 1-3.
Ruijie**#show running-config**	Show all configurations.

Following example shows how to configure the auth-fail max-attempt value.

```
Ruijie# configure terminal
Ruijie(config)# dot1x auth-fail max-attempt 2
```

Configuring to permit MAC Move

By default, after an 802.1x user passes authentication on a certain port, the MAC address of this user will be bound to this port and is not allowed to present on any other port.

However, under certain circumstances, after user passes authentication, it may need to move to other ports. For example: a separate router is deployed between 802.1x authentication enabled router and user PC to connect them. When user directly pulls out the network cable and moves from port 1 to port 2, since port 1 didn't receive the Down event and is unaware that the user is disconnected, the PC connected to port 2 won't be able to pass authentication and access network.

To enable the user to access network after being switched to port 2, configure to allow MAC move in global configuration mode. When user appears on port 2, the user on port 1 will be forced to disconnect from network, and re-authentication will be initiated on port 1. The user can move between different ports of the same device or even across different devices. The user can also move between controlled ports, or move from a controlled port to an uncontrolled port.

Execute the following steps to allow MAC move:

Command	Function
Ruijie**# configure terminal**	Enter global configuration mode.
Ruijie (config)**# dot1x mac-move permit**	Enable MAC move.
Ruijie (config)**# end**	Return to privileged EXEC mode.
Ruijie**# show dot1x**	Display 802.1x global configurations.

Configuration example:

```
Ruijie# configure terminal
Ruijie(config)# dot1x mac-move permit
```

Note If there is MAC address spoofing on the network, after enabling MAC move, authenticated users may be preempted by fake users.

Note If the user doesn't move to another port but change IP address on the original port or unplug/replug the network cable, the re-authentication process will be triggered.

Note If user's MAC address is configured as a static MAC address, the user won't be able to move.

Configuring Inaccessible Authentication Bypass

When all RADIUS servers configured on the router are inaccessible, the user's authentication request won't receive any reply, and the administrator won't be able to verify user's identity. From the perspective of user, if no other authentication method is configured on the router, it won't be able to access the network. To ensure that the new authenticated user can access network, Inaccessible Authentication Bypass (IAB) can be configured on the port.

Execute the following steps to enable IAB:

Command	Function
Ruijie**# configure terminal**	Enter global configuration mode.
Ruijie (config)**# interface** *interface-id*	Enter interface configuration mode.
Ruijie (config-if)**# dot1x critical**	Configure Inaccessible Authentication Bypass.
Ruijie (config-if)**# end**	Return to privileged EXEC mode.
Ruijie**# show running-config**	Display all configurations.

The following example shows how to configure Inaccessible Authentication Bypass:

```
Ruijie# configure terminal
Ruijie(config)# interface fa 0/1
Ruijie(config-if)# dot1x port-control auto
Ruijie(config-if)# dot1x critical
```

The following example shows how to configure server disabling parameters. The deadtime indicates the time of the server being forced back to the active state after it enters the dead state. The dead-criteria time indicates the interval at which packets are retransmitted. The tries indicates the times of packets retransmission. When the retransmission times reach the configured one and no response packet is received from the server, the server state will change from active to dead:

```
Ruijie# configure terminal
Ruijie(config)# aaa new-model
Ruijie(config)# radius-server deadtime 1
Ruijie(config)# radius-server dead-criteria time 5
Ruijie(config)# radius-server dead-criteria tries 4
```

Note After IAB is enabled on the port and all servers become inaccessible:
IAB will take effect only if the globally configured 802.1x authentication method list contains only RADIUS authentication method and all RADIUS servers have failed. If there are other authentication methods in the

list (such as local, none, etc), IAB won't take effect.
After globally enabling AAA multi-domain authentication, the globally configured authentication method list won't be adopted during 802.1x user authentication. Since IAB will directly allow the user to pass authentication without the need to enter username after the RADIUS servers in 802.1x authentication method list have all failed, AAA multi-domain authentication will fail on this port.
IAB-authenticated users won't send accounting request to the accounting server.
Normally authenticated users won't be affected and can still access network.
With 802.1x IP authorization enabled globally, if there is authenticated user on the port, the other users on this port cannot be authenticated in IAB mode.
With GSN address binding function enabled on the port, the user authenticated through the IAB cannot access the network.

Configuring IAB Authentication with Switching VLAN

When 802.1x controlled port enters into IAB state, it won't be able to verify user's identity. You can assign this port to a specific VLAN, and only allow the user to access network resources on this specific VLAN.

Execute the following steps to configure IAB authentication with switching VLAN:

Command	Function
Ruijie**# configure terminal**	Enter global configuration mode.
Ruijie (config)**# interface** <*interface-id*>	Enter interface configuration mode.
Ruijie (config-if)**# dot1x critical vlan** <*vlan-id*>	Configure IAB authentication with switching VLAN.
Ruijie (config-if)**# end**	Return to privileged EXEC mode.
Ruijie**# show running-config**	Display all configurations.

The following example shows how to configure Inaccessible Authentication Bypass:

```
Ruijie# configure terminal
Ruijie(config)# interface fa 0/1
Ruijie(config-if)# dot1x port-control auto
Ruijie(config-if)# dot1x critical
Ruijie(config-if)# dot1x critical vlan 100
```

Note

If there are already certain authenticated users on the port before all RADIUS servers fail, new users are authorized to access the network after servers have failed and if no inaccessible VLAN is configured on the port. If IAB authentication with inaccessible VLAN has been configured on the server, new users won't be authorized to access network in order to guarantee that the authenticated users have the priority to use network.

Note

If there are already normally authenticated users on the port before all servers have failed, the port will remain the original state and won't jump to the inaccessible VLAN if the servers are failed during user's re-authentication.


Note After all users under the port are disconnected, the port will automatically exit from the inaccessible VLAN.


Note If the inaccessible VLAN configured doesn't exist, the inaccessible VLAN will be created automatically when entered by the port and be removed automatically when exited by the port.


Note The inaccessible VLAN doesn't support private VLAN, remote VLAN and super VLAN (including SUB VLAN).

Configuring IAB Authentication with Recovery action

RADIUS server is failed, some users won't be able to pass the authentication, and the router will authorize the users to access network. When RADIUS server is recovered, this feature will allow IAB users under the port to reinitialize authentication to verify user's identity.

Execute the following steps to configure IAB authentication with recovery action:

Command	Function
Ruijie**# configure terminal**	Enter global configuration mode.
Ruijie (config)**# interface** <*interface-id*>	Enter interface configuration mode.
Ruijie (config-if)**# dot1x critical recovery action reinitialize**	Allow IAB users under the port to reinitialize authentication when the server has recovered.
Ruijie(config-if)**# end**	Return to privilege mode.
Ruijie**# show running-config**	Display all configurations.

When RADIS server is failed, some users won't be able to pass the authentication, and the switch will authorize the users to access network. When RADIUS server is recovered, this feature will allow IAB users under the port to reinitialize authentication to verify user's identity.

The following example shows how to configure Inaccessible Authentication Bypass:

```
Ruijie# configure terminal
Ruijie(config)# interface fa 0/1
Ruijie(config-if)# dot1x port-control auto
Ruijie(config-if)# dot1x critical
Ruijie(config-if)# dot1x critical recovery action reinitialize
```


Note After the server has recovered, normally authenticated users under the port can continue to access the network without re-authentication. After the server is failed, IAB-authenticated users will be subject to the authentication interaction initiated by the router.

Configuring Local Authentication

The local database can be used to authenticate accessed users when there is no RADIUS server or the RADIUS server is not used for authentication.

Perform the following steps to configure local authentication:

Command	Function
Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie (config)# **aaa new-model**	Enable AAA.
Ruijie (config)# **aaa authentication dot1x** *mlist* **local**	Configure the dot1x authentication method list *mlist* to perform local authentication.
Ruijie (config)# **username** *xxx* **password** *xxx*	Create a local user xxx.
Ruijie (config)# **dot1x authentication** *mlist*	It indicates the application method list *mlist*.
Ruijie (config)# **dot1x auht-mode pap/chap**	Configure the authentication method as PAP or CHAP.
Ruijie (config)# **end**	Return to the privileged mode.
Ruijie# **show running-config**	Show all configuration.

Note After local authentication is configured, the local database is used to authenticate users. This function also applies to MAC bypass authentication. It only needs to create a local user with the username and password being the MAC address.

Viewing the Configuration and Current Statistics of the 802.1x

Our 802.1X provides a full range of state machine information, which is very useful for network management and can be used by the administrator to monitor user status in real time and make easy troubleshooting.

- Viewing the Radius Authentication and Accounting Configuration
- Viewing the Number of Current Users
- Viewing the List of the Addresses Authenticable
- Viewing the User Authentication Status Information
- Showing the 1x Client Probe Time Configuration
- Example of Configuring 802.1X Port-Based Dynamic VLAN Skip

Viewing the Radius Authentication and Accounting Configuration

Run the **show radius server** command to check the related configuration of the Radius Sever, and run the **show aaa user** command to view the user-related information.

```
Ruijie# show radius server
Server IP:       192.168.5.11
Accounting Port:  1813
Authen  Port:    1812
Server State:    Ready
```

Viewing the Number of Current Users

Our 802.1X allows you to view the numbers of two types of users: one is the number of current users, and the other is that of the authorized users. The number of current users refers to the total number of users authenticated (whether successfully or unsuccessfully), while the number of authorized users means the total number of users authorized.

In the privileged EXEC mode, run the **show dot1x** command to check the current number of users and authenticated users, 1x configuration, including the current number of users and authenticated users.

The following example shows the 802.1x configuration:

```
Ruijie# show dot1x
802.1X Status:          Disabled
Authentication Mode:    EAP-MD5
Authed User Number:     0
Re-authen Enabled:      Disabled
Re-authen Period:       3600 sec
Quiet Timer Period:     10 sec
Tx Timer Period:        3 sec
Supplicant Timeout:     3 sec
Server Timeout:         5 sec
Re-authen Max:          3 times
Maximum Request:        3 times
Filter Non-RG Supp:     Disabled
Client Oline Probe:     Disabled
Eapol Tag Enable:       Disabled
Authorization Mode:     Disabled
MAC Move Permit:     Enabled
```

Viewing the Authenticable Address Table

Our 802.1x has expanded functions that allow you to set the hosts that can be authenticated on a particular port. This function allows the administrator to view the currently available settings.

In the privileged EXEC mode, you can view the list of hosts authenticable by performing the following steps:

Command	Function
Ruijie (config)**#dot1x auth-address-table address** *mac-addr* **interface** *interface*	Set the list of the hosts that can be authenticated.
Ruijie**#show dot1x auth-address-table**	Show the list of the hosts that can be authenticated.

Use the **no dot1x auth-address-table address** command to delete the specified authenticable host list. The following example shows the list of the hosts that can be authenticated.

```
Ruijie# show dot1x auth-address-table
interface:g3/1
---------------------------------
mac addr: 00D0.F800.0001
```

Viewing the User Authentication Status Information

The administrator can view the authentication status of the current users of the router for easier troubleshooting.

In the privileged EXEC mode, you can view the user authentication status information by performing the following steps:

Command	Function
show dot1x summary	Viewing the User Authentication Status Information

The following example shows the user authentication status information.

```
Ruijie# show dot1x summary
 ID   MAC      Interface  VLAN  Auth-State  Backend-State Port-Status
---- ----------- --------- ----  ----------  ------------   -----------
1   00d0f8000001 Gi3/1     1   Authenticated  IDLE        Authed
```

Showing the 1x Client Probe Timer Configuration

In the privileged EXEC mode, you can view the 1x timer setting by performing the following steps:

Command	Function
show dot1x probe-timer	Show the 1X timer setting

The following example shows the 1.1x timer setting:

```
Ruijie# show dot1x probe-timer
Hello Interval: 20 Seconds
Hello Alive: 250 Seconds
```

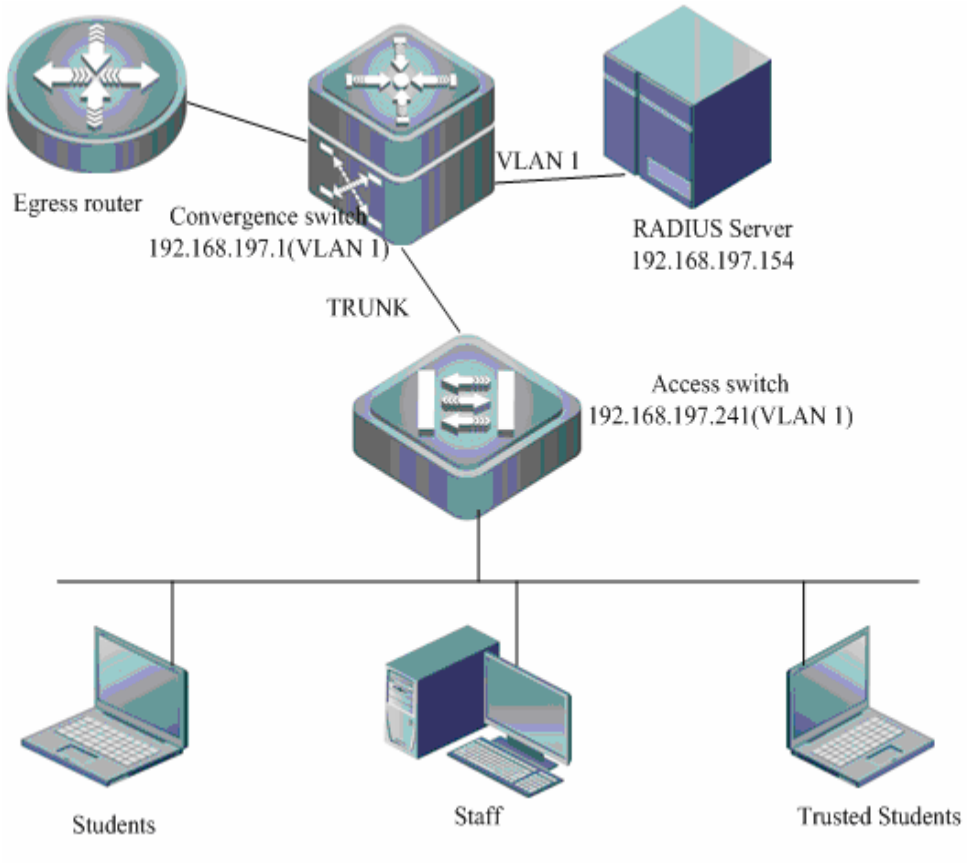
Example of Configuring 802.1X port-based dynamic VLAN assignment

In a school, there are three types of user groups as shown below:

- Students;
- Trusted students (such as student cadres);
- Teaching and administrative staff.
- Fundamental requirements are shown below:
- Each member of these three user groups can be connected to any port of the access device and join the corresponding VLAN.
- Complete data isolation shall be achieved between VLANs corresponding to three user groups, namely the members of one group cannot exchange data with members of another group.

Network topology is shown below:

Figure 11 Typical topology of dynamic VLAN assignment



Configuration example is shown below

1) Configure RADIUS server

Include a managerial access device of 192.168.197.241, which uses the default authentication and accounting ports of 1812 and 1813 and the shared key of "shared".

Configure the vlan for users of user group "students"

```
Tunnel-Type = "VLAN",
Tunnel-Medium-Type = "IEEE-802",
```

```
Tunnel-Private-Group-ID = "students"
```

Configure the vlan for users of user group "trusted_students"

```
Tunnel-Type = "VLAN",
Tunnel-Medium-Type = "IEEE-802",
Tunnel-Private-Group-ID = "trusted_students"
```

Configure the vlan for users of user group "staff"

```
Tunnel-Type = "VLAN",
Tunnel-Medium-Type = "IEEE-802",
Tunnel-Private-Group-ID = "staff"
```

2) Configure access router

Enable AAA

```
configure terminal
aaa new-model
```

Configure RADIUS server

```
configure terminal
radius-server host 192.168.197.154
radius-server key shared
```

Configure authentication method list

```
configure terminal
aaa authentication dot1x default group radius
aaa accounting network default start-stop group radius
```

802.1X to select the authentication method list

```
configure terminal
dot1x authentication default
dot1x accounting default
```

Enable 802.1X authentication on the interface

```
configure terminal
interface range fastEthernet 0/1-48
dot1x port-control auto
```

Enable dynamic VLAN assignment on the interface

```
configure terminal
interface interface_id
dot1x dynamic-vlan enable
```

Create VLANs to join after user authentication

```
configure terminal
vlan 2
name students
vlan 3
name trusted_students
vlan 4
name staff
```

Create the management IP for access device

```
configure terminal
interface vlan 1
ip address 192.168.197.241 255.255.255.0
```

By far, user's needs can be met.

Other Precautions for Configuring 802.1x

Concurrent use of 1X and ACL

In the non-IP authorization mode, if you enable the 802.1x authentication function of a port and at the same time associate one ACL with a interface, the ACL takes effect on the basis of the MAC address. In other words, only the packets from the source MAC addresses of the authenticated users can pass ACL filtering, and the packets from other source MAC addresses will be discarded. The ACL can only work on the basis of the MAC address.

For example, if the authenticated MAC address is 00d0.f800.0001, then all the packets from the source MAC address of 00d0.f800.0001 can be switched. If the port is associated with an ACL, the ACL will further filter these packets that can be switched, for example, rejecting the ICMP packets from the source MAC address of 00d0.f800.0001.

The restrictions for the condition that the users on the interface have being authenticated or the users have been authenticated:

- The port mode cannot be modified, such as the command **switchport mode trunk** cannot be used.
- The port Access VLAN can not be modified in the ACCESS mode.
- The port Allowed VLAN and Native VLAN can not be modified in the TRUNK mode.
- The port can not exit from or be added to the AP port.

The restrictions for the condition that the users in the VLAN have being authenticated or the users have been authenticated:

- VLAN can not be deleted
- VLAN type cannot be modified, such as the command **private-vlan primary** cannot be used.

GVRP cannot be co-used with the dynamic VLAN auto-switching function.

802.1x function can be co-used with other access control functions, such as the port security, IP+MAC binding,ect. When those access control functions are co-used, the packets can enter the router on the condition that those packets must address all access controls.

After the Native VLAN of the port is changed, effective VLAN-switching functions (such as: GUEST VLAN, FAIL VLAN, VLAN assignment and IAB authentication with switching VLAN) on the Trunk port or Hybrid port will cause the users in other VLANs can access the network without authorization. Therefore, it is suggest the aforementioned VLAN-switching function is enabled on the Access port only.

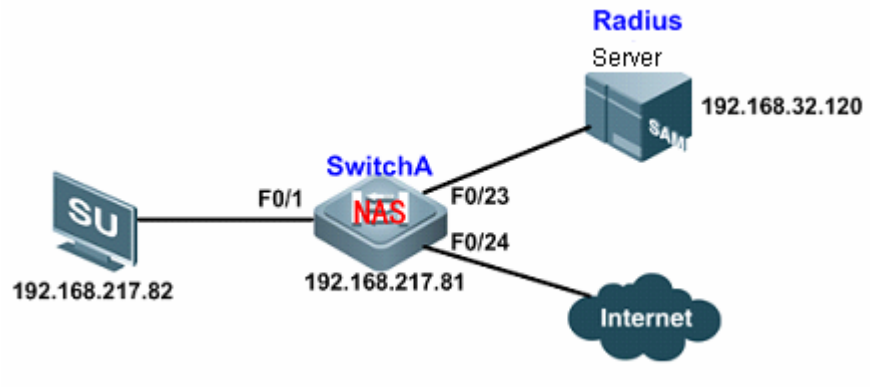
It is not suggested to enable the **dot1x redirect** command after the controlled function is enabled on the AP port. Otherwise, controlled function of this AP port may fail.

Typical 802.1X Configuration Examples

802.1X-based AAA Services

Network Topology

Figure 12 Network topology for the 802.1X-based AAA service



Networking Requirements

To ensure the validity of network access, the following requirements must be met:

- It is required that access users on each port must be subject to 1X authentication in order to control Internet access (unauthenticated users won't be able to access network);
- Only our client software (supplicant) can be used as the client for 802.1x authentication;
- Accounting shall be based on online time, and accounting update packets will be periodically sent to Radius Server (real-time accounting packets will be sent to RADIUS server every 15 minutes);
- After sending the authentication request to RADIUS server, the device will resend the request if no reply is received within 5 seconds, and will try for totally 6 times;
- Online monitoring of users to prevent authenticated user from being preempted by other users and to detect whether the user is disconnected;
- To protect server from hostile attacks, the access user can only initialize re-authentication after 500 seconds if it fails in authentication. Meanwhile, after trying for over 5 times, this user will be considered as disconnected and the authentication process will end.

Configuration Tips

- Turn on AAA switch and configure the communication between device and RADIUS SERVER; configure 802.1X authentication and configure the device port for client access as controlled port (here we take port F0/1 as the example); (corresponding to paragraph 1 of "Application Needs")
- Filter non-Ruijie supplicant (corresponding to paragraph 2 of "Networking requirements")
- Configure 802.1x accounting and accounting update, and configure the interval of accounting update packets (corresponding to paragraph 3 of " Networking requirements ")
- Configure the reply timeout timer of Radius Server as 5s, and configure the maximum authentication retries as 6 times (corresponding to paragraph 4 of " Networking requirements ")
- Configure periodic re-authentication of device (corresponding to paragraph 5 of " Networking requirements ")

- Configure the Quiet Period for failed authentication as 500s (waiting time) and configure the maximum authentication retries as 5 times (corresponding to paragraph 6 of " Networking requirements ")

Configuration Steps

Step 1: Configure relevant attributes of Radius Server

- Login SAM Security Accounting Management System and click "System Management - Device Management" to insert information about NAS device. The required configurations include: "Device IP" - 192.168.217.81, "Device Group" - haha, "Device Type" - switch, "Specific Model" - S21XX and later, "Device Key" - Ruijie, "Read/Write Community" - weilin, "Device Aging Duration" - 3s, as shown below:

Figure 0-8

- Click "User Management - User Management" to insert user information. The required configurations include: "Username" - qq, "Password" - 1234567, "User Group" - ceshi, as shown below:

Figure 0-9

Step 2: Configure access switch "SwitchA"

! Turn on AAA switch

```
Ruijie(config)#aaa new-model
```

! Configure RADIUS server

```
Ruijie(config)#radius-server host 192.168.32.120
```

! Configure RADIUS Key

```
Ruijie(config)#radius-server key ruijie
```

! Configure dot1x authentication method list

```
Ruijie(config)#aaa  authentication dot1x hello group radius
```

! Apply dot1x authentication method list

```
Ruijie(config)#dot1x authentication hello
```

! Configure F0/1 as controlled port (enable port-based authentication)

```
Ruijie(config)#interface fastEthernet 0/1
Ruijie(config-if-FastEthernet 0/1)#dot1x port-control auto
Ruijie(config-if-FastEthernet 0/1)#exit
```

! Filter non-Ruijie supplicant

```
Ruijie(config)#dot1x private-supplicant-only
```

! Configure 802.1X accounting method list

```
Ruijie(config)#aaa accounting network jizhang start-stop group radius
```

! Apply 802.1X accounting method list

```
Ruijie(config)#dot1x accounting jizhang
```

! Configure accounting update

```
Ruijie(config)#aaa accounting update
```

! Configure the accounting update interval as 15 minutes

```
Ruijie(config)#aaa accounting update periodic 15
```

! Configure the reply timeout timer of Radius Server as 5s

```
Ruijie(config)#dot1x timeout server-timeout 5
```

! Configure maximum transmission retries as 6 times

```
Ruijie(config)#dot1x max-req 6
```

! Enable periodic re-authentication

```
Ruijie(config)#dot1x re-authentication
```

! Configure the re-authentication interval as 1000s

```
Ruijie(config)#dot1x timeout re-authperiod 1000
```

! Configure the Quiet Period of device as 500s

```
Ruijie(config)#dot1x timeout quiet-period 500
```

! Configure the maximum authentication retries of device as 5 times

```
Ruijie(config)#dot1x reauth-max 5
```

! Configure the default route of device

```
Ruijie(config)#ip route 0.0.0.0 0.0.0.0 192.168.217.1
```

! Configure the IP address of device

```
Ruijie(config)#interface vlan 1
Ruijie(config-if-VLAN 1)#ip address 192.168.217.81 255.255.255.0
```

Step 3: Use authentication client (such as supplicant) to carry out authentication; type in the correct username and password and select the network adapter, and the authentication will succeed after a few seconds.

Verify Configurations

Step 1: Display the authentication state information of current user in order to eliminate faults.

```
Ruijie#show dot1x summary
ID       MAC      Interface VLAN   Auth-State    Backend-State Port-Status User-Type
-------- --------------  --------- ---- --------------- ------------ ----------- ---------
1       00d0.f864.6909  Fa0/1    1    Authenticated   Idle         Authed     static
```

Step 2: Display detailed information about authenticated user.

```
Ruijie#show dot1x user id 1

User name: qq
User id: 1
Type: static
Mac address is 00d0.f864.6909
Vlan id is 1
Access from port Fa0/1
Time online: 0days 0h 2m24s
User ip address is 192.168.217.82
Max user number on this port is 6000
Authorization session time is 20736000 seconds
Supplicant is private
Start accounting
Permit proxy user
Permit dial user
IP privilege is 0
 user acl-name qq_1_0_0 :
```

Step 3: Display 1X configurations about the existing number of users and the number of authenticated users;

```
Ruijie#show dot1x


802.1X Status:       enable
Authentication Mode:  eap-md5
Total User Number:    1(exclude dynamic user)
Authed User Number:   1(exclude dynamic user)
Dynamic User Number:  0
Re-authen Enabled:    enable
```

```
Re-authen Period:    1000 sec
Quiet Timer Period:   500 sec
Tx Timer Period:     3 sec
Supplicant Timeout:   3 sec
Server Timeout:      5 sec
Re-authen Max:       5 times
Maximum Request:     6 times
Private supplicant only:   enable
Client Online Probe:  disable
Eapol Tag Enable:    disable
Authorization Mode:   disable
```

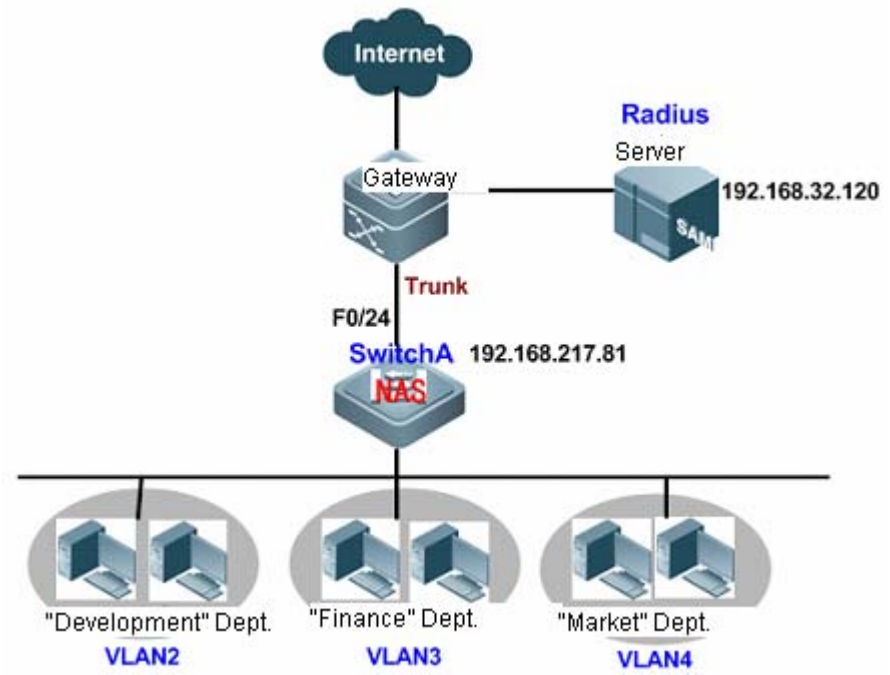
Step 4: Display Radius authentication and accounting related configurations;

```
Ruijie#show radius server

Server IP:   192.168.32.120
Accounting Port:  1813
Authen  Port:    1812
Server State:    ready
```

Application of 802.1X port-based dynamic VLAN assignment

Network Topology

Figure 13 Topoloy for 802.1X port-based dynamic VLAN assignment



Networking requirements

A company has three user groups, namely "development" department, "finance" department and "market" department. The following needs must be met:

- Each member of these three user groups can be connected to any port of the access device and join the corresponding VLAN after successful authentication ("development" department to join VLAN2, "finance" department to join VLAN3, and "market" department to join VLAN4).
- Complete data isolation shall be achieved between VLANs corresponding to three user groups, namely the members of one group cannot exchange data with members of another group.

Configuration Tips

- Turn on AAA switch and configure the communication between device and RADIUS SERVER;
- Configure 802.1X authentication and configure the device port for client access as controlled port;
- Enable dynamic VLAN assignment on the corresponding interface;
- Create VLANs to join after user authentication.

Configuration Steps

Step 1: Configure relevant attributes of Radius Server (Only key configurations will be described below, and we will not give other unnecessary details):

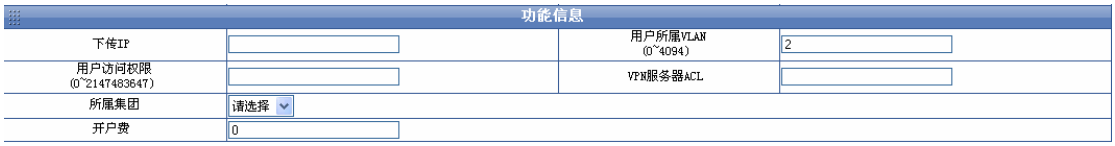
- Click "User Management - User Group Management" and add the corresponding user group (taking user group "development" as the example):

Figure 0-10

- Click "User Management - User Management" to insert the basic information about user and corresponding VLAN information (taking user group "development" as the example; the VLAN to which the user belongs is configured as

Figure 0-11

Figure 0-12



Step 2: Configure access switch "SwitchA"

! Turn on AAA switch

```
Ruijie(config)#aaa new-model
```

! Configure RADIUS server

```
Ruijie(config)#radius-server host 192.168.32.120
```

! Configure RADIUS key

```
Ruijie(config)#radius-server key ruijie
```

! Configure dot1x authentication method list

```
Ruijie(config)#aaa  authentication dot1x hello group radius
```

! Apply dot1x authentication method list

```
Ruijie(config)#dot1x authentication hello
```

! Configure 802.1X accounting method list

```
Ruijie(config)#aaa accounting network jizhang start-stop group radius
```

! Apply 802.1X accounting method list

```
Ruijie(config)#dot1x accounting jizhang
```

! Configure the port as controlled port (enable port-based authentication)

```
Ruijie(config)#interface range fastEthernet 0/1-23
Ruijie(config-if-range)#dot1x port-control auto
```

! Enable dynamic VLAN assignment on the corresponding interface

```
Ruijie(config-if-range)# dot1x dynamic-vlan enable
```

! Create VLANs to join after user authentication

```
Ruijie(config)#vlan 2
Ruijie(config-vlan)#name development
Ruijie(config-vlan)#exit
Ruijie(config)#vlan 3
Ruijie(config-vlan)#name finance
Ruijie(config-vlan)#exit
Ruijie(config)#vlan 4
Ruijie(config-vlan)#name market
Ruijie(config-vlan)#exit
```

! Configure uplink port F0/24 as the trunk port.

```
Ruijie(config)#interface fastEthernet 0/24
Ruijie(config-if-FastEthernet 0/24)#switchport mode trunk
```

! Configure the default route of device

```
Ruijie(config)#ip route 0.0.0.0 0.0.0.0 192.168.217.1
```

! Configure the IP address of device

```
Ruijie(config)#interface vlan 1
Ruijie(config-if-VLAN 1)#ip address 192.168.217.81 255.255.255.0
```

Step 3: Use client to complete authentication. After successful authentication, the CLI will display:
"%DOT1X-4-TRANS_AUTHOR: Setting interface FastEthernet 0/1 author-vlan 2 succeeded."

We can see that the user has been assigned to VLAN2.

Verify Configurations

Step 1: Display the authentication state information of current user to see the true VLAN to which the user belongs.

```
Ruijie#show dot1x summary
   ID        MAC      Interface VLAN   Auth-State    Backend-State Port-Status User-Type
-------- --------------  --------- ---- -------------- ------------ ----------- ---------
5       00d0.f864.6909  Fa0/1    2    Authenticated   Idle         Authed     static
```

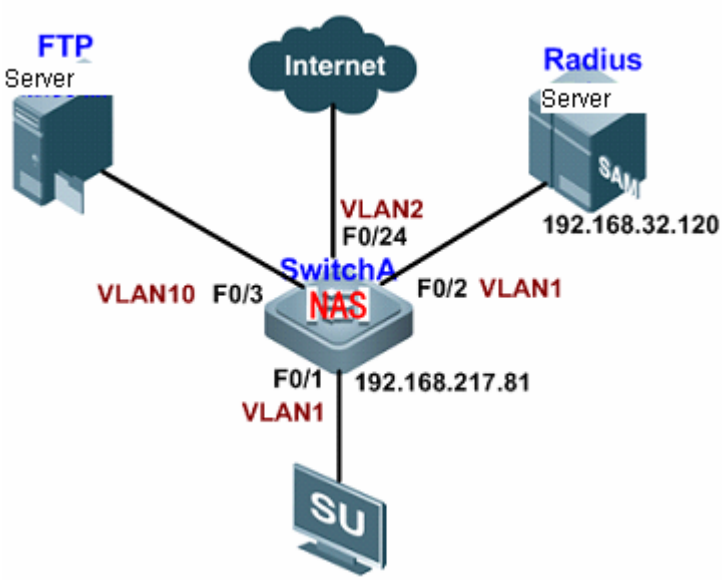
Step 2: Display detailed information about authenticated user.

```
Ruijie#show dot1x user id 5

User name: st
User id: 5
Type: static
Mac address is 00d0.f864.6909
Vlan id is 2
Access from port Fa0/1
Time online: 0days 0h 4m35s
User ip address is 192.168.217.82
Max user number on this port is 6000
Authorization vlan is 2
Authorization session time is 20731685 seconds
Supplicant is private
Start accounting
Permit proxy user
Permit dial user
IP privilege is 0
 user acl-name st_1_0_0 :
```

Application of 802.1X port-based Guest VLAN and VLAN assignment

Network Topology

Figure 14 Topology for 802.1X port-based Guest VLAN and VLAN assignment



Networking Requirements

The client accesses network through 802.1x authentication. RADIUS server is the authentication server, and FTP server is the server used by the client for software downloading and pack upgrade while it belongs to VLAN10. Radius Server is used for authentication, authorization, accounting and dynamic VLAN assignment, and it belongs to VLAN1. The Internet-connecting port F0/24 of switch belongs to VLAN2. The following needs must be met:

- If the switch receives no reply after sending authentication request packets (EAP-Request/Identity) for the configured number of tries, F0/1 will join the Guest VLAN (VLAN10). By this time, both Supplicant and FTP Sever belong to VLAN10, and Supplicant can access FTP Server and download 802.1x client.
- After successful authentication, RADIUS server will assign VLAN2. By this time, both Supplicant and F0/24 belong to VLAN2, and Supplicant can access Internet.

Configuration Tips

- Turn on AAA switch and configure the communication between device and RADIUS SERVER;
- Configure 802.1X authentication and configure the device port for client access as controlled port;
- Enable dynamic VLAN assignment on the corresponding interface;
- Configure whether or not enable guest VLAN on the corresponding interface.

Configuration Steps

Configure access switch "SwitchA":

! Configure the VLANs to which the port belong:

```
Ruijie(config)#interface fastEthernet 0/3
Ruijie(config-if-FastEthernet 0/3)#switchport access vlan 10
Ruijie(config-if-FastEthernet 0/3)#exit
Ruijie(config)#interface fastEthernet 0/24
Ruijie(config-if-FastEthernet 0/24)#switchport access vlan 2
Ruijie(config-if-FastEthernet 0/24)#exit
```

! Turn on AAA switch

```
Ruijie(config)#aaa new-model
```

! Configure RADIUS server

```
Ruijie(config)#radius-server host 192.168.32.120
```

! Configure RADIUS key

```
Ruijie(config)#radius-server key ruijie
```

! Configure dot1x authentication method list

```
Ruijie(config)#aaa  authentication dot1x hello group radius
```

! Apply dot1x authentication method list

```
Ruijie(config)#dot1x authentication hello
```

! Configure 802.1X accounting method list

```
Ruijie(config)#aaa accounting network jizhang start-stop group radius
```

! Apply 802.1X accounting method list

```
Ruijie(config)#dot1x accounting jizhang
```

! Configure the port as controlled port (enable port-based authentication)

```
Ruijie(config)#interface fastEthernet 0/1
Ruijie(config-if-FastEthernet 0/1)#dot1x port-control auto
```

! Enable dynamic VLAN assignment on the corresponding interface

```
Ruijie(config-if-FastEthernet 0/1)# dot1x dynamic-vlan enable
```

! Enable GUEST VLAN assignment on the interface

```
Ruijie(config-if-FastEthernet 0/1)#dot1x guest-vlan 10
```

! Configure the default route of device

```
Ruijie(config)#ip route 0.0.0.0 0.0.0.0 192.168.217.1
```

! Configure the IP address of device

```
Ruijie(config)#interface vlan 1
Ruijie(config-if-VLAN 1)#ip address 192.168.217.81 255.255.255.0
```

Verify Configurations

Step 1: If no reply is received after sending authentication request packets (EAP-Request/Identity) for the configured number of tries, the user connected to the port will automatically join VLAN10. The CLI will prompt:

```
%DOT1X-5-TRANS_DEFAULT_TO_GUEST: Transformed interface FastEthernet 0/1 from default-vlan 1
to guest-vlan 10 ok.
```

Step 2: The user downloads 802.1x client. After successful authentication, the CLI will prompt:

```
%DOT1X-4-TRANS_AUTHOR: Setting interface FastEthernet 0/1 author-vlan 2 succeeded.
```

1. Display the authentication state information of current user:

```
Ruijie#show dot1x summary
   ID       MAC      Interface VLAN   Auth-State    Backend-State Port-Status User-Type
-------- --------------  --------- ---- --------------- ------------ ----------- ---------
8       00d0.f864.6909  Fa0/1    2    Authenticated   Idle         Authed     static
```

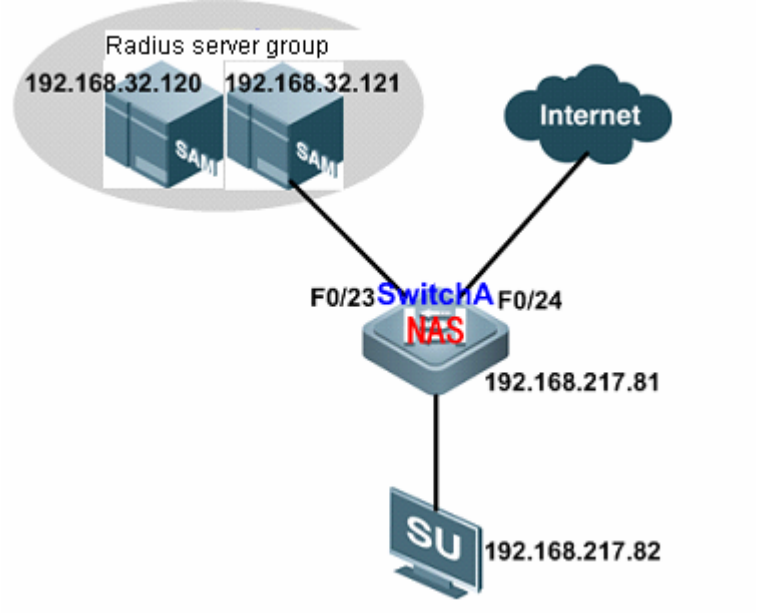
Step 2: Display detailed information about authenticated user.

```
Ruijie#show dot1x user id 8

User name: st
User id: 8
Type: static
Mac address is 00d0.f864.6909
Vlan id is 2
Access from port Fa0/1
Time online: 0days 0h 4m25s
User ip address is 192.168.201.56
Max user number on this port is 6000
Authorization vlan is 2
Authorization session time is 20736000 seconds
Supplicant is private
Start accounting
Permit proxy user
Permit dial user
IP privilege is 0
 user acl-name st_1_0_0 :
```

Application of port-based 1X authentication and IP authorization

Network Topology

Figure15 topology for port-based 1X authentication and IP authorization



Networking Requirements

The client accesses network through 802.1x authentication. RADIUS server is the authentication server. The following application needs must be met:

- When the active server fails due to certain reason, the device can automatically submit authentication request to the next server in the method list.
- When a user connected to one port of device passes the authentication, all users connected to this port will be able to access network freely.
- Dynamic user is not allowed to move between multiple authentication ports.
- The IP of an authenticated user must be assigned by the RADIUS Server, namely the authenticated user can only use the IP specified by RADIUS Server to access network.

Configuration Tips

- Turn on AAA switch and configure the communication between device and RADIUS SERVER;
- Configure 802.1X authentication and configure the device port for client access as controlled port;
- Configure active/standby server group
- Configure the control mode of user authentication under the corresponding port as port-based authentication;
- Configure to prohibit dynamic user from moving between ports;
- Configure IP authorization mode as radius Server mode.

Configuration Steps

Configure access switch "SwitchA":

! Turn on AAA switch

```
Ruijie(config)#aaa new-model
```

! Configure RADIUS server

```
Ruijie(config)#radius-server host 192.168.32.120
Ruijie(config)#radius-server host 192.168.32.121
```

! Configure RADIUS key

```
Ruijie(config)#radius-server key ruijie
```

! Configure server group (select active server and standby server)

```
Ruijie(config)#aaa group server radius rj
Ruijie(config-gs-radius)#server 192.168.32.120
Ruijie(config-gs-radius)#server 192.168.32.121
```

! Configure dot1x authentication list

```
Ruijie(config)#aaa  authentication dot1x hello group radius
```

! Apply dot1x authentication method list

```
Ruijie(config)#dot1x authentication hello
```

! Configure 802.1X accounting method list

```
Ruijie(config)#aaa accounting network jizhang start-stop group radius
```

! Apply 802.1X accounting method list

```
Ruijie(config)#dot1x accounting jizhang
```

! Configure the port as controlled port (enable port-based authentication)

```
Ruijie(config)#interface range fastEthernet 0/1-22
Ruijie(config-if-range)#dot1x port-control auto
```

! Configure the control mode of user authentication under the corresponding port as port-based authentication

```
Ruijie(config-if-range)# dot1x port-control-mode port-based
Ruijie(config-if-range)#exit
```

! Configure to prohibit dynamic user from moving between ports;

```
Ruijie(config)#dot1x stationarity enable
```

! Configure IP authorization mode of device as RADIUS Server mode

```
Ruijie(config)#aaa authorization ip-auth-mode radius-server
```

! Configure the default route of device

```
Ruijie(config)#ip route 0.0.0.0 0.0.0.0 192.168.217.1
```

! Configure the IP address of device

```
Ruijie(config)#interface vlan 1
Ruijie(config-if-VLAN 1)#ip address 192.168.217.81 255.255.255.0
```

Verify Configurations

Step 1: Display the authentication state information of current user:

```
Ruijie#show dot1x summary
```

```
   ID        MAC      Interface VLAN   Auth-State    Backend-State Port-Status User-Type
-------- --------------  --------- ---- -------------- ------------- ----------- ---------
none    00d0.f864.6909  Fa0/1    1    Authenticated   Idle         Authed     Dynamic
```

Step 2: Move this user to another authenticated port. It can be found that the user won't be able to access network.

RGOS Configuration Guide
V10.4(3b13)

Configuring QoS

Configuring QOS

What is QOS

In a traditional IP network, the router treats all packets in the same way on a First In First Out (FIFO) basis and sends them to their destinations at best effort. However, it does not provide any assurance for the performances such as reliability and transmission delay of the packets.

As Internet becomes increasingly popular worldwide and IT is more widely used in social activities, people demand more and more from the network. IT needs evolve from the pure data information to the interactive multimedia information, from separate service to integrated transmission of data, voice and image services on a single network. More and more voice and image and other important data that require low bandwidth delay and be jitter sensitive and highly real time are transmitted over the network. On one hand, network resources become much diversified. On the other hand, the assurance of the service quality of the network incures an important problem since the data, voice and image services have different requirements in delay, throughput or packet loss rate.

One solution to this problem is to increase the network bandwidth, which however is limited and costly as well. Other means to assure the service quality include the use of the techniques such as Policy-Based Routing, Congestion Management, Congestion Avoidance, Traffic Shaping and transmission compression to manage the traffic on the network and meet the needs of the increasing traffic on the network.

QoS (Quality of Service) is the ability of a network to provide better services for the specified network communications by using various basic technologies. To put it in simple way, different network service qualities are provided to suit the specific requirements: better qualities for the packets that are highly real-time and important; lower qualities for the common packets that do not need to be real time. To bear various services on the network, the network must be able to not only provide individual services but also offer different QoSs for them. It can be said for sure that QoS is a basic requirement for future IP networks.

Ruijie devices implement various QoS policies to meet the needs of different services for different QoSs.

Why QoS

QoS allows the network provides services for various network applications and communications in a proactive way. On the network, the QoS can be used to:

- Control resources: Users can control the network resources being used. For example, users can exercise control over the network resources occupied by FTP (File Transfer Protocol) transmission or assign higher priority for important data access.
- Sub-divide services. An ISP as a user can provide services of different QoS for different customers and packets of different requirements.
- In a network environment, different QoSs are provided for different applications to ensure network services for important packets. For example, prudential services are provided for important data; minimum delay is enabled for time-sensitive multimedia and voice applications.
- In addition, QoS lays a good foundation for future integration.

QoS under Differentiated Services

- What are differentiated services

For Differentiated Services (DiffServ), several services with the same feature are converged by using the mechanisms of DSCP (DiffServ CodePoint) and PHB to provide services for the entire converged traffic, instead of individual services.

The following three levels of differentiated services are provided:

1. Expedited Forwarding (EF)
2. Assured Forwarding (AF)
3. Best Effort (BE)

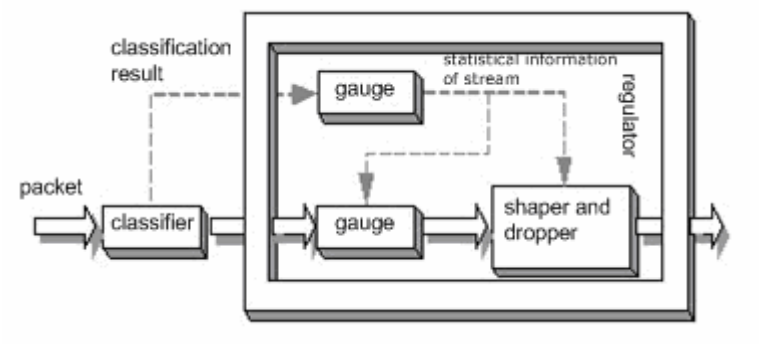
DiffServ greatly reduces the work of signaling and focuses instead on flow convergence and a set of “hop-by-hop behaviors” suitable for networkwide services. Data flows can be classified according to the pre-determined rules in order to converge multiple application traffic into a certain level of data flow.

Therefore, QoS is based on DiffServ system.

- QoS under Differentiated Services

In DiffServ, QoS includes classification/identification, measurement/shaping/packet dropping, and finally congestion management and congestion avoidance. The basic processing is illustrated as below:

Figure 1 Schematic diagram for the border node to classify and adjust the packets



The follow-up chapters separately describe the QoS under differentiated services.

IPv6 QoS

IPv6 QoS supports the 8-bit Traffic Class field, which has the same function as the ToS field of IPv4 to identify the service type of packets. The DSCP of IPv6 takes the first 6 bits in the Traffic Class filed as DHCP value. Thus DSCP=(TC&11111100)>>2. TC value is given by DSCP-to-TC mapping. IPv6 QoS also supports the 20-bit flow label field indicating the traffic belonging to the same classification. Currently, the definition and use of flow label is still in the draft phase, only Traffic Class-based QoS is supported by IPv6 QoS.

Congestion Management

What Is Congestion Management

Congestion occurs in a network node when packets arrive faster than an interface can send them. If the buffer space is insufficient for storing data on the network node, packet loss occurs. Network protocols, such as the Transmission Control Protocol (TCP), provide the data retransmission mechanism, in which the data sender node retransmits data when failing to receive a reply from the peer receiver node. This causes congestion on the peer receiver node and the performance of the entire network deteriorates.

The following are sample causes of congestion:
A packet flow enters **the router** through a high-speed link and leaves the device through a low-speed link;
Packet flows enter **the router** concurrently through multiple interfaces and leaves the device through only one interface;
CPU runs slowly.

Assume that the network needs to transmit some important data as well as much unimportant data. If the device processes all data in the same way with no regard to their importance level, unimportant data uses bulk network bandwidth and transmission of important data is delayed, which may cause tremendous loss.

To resolve these problems, congestion management is introduced. Congestion management features allow you to control congestion by determining the order in which packets are sent out an interface based on priorities assigned to those packets. A network device such as router determines the packet transmission order by controlling which packets are transmitted with priority, ensuring that key services are processed timely.

Policies of Congestion Management

Congestion management performs three tasks:
Create various types of queues.
Classify packets and place them to different queues.
Schedule queues and send packets in queues based on rules. The congestion management QoS features provide five types of queuing. Each type of queuing allows you to create a different number of queues. During periods with light traffic, that is, when no congestion exists, packets are sent out of the interface as soon as they arrive. During periods of transmit congestion at the outgoing interface, packets arrive faster than the interface can send them. If you use congestion management features, packets accumulating at an interface are queued until the interface is free to send them; they are then scheduled for transmission according to their assigned priority and the queuing mechanism configured for the interface. The device determines the packet transmission order by controlling which packets are placed in which queue and how queues are serviced with respect to each other.

This document discusses six types of queuing, which constitute the congestion management QoS features.

Note The NPE80 supports only the First-In, First-Out Queuing (FIFO) and Weighted Fair Queuing (WFQ).

FIFO

FIFO entails no concept of priority or traffic classes. With FIFO, transmission of packets out of the interface occurs in the order the packets arrive. FIFO is the default queuing mechanism that needs no intentional configuration.

WFQ

WFQ offers dynamic, fair queuing that divides bandwidth across queues of traffic based on weights. WFQ ensures that all traffic is treated fairly, given its weight. Given this handling, WFQ ensures satisfactory response time to critical applications, such as interactive, transaction-based applications, which are intolerant of performance degradation.

For WFQ, you define traffic classes based on source addresses, destination addresses, source port numbers, destination port numbers, and protocol types.

CBWFQ

Class-Based Weighted Fair Queuing (CBWFQ) extends the standard WFQ functionality. Same as WFQ, CBWFQ offers dynamic, fair queuing that divides bandwidth across queues of traffic based on weights. The difference lies in classification rules and weight calculation. For WFQ, you define traffic classes based on source addresses, destination addresses, source port numbers, destination port numbers, and protocol types. For CBWFQ, you define traffic classes based on user-defined criteria. WFQ weighs packet priorities based on fixed rules, for example, weighing the priority of an IP packet based on the Type of Service (ToS) domain. CBWFQ assigns communication queue bandwidth by proportion by weighing priorities based on user-defined bandwidth criteria.

CBWFQ allows you to define traffic classes and assign bandwidth in real time. Given these features, CBWFQ allows you to customize bandwidth assignment and ensures that different types of network data traffic acquire bandwidth by proportion.

LLQ and RTPQ

LLQ indicates Low Latency Queuing. The LLQ feature brings strict Priority Queuing (PQ) to CBWFQ. Strict PQ allows packets that are delay-sensitive and match traffic criteria to be sent and sent before packets in CBWFQ queues.

Functions of Real-time Transport Protocol Priority Queuing (RTPQ) are similar to those of LLQ. Each interface possesses an RTPQ queue exclusively used in the low-delay transmission of RTP packets. RTPQ matches the User Datagram Protocol (UDP) packets of ports in a specified range.

PQ

With PQ, packets belonging to one priority class of traffic are sent before all lower priority traffic to ensure timely delivery of those packets.

PQ guarantees strict priority for important network data and quickest processing of most-important network data on a network node where PQ is enabled. For PQ, priority can be defined flexibly based on network protocols such as IP, data input interfaces, packet lengths, source addresses, and destination addresses.

CQ

With Custom Queuing (CQ), each class of traffic acquires bandwidth by proportion. CQ allows you to assign bandwidth to all classes of traffic based on packet importance. Thus, important packets are delivered timely. You can also define the number of the bytes or packets abstracted from queues.

This function is suitable for interfaces that process data at low speeds.

Note You can assign only one queuing mechanism to an interface.

Deciding Which Queuing Policy to Use

Ruijie devices can meet service quality requirements of different services to some degree by implementing FIFO, PQ, CQ, WFQ, CBWFQ, and LLQ&RTPQ. The following section compares the five main queuing strategies.

- FIFO queuing performs the default first-come-first-serviced priorization of packets in user data traffic. It entails no concept of priority or classes of traffic. When FIFO is used, ill-behaved sources can consume available bandwidth, bursty data sources can cause delay in time-sensitive or important traffic, and important traffic may be dropped because less important traffic fills the queue.

- CQ guarantees some level of service to all traffic because you can assign bandwidth to all classes of traffic. You can define the size of the queue by determining its configured packet-count capacity, thereby controlling bandwidth usage.
- PQ guarantees strict priority in that it ensures that one type of traffic will be sent, possibly at the expense of all others. For PQ, a low priority queue can be detrimentally affected, and, in the worst case, never allowed to send its packets if a limited amount of bandwidth is available or if the transmission rate of critical traffic is high.
- WFQ does not use access lists to determine the preferred traffic on an interface. Rather, the fair queue algorithm dynamically sorts traffic into messages that are part of a conversation. Low-volume, interactive traffic gets fair allocation of bandwidth with WFQ, as does high-volume traffic such as file transfers.
- CBWFQ allows you to define traffic classes and assign bandwidth in real time. Specifically, CBWFQ allows you to specify the exact amount of bandwidth to be assigned for a specific class of traffic, which guarantees bandwidth of certain network applications. You can control bandwidth allocation on demand at any time.

The following table compares the main queuing strategies.

	FIFO	**WFQ**	**CBWFQ**	**PQ**	**CQ**
Number of Queues	1	Configurable (default: 256)	320 (64 CBWFQ queues, and 256 WFQ queues)	4	17 (16 user queues, and one system queue)
Advantage	Fast and simple processing	All traffic is treated fairly, given its weight.	Traffic that matches user-defined criteria is placed in CBWFQ queues, and other traffic is placed in WFQ queues. Network packets are delivered in proportion to their configured bandwidth.	High priority queues are serviced first. Absolute prioritization ensures critical traffic of highest priority.	CQ assigns bandwidth by proportion for different types of services. If one queue is empty, its assigned bandwidth is automatically added to another queue that had packets ready to send.
Defect	All packets are treated fairly. Packet delivery sequence is determined by their sequence of arriving at the interface, which may cause delay in delivery of critical applications.	Processing speed is slower than that of FIFO.	Processing speed is slower than that of FIFO.	Processing speed is slow, and a low priority queue can be never allowed to send its packets in the worst case.	Processing speed is relatively slow.
Configuration requirement	No configuration required	Simple configuration required	Configuration required	Configuration required	Configuration required

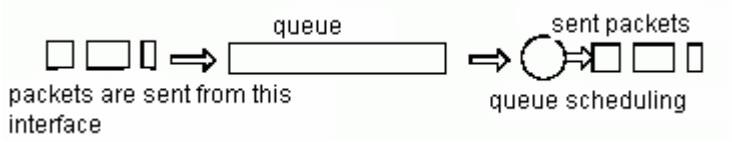
Work Mechanism of Congestion Management

FIFO

Working Principles

FIFO implements a simple service rule and provides only one queue. Packets are delivered based on the first-come-first serviced rule. FIFO does not guarantee delay restrictions or delivery rates, cannot isolate service flows that share a link. Therefore, FIFO cannot fairly treat service flows that share a link.

Figure 2 FIFO queuing



As shown in the preceding figure, packets are sent out an interface in the order in which they arrive. FIFO does not intervene with packets, but allows packets to use bandwidth and other resources in the order in which they arrive. Ill-behaved applications or attacks can consume all the bandwidth and important traffic can be dropped.

Applicable Environment

When there is no other queuing mechanism configured on the network, FIFO is enabled on all interfaces by default. FIFO possesses the quickest processing speed among queuing mechanisms. If congestion rarely occurs, FIFO is the most suitable on the network.

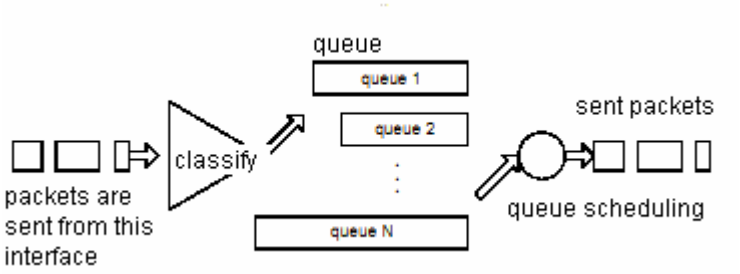
WFQ

Working Principles

WFQ removes FIFO restrictions. When FIFO queuing is enabled, traffic is sent out an interface in the order in which they arrive, disregarding bandwidth consumption and delay. As a result, file transfer and other network applications with large data volumes often generate packet links. A packet link consists of groups of packets and is transferred as a whole. These packet links may consume all available bandwidth and other traffic is dropped.

WFQ ensures that each flow shares link bandwidth fairly and that low-volume traffic gets transmitted in a timely fashion.

Figure 3 WFQ



As shown in the preceding figure, WFQ classifies packets by flow. A flow consists of packets of same source IP address, destination IP address, source MAC address, destination MAC address, source port number, destination port number, protocol type, and ToS. A flow is assigned to a queue with bandwidth in proportion to flow priority during delivery. A flow of high-priority gets more bandwidth than a flow of low-priority. Specifically, bandwidth assigned to a flow divided by the entire bandwidth of the link is equal to the sum (flow priority + 1) divided by the entire bandwidth of the link.

For example, seven flows exist on an interface, with their priority being 1, 2, 3, 4, 5, and 6. The bandwidth assigned to the interface equals the sum of all the flow priorities plus one:

1 + 2 + 3 + 4 + 5 + 6 + 7 = 28

Bandwidth ratio of a flow equals to the sum (flow priority + 1) divided by another sum (sum of all flow priorities + 1). Therefore, bandwidth ratios of flows are 1/28, 2/28, 3/28, 4/28, 5/28, 6/28, and 7/28.

If there are 10 data flows whose priority is 1, the entire bandwidth is:

1 + 2*10 + 3 + 4 + 5 + 6 + 7 = 46

Priority-0 data flows use 1/46 of the entire bandwidth, Priority-1 data flows use 2/46 of entire bandwidth, and accordingly Priority-6 data flows use 7/46 of the entire bandwidth.

When data flows are added or terminated, actual bandwidth changes consequently. By assigning bandwidth of each flow in real time, WFQ is suitable for the network environment that is constantly changing.

Applicable Environment

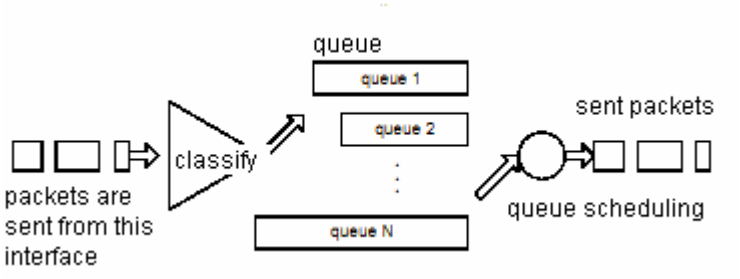
WFQ is suitable for serial interfaces with bandwidth equal to or less than 2.048 Mbps.

CBWFQ

Working Principles

CBWFQ extends the standard WFQ functionality to provide support for assigning bandwidth based on user-defined traffic classes.

Figure 4 CBWFQ



As shown in the preceding figure, CBWFQ defines classes for packets by flow. At first, classes are defined based on user-defined based on user-defined rules. Packets satisfying a same match criterion belong to a network data flow and are placed in a same CBWFQ queue. Packets satisfying no match criterion are classified in WFQ mode. Packets with the same source IP address, destination IP address, source MAC address, source port number, destination port number, protocol type, and ToS field belong to the same flow. When a packet is assigned to a flow, it is placed in the WFQ queue reserved for that flow. During delivery, CBWFQ assigns bandwidth based on the user-defined rules.

When data flows are added or terminated, actual bandwidth assigned by CBWFQ changes consequently. Therefore, CBWFQ is also suitable for the network environment that is constantly changing.

Applicable Environment

CBWFQ is suitable for applying strict classification rules and bandwidth allocation on serial interfaces with bandwidth equal to or less than 2.048 Mbps.

LLQ and RTPQ

Working Principles

LLQ extends the standard CBWFQ functionality. LLQ ensures that delay-sensitive data acquire bandwidth and are sent before packets in other queues are dequeued. The LLQ feature brings strict Priority Queuing (PQ) to CBWFQ. Strict PQ allows packets in LLQ queues to be sent and sent before packets in CBWFQ queues.

For LLQ queues, traffic of different types is monitored separately. If there is no congestion, traffic is allowed for delivery. In the event of congestion, transmission rates of all traffic are monitored, and packets are dropped if the bandwidth is exceeded.

Functions of RTPQ are similar to those of LLQ. Each interface possesses an RTPQ queue exclusively used in the low-delay transmission of RTP packets. RTPQ matches the UDP packets of ports in a specified range.

For RTPQ queues, traffic of different types is monitored separately. If there is no congestion, traffic is allowed for delivery. In the event of congestion, transmission rates of all traffic are monitored, and packets are dropped if the bandwidth is exceeded.

Both an RTPQ queue and an LLQ queue belongs can belong to only one interface, but the priority of an RTPQ queue is higher than that of an LLQ queue.

Applicable Environment

LLQ and RTPQ+CBWFQ are suitable for applying strict classification rules and bandwidth allocation on serial interfaces with bandwidth equal to or less than 2.048 Mbps.

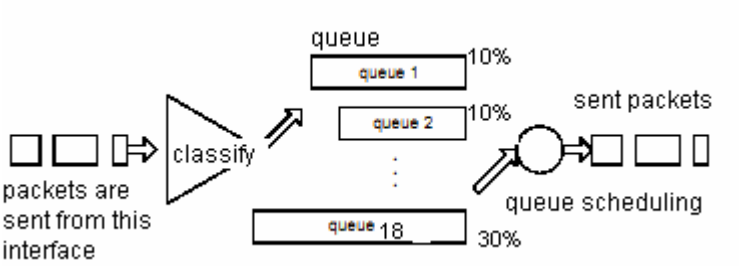
CQ

Working Principles

CQ defines 17 classes for packets, corresponding to 17 CQ queues. Packets enter corresponding CQ queues based on their classes and the FIFO policy. For queues 1 through 16, queue 0 is a system queue; queue 1 through 16 are user queues. Associated with each queue is a configurable byte count, which specifies how many bytes of data the system should deliver from the current queue before it moves on to the next queue. The system queue is emptied before any of the queues 1 through 16 are processed. For queues 1 through 16, the system cycles through the queues

using the pre-assigned bandwidth in a round-robin fashion, the system dequeues the configured byte count from each queue in each cycle and delivers packets in the current queue before moving on to the next one.

Figure 5 CQ



CQ ensures that no application or specified group of applications achieves more than a predetermined proportion of overall bandwidth when the line is under stress. Like PQ, CQ is statically configured and does not automatically adapt to changing network conditions. With CQ enabled, the system takes longer and consumes more resources to switch packets because packets need to be queued.

How to Determine Byte Count Values for Queues

In order to assign bandwidth to different queues, you must specify the byte count for each queue. This section describes how to determine byte count values for queues.

When the router cycles through queues in round-robin fashion, the device sends packets from a particular queue until the byte count is exceeded. If the byte count value is exceeded but packets of the queue are not completely sent, the device continues sending until all packets of the queue are sent. Therefore, if you set the byte count to 300 bytes and the packet size of your protocol is 1500 bytes, then every time this queue is serviced, 1500 bytes will be sent, not 300 bytes.

For example, suppose one protocol has 500-byte packets, another has 300-byte packets, and a third has 100-byte packets. If you want to split the bandwidth evenly across all three protocols, you might choose to specify byte counts of 200, 200, and 200 for each queue. However, this configuration does not result in a 33/33/33 ratio. When the device services the first queue, it sends a single 500-byte packet; when it services the second queue, it sends a 300-byte packet; and when it services the third queue, it sends two 100-byte packets. The effective ratio is 50/30/20.

Thus, setting the byte count too low can result in an unintended bandwidth allocation. However, very large byte counts will produce a “jerky” distribution. That is, if you assign 10 KB, 10 KB, and 10 KB to three queues in the example given, each protocol is serviced promptly with equal bandwidth assigned when its queue is the one being serviced, but it may be a long time before the queue is serviced again. A better solution is to specify 500-byte, 600-byte, and 500-byte counts for the queue. This configuration results in a ratio of 31/38/31, which may be acceptable. In order to service queues in a timely manner and ensure that the configured bandwidth allocation is as close as possible to the required bandwidth allocation, you must determine the byte count based on the packet size of each protocol; otherwise your percentages may not match what you configure.

To determine the correct byte counts, perform the following steps:

1. For each queue, divide the percentage of bandwidth you want to assign to the queue by the packet size, in bytes. For example, assume the packet size for protocol A is 1086 bytes, protocol B is 291 bytes, and protocol C is 831 bytes. You want to assign 20 percent for A, 60 percent for B, and 20 percent for C. The ratios would be:
   20/1086, 60/291, 20/831
   or 0.01842, 0.20619, 0.02407
2. Normalize the numbers by dividing by the lowest number:
   1, 11.2, 1.3
   The result is the ratio of the number of packets that must be sent so that the percentage of bandwidth that each protocol uses is approximately 20, 60, and 20 percent.
3. A fraction in any of the ratio values means that an additional packet will be sent. Round up the numbers to the next whole number to obtain the actual packet count. In this example, the actual ratio will be 1 packet, 12 packets, and 2 packets.
4. Convert the packet number ratio into byte counts by multiplying each packet count by the corresponding packet size. In this example, the number of packets sent is one 1086-byte packet, twelve 291-byte packets, and two831-byte packets, or 1086, 3492, and 1662 bytes, respectively, from each queue. These are the byte counts you would specify in your CQ configuration.
5. To determine the bandwidth distribution this ratio represents, first determine the total number of bytes sent after all three queues are serviced:
   (1 x 1086) + (12 x 291) + (2 x 831) = 1086 + 3492 + 1662 = 6240

6. Then determine the percentage of the total number of bytes sent from each queue:
   1086/6240, 3492/6240, 1662/6240 = 17.4, 56, and 26.6 percent
   This result is close to the desired ratio of 20/60/20.
7. If the actual bandwidth is not close enough to the desired bandwidth, multiply the original ratio of1:11.2:1.3 by the best value, trying to get as close to three integer values as possible. Note that the multiplier you use need not be an integer. For example, if we multiply the ratio by two, we get 2:22.4:2.6. You would now send two 1086-byte packets, twenty-three 291-byte packets, and three 831-byte packets, or 2172/6693/2493, for a total of 11,358 bytes. The resulting ratio is 19/59/22 percent, which is much closer to the desired ratio that we achieved.

Window size also affects the bandwidth distribution. If the window size of a particular protocol is set to one, then that protocol will not place another packet into the queue until it receives an acknowledgment. The CQ algorithm moves to the next queue if the byte count is exceeded or no packet is in that queue. Therefore, with a window size of one, only one frame will be sent each time. If your frame count is set to 2 kilobytes, and your frame size is 256 bytes, then only 256 bytes will be sent each time this queue is serviced.

Applicable Environment

This function is suitable for interfaces that process data at low speeds.

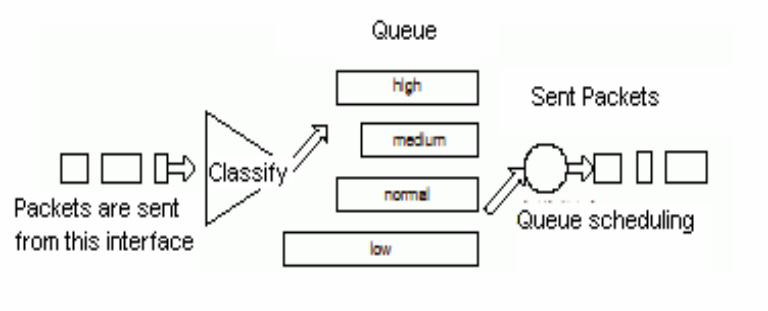
Note CQ is not supported on any tunnels.

PQ

Working Principles

PQ allows you to define how traffic is prioritized in the network. You can configure four traffic priorities. You can define a series of filters based on packet characteristics (source addresses, destination addresses, protocol types, and packet sizes) to place traffic into these four queues; the queue with the highest priority is serviced first until it is empty, then the lower queues are serviced in sequence.

Figure 6 PQ



As shown in the preceding figure, packets are classified and placed in four output types of output queues based on user-defined criteria. The priority queues on that interface are scanned for packets in descending order of priority. The high priority queue is scanned first, then the medium priority queue, and so on. The packet at the head of the highest queue is chosen for transmission. This procedure is repeated every time a packet is to be sent.

When choosing to use PQ, consider that because lower priority traffic is often denied bandwidth in favor of higher priority traffic, use of PQ could, in the worst case, result in lower priority traffic never being sent. PQ introduces extra system resource consumption that is acceptable for slow interfaces, but may not be acceptable for higher speed interfaces such as Ethernet. With PQ enabled, the system takes longer to switch packets, degrading system performance. PQ uses a static configuration and does not adapt to changing network conditions.

Applicable Environment

Although you can enable PQ for any interface, it is best used for low-bandwidth, congested serial interfaces.

Note PQ is not supported on any tunnels.

WFQ

WFQ Configuration Tasks

When standard WFQ is enabled, packets are classified by flow. Packets with the same source IP address, destination IP address, source TCP or UDP port, and destination TCP or UDP port belong to the same flow. WFQ assigns an equal share of bandwidth to each flow. Flow-based WFQ is also called fair queueing because all flows are equally weighted.

Configuring WFQ entails the following two processes:

- Configuring WFQ
- Monitoring fair queuing

Note

Memory configuration is different for routers on different platforms. You are advised to run the **fair-queue** command to configure depth and count of different queues.

Configuring WFQ

To configure WFQ, run the following commands in the interface configuration mode:

Command	Function
Ruijie(config-if)# **fair-queue** [*congestive-discard-threshold* [*dynamic-queues*]]	Configure WFQ.
Ruijie(config-if)# **no fair-queue**	Cancel WFQ configuration.

The following table describes parameters related to WFQ configuration.

Command	Function
congestive-discard-threshold	Specify the maximum threshold of packets allowed in each queue. The default value is 64 and the value range is 1–4096. When the packet count reaches the threshold, newly arrived packets will be discarded. This parameter is optional.
dynamic-queues	Specify the number of dynamic queues. The default value is 256 and the value must be 2^n within 16–4096. This parameter is optional.

Note

To configure the WFQ congestion management policy, ensure that the fast-switching function configuration (enable or disable the function) is consistent on all system interfaces. Otherwise, the congestion management policy becomes invalid.

Note

The value of *dynamic-queues* needs to be adjusted dynamically according to the current service traffic status. Ensure that the value of *dynamic-queues* be greater than the number of service flows; otherwise, multiple service flows enter a same dynamic queue. You are advised to set the *dynamic-queues* to a value greater than both 64 and the number of service flows.

Monitoring WFQ

To view information about WFQ that has been configured, run the following commands in the privileged user mode:

Command	Function

Ruijie# **show queue wfq**	Show configuration information about WFQ queues.
Ruijie# **show queue interface** *interface-name interface-number*	Show interface statistic information about WFQ queues.

For routers of the RSR series, you can view statistic information about fast-switching WFQ queue interfaces by running the **show queue interface** command. "Qos Ref queue information" identifies statistic information about fast-switching WFQ queue interfaces.

WFQ Configuration Example

In the following instance, fair queueing is configured on synchronization port 0. Specifically, serial port 0 is configured with 128 message queues, 512 dynamic queues, and 50 reserved queues.

```
interface Serial 1/0
ip address 1.1.1.1 255.255.255.0
fair-queue 128 512
```

The following are examples of viewing the interface configuration in the privileged user mode:

```
Ruijie# show queue interface serial 1/0
Queuing strategy: weighted fair
Output queue: 0/300/128/0 (size/max total/threshold/drops)
Output queue num: 0/0/512 (now active/max active/max total)
```

The preceding output shows that WFQ is enabled on the interface and the threshold for discarding packets is **128** in the event of congestion.

CBWFQ

CBWFQ Configuration Tasks

By default, the QoS policy of FIFO is enabled on Ruijie network interfaces with bandwidth lower than 4 Mbps.

Configuring CBWFQ

Defining Class-Maps

This function is required for realizing CBWFQ functionality. You can define packet classification rules in class-maps, and specify the class-map names for using them in policy-maps. A class-map can be used by one or more policy-maps. The following table describes the typical configuration of this function.

Command	Function
Ruijie(config)# **class-map** *match-all class-map-name*	Access and create the class-map of the "AND" type. That is, all conditions in the class-map must be met.
Ruijie(config)# **class-map** *match-any class-map-name*	Access and create the class-map of the "OR" type. That is, all conditions in the class-map must be met.
Ruijie(config-cmap)# **match access-group** *access-list-number* or Ruijie(config-cmap)# **match input-interface** *interface-name* or Ruijie(config-cmap)# **match protocol** *protocol-name* or Ruijie(config-cmap)# **match cos** *value* or Ruijie(config-cmap)# **Match ip dscp** *value* or Ruijie(config-cmap)# **Match ip precedence** *value* or Ruijie(config-cmap)# **Match not** *match-type value*	Configure the packet classification rules. The rules can be the positive or negative forms of the ACL, packet receiving interface, encapsulation protocol type, COS value, IP DSCP code, and IP Precedence code.
Ruijie(config-cmap)# **exit**	Exit from the configuration layer of class-maps.

Class-map-name: indicates the name of a class-map.

Match-all: All conditions in the class-map must be met. By default, a created class-map is of the **Match-all** type.

Match-any: indicates that only one condition in the class-map needs to be met.

Access- list-number: indicates the number of the access control list (ACL).

Interface- name: indicates the name of a network interface.

Protocol-name: indicates the packet encapsulation protocol.

COS: indicates the COS value of an Ethernet packet.

IP dscp: indicates the DSCP code value of the packet IP TOS domain.

IP Precedence: indicates the Precedence code value of the packet IP TOS domain.

Not match-type: indicates the negative form of a classification rule.

Configuring Rules in Policy-Maps

This function is required for realizing CBWFQ functionality. In a policy-map, you can use all class-maps configured on the router and use a maximum of 64 class-maps concurrently. You can define bandwidth for class-maps that are used under the precondition that the sum of bandwidth for all class-maps is equal to or smaller than the bandwidth assigned to CBWFQ on a specified interface that applies the policy-map. The following table describes the typical configuration of this function.

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Access and create a policy-map.
Ruijie(config-pmap)# **class** *class-map-name*	Use class-maps that have been defined.
Ruijie(config-pmap-c)# **bandwidth** { *bandwidth-kbps* | **percent** *percent-number* }	Specify bandwidth assigned to specified types of data flows.
Ruijie(config-pmap-c)# **queue-limit** *number-of-packets*	Set the queue depth.
Ruijie(config-pmap-c)# **exit**	Exit from the configuration layer of class using.
Ruijie(config-pmap)# **exit**	Exit from the configuration layer of policy-maps.

Policy-map-name: indicates the name of a policy-map.

Class-map-name: indicates the name of a class-map.

Bandwidth-kbps: indicates the assigned bandwidth in kbps.

Percent-number: indicates the assigned-bandwidth to all-available-bandwidth ratio.

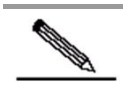
Number-of-packets: indicates the depth of a CBWFQ queue (the maximum number of packets that are allowed).

Applying Service Rules on Specified Interfaces

This function is required for realizing CBWFQ functionality. If service rules are enabled on specified interfaces, CBFWQ functionality is enabled and classes used in policy-maps obtain their processing queues. The following table describes the typical configuration of this function.

Command	Function
Ruijie(config-if)# **service-policy output** policy-map-name	Enable CBWFQ and specify the policy-maps to be applied.
Ruijie(config-if)# **service-policy input** policy-map-name	Enable the policy-map strategy for interface input packets.

Policy-map-name: indicates the name of a policy-map.



Note

If CBWFQ characteristics (such as the **Bandwidth** command or the **Priority** command) are enabled for a policy-map, the policy-map can be only be used in the **Service-policy Output** command, but not the **Service-policy Input** command.

Note

To configure the policy-map of an interface, ensure that the fast-switching function configuration (enable or disable the function) is consistent on all system interfaces. Otherwise, the functions such as CBWFQ and police of the policy-map become invalid.

Note

Ensure that the fast-switching function is disabled, if an interface configured with an input-direction policy-map or associated with an output-direction policy mapping mapping of the shape and red functions. This is a required in the current software version.

Configuring Bandwidth for Specified Classes

This function is optional for realizing CBWFQ functionality. The following table describes the typical configuration of this function.

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Access and create a policy-map.
Ruijie(config-pmap)# **class** *class-name*	Use class-maps that have been defined.
Ruijie (config-pmap-c)# **bandwidth** { bandwidth-kbps | **percent** percent}	Specify bandwidth assigned to specified types of data flows.

Policy-map-name: indicates the name of a policy-map.

Class-map-name: indicates the name of a class-map.

Bandwidth-kbps: indicates the assigned bandwidth in kbps.

Percent-number: indicates the assigned-bandwidth to all-available-bandwidth ratio.

You can specify bandwidth assigned to specified types of data flows. By default, the system assigns 1% of the bandwidth to a specified type of data flow.

Configuring Queue Depth for Specified Classes

This function is optional for realizing CBWFQ functionality. The following table describes the typical configuration of this function.

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Access and create a policy-map.
Ruijie(config-pmap)# **class** *class-name*	Use class-maps that have been defined.
Ruijie(config-pmap-c)# **queue-limit** *number-of-packets*	Set the queue depth.

Policy-map-name: indicates the name of a policy-map.

Class-map-name: indicates the name of a class-map.

Number-of-packets: indicates the depth of a CBWFQ queue (the maximum number of packets that are allowed).

You can set the depth of a CBWFQ queue corresponding to a specified type of data flow. The system default value is **64**. That is, the system will discard packets attempting to enter a CBFWQ queue if the queue has got 64 packets. In this case, Ruijie products support the congestion processing only in Tail-Drop mode, not in RED/WRED mode.

Note

Queue depth configuration depends on network requirements. When forwarded data is delay-sensitive, you can decrease the queue depth to lower delay. When the forwarded data is burst or contains many small packets, you can increase the queue depth to improve the system buffer capability.
Do not adjust the queue depth to a value that is too small; otherwise, the bandwidth guarantee function

becomes abnormal.
In an environment where the forwarded data is burst or contains many small packets, bandwidth may fail to be guaranteed. You need to increase the queue depth to improve the system buffer capability.

Configuring the DSCP Code Value of the IP TOS Domain for a Specified Class

This function is optional for realizing CBWFQ functionality. The following table describes the typical configuration of this function.

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Access and create a policy-map.
Ruijie(config-pmap)# **class** *class-name*	Use class-maps that have been defined.
Ruijie(config-pmap-c)# **set ip dscp** *values*	Set the packet DSCP value.

Policy-map-name: indicates the name of a policy-map.

Class-map-name: indicates the name of a class-map.

Values: indicates the packet DSCP value to be set.

Configuring the DSCP Code Value of the IPv4 TOS Domain and the IPv6 Traffic Class Domain for a Specified Class

This function is optional for realizing CBWFQ functionality. The following table describes the typical configuration of this function.

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Access and create a policy-map.
Ruijie(config-pmap)# **class** *class-name*	Use class-maps that have been defined.
Ruijie(config-pmap-c)# **set dscp** *values*	Set the packet DSCP value.

Policy-map-name: indicates the name of a policy-map.

Class-map-name: indicates the name of a class-map.

Values: indicates the packet DSCP value to be set.

Configuring the Precedence Code Value of the IP TOS Domain for a Specified Class

This function is optional for realizing CBWFQ functionality. The following table describes the typical configuration of this function.

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Access and create a policy-map.
Ruijie(config-pmap)# **class** *class-name*	Use class-maps that have been defined.
Ruijie(config-pmap-c)# **set ip precedence** *values*	Set the packet Precedence value.

Policy-map-name: indicates the name of a policy-map.

Class-map-name: indicates the name of a class-map.

Values: indicates the packet Precedence value to be set.

Configuring the Precedence Code Value of the IPv4 TOS Domain and the IPv6 Traffic Class Domain for a Specified Class

This function is optional for realizing CBWFQ functionality. The following table describes the typical configuration of this function.

Command	Function

Ruijie(config)# **policy-map** *policy-map-name*	Access and create a policy-map.
Ruijie(config-pmap)# **class** *class-name*	Use class-maps that have been defined.
Ruijie(config-pmap-c)# **set precedence** *values*	Set the packet Precedence value.

Policy-map-name: indicates the name of a policy-map.

Class-map-name: indicates the name of a class-map.

Values: indicates the packet Precedence value to be set.

Configuring the COS Value of Ethernet Packets for a Specified Class

This function is optional for realizing CBWFQ functionality. The following table describes the typical configuration of this function.

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Access and create a policy-map.
Ruijie(config-pmap)# **class** *class-name*	Use class-maps that have been defined.
Ruijie(config-pmap-c)# **set cos** *values*	Set the packet COS value.

Policy-map-name: indicates the name of a policy-map.

Class-map-name: indicates the name of a class-map.

Values: indicates the packet COS value to be set.

Configuring Bandwidth Assigned to CBWFQ

This function is optional for realizing CBWFQ functionality. The following table describes the typical configuration of this function.

Command	Function
Ruijie(config-if)# **max-reserved-bandwidth** percent	Set bandwidth assigned to CBWFQ.

Percent: indicates percentage of the bandwidth assigned to CBWFQ on an interface.

You can customize the value of the **percent** parameter. The system default value is **75**. That is, 75% of all available bandwidth of the corresponding network interface will be assigned to CBWFQ queues.

Monitoring CBWFQ

To view information about input and output queues when CBWFQ is enabled on an interface, run the following commands in the privileged user mode:

Command	Function
Ruijie# **show class-map**	Show information about all class-maps.
Ruijie# **show class-map** *class-map-name*	Show information about a specified class-map.
Ruijie# show policy-map	Show information about all policy-maps.
Ruijie# **show policy-map name** *policy-map –name*	Show information about a specified policy-map.
Ruijie# **show policy-map name** *policy-map -name* **class** *class-name*	Show information about specified class-maps in a specified policy-map.
Ruijie# **show policy-map interface** interface-name interface-number	Show information about policy-maps applied on a specified interface.
Ruijie# **show queue interface** interface-name *interface-number*	Show interface statistic information about CBWFQ queues.

Class-map-name: indicates the name of a class-map.

Policy-map-name: indicates the name of a policy-map.

Interface-name: indicates the name of a network interface.

Note

For routers of the RSR series, you can view statistic information about fast-switching CBWFQ queue interfaces by running the **show queue interface** command. "Qos Ref queue information" identifies statistic information about fast-switching CBWFQ queue interfaces.

Note

You can run the **show policy-map interface** command to view statistic information about fast-switching policy-maps on routers of the RSR series.

CBWFQ Configuration Example

In the following example, CBWFQ is enabled on a WAN interface Serial1/0 (S1/0) of the router. 30% of all available bandwidth on the interface S0 is used in the IP communication between the host 192.168.201.213 and the host 192.168.12.216. 10% of all available bandwidth on the interface S0 is used in the IP communication between the host 192.168.201.213 and the host 192.168.12.77.

The following is the configuration of the device where CBWFQ is enabled:

```
Ruijie# show running-config
!
.. .. ..
!
class-map class1
match access-group 101
class-map class2
match access-group 102
!
policy-map policy1
class class1
bandwidth percent 30
class class2
bandwidth percent 10
!
interface FastEthernet0/0
ip address 192.168.201.1 255.255.255.0
!
interface Serial1/0
ip address 192.168.20.3 255.255.255.0
encapsulation ppp
service-policy output policy1
clock rate 115200
!
ip route 0.0.0.0 0.0.0.0 Serial1/0
access-list 101 permit ip host 192.168.201.213 host 192.168.12.216
access-list 102 permit ip host 192.168.201.213 host 192.168.12.77
!
.. .. ..
```

In the following example, the DSCP value is set for five types of packets matching the ACL on the ingress interface and the packets are transformed into four types of macro-flows for the differentiated services. The bandwidth assigned to CBWFQ queues is adjusted.

The following is the configuration of the device where CBWFQ is enabled:

```
class-map match-all dlsw
match access-group 101
class-map match-all voip
match access-group 102
class-map match-all notes
match access-group 103
class-map match-all http
match access-group 104
class-map match-all ftp
match access-group 105
class-map match-all ef
match ip dscp 46
```

```
class-map match-all af1
match ip dscp 10
class-map match-all af2
match ip dscp 18
class-map match-all af3
match ip dscp 26
!
!
policy-map 1
class dlsw
set ip dscp 46
class voip
set ip dscp 46
class notes
set ip dscp 10
class http
set ip dscp 18
class ftp
set ip dscp 26
policy-map 2
class ef
bandwidth 800
class af1
bandwidth 500
class af2
bandwidth 300
class af3
bandwidth 380
!
access-list 101 permit udp any any eq 2065
access-list 102 permit udp any any range 16384 32767
access-list 103 permit udp any any eq 1352
access-list 104 permit udp any any eq 80
access-list 105 permit udp any any eq 20
!
interface serial 2/1
encapsulation PPP
no ip route-cache
ip address 1.1.1.2 255.255.255.0
max-reserved-bandwidth 99
service-policy output 2
clock rate 2048000
!
interface FastEthernet 0/0
no ip route-cache
ip address 192.168.200.1 255.255.255.0
service-policy input 1
duplex auto
mac-address 00d0.3456.eeee
speed auto
!
ip route 0.0.0.0 0.0.0.0 serial 2/1
!
```

Configuring LLQ and RTPQ

Configuration Tasks of LLQ and RTPQ

LLQ configuration is combined with CBWFQ configuration, but RTPQ configuration is independent.

Configuring LLQ and RTPQ

To configure LLQ, run the following commands in the configuration mode of the Policy-map command layer:

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Access and create a policy-map.

Ruijie(config-pmap)# **class** *class-name*	Use class-maps that have been defined.
Ruijie (config-pmap-c)# **priority** { *bandwidth-kbps* | **percent** *percent*} {*Burst bytes*}	Specify bandwidth assigned to specified types of data flows.
Ruijie(config-if)# service-policy output policy-map-name	Enable CBWFQ and specify the policy-maps to be applied.

Policy-map-name: indicates the name of a policy-map.

Class-map-name: indicates the name of a class-map.

Bandwidth-kbps: indicates the assigned bandwidth in kbps.

Percent-number: indicates the assigned-bandwidth to all-available-bandwidth ratio.

You can specify bandwidth assigned to specified types of data flows. By default, the system assigns 1% of the bandwidth to a specified type of data flow.

Burst bytes: indicates the byte count that can be exceeded.

Note

Queue depth configuration depends on network requirements. When forwarded data is delay-sensitive, you can decrease the queue depth to lower delay. When the forwarded data is burst or contains many small packets, you can increase the queue depth to improve the system buffer capability.
Do not adjust the queue depth to a value that is too small; otherwise, the bandwidth guarantee function becomes abnormal.
In an environment where the forwarded data is burst or contains many small packets, bandwidth may fail to be guaranteed. You need to increase the queue depth to improve the system buffer capability.

To configure RTPQ, run the following commands in the configuration mode of the interface configuration command layer:

Command	Function
Ruijie(config-if)# **ip rtp priority** *starting-rtp-port-number port-number-range bandwidth*	Create RTPQ queues for an interface and assign bandwidth to these queues.

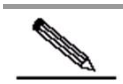
Starting-rtp-port-number: indicates the starting port number among the matching UDP ports.

Port-number-range: indicates the port number range of the matching UDP ports.

Bandwidth-kbps: indicates the assigned bandwidth in kbps.

Note

The following three commands affect the bandwidth assigned for interfaces:
The **Bandwidth** command of CBWFQ
The **Priority** command of LLQ
The **ip rtp priority** command of RTPQ
The **Bandwidth** command of the interface is used to set the entire bandwidth.
That is, Bandwidth = max_reserve +default wfq bandwidth;
max_reserve = bandwidth (policy-map) + priority (policy-map) +ip RTP priority



Note

To configure the interface congestion management policy, ensure that the fast-switching function configuration (enable or disable the function) is consistent on all system interfaces. Otherwise, the congestion management policy becomes invalid.

Monitoring LLQ and RTPQ

To view information about LLQ that has been configured, run the following commands in the privileged user mode:

Command	Function
Ruijie# **show policy-map** *interface-name interface-number*	Show information about policy-maps applied on a specified interface.

To view information about RTPQ that has been configured, run the following commands in the privileged user mode:

Command	Function
Ruijie# **show queue rtpq**	Show information about RTPQ queues.

Note

For routers of the RSR series, you can view statistic information about fast-switching RTPQ queue interfaces by running the **show queue interface** command. "Qos Ref queue information" identifies statistic information about fast-switching RTPQ queue interfaces.
You can run the **show policy-map interface** command to view statistic information about fast-switching policy-maps on routers of the RSR series.

Configuration Examples of LLQ and RTPQ

In the following example, on SYNC port 0, an RTPQ queue is configured for serving RTP of VOIP and an LLQ queue is configured for serving DOSQ office packets. CBFWQ queues process Notes packets and default WFQ queues in CBWFQ process other packets.

```
!
class-map match-all dlsw
match access-group 101
class-map match-all voip
match access-group 102
class-map match-all notes
match access-group 103
class-map match-all http
match access-group 104
class-map match-all ftp
match access-group 105
!
policy-map 3
class dlsw
priority 30 2000
class notes
bandwidth 13
!
access-list 101 permit udp any any eq 2065
access-list 102 permit udp any any range 16384 32767
access-list 103 permit udp any any eq 1352
access-list 104 permit udp any any eq 80
access-list 105 permit udp any any eq 20
!
interface serial 2/1
encapsulation PPP
ip rtp priority 16384 16383 40
no ip route-cache
ip address 1.1.1.2 255.255.255.0
max-reserved-bandwidth 99
service-policy output 3
clock rate 64000
bandwidth 84
!
interface FastEthernet 0/0
ip address 192.168.200.1 255.255.255.0
duplex auto
```

```
mac-address 00d0.3456.eeee
speed auto
!
ip route 0.0.0.0 0.0.0.0 serial 2/1
!
```

Configuring CQ

CQ Configuration Tasks

Configuring CQ

You can configure a maximum of 16 groups for CQ. That is, the List-number range is 1–16. In each group, you can specify queues of packets, queue length, and byte count that can be continuously sent after a queue obtains the controlling right of sending packets.

Determining the Maximum Capacity of CQ

To configure the maximum packet capacity for each queue, run the following commands in the global configuration mode:

Command	Function
Ruijie(config)# **queue-list** *list-number* **queue** *queue-number* limit *limit-number*	Specify the maximum packet count in a CQ queue. The no form of this command can be run to restore the default queue length 20.
Ruijie(config)# **queue-list** *list-number* **queue** *queue-number* **byte-count** *byte-count-number*	Specify the maximum byte count in a queue. The no form of this command can be run to restore the default byte count 1500.

List-number: indicates the number of a queue list within 1–16.

Queue-number: indicates the number of a custom queue number within 1–16.

Limit-number: indicates the maximum packet count in a queue. The value range is 0–32767, and the default value is **20**.

Byte-count-number: specifies how many bytes of data should be delivered from the current queue by the system before the system moves on to the next queue until the value of **Byte-count-number** is exceeded or no packet is in that queue. The value range is 0–16777215, and the default value is **1500**. To determine the correct byte counts, see the related section.

Note To configure the interface congestion management policy, ensure that the fast-switching function configuration (enable or disable the function) is consistent on all system interfaces. Otherwise, the congestion management policy becomes invalid.

Note You should configure Byte-count-number based on traffic in each queue. Do not configure a large byte count for a slow traffic queue. Otherwise, the current queue may keep being dispatched, resulting in that other queues cannot be processed.

Assigning Packets to CQ Queues

You can assign a packet to a CQ queue based on the protocol type and the interface where the packet enters the device. You can also configure a default queue with multiple rules for packets matching no allocation criterion.

To configure the CQ queue list, run the following commands in the global configuration mode:

Command	Function
Ruijie(config)# **queue-list** *list-number* **protocol** protocol-name queue-number [queue-keyword] [keyword-value]	Assign a packet to a CQ queue based on the protocol type.
Ruijie(config)# **queue-list** *list-number* **interface** interface-type interface-number queue-number	Assign a packet to a CQ queue based on the type of the interface where the packet enters the device.

Ruijie(config)# **queue-list** *list-number* **default** queue-number	Assign packets matching no assignment rules in the CQ queue list to a CQ queue. The default CQ queue number is **1**.

For the description about **List-number** and **Queue-number**, see the preceding section.

Protocol-name: indicates the type of a protocol. The value can be **IP** (frequently used), **PAD**, and so on.

Queue-keyword and **Keyword-value**: indicates options about protocols. The following table describes values and meanings of the two parameters when IP is used.

queue-keyword	keyword-value	Meaning
Blank	Blank	All IP packets can enter a specified queue.
fragments	Blank	All fragment IP packets can enter a specified queue.
list	List-number	All packets matching the access-list-number can enter a specified queue.
lt	Byte-count	Packets whose length is smaller than the value of byte-count can enter a specified queue.
gt	Byte-count	Packets whose length is greater than the value of byte-count can enter a specified queue.
tcp	Port	IP packets whose source or destination TCP port number is port can enter a specified queue.
udp	Port	IP packets whose source or destination UDP port number is port can enter a specified queue.

Ensure that the fast-switching function is disabled on an interface when you specify the fragments policy for protocol rules. This is required in the current software version.

Specifying the Lowest CQ Queue Number

By default, you can customize CQ queues numbered 1 to 16. CQ reserves queue 0 for routing protocols and queue 0 functions as the absolute priority queue higher than all customize queues. If there is other traffic that needs to be processed with high priority, CQ allows you to increase the number of absolute priority queues by adjusting the lowest custom queue list number.

By default, the lowest custom queue number is 1. That is, only queue 0 is the absolute priority queue, and queues 1–16 are custom queues.

To configure the lowest CQ queue number, run the following commands in the global configuration mode:

Command	Function
Ruijie(config)# **queue-list** *list-number* **lowest-custom** *queue-number*	Customize the lowest CQ queue number.

List-number: indicates the number of a queue list within 1–16.

Queue-number: indicates the number of a custom queue within 0–16.

Applying the CQ List on an Interface

To apply a CQ list on an interface, run the following command in the interface configuration mode:

Command	Function
Ruijie(config-if)#**custom-queue-list** *list-number*	Set the queueing policy of an interface to a specified CQ list.

Note Each interface can use only one queueing policy and one matching list.

Monitoring CQ

To view information about input and output queues when CQ is enabled on an interface, run the following commands in the privileged user mode:

Command	Function
Ruijie# **show queue cq**	Show configuration information about CQ queues.
Ruijie# **show queue interface** interface-name *interface-number*	Show interface statistic information about CQ queues.
Ruijie# **debug qos cq**	Enable CQ debugging.

Note

For routers of the RSR series, you can view statistic information about fast-switching CQ queue interfaces by running the **show queue interface** command. "Qos Ref queue information" identifies statistic information about fast-switching CQ queue interfaces.

CQ Configuration Examples

Set CQ list 2: Assign IP packets whose length is greater than 200 bytes to queue 12.

```
Ruijie(config)# queue-list 2 protocol ip 12 gt 200
```

Set CQ list 4: Assign IP packets whose length is smaller than 300 bytes to queue 2.

```
Ruijie(config)# queue-list 4 protocol ip 2 lt 300
```

Set CQ list 1: Assign traffic matching IP-access-list 10 to queue 11.

```
Ruijie(config)# queue-list 1 protocol ip 11 list 10
```

Set CQ list 4: Assign Telnet packets to queue 12.

```
Ruijie(config)# queue-list 4 protocol ip 12 tcp 23
```

Set CQ list 4: Assign UDP domain name service packets to queue 2.

```
Ruijie(config)# queue-list 4 protocol ip 2 udp 53
```

Set CQ list 3: Assign packets transmitted from ASNC port 1 to queue 7.

```
Ruijie(config)# queue-list 3 interface serial 1 7
```

Set CQ list 9: Set the byte count of queue 10 to **1800**.

```
Ruijie(config)# queue-list 9 queue 10 byte-count 1800
```

Set CQ list 5: Set the queue length of queue 10 to **40**.

```
Ruijie(config)# queue-list 5 queue 10 limit 40
```

Set the queueing policy of SYNC port 0 to CQ list 5.

```
Ruijie(config)# interface serial 0
Ruijie(config-if)# custom-queue-list 1
```

Configuring PQ

PQ Configuration Tasks

Configuring PQ

You can configure a maximum of 16 groups for PQ. That is, the List-number range is 1–16. In each group, you can specify queues of packets, queue length, and byte count that can be continuously sent after a queue obtains the controlling right of sending packets.

Determining the Maximum Capacity of PQ

There are four queues (each assigned with the high, medium, normal, and low priority) in each group of queue lists. To specify the maximum number of packets allowed in each of the priority queues, run the following command in global configuration mode:

Command	Function
Ruijie(config)# **priority-list** *list-number* **queue-limit** [high-limit [medium-limit [normal-limit [low-limit]]]]	Specify the maximum packet count in a PQ queue.

List-number: indicates the number of a queue list within 1–16.

The following table describes the default queue lengths.

Queue	Length
high	20
medium	40
normal	60
Low	80

Note To configure the interface congestion management policy, ensure that the fast-switching function configuration (enable or disable the function) is consistent on all system interfaces. Otherwise, the congestion management policy becomes invalid.

Assigning Packets to PQ Queues

You can specify multiple assignment rules. The **priority-list** commands are read in order of appearance until a matching protocol or interface type is found. When a match is found, the packet is assigned to the appropriate queue and the search ends. Packets that do not match other assignment rules are assigned to the default queue. To specify which queue to place a packet in, run the following commands in global configuration mode:

Command	Function
Ruijie(config)# **priority-list** *list-number* **protocol** *protocol-name* {**high** | **medium** | **normal** | **low**} [queue-keyword] [keyword-value]	Assign a packet to a PQ queue based on the protocol type.
Ruijie(config)# **priority-list** list-number **interface** *interface-type interface-number* {high | medium | normal | low}	Assign a packet to a PQ queue based on the type of the interface where the packet enters the device.
Ruijie(config)# **priority-list** *list-number* **default** {**high** | **medium** | **normal** | **low**}	Assign a default PQ queue with the normal priority for those packets that do not match any other rule in the priority list.

List number indicates the number of a priority queue. **Protocol-name** indicates the name of a protocol, such as IP, PAD, and so on. The values and meanings of **Queue-keyword** and **Eyword-value** are the same as these of CQ.

Applying the PQ List on an Interface

To apply a PQ list on an interface, run the following command in the interface configuration mode:

Command	Function
Ruijie(config-if)# **priority-group** *list-number*	Set the queueing policy of an interface to a specified PQ list.

Note Each interface can use only one queueing policy and one matching list.

Monitoring PQ

To view information about input and output queues when PQ is enabled on an interface, run the following commands in the privileged user mode:

Command	Function
Ruijie# **show queue pq**	Show configuration information about PQ queues.
Ruijie# **show queue interface** interface-name *interface-number*	Show interface statistic information about PQ queues.
Ruijie# **debug qos cq**	Enable PQ debugging.

Note

For routers of the RSR series, you can view statistic information about fast-switching PQ queue interfaces by running the **show queue interface** command. "Qos Ref queue information" identifies statistic information about fast-switching PQ queue interfaces.

PQ Configuration Examples

Set PQ list 3: Assign packets transmitted from ASNC port 1/1 to the medium priority queue.

```
Ruijie(config)# priority-list 3 interface serial 1/1 medium
```

Set PQ list 6: Assign packets with a byte count greater than 250 to the medium priority queue.

```
Ruijie(config)# priority-list 6 protocol ip medium gt 250
```

Set PQ list 11: Assign IP packets with a byte count smaller than 250 to the medium priority queue.

```
Ruijie(config)# priority-list 11 protocol ip medium lt 250
```

Set PQ list 7: Assign packets matching IP access list 101 to the high priority queue.

```
Ruijie(config)# priority-list 7 protocol ip high list 101
```

Set PQ list 6: Assign Telnet packets to the high priority queue.

```
Ruijie(config)# priority-list 6 protocol ip high tcp 23
```

Set PQ list 6: Assign UDP domain name service packets to the low priority queue.

```
Ruijie(config)# priority-list 6 protocol ip low udp 53
```

Set PQ list 1: Assign packets that do not match any other rules in the priority list to the medium priority queue.

```
Ruijie(config)# priority-list 1 default medium
```

Set PQ list 2: set the lengths of the high, medium, normal, and low priority queues to 10, 40, 60, and 80.

```
Ruijie(config)# priority-list 2 queue-limit 10 40 60 80
```

Configuring Hold-queue

Configuring hold-queue

Run this command to set queue length on an interface in interface configuration mode.

Command	Function
Ruijie(config-if)# **hold-queue** *queue length* { **in** | **out** }	Sets queue length on an interface.

Queue length refers to the threshold of packets in a queue. When the number of packets reaches the threshold, the coming packets will be discarded.

The default values for input queue and output queue are 75 and 40 respectively.


Caution This command is used to modify three color-based thresholds of a queue for interface congestion and prevent green packets drop preferentially. The default settings are applied generally. When cached packets exceed the red threshold, you should modify the value to make the number of cached packets below the red threshold.

Monitoring hold-queue

Run this command to show input and output queues information.

Command	Function
Ruijie# **show queue interface** *interface-name interface-number* [*queue-number*]	Shows queue information on an interface.

hold-queque Configuration Example

Configure fair queueing on synchronous interface 0 and set the threshold of packet number in an input queue to 128. When the packet number reaches the threshold, coming packets will be discarded.

```
Ruijie(config)# interface Serial 0
Ruijie(config-if)# hold-queue 128 in
```

Traffic Policing and Shaping

What Are Traffic Policing and Traffic Shaping

Traffic policing is used to control the rate of classified traffic flowing across an interface.

Traffic shaping allows you to control the burst traffic going out an interface to ensure that packets are delivered at stable rates and the network traffic remains stable.


Note NPE80 does not support traffic policing and shaping.

Overview of Traffic Policing and Shaping

- About Traffic Policing

Ruijie series of devices use the committed access rate (CAR) technology to limit the rate of traffic accessing the network to the committed rate. The rate-limiting feature and the packet classification feature can be configured together.

CAR uses the token bucket algorithm. You can set the capacity of the token bucket. If packets satisfy the preconfigured match rules, the token bucket accepts and processes the packets. If packets do not satisfy the preconfigured match rules, the token bucket refuses the packets and they continue to be transmitted. If there are sufficient tokens, packets processed by the token bucket continue to be transmitted. If tokens are insufficient, packets are discarded.

Ruijie series of devices support the configuration of at least 1-KB flow limit, the binding of CAR and ACL, and enable you to perform rate-limiting and traffic classification at the same time.

Ruijie series of devices support the service flow-limiting function based on IP applications. This enables you to limit service traffic flexibly based on IP applications' requirements on service traffic. For example, you can implement the service flow-limiting function based on the IPSec VPN tunnel.

- About Traffic Shaping

Ruijie series of devices shape traffic that is irregular or matches no predefined traffic features through the GTS (Generic Traffic Shaping) to facilitate bandwidth assignment between the upstream and downstream traffic on the network. GTS shapes traffic by buffering high-speed outbound traffic flow in the buffering area by constraining traffic to a particular bit rate using the token bucket.

Traffic shaping of routers is performed based on the following data flows:

1. All data flows passing physical interfaces
2. Data flows that are classified by using the standard or extended ACLs

- About the Token Bucket

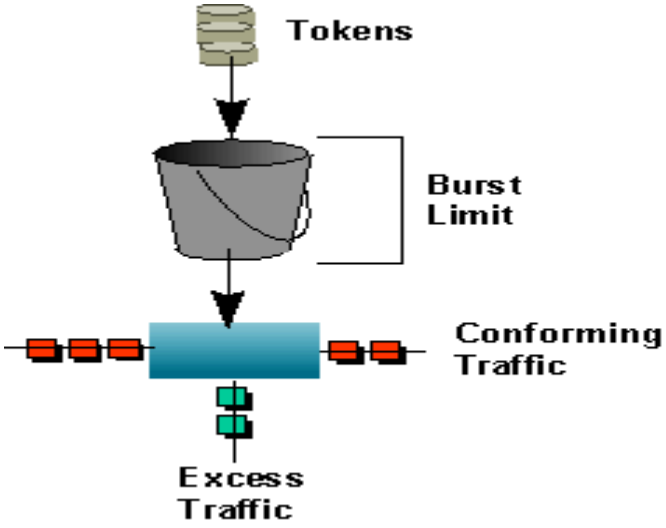
The token bucket algorithm is based on an analogy of a buffer (bucket) into which tokens, normally representing virtual data, are added at a fixed rate.

After entering the bucket, each token collects a packet from data queues and then is deleted from the bucket. This algorithm is associated with the token flow and the data flow. The following are three scenarios:

1. The data flow arrives at TBF using a rate equal to the rate of the token flow. In this case, each packet obtains a token and passes the queue without delay.
2. The data flow arrives at TBF using a rate smaller than the rate of the token flow. In this case, packets use some of the tokens and remaining tokens accumulate in the bucket until the bucket is full. Remaining tokens need to be consumed by the data flow arriving at TF using a rate greater than the rate of the token flow. In this case, burst transmission occurs.
3. The data flow arrives at TBF using a rate greater than the rate of the token flow. In this case, the bucket runs out of tokens quickly. This causes TBF interrupted for a period, namely, "threshold crossing". If packets arrive continuously, packets loss occurs.

The following figure shows the process.

Figure 7



What exactly is a token?

A token is the rate calibrated scale related to the value of CIR. Suppose that you configure an interface with a CIR rate of 8000 bit/s. Then, this interface can send 1000-bytes packets per second. At this time, the token equals to 1000 bytes, indicating that a token equal to 1000 is updated per second. Then, you can use the token to monitor whether packets accessing the interface exceed the committed rate.

Note

Ensure that the capacity of the token bucket is configured based on traffic bursts on the network. You need to expand the capacity of the token bucket to enhance the QoS tolerance capability for burst traffic on the network where burst traffic such as video or file transfer exists. Normally, the token bucket should at least support the 200-ms buffer capacity, that is, (CIR/8)*200ms.

Note

When GTS is used in rate-limiting, the frame gap and CRC are taken into account. The GRS rate limiting calculation is as follows:
1) Packet Per Second (PPS) = GTS rating limiting value in bps / ((packet length + frame gap + CRC) x 8); Round down the result for accuracy.
2) Receiver rate: PPS x actually received packet count in bytes x 8

Configuration Tasks of Traffic Policing

To configure the CAR traffic policing feature, run the following commands in the interface configuration mode:

Command	Function
Ruijie(config)# **interface** *interface-type interface-number*	Specify an interface where CAR rate limiting is to be enabled.
Ruijie(config-if)# **rate-limit** {**input** | **output**} **bps** burst-normal burst-max **conform-action** action exceed-action *action*	Perform packet rate-limiting for input or output packets of all traffic accessing the interface.

Input|output: indicates the input or output traffic that you need to limit.

Bps: indicates the maximum threshold rate (in bps) that you need to set for traffic.

Burst-normal burst-max: indicates the capacity of the token bucket in bytes.

Conform-action: indicates the processing policy for traffic that conforms to the rate limit.

Exceed-action: indicates the processing policy for traffic that exceeds the rate limit.

Action: indicates a processing policy. The processing policies are described as follows:

- Proceed to match the next policy.
- **Continue**: Match the next policy.
- **Drop**: Discard the packet.
- **Set-dscp-continue**: Continue to match the packet with the next policy after the DSCP domain is set for the packet.
- **Set-dscp-transmit**: Transmit the packet after the DSCP domain is set for the packet.
- **Set-prec-continue**: Continue to match the packet with the next policy after the IP Precedence domain is set for the packet.
- **Set-prec-transmit**: Transmit the packet after the IP Precedence domain is set for the packet.
- **Transmit**: Transmit the packet.

Caution After IPSec encryption is enabled, the inbound traffic monitoring CAR will not support the packet revising policies including **set-dscp-continue**, **set-prec-continue**, **set-dscp-transmit**, and **set-prec-transmit,**

To configure the CAR rate limit feature for different types of traffic based on ACL or DSCP values, run the following commands in the interface configuration mode:

Command	Function
Ruijie(config)# **access-list** *acl-index*	Configure the ACL matching traffic.
Ruijie(config)# **interface** *interface-type* interface-number	Specify an interface where CAR rate limiting is to be enabled.
Ruijie(config-if)# **rate-limit** {**input** | **output**} [**access-group** *acl-index*] *bps* burst-normal burst-max **conform-action** action exceed-action *action*	Perform packet rate-limiting for the input or output packets of the traffic that matches the Acl-index access list.
Ruijie(config-if)# **rate-limit {input | output}** [**dscp** dscp-value] bps *burst-normal burst-max* **conform-action** *action* exceed-action *action*	Perform packet rate-limiting for the input or output packets of the traffic that matches the DSCP code value.

Caution If multiple ACL CARs are configured and each flow matches an ACL,all matched flows take effect. If a flow is configure with ACL1 and ACL2, ACL1 takes effect. If a flow is configured with the same ACL rules and different action, all ACL rules take effect.

To configure the service rate limiting based on IP applications, run the following commands in the global configuration mode:

Command	Function
Ruijie(config)# **flow-limit** {**input** | **output**} **label** label-num *bps* burst-normal burst-max **conform-action** action **exceed-action** *action*	Configure the global service rate limiting template.
Ruijie(config)# **crypto map** *map-name seq-num* ipsec-isakmp	Enter the IPSec policy-map mode.
Ruijie(config-crypto-map)# **flow-label** *label-num*	Specify the flow label of the IPSec policy-map.

Input|output: indicates the input or output traffic that you need to limit.

label-num: indicates the label number the service rate limiting feature needs to match.

Bps: indicates the maximum threshold rate (in bps) that you need to set for traffic.

Burst-normal burst-max: indicates the capacity of the token bucket in bytes.

Conform-action: indicates the processing policy for traffic that conforms to the rate limit.

Exceed-action: indicates the processing policy for traffic that exceeds the rate limit.

Action: indicates a processing policy. The processing policies are described as follows:

Drop: Drop the packet.

Transmit: Transmit the packet.

Configuration Tasks of Traffic Shaping

To configure the GTS feature, run the following commands in the interface configuration mode:

Command	Function
Ruijie(config)# **interface** *interface-type interface-number*	Specify an interface where traffic shaping is to be enabled.
Ruijie(config-if)# **traffic-shape rate** *bit-rate* [*burst-size*] [*excess-burst-size*] [*buffer-limit*]	Shape the entire traffic of an interface.

Bit-rate: indicates the maximum threshold rate (in bps) that you need to shape. The maximum value is **1000000000**, indicating 1 Gbps.

Burst-size: indicates the size of burst packets that can be transmitted during each interval. The unit is bit.

Excess-burst-size: indicates the size of burst packets that can be exceedingly transmitted during first interval. The unit is bit.

Buffer-limit: indicates the buffer size of a GTS buffer queue. The default value is **1000**.

Note

The system processing traffic shaping policy takes effect based on an interface. After GTS is enabled on the interface, GTS must be enabled on all subinterfaces of the interface. Otherwise, the subinterfaces transmit data unevenly.

Note

After traffic shaping is enabled on an interface, **Burst-size** must be an integral multiple of a certain value (the packet size sent in 10 ms by using the traffic shaping rate). Otherwise, the system invokes the packet configuration parameter to round off **Burst-size** to the certain value to make the parameter take effect legally.

Note Buffer queue configuration depends on network requirements. When forwarded data is delay-sensitive, you can decrease the queue depth to lower delay. When the forwarded data is burst or contains many small packets, you can increase the queue depth to improve the system buffer capability.

Note When RSR30-44 performing large MSTP nodes aggregation, GTS rate might be slightly inaccurate for the aggregation capacity of RSR30-44 is limitied.

To configure the GTS feature for different types of traffic based on ACLs, run the following commands in the interface configuration mode:

Command	Function
Ruijie(config)# **access-list** *acl-index*	Create the ACL matching traffic.
Ruijie(config)# **interface** *interface-type* interface-number	Specify an interface where GTS is to be enabled.
Ruijie(config-if)# **traffic-shape group** access-list bit-rate [burst-size [excess-burst-size]]	Perform interface traffic shaping for the input or output packets of the traffic that matches the acl-index access list.

Note The **traffic-shape group** command and the **traffic-shape rate** command are mutually exclusive on an interface**.** That is, you cannot configure the two commands on the same interface.

Note Ensure that the fast-switching function is disabled on the interface that deploys the traffic shaping function associated with ACL classification. This is required by in the current software version.

Configuration Tasks of Traffic Policing on a Policy-Map

To configure CAR rate limiting of a single rate on a policy-map, run the following commands:

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Access and create a policy-map.
Ruijie(config-pmap)# **class** *class-map-name*	Use class-maps that have been defined.
Ruijie(config-pmap-c)# **police cir** [*bps*] [*burst-normal*] [*burst-max*] **conform-action** [*action*] **exceed-action** [*action*] **violate-action** [*action*]	Deploy the token bucket rate limiting of a single rate for this type of traffic.
Ruijie(config-if)# service-policy output policy-map-name	Specify the policy-map to be applied.

CIR: indicates the maximum threshold rate (in bps) that you need to set for traffic.

Burst-normal burst-max: indicates the capacity of the token bucket in bytes.

Conform-action: indicates the processing policy for traffic that conforms to the rate limit.

Exceed-action: indicates the processing policy for traffic that exceeds the rate limit.

violate-action: indicates the processing policy for traffic that exceeds the rate limit set for the second token bucket when there are two token buckets.

Action: indicates a processing policy. The processing policies are described as follows:

- **Drop**: Drop the packet.

- **Set-dscp-transmit**: Transmit the packet after the DSCP domain is set for the packet.
- **Set-prec-transmit**: Transmit the packet after the IP Precedence domain is set for the packet.
- **Transmit**: Transmit the packet.

To configure CAR rate limiting of two rates on a policy-map, run the following commands:

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Access and create a policy-map.
Ruijie(config-pmap)# **class** *class-map-name*	Use class-maps that have been defined.
Ruijie(config-pmap-c)# **police cir** [bps] **pir** [*bps*] [*burst-normal*] [*burst-max*] **conform-action** [*action*] **exceed-action** [*action*] **violate-action** [*action*]	Deploy the token bucket rate limiting of two rates for this type of traffic.
Ruijie(config-if)# **service-policy output** policy-map-name	Specify the policy-map to be applied on the interface.

CIR: indicates the maximum threshold rate (in bps) that you need to set for traffic.

PIR: indicates the peak maximum threshold rate (in bps) that you need to set for traffic.

Burst-normal burst-max: indicates the capacity of the token bucket in bytes.

Conform-action: indicates the processing policy for traffic that conforms to the rate limit.

Exceed-action: indicates the processing policy for traffic that exceeds the rate limit.

violate-action: indicates the processing policy for traffic that exceeds the rate limit set for the second token bucket when there are two token buckets.

Action: indicates a processing policy. The processing policies are described as follows:

Drop: Drop the packet.

Set-dscp-transmit: Transmit the packet after the DSCP domain is set for the packet.

Set-prec-transmit: Transmit the packet after the IP Precedence domain is set for the packet.

Transmit: Transmit the packet.

Note

You can choose to use one of the four token bucket algorithms for rate limit on a policy-map:
1. Single token bucket algorithm: Use this algorithm if you have not configured **violate-action** and the value of **burst-normal** is equal to the value of **burst-max**.
2. Load mode of the single token bucket algorithm: Use this mode if you have not configured **violate-action** and the value of **burst-normal** is smaller than the value of **burst-max**.
3. Single-rate two-token-buckets algorithm: Use this algorithm if you have configured **violate-action** but not **pir**.
4. Two-rate two-token-bucket algorithm: Use this algorithm if you have configured both **violate-action** and **pir**.

Configuration Tasks of Traffic Shaping on a Policy-Map

To configure traffic shaping with an average rate on a policy-map, run the following commands:

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Access and create a policy-map.
Ruijie(config-pmap)# **class** *class-map-name*	Use class-maps that have been defined.
Ruijie(config-pmap-c)# **shape average cir** [*bps*] [*bc*] [*be*]	Deploy traffic shaping with an average rate for this type of traffic.
Ruijie(config-if)# service-policy output policy-map-name	Specify the policy-map to be applied on the interface.

Bit-rate: indicates the maximum threshold rate (in bps) that you need to set for traffic shaping.

BC: indicates the size of burst packets that can be transmitted during each interval. The unit is bit.

BE: indicates the size of burst packets that can be exceedingly transmitted during first interval. The unit is bit.

To configure traffic shaping with a peak rate on a policy-map, run the following commands:

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Access and create a policy-map.
Ruijie(config-pmap)# **class** *class-map-name*	Use class-maps that have been defined.
Ruijie(config-pmap-c)# **shape peak** [*bps*] [*bc*] [*be*]	Deploy traffic shaping with a peak rate for this type of traffic.
Ruijie(config-if)# **service-policy output** *policy-map-name*	Specify the policy-map to be applied on the interface.

Bit-rate: indicates the maximum threshold rate (in bps) that you need to set for traffic shaping.

BC: indicates the size of burst packets that can be transmitted during each interval. The unit is bit.

BE: indicates the size of burst packets that can be exceedingly transmitted during first interval. The unit is bit.

To configure the buffer size of traffic shaping on a policy-map, run the following commands:

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Access and create a policy-map.
Ruijie(config-pmap)# **class** *class-map-name*	Use class-maps that have been defined.
Ruijie(config-pmap-c)# **shape max-buffers** [number-of-buffers]	Configure the buffer size of traffic shaping.
Ruijie(config-if)# **service-policy output** policy-map-name	Specify the policy-map to be applied on the interface.

Number-of-buffers: indicates the buffer size of traffic shaping. The default value is **1000**.

Note

Configurations of **shape average bps** and **shape peak bps** bring different traffic shaping results.
In traffic shaping, the peak rate is greater than the average rate. The calculation is as follows:
Peak rate = cir (1+ bc/be)

Note

Ensure that the fast-switching function is disabled on the interface that deploys the traffic shaping function associated with a policy map. This is required by in the current software version.

Configuration Examples of Traffic Policing

Configuration Examples of Traffic Policing for Entire Traffic of an Interface

In the following examples, CAR traffic policing is configured on the ingress interface and the egress interface:

Configure CAR traffic policing of egress interface packets on a serial interface.

Limit the egress interface traffic to 300 kbps. If the traffic conforms to the rate limit, the traffic is transmitted. If the traffic exceeds the rate limit, the traffic is discarded.

```
interface Serial1/0
ip address 192.168.20.3 255.255.255.0
encapsulation ppp
rate-limit output 300000 3000 3000 conform-action  transmit exceed-action  drop
```

Configure CAR traffic policing of ingress interface packets on a FastEthernet interface.

Limit the ingress interface traffic to 2 Mbps. If the traffic conforms to the rate limit, the traffic is transmitted. If the traffic exceeds the rate limit, the traffic is discarded.

```
interface FastEthernet 0/0
ip address 192.168.20.3 255.255.255.0
```

```
encapsulation ppp
rate-limit input 2000000 3000 3000 conform-action  transmit exceed-action  drop
```

Configuration Examples of Traffic Policing for Traffic Satisfying Certain Conditions

In the following examples, CAR traffic policing is configured for egress traffic that satisfies certain conditions:

Configure ACLs based on different TCP and UDP ports.

```
access-list 101 permit tcp any any eq 2065
access-list 102 permit udp any any range 16384 32767
access-list 103 permit tcp any any eq 1352
access-list 104 permit tcp any any eq www
access-list 105 permit tcp any any eq ftp-data
```

Configure CAR traffic policing of egress interface packets based on ACLs on a serial interface.

```
interface Serial1/0
ip address 192.168.20.3 255.255.255.0
encapsulation ppp
rate-limit output access-group 101 256000 5000 5000 conform-action  transmit exceed-action
set-dscp-transmit 46
rate-limit output access-group 102 200000 3000 3000 conform-action  transmit exceed-action
set-prec-transmit 5
rate-limit output access-group 103 128000 3000 3000 conform-action  transmit exceed-action
set-prec-transmit 1
rate-limit output access-group 104 64000 3000 3000 conform-action  transmit exceed-action
drop
rate-limit output access-group 105 32000 3000 3000 conform-action  transmit exceed-action
drop
```

Configure CAR traffic policing of egress interface packets based on DSCP code on a serial interface.

Limit rates of traffic conforming to ACLs to 256 kbps, 200 kbps, 128 kbps, 64 kbps, and 32 kbps.

```
interface Serial1/0
ip address 192.168.20.3 255.255.255.0
encapsulation ppp
rate-limit output dscp 46 256000 5000 5000 conform-action  transmit exceed-action
set-dscp-transmit 46
rate-limit output dscp 10 200000 3000 3000 conform-action  transmit exceed-action
set-prec-transmit 5
rate-limit output dscp 18 128000 3000 3000 conform-action  transmit exceed-action
set-prec-transmit 1
rate-limit output dscp 20 64000 3000 3000 conform-action  transmit exceed-action  drop
```

Note

Do not set **token bucket** to a value that is too small. Otherwise, the system automatically adjust **token bucket** to a default value.
If you do not need to use the exceeding token bucket algorithm, you need to set the value of **Burst-normal** to be equal to or greater than the value of **burst-max**. If is normally feasible when the value of **Burst-normal** is equal to the value of **burst-max**.

Configuration Tasks of Traffic Policing on a Policy-Map

In the following examples, traffic policing based on policy maps is enabled for egress interface traffic satisfying conditions, and rate limit is enabled for each type of traffic using the single-rate two-token-buckets algorithm.

```
access-list 101 permit udp any any eq 100
access-list 102 permit udp any any eq 200
access-list 103 permit udp any any eq 300
access-list 104 permit udp any any eq 400
!
class-map match-all a1
match access-group 101
class-map match-all a2
match access-group 102
class-map match-all a3
match access-group 103
```

```
class-map match-all a4
match access-group 104
!
policy-map police
class a1
police cir 80000 2000 2000 conform-action transmit exceed-action drop violate-action drop
class a2
police cir 160000 2000 2000 conform-action transmit exceed-action drop violate-action drop
class a3
police cir 320000 6000 6000 conform-action transmit exceed-action drop violate-action drop
class a4
police cir 640000 6000 6000 conform-action transmit exceed-action drop violate-action drop
!
interface Serial1/0
ip address 192.168.20.3 255.255.255.0
encapsulation ppp
service-policy output police
```

In the following examples, traffic policing based on policy maps is enabled for egress interface traffic satisfying conditions, and rate limit is enabled for each type of traffic using the two-rate two-token-bucket algorithm.

```
!
policy-map police
class a1
police cir 80000 pir 100000 2000 2000 conform-action transmit exceed-action drop violate-action
drop
class a2
police cir 160000 pir 200000 2000 2000 conform-action transmit exceed-action drop
violate-action drop
class a3
police cir 320000 pir 400000 6000 6000 conform-action transmit exceed-action drop
violate-action drop
class a4
police cir 640000 pir 700000 6000 6000 conform-action transmit exceed-action drop
violate-action drop
!
interface Serial1/0
ip address 192.168.20.3 255.255.255.0
encapsulation ppp
service-policy output police
```

Configuration Examples of Traffic Shaping

Configuration Examples of Traffic Shaping for Entire Traffic of an Interface

Configure GTS traffic shaping of egress interface packets on a serial interface.

Shape the egress interface traffic to 300 kbps. If the traffic conforms to the rate limit, the traffic is transmitted. If the traffic exceeds the rate limit, the traffic is discarded. In this way, traffic is shaped.

```
interface Serial1/0
ip address 192.168.20.3 255.255.255.0
encapsulation ppp
traffic-shape rate 300000 9000 9000 1000
```

Configuration Examples of Traffic Shaping for Traffic Satisfying Certain Conditions

In the following examples, GTS is configured for egress traffic that satisfies certain conditions:

Configure ACLs based on different TCP and UDP ports.

```
access-list 101 permit tcp any any eq 2065
access-list 102 permit udp any any range 16384 32767
access-list 103 permit tcp any any eq 1352
access-list 104 permit tcp any any eq www
access-list 105 permit tcp any any eq ftp-data
```

Configure GTS of egress interface packets based on ACLs on a serial interface.

```
# Shape rates of traffic conforming to ACLs to 256 kbps, 200 kbps, 128 kbps, 64 kbps, and 32
kbps.
interface Serial1/0
```

```
ip address 192.168.20.3 255.255.255.0
encapsulation ppp
traffic-shape group 101 256000 10240 10240 1000
traffic-shape group 102 200000 8000 8000 1000
traffic-shape group 103 128000 10240 10240 1000
traffic-shape group 104 64000 12800 12800 1000
traffic-shape group 105 32000 12800 12800 1000
```

Note

In traffic policing, tokens are updated in the token bucket every time packets enter the bucket.
In traffic shaping, tokens are updated in the token bucket at each fixed interval.
In traffic policing, you can configure processing polices for input and output packets at the ingress interface and egress interface.
In traffic shaping, buffering and rate limiting can be configured only for egress interface packets.

Configuration Tasks of Traffic Shaping on a Policy-Map

In the following examples, traffic shaping based on a policy map is enabled for egress interface traffic satisfying conditions, and traffic shaping is enabled for each type of traffic using the common single-token-bucket algorithm.

```
access-list 101 permit udp any any eq 100
!
class-map match-all a1
match access-group 101
!
policy-map shape
class a1
shape  average 100000
shape  max-buffers 200  //buffer size: 200
!
interface Serial1/0
ip address 192.168.20.3 255.255.255.0
encapsulation ppp
service-policy output shape
!
```

In the following examples, traffic shaping with a peak rate based on a policy map is enabled for egress interface traffic satisfying conditions, and traffic shaping with a peak rate is enabled for each type of traffic using the common single-token-bucket algorithm.

```
access-list 101 permit udp any any eq 100
!
class-map match-all a1
match access-group 101
!
policy-map shape
class a1
shape  peak 100000
shape  max-buffers 200  //buffer size: 200
!
interface Serial1/0
ip address 192.168.20.3 255.255.255.0
encapsulation ppp
service-policy output shape
!
```

Maintenance and Debugging of Traffic Policing and Shaping

To monitor status of traffic policing and shaping, run the following commands in the privileged user mode:

Command	Function
Ruijie# show rate-limit interfaces [*interface-name*]	Show the rate limit of an interface.
Ruijie# **show traffic-shape** [*interface-name*]	Show the traffic shaping configuration policy of an interface.
Ruijie# **show traffic-shape statistics** [interface-name]	Show the packet statistic information about an interface in actual traffic shaping.
Ruijie# **show traffic-shape queue**	Show the queue information of the entire traffic shaping policy that is configured.

The following are examples of **show rate-limit**:

```
Ruijie#show rate-limit
serial 1/0
Output
matches access-group 101
params:  256000 bps, 3000 limit, 3000 extended limit
conformed 0 packets, 0 bytes; action: transmit 0
exceeded 0 packets, 0 bytes; action: drop 0
cbucket 0, cbs 3000; ebucket 0 ebs 0
```

The following are examples of **show traffic-shape interfaces**:

Interval indicates the interval for updating the token bucket. It is set to 30 ms in this example.

Byte Limit indicates the packet count allowed to transmit per second. It is set to 2250 bytes in this example.

```
Ruijie#show traffic-shape
Interface serial 1/0
Access   Target    Byte   Sustain    Excess    Interval   Increment   Adapt
VC    List    Rate    Limit   bits/int   bits/int   (ms)    (bytes)     Active
-    -     300000       2250     9000     9000      30        1125    -
Ruijie#
```

The following are examples of **show raffic-shape statistics**:

```
Ruijie#show traffic-shape statistics
Interface serial 1/0
Acc. Queue   Packets   Bytes   Packets   Bytes      Shaping
List  Depth                 Delayed   Delayed    Active
  -    0          0     0      0     0         no
Ruijie#
```

The following are examples of **show traffic-shape queue**:

```
Ruijie#show traffic-shape queue
Traffic queued in shaping queue on serial 1/0
Traffic shape group: null
Queuing strategy: weighted fair
Output queue: 0/1000/64/0 (size/max total/threshold/drops)
Output queue num: 0/0 (now/max)
Ruijie#
```

To debug packet compression, run the following commands in the privileged user mode:

Command	Function
Ruijie# **debug tc in**	Debug the traffic control for ingress interface packets.
Ruijie# **debug tc out**	Debug the traffic control for egress interface packets.

Note

For routers of the RSR series, you can view the token information about fast-switching traffic shaping interfaces by running the **show queue interface** command. "Qos Ref queue information" identifies the fast-switching statistic information.
You can run the **show rate-limit interface** command to view traffic policing statistic information about fast-switching interfaces on routers of the RSR series.

Congestion Avoidance

Overview

Congestion avoidance techniques monitor network traffic loads in an effort to anticipate and avoid congestion at common network bottlenecks. Congestion avoidance is achieved through packet dropping. Among the more commonly used congestion avoidance mechanisms is Random Early Detection (RED), which is optimum for high-speed transit networks.

Overdue congestion brings great risks to network resources, and operations must be performed to eliminate congestion. Here, congestion avoidance indicates technologies used to monitor network traffic (such as queues and memory buffer) usage in an effort to avoid network overloading by initiatively dropping packets in the event of network congestion.

Traditional Packet-Drop Policy – Tail-Drop

Traditional packet-drop policy indicates tail-drop. Tail drop treats all traffic equally and does not differentiate between classes of service. Queues fill during periods of congestion. When the output queue is full and tail drop is in effect, packets are dropped until the congestion is eliminated and the queue is no longer full.

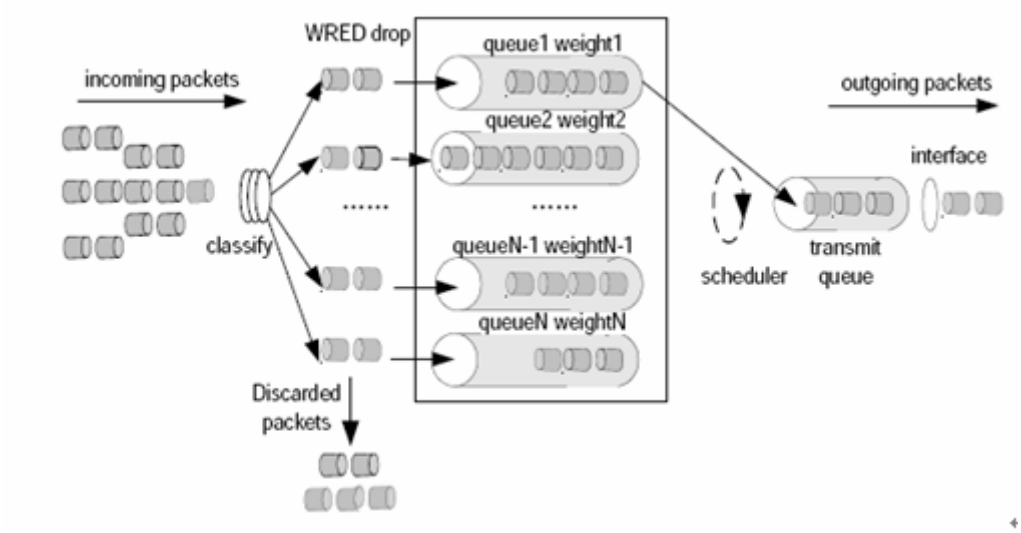
A host running TCP reduces the packet transmission rate when a lot of packets are lost and restore the packet transmission rate when the congestion is eliminated. This causes TCP global synchronization. When queues drop multiple TCP packets, hosts will reduce TCP traffic (referred to as slow start) in response, and then ramp up again simultaneously. When congestion is eased, traffic peaks occur. The two situations repeat one by one, causing cyclical periods of extreme congestion, followed by periods of under-utilization of the link.

RED and WRED

RED and WRED avoid TCP global synchronization by dropping packets randomly. When packets of a TCP connection are dropped and the transmission rate is reduced, other TCP connections still enjoy high transmission rates. In this case, there are TCP connections enjoy high transmission rates at any time, increasing the usage rate of line bandwidth.

Both RED and WRED randomly drop queued packets after comparing the length, maximum threshold, and minimum threshold of a queue (configuring absolute length of the queue threshold). This is unfair for burst traffic and adverse to transmission. Therefore, the relative length of a queue is compared with the maximum threshold and minimum threshold (configuring the relative value for comparison between the queue threshold and the average length) for dropping packets. The average length of the queue is obtained by using the low-pass filter. It reflects the queue change trend but stays insensitive to the burst change of queue length, avoiding unfair treatment of burst traffic. The following figure shows the relationship between WRED and the queue mechanism.

Figure 8



In algorithms of the RED type, each queue is configured with a pair of maximum threshold and minimum threshold values. RED will drop packets using one of three methods:

- **No drop** – used when the queue length is smaller than the minimum threshold.
- **Drop all** – used when the queue length is greater than the maximum threshold.
- **Drop based on the WRED algorithm** – used when the queue length is between the maximum threshold and the minimum threshold.

Specifically: A random number is assigned to each packet that arrives. The random number is compared with the current mark probability denominator (MPD) of the queue. Packets are dropped if the random number is greater than the current MPD. The MPD increases in proportion to queue length, but there is a maximum MPD.

Configuration Tasks of Congestion Avoidance (WRED) Based on an Interface

To configure congestion avoidance based on precedence for an interface, run the following commands in the interface configuration mode:

Command	Function
Ruijie(config)# **interface** *interface-type interface-number*	Specify an interface where congestion avoidance is to be enabled.
Ruijie(config-if)# **random-detect prec-based**	Enable congestion avoidance based on precedence for the entire traffic of an interface.

To configure congestion avoidance based on DSCP classification, for an interface, run the following commands in the interface configuration mode:

Command	Function
Ruijie(config)# **interface** *interface-type interface-number*	Specify an interface where congestion avoidance is to be enabled.
Ruijie(config-if)# **random-detect** *dscp-based*	Enable congestion avoidance based on DSCP for the entire traffic of an interface.

Note NPE80 does not support WRED congestion avoidance based on precedence and DSCP classification. NPE80 provides only the following command for enabling and disabling WRED:
Ruijie(config-if)# **random-detect**

Note To configure the interface congestion avoidance policy, ensure that the fast-switching function configuration (enable or disable the function) is consistent on all system interfaces. Otherwise, the congestion avoidance policy becomes invalid.

To configure the maximum threshold, the minimum threshold, and the MPD for each type of traffic based on DSCP classification, run the following commands in the interface configuration mode:

Command	Function
Ruijie(config)# **interface** *interface-type interface-number*	Specify an interface where congestion avoidance is to be enabled.
Ruijie(config-if)# **random-detect dscp** [*dscp-value*] [*min-threshold*] [*max-threshold*] [*mark-prob-denominator*]	Configure the maximum threshold, the minimum threshold, and the MPD for each type of traffic based on DSCP classification.

DSCP-value: indicates the value of DSCP. Traffic is classified based on this value.

Min-threshold: indicates the minimum drop threshold. The default values vary by traffic type.

Max-threshold: indicates the maximum drop threshold. The default values vary by traffic type.

Mark-prob-denominator: indicates the MPD that determines the number of packets that will be dropped. This is measured as a fraction, specifically 1/MPD. The greater the MPD is, the smaller the chance of each packet will be dropped. The default MPD is set to **10**, and one out of every 10 packets will be dropped. In other words, the chance of each packet being dropped is 10%.

To configure the maximum threshold, the minimum threshold, and the MPD for each type of traffic based on precedence classification, run the following commands in the interface configuration mode:

Command	Function
Ruijie(config)# **interface** *interface-type interface-number*	Specify an interface where congestion avoidance is to be enabled.
Ruijie(config-if)# **random-detect precedence** [*prec-value*] [*min-threshold*] [*max-threshold*] [*mark-prob-denominator*]	Configure the maximum threshold, the minimum threshold, and the drop probability for each type of traffic based on precedence classification.

Prec-value: indicates the value of Precedence. Traffic is classified based on this value.

Min-threshold: indicates the minimum drop threshold. The default values vary by traffic type.

Max-threshold: indicates the maximum drop threshold. The default values vary by traffic type.

Mark-prob-denominator: indicates the drop probability that determines the number of packets that will be dropped. This is measured as a fraction, specifically 1/MPD. The greater the MPD is, the smaller the chance of each packet will be dropped. The default MPD is set to **10**, and one out of every 10 packets will be dropped. In other words, the chance of each packet being dropped is 10%.

Note

NPE80 does not support WRED congestion avoidance based on precedence and DSCP classification. You can run the following command to set the maximum threshold and the minimum threshold:
Ruijie(config-if)# **random-detect** [*min-threshold*] [*max-threshold*] [*mark-prob-denominator*]

To configure the weighting factor of congestion avoidance for an interface, run the following commands in the interface configuration mode:

Command	Function
Ruijie(config)# **interface** *interface-type interface-number*	Specify an interface where congestion avoidance is to be enabled.
Ruijie(config-if)# **random-detect exponential-weighting-constant** [*exponential-value*]	Configure the weighting factor of congestion avoidance for an interface.

Exponential-value: indicates the weighting factor. The default value is **9**. The greater the value is, the smaller the MPD is.

Note

If the queueing algorithm of an interface is not FIFO, you need to cancel the current queueing algorithm before configuring WRED congestion avoidance for the interface.

Configuration Tasks of Congestion Avoidance (WRED) Based on a Policy-Map

Note

NPE80 does not support congestion avoidance (WRED) based on a policy-map.

To configure congestion avoidance based on precedence for a policy-map, run the following commands:

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Access and create a policy-map.
Ruijie(config-pmap)# **class** *class-map-name*	Use class-maps that have been defined.
Ruijie(config-if)# **random-detect prec-based**	Enable congestion avoidance based on precedence for the entire traffic of an interface.

To configure congestion avoidance based on DSCP classification for a policy-map, run the following commands:

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Access and create a policy-map.
Ruijie(config-pmap)# **class** *class-map-name*	Use class-maps that have been defined.
Ruijie(config-if)# **random-detect dscp-based**	Enable congestion avoidance based on DSCP for the entire traffic of an interface.

To configure the maximum threshold, the minimum threshold, and the MPD for each type of traffic based on DSCP classification, run the following commands:

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Access and create a policy-map.
Ruijie(config-pmap)# **class** *class-map-name*	Use class-maps that have been defined.

Ruijie(config-if)# **random-detect dscp** [*dscp-value*] [*min-threshold*] [*max-threshold*] [*mark-prob-denominator*]	Configure the maximum threshold, the minimum threshold, and the MPD for each type of traffic based on DSCP classification.

DSCP-value: indicates the value of DSCP. Traffic is classified based on this value.

Min-threshold: indicates the minimum drop threshold. The default values vary by traffic type.

Max-threshold: indicates the maximum drop threshold. The default values vary by traffic type.

Mark-prob-denominator: indicates the drop probability that determines the number of packets that will be dropped. This is measured as a fraction, specifically 1/MPD. The greater the MPD is, the smaller the chance of each packet will be dropped. The default MPD is set to **10**, and one out of every 10 packets will be dropped. In other words, the chance of each packet being dropped is 10%.

To configure the maximum threshold, the minimum threshold, and the MPD for each type of traffic based on precedence classification, run the following commands:

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Access and create a policy-map.
Ruijie(config-pmap)# **class** *class-map-name*	Use class-maps that have been defined.
Ruijie(config-if)# **random-detect precedence** [*prec-value*] [*min-threshold*] [*max-threshold*] [*mark-prob-denominator*]	Configure the maximum threshold, the minimum threshold, and the MPD for each type of traffic based on precedence classification.

Prec-value: indicates the value of Precedence. Traffic is classified based on this value.

Min-threshold: indicates the minimum drop threshold. The default values vary by traffic type.

Max-threshold: indicates the maximum drop threshold. The default values vary by traffic type.

Mark-prob-denominator: indicates the drop probability that determines the number of packets that will be dropped. This is measured as a fraction, specifically 1/MPD. The greater the MPD is, the smaller the chance of each packet will be dropped. The default MPD is set to **10**, and one out of every 10 packets will be dropped. In other words, the chance of each packet being dropped is 10%.

To configure the weighting factor of congestion avoidance for a policy-map, run the following commands:

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Access and create a policy-map.
Ruijie(config-pmap)# **class** *class-map-name*	Use class-maps that have been defined.
Ruijie(config-if)# **random-detect exponential-weighting-constant** [*exponential-value*]	Configure the weighting factor of congestion avoidance for an interface.

Exponential-value: indicates the weighting factor. The default value is **9**. The greater the value is, the smaller the drop probability is.

Configuration Examples of Congestion Avoidance (WRED)

Configuration Examples of Congestion Avoidance for Entire Traffic of an Interface

In the following examples, WRED congestion avoidance is configured on a SYNC interface:

Configure WRED congestion avoidance based on precedence classification for packets on a serial interface.

Set that the minimum threshold to **5**, maximum threshold to **100**, and MPD to **10** for traffic with precedence 1.

Set that the minimum threshold to **10**, maximum threshold to **100**, and MPD to **10** for traffic with precedence 2.

Set that the minimum threshold to **20**, maximum threshold to **100**, and MPD to **10** for traffic with precedence 3.

Set that the minimum threshold to **30**, maximum threshold to **100**, and MPD to **10** for traffic with precedence 4.

```
interface Serial1/0
ip address 192.168.20.3 255.255.255.0
encapsulation ppp
random-detect
random-detect precedence 1 5 100 10
random-detect precedence 2 10 100 10
random-detect precedence 3 20 100 10
random-detect precedence 4 30 100 10
```

Configuration Examples of Congestion Avoidance on a Policy-Map

In the following examples, WRED congestion avoidance is configured on a SYNC interface:

Configure WRED congestion avoidance based on policy-map classification for packets on a serial interface.

Set that the minimum threshold to **5**, maximum threshold to **100**, and MPD to **10** for traffic with DSCP af11.

Set that the minimum threshold to **10**, maximum threshold to **100**, and MPD to **10** for traffic with DSCP af21.

Set that the minimum threshold to **20**, maximum threshold to **100**, and MPD to **10** for traffic with DSCP af31.

Set that the minimum threshold to **30**, maximum threshold to **100**, and MPD to **10** for traffic with DSCP af41.

```
access-list 101 permit udp any any eq 100
access-list 102 permit udp any any eq 200
access-list 103 permit udp any any eq 300
access-list 104 permit udp any any eq 400
class-map match-any b1
match access-group 101
match access-group 102
class-map match-any b2
match access-group 103
match access-group 104
policy-map random
class b1
bandwidth 900
random-detect dscp-base
random-detect dscp af11 5 100 10
random-detect dscp af21 10 100 10
class b2
bandwidth 900
random-detect dscp-base
random-detect dscp af31 20 100 10
random-detect dscp af41 30 100 10
interface Serial1/0
ip address 192.168.20.3 255.255.255.0
encapsulation ppp
service-policy output random
```

Maintenance of Congestion Avoidance

The following section describes maintenance of congestion avoidance based on an interface:

```
Ruijie# show queue interface s 1/2
Current random-detect configuration:
serial 1/2
Queuing strategy: random early detection (WRED)
Exp-weight-constant: 9 (1/512)
Mean queue depth: 81407
Avg arrive time: 3000
class          Random drop     Tail drop    Minimum Maximum  Mark
pkts/bytes      pkts/bytes    thresh  thresh  prob
0     0/0     0/0     20     40     1/10
1     336/81312     6174/1494108     5     100     1/10
2     288/69696     6168/1492656     10     100     1/10
3     238/57596     6175/1494350     20     100     1/10
4     112/27104     6321/1529682     30     100     1/10
5     0/0     0/0     31     40     1/10
6     0/0     0/0     33     40     1/10
7     0/0     0/0     35     40     1/10
Ruijie#
```

The following section describes maintenance of congestion avoidance based on a policy-map:

```
Ruijie# show policy-map interface s 1/2
serial 1/2  output : random1
Class b1
Current random-detect configuration:
Exp-weight-constant: 9 (1/512)
Mean queue depth: 65529
Avg arrive time: 3000
class       Random drop     Tail drop    Minimum Maximum  Mark
```

```
pkts/bytes      pkts/bytes   thresh  thresh  prob
0     0/0     0/0     20     40     1/10
1     739/178838     0/0     5     100     1/10
2     614/148588     0/0     10     100     1/10
3     0/0     0/0     26     40     1/10
4     0/0     0/0     28     40     1/10
5     0/0     0/0     31     40     1/10
6     0/0     0/0     33     40     1/10
7     0/0     0/0     35     40     1/10
Class b2
Current random-detect configuration:
Exp-weight-constant: 9 (1/512)
Mean queue depth: 65530
Avg arrive time: 3000
class     Random drop     Tail drop   Minimum Maximum  Mark
pkts/bytes      pkts/bytes   thresh  thresh  prob
0     0/0     0/0     20     40     1/10
1     0/0     0/0     22     40     1/10
2     0/0     0/0     24     40     1/10
3     394/95348     0/0     20     100     1/10
4     68/16456     0/0     30     100     1/10
5     0/0     0/0     31     40     1/10
6     0/0     0/0     33     40     1/10
7     0/0     0/0     35     40     1/10
serial 1/2  output : random1
Weighted Fair Queuing
Class b1
Output Queue: queue_num 265
Bandwidth 900 (kbps) Packets Matched 17188 Sended 5217 Max Thresh 64 (packets)
(discards/tail drops) 11971/489148 , weight 91
Class b2
Output Queue: queue_num 266
Bandwidth 900 (kbps) Packets Matched 17793 Sended 5218 Max Thresh 64 (packets)
(discards/tail drops) 12575/489148 , weight 91
Ruijie#
```

Configuring MPLS QOS

MPLS QOS

MPLS QoS provided by Ruijie Networks supports the following functions:

- Congestion management

Currently, MPLS experimental value based WFQ, CBWFQ, PQ and LLQ queues are supported.

- Traffic policing and traffic shaping

Currently, MPLS experimental value based car is supported to limit the bandwidth of data stream, specify actions for handling excess traffic, and limit traffic burst in respect of MPLS traffic shaping so that message flows can be transmitted at an even rate.

- Congestion avoidance

Currently, MPLS experimental value based RED and WERD are supported.

For more QoS related features, please refer to QoS configuration guideline

Congestion Management

Configuration of Weighted Fair Queuing (WFQ)

WFQ Configuration Tasks

When standard WFQ is used, the data packets will be classified through traffic. Ruijie routers currently support MPLS EXP value based traffic classification. WFQ allocates the same bandwidth for respective traffics. The traffic-based WFQ is also called fair queuing, as all traffic are provided with the same weight.

To configure WFQ, the following tasks need to be completed:

- Configuring WFQ
- Monitoring fair queuing

Note Since the flash configurations varies from router to router, it is suggested to use "fair-queue" command to configure different queue depth and numbers.

Configuring WFQ

To configure WFQ, execute the following commands in interface configuration mode:

Command	Function
Ruijie(config-if)# **fair-queue** [*congestive-discard-threshold* [*dynamic-queues*]]	Configure WFQ
Ruijie(config-if)# no fair-queue	Remove WFQ configurations

WFQ parameters:

Parameter	Description
congestive-discard-threshold	The maximum number of packets (threshold) allowed in each queue (64 by default). When the number of packets reaches this threshold, the incoming new packets will be discarded. (This parameter is optional)
dynamic-queues	Number of dynamic queues. Default: 256; scope: integer between 16 and 4096, and must be the power of 2. (This parameter is optional)

Note To configure WFQ congestion management policy on the interface, all interfaces of the system must enable fast forwarding function, otherwise this function will become invalid.

Note We can find out the WFQ congestion management configurations of fast-forward IP QoS and MPLS QoS are same. The two functions may overlap on LSP Egress device, and the current software version will give preference to the WFQ function of MPLS QoS under such a circumstance.

Monitoring WFQ

To view WFQ configurations of interface, execute the following commands in privileged user mode.

Command	Function
Ruijie# **show queue interface** *interface–name interface-number [queue-number]*	Display the QoS queue information on the designated network interface.

WFQ Configuration Examples

As shown below, configure fair queuing on the synchronization interface: congestion drop threshold (threshold) being 128 packets and dynamic queues being 512.

```
interface Serial 3/0
 ip ref
 ip address 192.168.200.1 255.255.255.0
 mpls ip
 fair-queue 128 512
An example of viewing interface configurations in privileged user mode is shown below:
Ruijie# show queue interface serial 3/0

  Queueing strategy: weighted fair
  Output queue: 0/300/128/0 (size/max total/threshold/drops)
  Output queue num: 0/0/512 (now active/max active/max total)

  Qos Ref queue information
  Current Policy(s) : WFQ
  interface cir: 2048000
  Queueing strategy: weighted fair
    Dequeue threshold:  Green 25000, Yellow 37500, Red 50000
    Queues: Queues total len 0, MeanBurst 800
    Queues: gts gap 7, deta bits 262, token bucket 51200
    Queues: Max 19353 pkts, used 0 pkts
    Queues: rtpQ: 0 pkts, 0 bytes
    Queues: llQ:  0 pkts, 0 bytes
    Queues: genQ: 0 pkts, 0 bytes
    wfq para: cir(2048000), delta(13/2080)
    wfq_tb para: cir(3938), delta(7/129)
    Output queue: 0/0(send/drops)
```

From the above messages, it can be observed that the queuing policy of interface adopts WFQ and the congestion drop threshold (threshold) is 128.

Configuration of Class-based Weighted Fair Queueing (CBWFQ)

CBWFQ Configuration Tasks

In order to configure CBWFQ, the following tasks need to be completed:

Configuring CBWFQ

Defining Class Maps

This function is required in order to realize CBWFQ function. The user can define network packet classifying policy in the class map, and use these class maps by specifying the name of class map in the policy map. The same class map can be used by one or more policy maps. The typical configurations of this function are shown below:

Command	Function
Ruijie(config)# **class-map** *match-all class-map-name*	Enter/create AND-type class map (to meet all conditions in the class map).
Ruijie(config)# **class-map match-any** *class-map-name*	Enter/create OR-type class map (to meet only one condition in the class map).
Ruijie(config-cmap)# **match mpls experimental** *value* or Ruijie(config-cmap)# **match qos-group** *value* Ruijie(config-cmap)# **match not** *match-type value*	Configure network packet classifying policy (according to the group ID of message, EXP value of MPLS message or the false condition of the abovementioned classifying policies.
Ruijie(config-cmap)# **exit**	Exit class map configuration layer

Class-map-name: name of class map;

Match-all: To meet all conditions in the class map; the default type of class map is Match-all;

Match-any: to meet only one condition in the class map;

Mpls Experimental: the value of Experimental field of MPLS packets;

Qos-group: group ID of packets;

Not match-type: false condition of classifying policy.

Configuring Class Policy in the Policy Map

This function is required in order to realize CBWFQ function. In the policy map, the user can use all class maps configured on the device (up to 64 different class maps). The user may allocate bandwidth for the class map used, but the total bandwidth allocated for all used class maps must not exceed the bandwidth allocated to CBWFQ by the interface applied with this policy map. The typical configurations of this function are shown below:

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Enter/create policy map
Ruijie(config-pmap)# **class** *class-map-name*	Use the class map defined.
Ruijie(config-pmap-c)# **bandwidth** { *bandwidth-kbps* | **percent** *percent-number* }	Allocate bandwidth for specific class of traffic
Ruijie(config-pmap-c)# **queue-limit** *number-of-packets*	Define queue depth
Ruijie(config-pmap-c)# **exit**	Exit class reference configuration layer
Ruijie(config-pmap)# **exit**	Exit policy map configuration layer

Policy-map-name: name of policy map;

Class-map-name: name of class map;

Bandwidth-kbps: bandwidth allocated (unit: kbps);

Percent-number: percentage of bandwidth allocated (in regard to all available bandwidth of network interface);

Number-of-packets: CBWFQ queue depth (maximum number of packets allowed).

Applying Service Policy on the Designated Interface

This function is required in order to realize CBWFQ function. Applying service policy on the designated interface will enable CBWFQ function, after which the class used by the corresponding policy map will have the corresponding queue. The typical configuration of this function is shown below:

Command	Function
Ruijie(config-if)# **service-policy output** *policy-map-name*	Enable CBWFQ and specify the policy map to be applied.

Policy-map-name: name of policy map.

Note	To configure policy map on the interface, all interfaces of the system must enable fast forwarding function, otherwise this function will become invalid.

Configuring Bandwidth for an Existing Class

This function is optional for CBWFQ. The typical configurations of this function are shown below:

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Enter/create policy map
Ruijie(config-pmap)# **class** *class-map-name*	Use the class map defined.
Ruijie (config-pmap-c)# **bandwidth** { *bandwidth-kbps* | **percent** *percent*}	Allocate bandwidth for specific class of traffic

Policy-map-name: name of policy map;

Class-map-name: name of class map;

Bandwidth-kbps: bandwidth allocated (unit: kbps);

Percent-number: percentage of bandwidth allocated (in regard to all available bandwidth of network interface);

The user may allocate bandwidth for the specific type of network traffic. By default, 1% of bandwidth is allocated to the specific type of network traffic.

Configuring the Queue Depth for an Existing Class

This function is optional for CBWFQ. The typical configurations of this function are shown below:

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Enter/create policy map
Ruijie(config-pmap)# **class** *class-map-name*	Use the class map defined.
Ruijie(config-pmap-c)# **queue-limit** *number-of-packets*	Define queue depth

Policy-map-name: name of policy map;

Class-map-name: name of class map;

Number-of-packets: CBWFQ queue depth (maximum number of packets allowed).

The user may configure queue depth for the corresponding CBWFQ queue of specific network traffic. The default value is 64, which means that after the corresponding CBWFQ queue has 64 packets, the system will discard subsequent network packets entering into this queue. By this time, Ruijie router only supports Tail-Drop congestion management instead of RED/WRED congestion management.

Configuring EXP Value of MPLS Message for an Existing Class

This function is optional for CBWFQ. The typical configurations of this function are shown below:

Command	Function

Ruijie(config)# **policy-map** *policy-map-name*	Enter/create policy map
Ruijie(config-pmap)# **class** *class-map-name*	Use the class map defined.
Ruijie(config-pmap-c)# **set mpls experimental** *exp-value*	Configure EXP Value of MPLS Message
Ruijie(config-pmap-c)# **set mpls experimental** *dscp*	Set mpls experimental value to ip dscp value
Ruijie(config-pmap-c)# **set mpls experimental** *precedence*	Set mpls experimental value to ip precedence value

Policy-map-name: name of policy map;

Class-map-name: name of class map;

Exp-values: EXP value of message to be configured.

Note	When MPLS experimental value configured is ip dscp, only the first three bits of dscp will be used for mapping.

Configure EXP Value of MPLS Message for an Existing Class (use table-map)

This function is optional for CBWFQ. The typical configurations of this function are shown below:

Command	Function
Ruijie(config)# **table-map** *table-map-name*	Enter/create table-map
Ruijie(config-tablemap)#**map from** *from-value* **to** *to-value*	Add mapping relationship into table-map
Ruijie(config-tablemap)#**default** { *default-value* | **copy** | **ignore** }	Specify the action of table-map when specifying unnecessary mapping relationship for table-map
Ruijie(config)# **policy-map** *policy-map-name*	Enter/create policy map
Ruijie(config-pmap)# **class** *class-map--name*	Use the class map defined.
Ruijie(config-pmap-c)# **set mpls experimental dscp table** *table-map-name*	Set mpls experimental value to ip dscp value according to the configuration of table-map
Ruijie(config-pmap-c)# **set mpls experimental precedence table** *table-map-name*	Set mpls experimental value to ip precedence value according to the configuration of table-map
Ruijie(config-pmap-c)# **set mpls experimental qos-group table** *table-map-name*	Set mpls experimental value to qos-group value according to the configuration of table-map

From-value: value mapped;

To-value: map value;

Default-value: default map value;

Table-map-name: name of table map;

Policy-map-name: name of policy map;

Class-map-name: name of class map;

Configuring DSCP Value of IP Message for an Existing Class

This function is optional for CBWFQ. The typical configurations of this function are shown below:

Command	Function

Ruijie(config)# **policy-map** *policy-map-name*	Enter/create policy map
Ruijie(config-pmap)# **class** *class-map-name*	Use the class map defined.
Ruijie(config-pmap-c)# **set dscp** dscp-*value*	Configure dscp Value of IP Message
Ruijie(config-pmap-c)# **set dscp experimental**	Set ip dscp to mpls experimental value

Policy-map-name: name of policy map;

Class-map-name: name of class map;

Dscp-values: dscp value of message to be configured.

 **Note**	When MPLS experimental value configured is ip dscp, only the first three bits of dscp will be used for mapping.

Configuring DSCP Value of IP Message for an Existing Class (use table-map)

This function is optional for CBWFQ. The typical configurations of this function are shown below:

Command	Function
Ruijie(config)# **table-map** *table-map-name*	Enter/create table-map
Ruijie(config-tablemap)#**map from** *from-value* **to** *to-value*	Add mapping relationship into table-map
Ruijie(config-tablemap)#**default** { *default-value* | **copy** | **ignore** }	Specify the action of table-map when specifying unnecessary mapping relationship for table-map
Ruijie(config)# **policy-map** *policy-map-name*	Enter/create policy map
Ruijie(config-pmap)# **class** *class-map-name*	Use the class map defined.
Ruijie(config-pmap-c)# **set dscp experimental table** *table-map-name*	Set ip dscp to mpls experimental value according to the configuration of table-map
Ruijie(config-pmap-c)# **set dscp qos-group table** *table-map-name*	Set ip dscp to qos-group value according to the configuration of table-map

From-value: value mapped;

To-value: map value;

Default-value: default map value;

Table-map-name: name of table map;

Policy-map-name: name of policy map;

Class-map-name: name of class map;

Configuring Precedence Value of IP Message for an Existing Class

This function is optional for CBWFQ. The typical configurations of this function are shown below:

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Enter/create policy map
Ruijie(config-pmap)# **class** *class-map-name*	Use the class map defined.

Ruijie(config-pmap-c)# **set precedence** prec-*value*	Configure prec Value of IP Message
Ruijie(config-pmap-c)# **set precedence experimental**	Set ip prec to mpls experimental value

Policy-map-name: name of policy map;

Class-map-name: name of class map;

Prec-values: precedence value of message to be configured.

Configuring Precedence Value of IP Message for an Existing Class (use table-map)

This function is optional for CBWFQ. The typical configurations of this function are shown below:

Command	Function
Ruijie(config)# **table-map** *table-map-name*	Enter/create table-map
Ruijie(config-tablemap)#**map from** *from-value* **to** *to-value*	Add mapping relationship into table-map
Ruijie(config-tablemap)#**default** { *default-value* | **copy** | **ignore** }	Specify the action of table-map when specifying unnecessary mapping relationship for table-map
Ruijie(config)# **policy-map** *policy-map-name*	Enter/create policy map
Ruijie(config-pmap)# **class** *class-map-name*	Use the class map defined.
Ruijie(config-pmap-c)# **set precedence experimental table** *table-map-name*	Set ip prec to mpls experimental value according to the configuration of table-map
Ruijie(config-pmap-c)# **set precedence qos-group table** *table-map-name*	Set ip prec to qos-group value according to the configuration of table-map

From-value: value mapped;

To-value: map value;

Default-value: default map value;

Table-map-name: name of table map;

Policy-map-name: name of policy map;

Class-map-name: name of class map;

Configuring Group ID of Message for an Existing Class

This function is optional for CBWFQ. The typical configurations of this function are shown below:

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Enter/create policy map
Ruijie(config-pmap)# **class** *class-map-name*	Use the class map defined.
Ruijie(config-pmap-c)# set qos-group group-*value*	Set the group ID of message
Ruijie(config-pmap-c)# **set qos-group dscp**	Set group ID of message to ip dscp value.
Ruijie(config-pmap-c)# **set qos-group precedence**	Set group ID of message to ip precedence value.
Ruijie(config-pmap-c)# **set qos-group mpls experimental**	Set group ID of message to mpls experimental value.

Ruijie(config-pmap-c)# **set qos-group cos**	Set group ID of message to cos value.

Policy-map-name: name of policy map;

Class-map-name: name of class map;

Group-values: group ID of message to be configured.

Configuring Group ID of Message for an Existing Class (use table-map)

This function is optional for CBWFQ. The typical configurations of this function are shown below:

Command	Function
Ruijie(config)# **table-map** *table-map-name*	Enter/create table-map
Ruijie(config-tablemap)#**map from** *from-value* **to** *to-value*	Add mapping relationship into table-map
Ruijie(config-tablemap)#**default** { *default-value* | **copy** | **ignore** }	Specify the action of table-map when specifying unnecessary mapping relationship for table-map
Ruijie(config)# **policy-map** *policy-map-name*	Enter/create policy map
Ruijie(config-pmap)# **class** *class-map-name*	Use the class map defined.
Ruijie(config-pmap-c)# **set qos-group dscp table** *table-map-name*	Set group ID of message to ip dscp value according to the configuration of table-map
Ruijie(config-pmap-c)# **set qos-group precedence table** *table-map-name*	Set group ID of message to ip precedence value according to the configuration of table-map
Ruijie(config-pmap-c)# **set qos-group mpls experimental table** *table-map-name*	Set group ID of message to mpls experimental value according to the configuration of table-map
Ruijie(config-pmap-c)# **set qos-group cos table** *table-map-name*	Set group ID of message to cos value according to the configuration of table-map

From-value: value mapped;

To-value: map value;

Default-value: default map value;

Table-map-name: name of table map;

Policy-map-name: name of policy map;

Class-map-name: name of class map;

Configuring the Bandwidth Allocated to CBWFQ

This function is optional for CBWFQ. The typical configurations of this function are shown below:

Command	Function
Ruijie(config-if)# **max-reserved-bandwidth** *percent*	Configure the Bandwidth Allocated to CBWFQ

Percent: Percentage of bandwidth allocated to CBWFQ on the existing network interface.

The user may allocate the available bandwidth percentage allocated to CBWFQ. The default value is 75, which means 75% of gross available bandwidth of network interface will be allocated to CBWFQ.

Monitoring CBWFQ

When CBWFQ becomes valid on a specific interface, to display input and output queues, the user can execute the following commands in privileged user mode:

Command	Function
Ruijie# **show class-map**	Display all class maps
Ruijie# **show class-map** *class-map-name*	Display the information of a specific class map
Ruijie# **show policy-map**	Display all policy maps
Ruijie# **show policy-map name** *policy-map –name*	Display the information of a specific policy map
Ruijie# **show policy-map name** *policy-map-name* class *class-name*	Display a specific class map in a specific policy map
Ruijie# **show policy-map interface** *Interface-name interface-number*	Display the policy map applied on a specific network interface
Ruijie# **show queue** *interface-name interface-number*	Display the QoS queue information on the designated network interface.

Class-map-name: name of class map;

Policy-map-name: name of policy map;

Interface-name: name of network interface;

Interface-number: network interface ID.

CBWFQ Configuration Examples

The following example shows how to configure MPLS Experimental based CBWFQ congestion management policy on the synchronization interface:

```
class-map 101
match mpls experimental 1
class-map 102
match mpls experimental 2
class-map 103
match mpls experimental 3
!
policy-map 1
 class 101
  bandwidth 600
 class 102
  bandwidth 400
 class 103
  bandwidth 200
!
interface Serial 3/0
 ip ref
 ip address 192.168.200.1 255.255.255.0
 mpls ip
 service-policy output 1
```

An example of viewing interface configurations in privileged user mode is shown below:

```
Ruijie# show queue interface serial 3/0

  Queueing strategy: cb weighted fair
  Output queue: 0/300/128/0 (size/max total/threshold/drops)
   cb queue_num  0/0 (active/max active)
   wfq queue_num  0/0 (active/max active)
     Reserved queue_num 3/3 (allocated/max allocated)
     Llq is close

  Qos Ref queue information
  Current Policy(s) : CBWFQ
  interface cir: 2048000
  Queueing strategy: cb weighted fair
   Dequeue threshold:  Green 25000, Yellow 37500, Red 50000
```

```
  Queues: Queues total len 0, MeanBurst 800
  Queues: gts gap 7, deta bits 262, token bucket 51200
  Queues: Max 19353 pkts, used 0 pkts
  Queues: rtpQ: 0 pkts, 0 bytes
  Queues: llQ:  0 pkts, 0 bytes
  Queues: genQ: 0 pkts, 0 bytes
 Output Stat.: 0/0/ (send/drops)
  queue_num  128/256 (cb num/wfq num)
  cb packet Stat. 0/0 (send /drop)
  wfq packet Stat. 0/0 (send /drop)
    Reserved queue_num 3/3 (allocated/max allocated)
    Llq is close
```

Configuration of Custom Queueing (CQ)

CQ Configuration Tasks

Custom Queue configuration tasks are shown below:

Configuring CQ

CQ can configure up to 16 groups, namely the scope of List-number is 1-16. Each group specifies the type of queues that can be entered by different kinds of packets, queue length, and byte count that is allowed to be sent.

Determining the Maximum Capacity of Queue Adopting CQ

To configure the maximum packet capacity for each queue, execute the following commands in global configuration mode:

Command	Function
Ruijie(config)# **queue-list** *list-number* **queue** *queue-number* **limit** *limit-number*	Specify the maximum number of packets allowed by each custom queue. The no form of this command can be used to restore the queue length to the default value of 20.
Ruijie(config)# **queue-list** *list-number* **queue** *queue-number* **byte-count** *byte-count-number*	Specify the number of bytes allowed by each queue. The no form of this command can be used to restore the byte count to the default value of 1500.

List-number: number of queue list (any number between 1-16);

Queue-number: queue number (any number between 1-16);

Limit-number: The maximum number of packets allowed by the queue, within the range being from 1 to 32767. The default value is 20.

Byte-count-number: Specify how many bytes of data should be delivered from the current queue by the system before the system moves on to the next queue. When a particular queue is being processed, packets are sent until the number of bytes sent exceeds the byte-count-number configured (within the range of 1 to 16777215, 1500 by default) or until the queue is empty. For how to determine the best byte count of data to be sent, please refer to the foregoing chapters.

Note To configure CQ congestion management policy on the interface, all interfaces of the system must disable the fast forwarding function, which is not supported by CQ congestion management policy.

Assigning Packets to CQ

You can assign the packets to custom queues based on the protocol type or the interface where the packets enter the device. Additionally, you can set the default queue for the packets that do not match other assignment rules. You can also specify multiple rules.

To define the CQ lists, use the following commands in global configuration mode:

Command	Function

Ruijie(config)# **queue-list** *list-number* **protocol** **mpls** *queue-number* [**experimental** *exp-value*]	Assign the packets to the specified custom queue based on the protocol type.

Therein, exp-value refers to MPLS experimental value.

Applying CQ List on the Interface

To apply a CQ list to an interface, use the following command in interface configuration mode:

Command	Function
Ruijie(config-if)# **custom-queue-list** *list-number*	Set the queuing policy of this interface to a specific CQ list.

Note	You can only specify one queuing policy for each interface, and only one queue list can be specified in the mean time.

Monitoring CQ

To display information about input and output queues when CQ is enabled on an interface, use the following commands in privileged user mode:

Command	Function
Ruijie# show queue cq	Display information about CQ.
Ruijie# **show queue interface** *interface-name interface-number* [*queue-number*]	Display information about CQ interface.
Ruijie# **debug qos cq**	Turn on the CQ debug switch if the priority queue is configured.

CQ Configuration Examples

Configure custom list 2, and assign packets with MPLS EXP value being 2 to queue number 12 :

```
Ruijie(config)# queue-list 2 protocol mpls 12 experimental 2
```

Configure custom list 1, and assign packets with MPLS EXP value being 5 to queue number 11:

```
Ruijie(config)# queue-list 1 protocol mpls 11 experimental 5
```

Apply custom list 1 configured previously to the synchronization interface:

```
Ruijie(config)# interface serial 0
Ruijie(config-if)# custom-queue-list 1
```

Configuration of Priority Queueing (PQ)

PQ Configuration Tasks

Priority Queue configuration tasks are shown below:

Configuring PQ

PQ can configure up to 16 groups, namely the scope of List-number is 1-16. Each group specifies the type of queues that can be entered by different kinds of packets, as well as the maximum number of packets allowed by each queue.

Determining the Maximum Capacity of Queue Adopting PQ

In the queue list of each group, there are four queues divided into high, medium, normal and low. The user may configure the maximum packet capacity of each queue. Execute the following commands in global configuration mode:

Command	Function
Ruijie(config)# **priority-list** *list-number* **queue-limit** *high-limit medium-limit normal-limit low-limit*	Specify the maximum number of packets allowed by each priority queue.

List-number: number of queue list (any number between 1-16);

The default length of priority queue is shown below:

Queue	Length
high	20
medium	40
normal	60
Low	80

Note To configure PQ congestion management policy on the interface, all interfaces of the system must enable fast forwarding function, otherwise this function will become invalid.

Assigning Packets to PQ

The system can specify multiple assignment rules. This list will be searched according to the sequence specified by priority-list until a matching protocol or interface type is found. When a matching entry is found, this packet will be allocated to the corresponding queue and the search will end. Packets failing to match other assignment rules can be allocated to the default queue. To specify the queue for assigning packets, execute the following command in global configuration mode:

Command	Function
Ruijie(config)# **priority-list** *list-number* **protocol mpls {high | medium | normal | low}** [**experiemtal** *exp-value*]	Assign packets to a specific PQ according to the EXP value of MPLS message.
Ruijie(config)# **priority-list** *list-number* **default {high | medium | normal | low}**	Assign packets matching no rules to the default PQ (normal).

Therein, List-number is the group ID of PQ, and exp-value refers to MPLS experimental value.

Applying PQ list on the Interface

To apply a PQ list to an interface, execute the following command in interface configuration mode:

Command	Function
Ruijie(config-if)# priority-group *list-number*	Set the queuing policy of this interface to a specific PQ list.

Note You can only specify one queuing policy for each interface, and only one queue list can be specified in the mean time.

Monitoring PQ

When PQ becomes valid on a specific interface, to display input and output queues, the user can execute the following commands in privileged user mode:

Command	Function

Ruijie# **show queue interface** *interface–name interface-number [queue-number]*	Display the PQ information on the designated network interface.

PQ Configuration Examples

Configure priority list 1, and allocate packets with MPLS EXP value being 7 to the medium PQ:
`priority-list 1 mpls experiemtal 7 medium`
Configure priority list 1, and allocate packets received by synchronization serial port to the medium PQ:
`priority-list 1 interface serial 1/1 medium`
Configure priority list 1, and allocate packets matching no rules in the priority list to the medium PQ:
`priority-list 1 default medium`
Configure priority list 1, and configure the length of high, medium, normal and low PQs to 10, 40, 60 and 80 respectively:
`priority-list 1 queue-limit 10 40 60 80`

Apply priority list 1 configured previously to the synchronization interface:
`interface Serial 3/0`

```
 ip ref
 ip address 192.168.200.1 255.255.255.0
 mpls ip
 priority-group 1
```

An example of viewing interface configurations in privileged user mode is shown below:

```
Ruijie# show queue interface serial 3/0

  Queueing strategy: priority-list 1
  Output queues: (queue #: size/max/send/drops)
  Output queue: high 0/20/0/0, medium 0/40/0/0, normal 0/60/0/0, low 0/80/0/0

  Qos Ref queue information
  Current Policy(s) : PQ
  Queueing strategy: priority-list 1
  interface cir: 2048000
  Dequeue threshold:  Green 25000, Yellow 37500, Red 50000
  Queues: Queues total len 0, MeanBurst 800
  Queues: gts gap 7, deta bits 262, token bucket 51200
  Queues: Max 19353 pkts, used 0 pkts
  Queues: rtpQ: 0 pkts, 0 bytes
  Queues: llQ:  0 pkts, 0 bytes
  Queues: genQ: 0 pkts, 0 bytes
  Threshold: MeanBurst 800, Priority LOW, Dec 4560, Inc 4560, Drop 16720
  Counter:   PriInc 0, PriDec 0, Drop 0
  Queues: Queues len 0, MeanBurst 800, gts token bucket 51200
  Queues: Max 19353 pkts, used 0 pkts, rtpQ: 0 pkts, 0 bytes. genQ: 0 pkts, 0 bytes
  (size/max/send/drops)
  high 0/0/0/0, medium 0/0/0/0, normal 0/0/0/0, low 0/0/0/0
```

Configuration of Low Latency Queuing (LLQ)

LLQ Configuration Tasks

LLQ configuration is performed jointly with CBWFQ configuration. To configure LLQ, the following tasks need to be done:

Configuring LLQ

To configure LLQ, execute the following commands in Policy-map command layer configuration mode:

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Enter/create policy map
Ruijie(config-pmap)# **class** *class-map-name*	Use the class map defined.
Ruijie (config-pmap-c)# **priority** { *bandwidth-kbps* | **percent** *percent*} [*Burst bytes*]	Allocate bandwidth for specific class of traffic

Ruijie(config-if)# **service-policy output** *policy-map-name*	Enable CBWFQ and specify the policy map to be applied.

Policy-map-name: name of policy map;

Class-map-name: name of class map;

Bandwidth-kbps: bandwidth allocated (unit: kbps);

Percent: percentage of bandwidth allocated (in regard to all available bandwidth of network interface);

The user may allocate bandwidth for the specific type of network traffic. By default, 1% of bandwidth is allocated to the specific type of network traffic.

Burst bytes: number of bytes allowed in a burst above the committed rate limit.

Note

Generally, the bandwidth allocation on the interface will be influenced by the following commands: Bandwidth (CBWFQ), Priority (LLQ), ip rtp priority (RTPQ), and max-reserved-bandwidth (interface). The total bandwidth depends on the "Bandwidth" command of interface. I.e., Bandwidth = max-reserved-bandwidth +default wfq bandwidth; max-reserved-bandwidth = bandwidth(policy-map) +priority(policy-map) +ip RTP priority

Note

To configure PQ congestion management policy on the interface, all interfaces of the system must enable fast forwarding function, otherwise this function will become invalid.

Monitoring LLQ

To view LLQ configurations of interface, execute the following command in privileged user mode.

Command	Function
Ruijie# **show policy-map** *interface-name interface-number*	Display the interface information of LLQ.

LLQ Configuration Examples

The following example shows how to configure a LLQ on the synchronization interface to serve packets with MPLS EXP value being 7:

```
class-map match-all 201
 match mpls experimental 7
!
policy-map 1
 class 201
  priority 30 2000
!
interface Serial 3/0
 ip ref
 ip address 192.168.200.1 255.255.255.0
 mpls ip
 service-policy output 1
```

An example of viewing interface configurations in privileged user mode is shown below:

```
Ruijie#show queue interface serial 3/0

  Queueing strategy: cb weighted fair
  Output queue: 0/300/128/0 (size/max total/threshold/drops)
   cb queue_num  0/0 (active/max active)
   wfq queue_num  0/0 (active/max active)
     Reserved queue_num 1/1 (allocated/max allocated)
     Llq is open

  Qos Ref queue information
```

```
Current Policy(s) : CBWFQ
interface cir: 2048000
Queueing strategy: cb weighted fair
 Dequeue threshold:  Green 25000, Yellow 37500, Red 50000
  Queues: Queues total len 0, MeanBurst 800
  Queues: gts gap 7, deta bits 262, token bucket 51200
  Queues: Max 19353 pkts, used 0 pkts
  Queues: rtpQ: 0 pkts, 0 bytes
  Queues: llQ:  0 pkts, 0 bytes
  Queues: genQ: 0 pkts, 0 bytes
 Output Stat.: 0/0/ (send/drops)
  queue_num  128/256 (cb num/wfq num)
  cb packet Stat. 0/0 (send /drop)
  wfq packet Stat. 0/0 (send /drop)
    Reserved queue_num 1/1 (allocated/max allocated)
    Llq is open
```

Traffic Policing and Traffic Shaping

Introduction to Traffic Policing and Traffic Shaping

In traffic policing, certain actions will be taken to limit the data rate of classified traffics entering the network.

Traffic shaping will restrict the burst of traffics, so that message flows can be transmitted at an even rate and the network traffic can maintain stable.

Traffic Policing Configuration Tasks

To configure Car traffic shaping on the interface, execute the following commands in interface configuration mode:

Command	Function
Ruijie(config)# **interface** *interface-type interface-number*	Specify the interface for Car traffic policing.
Ruijie(config-if)# **rate-limit {input | output} bps** *burst-normal burst-max* **conform-action** *action* **exceed-action** *action*	Applying rate limiting on all traffics entering the receiving interface or outgoing interface.

Input|output: The input or output data rate to be limited by the user.

Bps: Maximum data rate of the traffic desired by the user (unit: bps).

Burst-normal burst-max: Size of token bucket (unit: bytes).

Conform-action: Traffic handling policy under rate limitation.

Exceed-action: Data rate handling policy when rate limit is exceeded.

Action: Handling policy, including:

Continue to match the next policy

- Drop: drop the packet
- Set-mpls-exp-transmit: transmit this packet after setting mpls experimental field
- Set-mpls-exp-continue: after setting mpls experimental field, this packet continue to match the next policy
- Transmit: transmit this packet

Note To configure traffic policing on the interface, all interfaces of the system must enable fast forwarding function, otherwise this function will become invalid.

Traffic Shaping Configuration Tasks

To configure GTS traffic shaping on the interface, execute the following commands in the interface configuration mode:

Command	Function
Ruijie(config)# **interface** *interface-type interface-number*	Specify the interface for traffic shaping.
Ruijie(config-if)# **traffic-shape rate** *bit-rate* [*burst-size*] [*excess-burst-size*] [*buffer-limit*]	Carry out traffic shaping of all traffics on the interface.

Bit-rate: the maximum data rate to be shaped by the user (unit: bps).

Burst-size: the maximum traffic size that is permitted in each burst at each interval (unit: bit)

Excess-size: transient burst of traffic that the first interval can forward (unit: bit)

Buffer-limit: buffer size of gts buffer queue (default: 1000).

Note To configure traffic shaping on the interface, all interfaces of the system must enable fast forwarding function, otherwise this function will become invalid.

Note The traffic shaping policy handled by the system will function on the interface. When GTS has been configured for the interface, all related sub-interfaces of this interface must enable GTS, otherwise the traffic forwarding will become uneven on related sub-interfaces.

Note After traffic shaping is enabled on the interface, the burst traffic must be the integral multiple of the data transmitted at 10ms under traffic-shaping rate, otherwise the system will round off the burst traffic configuration parameters according to the data transmitted at 10ms under traffic-shaping rate, so that the parameters can become valid.

Configuring Traffic Policing under Policy-map

To configure single-rate Car traffic limiting in Policy-map, execute the following commands:

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Enter/create policy map
Ruijie(config-pmap)# **class** *class-map-name*	Use the class map defined.
Ruijie(config-pmap-c)# **police cir** *bps burst-normal burst-max* **conform-action** *action* **exceed-action** *action* **violate-action** *action*	Perform single-rate token bucket limiting of such traffics.
Ruijie(config-if)# **service-policy output** *policy-map-name*	Specify the policy map to be applied to the interface.

CIR: Maximum data rate of the traffic desired by the user (unit: CIR).

Burst-normal burst-max: Size of token bucket (unit: bytes).

Conform-action: Traffic handling policy under rate limitation.

Exceed-action: Data rate handling policy when rate limit is exceeded.

Violate-action: Traffic handling policy when the second token bucket rate limit is exceeded in the case of two token bucket system.

Action: Handling policy, including:

- Drop: drop the packet

- Set-mpls-exp-transmit: transmit this packet after setting mpls experimental field
- Transmit: transmit this packet

To configure dual-rate Car traffic limiting in Policy-map, execute the following commands:

Command	Function
Ruijie(config)# **policy-map** *policy-map-name*	Enter/create policy map
Ruijie(config-pmap)# **class** *class-map-name*	Use the class map defined.
Ruijie(config-pmap-c)# **police cir** *bps* **pir** *bps* *burst-normal burst-max* **conform-action** *action* **exceed-action** *action* **violate-action** *action*	Perform dual-rate token bucket limiting of such traffics.
Ruijie(config-if)# **service-policy output** *policy-map-name*	Specify the policy map to be applied to the interface.

CIR: Maximum data rate of the traffic desired by the user (unit: CIR).

PIR: Peak data rate of the traffic desired by the user (unit: CIR).

Burst-normal burst-max: Size of token bucket (unit: bytes).

Conform-action: Traffic handling policy under rate limitation.

Exceed-action: Data rate handling policy when rate limit is exceeded.

Violate-action: Traffic handling policy: when the second token bucket rate limit is exceeded in the case of two token bucket system.

Action: Handling policy, including:

- Drop: drop the packet
- Set-mpls-exp-transmit: transmit this packet after setting mpls experimental field
- Transmit: transmit this packet

Note There are four token bucket algorithms for rate limiting under policy-map. The user may select different token bucket algorithm according to different configurations.

Note Single token bucket algorithm: If violate-action is not configured and the value of burst-normal equals to the value of burst-max, the single token bucket algorithm is adopted.

Note Borrowing mode of single token bucket algorithm: If violate-action is not configured and the value of burst-normal is smaller than the value of burst-max, the borrowing mode of single bucket algorithm is adopted.

Note Single-rate token bucket algorithm: If violate-action is configured but pir is not configured, the single-rate dual token bucket algorithm is adopted.

Note Dual-rate token bucket algorithm: If both violate-action and pir are configured, the dual-rate dual token bucket algorithm is adopted.

Traffic Policing Configuration Examples

Example of Applying Traffic Policing on All Traffics on the Interface

Configure car traffic policing of incoming messages on Serial interface

Limit traffics on the receiving interface at 2Mbps; transmit conforming traffics after setting mpls experimental value to 2 and drop excess traffics.

```
interface Serial 3/0
 ip ref
 ip address 192.168.20.3 255.255.255.0
 mpls ip
 rate-limit input 2000000 3000 3000 conform-action set-mpls-exp-transmit 2 exceed-action  drop
```

An example of viewing interface configurations in privileged user mode is shown below:

```
Ruijie#show rate-limit interface serial 3/0
Serial 3/0
  Input
    matches all traffic
      params:  2000000 bps, 3000 limit, 3000 extended limit
      conformed 0 packets, 0 bytes; action: set mpls transmit
      exceeded 0 packets, 0 bytes; action: drop
      cbucket 6000, cbs 6000; ebucket 0 ebs 0
```

Example of Traffic Policing Configuration under Policy-map

The following example shows how to apply Policy-map based traffic limiting on conforming traffics on the outgoing interface. Single-rate dual token bucket algorithm is applied to limit each kind of traffic.

```
!
class-map match-all a1
match mpls experimental 1
class-map match-all a2
match mpls experimental 2
class-map match-all a3
match mpls experimental 3
class-map match-all a4
match mpls experimental 4
!
policy-map police
class a1
police cir 80000 2000 2000 conform-action transmit exceed-action drop violate-action drop
class a2
police cir 160000 2000 2000 conform-action transmit exceed-action drop violate-action drop
class a3
police cir 320000 6000 6000 conform-action transmit exceed-action drop violate-action drop
class a4
police cir 640000 6000 6000 conform-action transmit exceed-action drop violate-action drop
!
interface Serial 3/0
 ip ref
 ip address 192.168.20.3 255.255.255.0
 mpls ip
 service-policy output police
```

View interface configurations in privileged user mode:

```
Ruijie#show policy-map interface serial 3/0

Serial 3/0  output(tc policy): police
   Class a1
     current token tbf: TC_SRTMC
     params:  80000 bps, 2000 limit, 2000 extended limit , 0 pir
     conformed 0 packets, 0 bytes; action: transmit 0
     exceeded 0 packets, 0 bytes; action: drop 0
     violated 0 packets, 0 bytes; action: drop 0
     cbucket 2000, cbs 2000; ebucket 2000 ebs 2000
   Class a2
     current token tbf: TC_SRTMC
     params:  160000 bps, 2000 limit, 2000 extended limit , 0 pir
```

```
     conformed 0 packets, 0 bytes; action: transmit 0
     exceeded 0 packets, 0 bytes; action: drop 0
     violated 0 packets, 0 bytes; action: drop 0
     cbucket 2000, cbs 2000; ebucket 2000 ebs 2000
   Class a3
     current token tbf: TC_SRTMC
     params:  320000 bps, 6000 limit, 6000 extended limit , 0 pir
     conformed 0 packets, 0 bytes; action: transmit 0
     exceeded 0 packets, 0 bytes; action: drop 0
     violated 0 packets, 0 bytes; action: drop 0
     cbucket 6000, cbs 6000; ebucket 6000 ebs 6000
   Class a4
     current token tbf: TC_SRTMC
     params:  640000 bps, 6000 limit, 6000 extended limit , 0 pir
     conformed 0 packets, 0 bytes; action: transmit 0
     exceeded 0 packets, 0 bytes; action: drop 0
     violated 0 packets, 0 bytes; action: drop 0
     cbucket 6000, cbs 6000; ebucket 6000 ebs 6000
```

The following example shows how to apply Policy-map based traffic limiting on conforming traffics on the outgoing interface. Dual-rate dual token bucket algorithm is applied to limit each kind of traffic.

```
!
policy-map police
class a1
police cir 80000 pir 100000 2000 2000 conform-action transmit exceed-action drop violate-action
drop
class a2
police cir 160000 pir 200000 2000 2000 conform-action transmit exceed-action drop
violate-action drop
class a3
police cir 320000 pir 400000 6000 6000 conform-action transmit exceed-action drop
violate-action drop
class a4
police cir 640000 pir 700000 6000 6000 conform-action transmit exceed-action drop
violate-action drop
!
interface Serial 3/0
 ip ref
 ip address 192.168.20.3 255.255.255.0
 mpls ip
 service-policy output police
```

View interface configurations in privileged user mode:

```
Ruijie#show policy-map interface serial 3/0

Serial 3/0  output(tc policy): police
   Class a1
     current token tbf: TC_TRTMC
     params:  80000 bps, 2000 limit, 2000 extended limit , 100000 pir
     conformed 0 packets, 0 bytes; action: transmit 0
     exceeded 0 packets, 0 bytes; action: drop 0
     violated 0 packets, 0 bytes; action: drop 0
     cbucket 2000, cbs 2000; ebucket 2000 ebs 2000
   Class a2
     current token tbf: TC_TRTMC
     params:  160000 bps, 2000 limit, 2000 extended limit , 200000 pir
     conformed 0 packets, 0 bytes; action: transmit 0
     exceeded 0 packets, 0 bytes; action: drop 0
     violated 0 packets, 0 bytes; action: drop 0
     cbucket 2000, cbs 2000; ebucket 2000 ebs 2000
   Class a3
     current token tbf: TC_TRTMC
     params:  320000 bps, 6000 limit, 6000 extended limit , 400000 pir
     conformed 0 packets, 0 bytes; action: transmit 0
     exceeded 0 packets, 0 bytes; action: drop 0
     violated 0 packets, 0 bytes; action: drop 0
     cbucket 6000, cbs 6000; ebucket 6000 ebs 6000
   Class a4
     current token tbf: TC_TRTMC
```

```
     params:  640000 bps, 6000 limit, 6000 extended limit , 700000 pir
     conformed 0 packets, 0 bytes; action: transmit 0
     exceeded 0 packets, 0 bytes; action: drop 0
     violated 0 packets, 0 bytes; action: drop 0
     cbucket 6000, cbs 6000; ebucket 6000 ebs 6000
```

Traffic Shaping Configuration Examples

Example of Applying Traffic Shaping on All Traffics on the Interface

Configure GTS traffic shaping of outgoing messages on Serial interface

Shape traffics on the outgoing interface at 300kbps; transmit conforming traffics and put excess traffics in the buffer queue for later transmission.

```
interface Serial 3/0
 ip ref
 ip address 192.168.20.3 255.255.255.0
 mpls ip
 traffic-shape rate 2000000 40000 40000 1000
# View interface configurations in privileged user mode:
Ruijie#show traffic-shape serial 3/0
Interface Serial 3/0
      Access Target    Byte     Sustain   Excess    Interval  Increment Adapt
VC    List   Rate      Limit    bits/int  bits/int  (ms)      (bytes)   Active
-     -      2000000   10000    40000     40000     20        5000      -
```

Congestion Avoidance

Introduction to Congestion Avoidance

Congestion avoidance is deployed at the network bottle neck to effectively monitor network traffics and avoid anticipated congestion developed at the network bottle neck by dropping information packets. Among the extensive avoidance congestion mechanisms, the most widely applied RED (Random Early Detection) is optimal for a high-speed transmission network.

Excess congestion will cause great harms to network resources, and certain measures shall be taken accordingly. The Congestion Avoidance as mentioned herein refers to the mechanism of actively dropping packets when congestion is expected by monitoring how the network resources are utilized (such as queues or memory buffers), as so to alleviate the load on the network.

RED and WRED

Both RED and WRED avoid global TCP synchronization by randomly dropping packets. Thus, while the sending rates of some TCP sessions slow down after their packets are dropped, other TCP sessions remain at high sending rates. As there are always TCP sessions at high sending rates, link bandwidth is efficiently utilized.

Before dropping packets, both RED and WRED will compare the queue size with lower threshold and upper threshold (the absolute length of queue threshold), and this will result in the unequal treatment of burst traffics and compromise traffic transmission. Therefore, when dropping packets by comparing between lower threshold and upper threshold, the average size of queue will be adopted (this should be the relative value upon comparison between queue threshold and average size). The average queue size is the result of low pass filtering of queue size, and avoids the unequal treatment in the burst of queue size as it reflects the change tendency of queue and is not sensitive to the changes in queue size. The relationship between WRED and queuing mechanism is shown below:

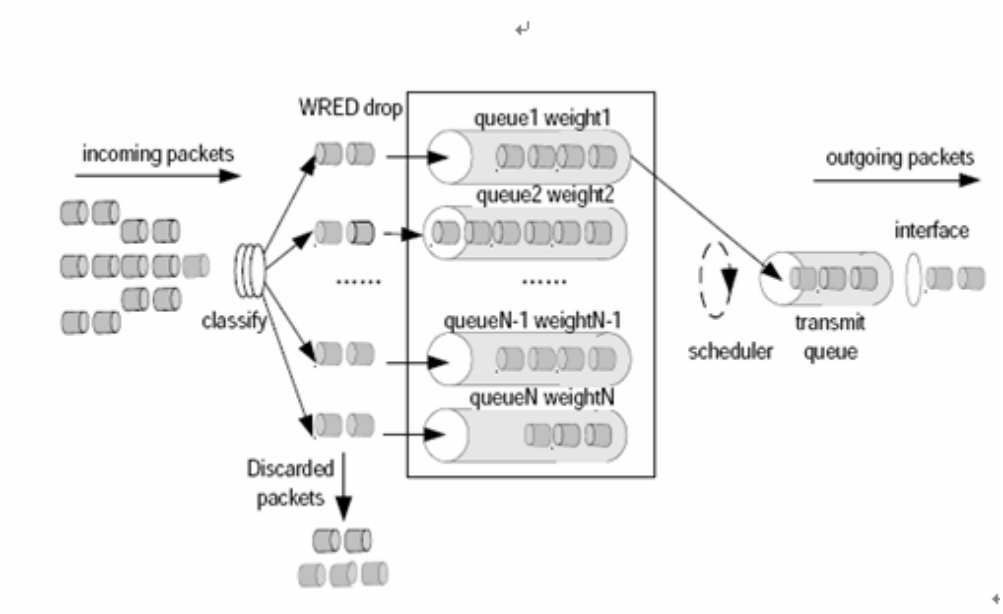


Figure 1

The RED algorithm sets upper and lower thresholds for each queue, and processes the packets in a queue as follows:

- When the queue size is shorter than the lower threshold, no packet is dropped;
- When the queue size reaches the upper threshold, all subsequent packets are dropped;
- When the queue size is between the lower threshold and the upper threshold, the WRED algorithm will be adopted to determine whether the packets will be dropped or not.

In practice, a random number will be assigned to each incoming packets, and this random number is compared with the drop probability of the existing queue. If this random number is larger than the drop probability, the packets will be dropped. The longer the queue is, the higher the drop probability will be. However, there will be a maximum drop probability.

Configure Congestion Avoidance

Congestion Avoidance (WRED) Configuration Tasks

To enable MPLS EXP value based congestion avoidance on the interface, execute the following command:

Command	Function
Ruijie(config-if)# **random-detect mpls-exp-based**	Enable congestion avoidance based on the EXP value of MPLS packets.

Note

To configure congestion avoidance on the interface, all interfaces of the system must enable fast forwarding function, otherwise this function will become invalid.

To configure the maximum threshold, minimum threshold and drop probability of each kind of traffics classified by experimental, execute the following commands in interface configuration mode:

Command	Function
Ruijie(config)# **interface** *interface-type interface-number*	Specify the interface for congestion avoidance.
Ruijie(config-if)# **random-detect experimental** *exp-value min-threshold max-threshold mark-prob-denominator*	Configure the maximum threshold, minimum threshold and drop probability of each kind of traffics classified by experimental.

Exp-value: experimental value; traffics are classified according to this value.

Min-threshold: the minimum drop threshold; the default value differs from traffic to traffic.

Max-threshold: the maximum drop threshold; the default value differs from traffic to traffic.

Mark-prob-denominator: drop probability; the default value is 10, i.e., 1/10. The larger this value is, the smaller the drop probability will be.

To configure the weight factor for traffic congestion avoidance on the interface, execute the following commands in privileged user mode:

Command	Function
Ruijie(config)# **interface** *interface-type interface-number*	Specify the interface for congestion avoidance.
Ruijie(config-if)# **random-detect exponential-weighting-constant** *exponential-value*	Configure the weight factor for traffic congestion avoidance on the interface.

Exponential-value: the default value of weight factor is 9; the smaller this value is, the larger the drop probability will be; the larger this value is, the smaller the drop probability will be.

Note

If the queuing algorithm of Ethernet interface is not FIFO, you must "no" the queuing algorithm before configuring WRED congestion avoidance on the interface. If the queuing algorithm of synchronization interface is not FIFO or WFQ, you must "no" the queuing algorithm before configuring WRED congestion avoidance on the interface.

Congestion Avoidance (WRED) Configuration Examples

Example of Configuring Congestion Avoidance on the Interface

Configure WRED congestion avoidance based on MPLS experimental traffic classification on the synchronization interface.

Set lower threshold to 5, upper threshold to 100 and drop probability to 10 for packets with experimental value being 1.

Set lower threshold to 10, upper threshold to 100 and drop probability to 10 for packets with experimental value being 2.

Set lower threshold to 20, upper threshold to 100 and drop probability to 10 for packets with experimental value being 3.

Set lower threshold to 30, upper threshold to 100 and drop probability to 10 for packets with experimental value being 4.

```
interface Serial 3/0
 ip ref
 ip address 192.168.20.3 255.255.255.0
 mpls ip
 random-detect mpls-exp-based
 random-detect experimental 1 5 100 10
 random-detect experimental 2 10 100 10
 random-detect experimental 3 20 100 10
 random-detect experimental 4 30 100 10
# View interface configurations in privileged user mode:
Ruijie#show queue interface serial 3/0

Current random-detect configuration:
   Serial 3/0
       Queueing strategy: random early detection (WRED)
       Exp-weight-constant: 9 (1/512)
       Mean queue depth: 0
class           Random drop     Tail drop    Minimum Maximum  Mark
                pkts/bytes      pkts/bytes    thresh  thresh  prob
0         0/0               0/0              20      40     1/10
1         0/0               0/0               5     100     1/10
2         0/0               0/0              10     100     1/10
3         0/0               0/0              20     100     1/10
4         0/0               0/0              30     100     1/10
5         0/0               0/0              31      40     1/10
6         0/0               0/0              33      40     1/10
7         0/0               0/0              35      40     1/10

  Qos Ref queue information
  Current Policy(s) : WRED
  Queueing strategy: random early detection (WRED)
  interface cir: 2048000
  Dequeue threshold:  Green 25000, Yellow 37500, Red 50000
  Queues: Queues total len 0, MeanBurst 800
  Queues: gts gap 7, deta bits 262, token bucket 51200
  Queues: Max 19353 pkts, used 0 pkts
  Queues: rtpQ: 0 pkts, 0 bytes
  Queues: llQ:  0 pkts, 0 bytes
  Queues: genQ: 0 pkts, 0 bytes
```

QoS Overview

Understanding QoS

QoS Overview

Devices on a conventional IP network equally treat all data packets with a First In First Out (FIFO) policy and deliver each data packet with the best effort to the destination. They do not provide any guarantee for packet transmission performance such as reliability and transmission delay.

As the Internet becomes rapidly popular in the globe and information networks emerge one after another in today's society, people raise increasingly-higher requirements for networks. Today, information requirements are no longer confined to mere data information but also extend to interactive multimedia. Services are developing towards data, voice, unified image, and integrated network transmission. Highly-real-time voice, image, and important data services sensitive to bandwidth delay and jitter tend to be more widely transmitted on networks. On one hand, this helps greatly improve network resources. On the other hand, an issue about how to guarantee network Quality of Service (QoS) arises, since voice, data, and image services have different delay, throughput, and packet loss rate requirements.

The QoS mechanism is intended to provide different QoS to meet diversified service quality requirements.

Basic Concepts

Three QoS models are defined to meet different service quality requirements. They are the Best-Effort Service model, the Integrated Service Model, and the Differentiated Service (DiffServ) model.

Best-Effort Service

The Best-Effort Service model enables a network to transmit packets with the best effort but does not provide any guarantee for transmission performance such as delay and reliability. It is a default service model applied on the conventional Internet.

Integrated Service

In the Integrated Service model, an application program needs to submit a specific QoS request to the network before sending a packet. The request covers the required bandwidth and delay. The application program starts to send the packet only after receiving an acknowledgment from the network (that is, after the network reserves resources for the application program). In addition, packets sent by the application program must be controlled within the traffic range described by traffic parameters.

Differentiated Service

In the Differentiated Service model, an application program does not need to submit a resource request to the network before sending a packet. Instead, it sets QoS parameter information in the IP header of the packet to inform network nodes of its QoS requirements. All routers on the packet propagation path can analyze the IP header to obtain the QoS class of the packet.

Working Principles

Major QoS technologies include traffic classification, traffic policing, traffic shaping, congestion management, and congestion avoidance. The Integrated Service model also introduces a protocol called the Resource Reservation Protocol (RSVP).

Traffic Classification

Objects are identified based on certain matching rules. Traffic classification is a precondition for implementing differentiated services.

Traffic Policing

Traffic policing is used to monitor and control the specifications of specific traffic inbound to routers. It applies when traffic goes beyond specifications.

Traffic Shaping

Traffic shaping is a means to control traffic by actively adjusting the output rate of traffic. In general, it enables traffic to adapt to available network resources on the downstream router so as to avoid packet loss or congestion.

Congestion Management

Congestion management is a measure for solving resource contention in the event of network congestion. In general, packets are cached in queues and a certain scheduling algorithm is applied to arrange the forwarding sequence of packets.

Congestion Avoidance

Excessive congestion will cause great harm to network resources.

RSVP

RSVP is an end-to-end (E2E) resource reservation protocol. Resource requests are transmitted between network nodes. Upon receipt of these requests, a network node needs to allocate resources for these requests.

Ruijie QoS mechanism supports the DiffServ model. The following sections describe how to configure QoS technologies.

Traffic Classification Configuration

Understanding Traffic Classification

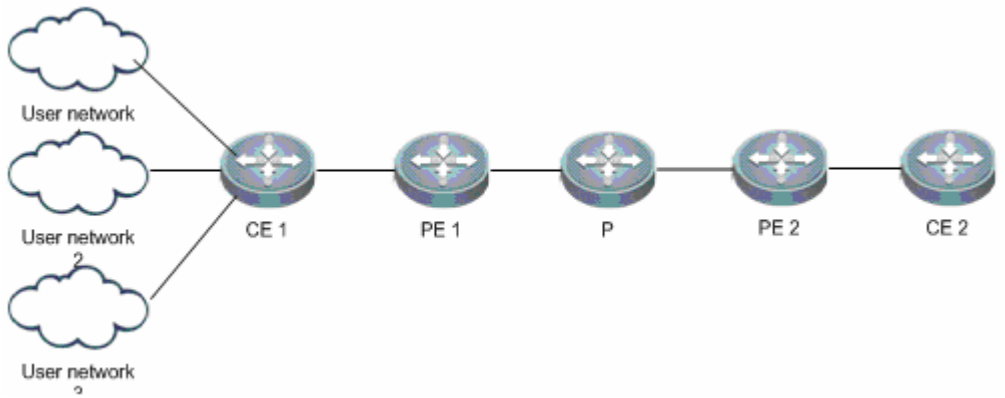
Traffic Classification Overview

When the DiffServ model is applied for QoS implementation, routers need to identify various flows and therefore traffic classification must be performed for packets. Two methods can be used for traffic classification: complex traffic classification and simple traffic classification.

Complex traffic classification is a means to classify packets in a fine manner using complex rules, such as rules based on link layer, network layer, and transport layer information (e.g. source MAC address, destination MAC address, source IP address, destination IP address, user group number, protocol type, or TCP/UDP port number of applications). In general, complex traffic classification is applied to traffic on border routers in the DiffServ domain.

As shown in Figure 9, CE 1, PE 1, P, PE 2, and CE 2 form a service provider network. PE 1, P, and PE 2 establish MPLS neighbors with each other. User networks 1, 2, and 3 access an MPLS network from CE 1 which is a service provider edge device. The traffic of user networks accesses the MPLS network from CE 1. Priority remarking must be performed for traffic of the three user networks, so that the traffic of different users is processed on the MPLS network according to different priorities. CE 1 must support complex traffic classification and related policies in terms of QoS.

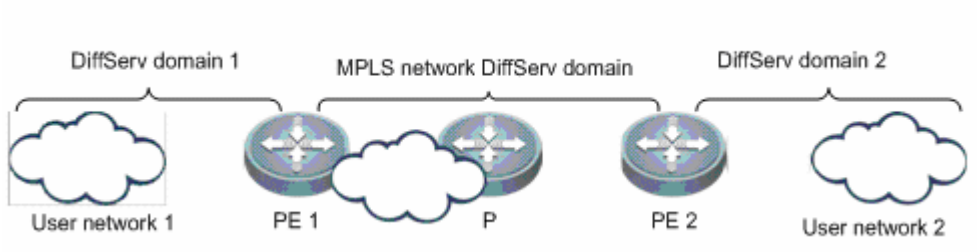
Figure 9 QoS Mapping for User Network Traffic Accessing an MPLS Network



Simple traffic classification is a means to roughly classify packets using simple rules, such as the IP priority or DSCP value of an IP packet, the EXP value of an MPLS packet, or the 802.1p value of a VLAN packet, so as to identify traffic featuring different priorities or Classes of Service (CoSs). In general, simple traffic classification is applied only on core routers in the DiffServ domain.

As shown in Figure 10, PE 1, P, and PE 2 form a backbone network and establish MPLS neighbors with each other. User networks 1 and 2 access the backbone network from the PE. The traffic of user network 1 reaches user network 2 through the backbone network. Service priority mapping must be performed for services between different DiffServ domains.

Figure 10 QoS Mapping for User Network Traffic Across an MPLS Network



Basic Concepts

QoS Priority

Services are classified by QoS requirements into eight types. Packets are first classified and marked after accessing the system. They are treated differently according to packet priorities on the entire forwarding path. The following table defines service priorities.

Table 1 Service Priorities

Code	Service Level		Description
7	CS7		Used for in-band control messages, it represents the highest priority.
6	CS6		Used for protocol packets on the control plane, such as routing protocol packets and Bidirectional Forwarding Detection (BFD) packets.
5	EF (Expedited Forwarding)		Used for services sensitive to delay, jitter, and the packet loss rate, such as VoIP/TDM service packets.
4	AF4	Assured Forwarding	Such services are surely forwarded when they do not exceed the maximum allowed bandwidth. Once the maximum bandwidth is exceeded, however, some packets will be discarded according to a discard priority. Such services are further classified into four types, and different bandwidths are allocated to different service types.
3	AF3		
2	AF2		
1	AF1		

0	BE (Best Effort)	Used for services insensitive to delay, jitter, and the packet loss rate, such as web, FTP, and other Internet services.

QoS Coloring

RFC 2697 and RFC 2698 have defined a service coloring mechanism, which uses three colors Green, Yellow, and Red to implement traffic control for services.

The system colors services based on different service policies to implement different packet discard polices.

Traffic Classifier

In complex traffic classification, it is necessary to define classifiers for various service flows, including classifiers based on different network features such as IPv4, IPv6, MPLS, and VLAN.

In simple traffic classification, traffic classifiers are used to classify traffic based on priorities only, such as DSCP for an IP network, EXP for an MPLS network, and CoS for an 802.1P network.

Traffic Behavior

In complex traffic classification, It is necessary to define the behaviors of various flows, such as Hierarchical QoS (HQoS) marking, priority re-marking, and QoS marking. QoS marking includes priority marking and packet coloring.

In simple traffic classification, however, traffic behaviors support only QoS marking and priority marking.

Traffic Policy

In complex traffic classification, traffic policies are used to associate traffic classifiers with traffic behaviors. One traffic policy can be used to associate multiple traffic classifiers with traffic behaviors so as to perform different operations for different service flows.

In simple traffic classification, a traffic policy consists of an uplink traffic classification mapping table and a downlink traffic classification mapping table. The uplink traffic classification mapping table implements mapping between priorities and QoS levels, whereas the downlink traffic classification mapping table implements mapping from QoS levels to priorities.


Caution

Simple traffic classification supports mapping between service priorities, CoSs, and discard priorities so as to implement priority bearing and mapping for inter-domain devices.


Caution

In complex traffic classification, priority marking supports only traffic policies for traffic classification and behaviors on homogeneous networks. For example, the system can perform MPLS priority marking after matching packets with MPLS traffic features.

DiffServ Domain

In the DiffServ model, multiple DiffServ domains are defined and various priority policies are applied. The priority policies for different domains may be different. Therefore, priority mapping must be performed for services across DiffServ domains to guarantee point-to-point QoS.

Universal priority policies are respectively defined for QoS of IP, MPLS, and VLAN networks. DSCP is used for IP networks, EXP for MPLS networks, and CoS for VLAN networks.

Table 2 Default Mapping Between DiffServ Domain DSCP Values and QoS Service Types

DSCP	Service	Color	DSCP	Service	Color
00	BE	Green	32	AF4	Green
01	BE	Green	33	BE	Green
02	BE	Green	34	AF4	Green
03	BE	Green	35	BE	Green
04	BE	Green	36	AF4	Yellow
05	BE	Green	37	BE	Green
06	BE	Green	38	AF4	Red
07	BE	Green	39	BE	Green

DSCP	Service	Color	DSCP	Service	Color
08	AF1	Green	40	EF	Green
09	BE	Green	41	BE	Green
10	AF1	Green	42	BE	Green
11	BE	Green	43	BE	Green
12	AF1	Yellow	44	BE	Green
13	BE	Green	45	BE	Green
14	AF1	Red	46	EF	Green
15	BE	Green	47	BE	Green
16	AF2	Green	48	CS6	Green
17	BE	Green	49	BE	Green
18	AF2	Green	50	BE	Green
19	BE	Green	51	BE	Green
20	AF2	Yellow	52	BE	Green
21	BE	Green	53	BE	Green
22	AF2	Red	54	BE	Green
23	BE	Green	55	BE	Green
24	AF3	Green	56	CS7	Green
25	BE	Green	57	BE	Green
26	AF3	Green	58	BE	Green
27	BE	Green	59	BE	Green
28	AF3	Yellow	60	BE	Green
29	BE	Green	61	BE	Green
30	AF3	Red	62	BE	Green
31	BE	Green	63	BE	Green

Table 3 Default Mapping Between DiffServ Domain QoS Service Types and DSCP Values

Service	Color	DSCP
BE	Green, Yellow, Red	0
AF1	Green	10
AF1	Yellow	12
AF1	Red	14
AF2	Green	18
AF2	Yellow	20
AF2	Red	22
AF3	Green	26
AF3	Yellow	28
AF3	Red	30
AF4	Green	34
AF4	Yellow	36
AF4	Red	38
EF	Green, Yellow, Red	46
CS6	Green, Yellow, Red	48
CS7	Green, Yellow, Red	56

Table 4 Default Mapping Between DiffServ Domain EXP Values and QoS Service Types

EXP	Service	Color
00	BE	Green
01	AF1	Green
02	AF2	Green
03	AF3	Green
04	AF5	Green
05	EF	Green
06	CS6	Green
07	CS7	Green

Table 5 Default Mapping Between DiffServ Domain QoS Service Types and EXP Values

Service	Color	EXP
BE	Green, Yellow, Red	0
AF1	Green, Yellow, Red	1
AF2	Green, Yellow, Red	2
AF3	Green, Yellow, Red	3

AF4	Green, Yellow, Red	4
EF	Green, Yellow, Red	5
CS6	Green, Yellow, Red	6
CS7	Green, Yellow, Red	7

Table 6 Mapping Between CoSs and QoS Service Types

CoS	Service	Color
00	BE	Green
01	BE	Green
02	AF2	Green
03	AF2	Green
04	AF4	Green
05	AF4	Green
06	CS6	Green
07	CS7	Green

Table 7 Default Mapping Between DiffServ Domain QoS Service Types and CoSs

Service	Color	CoS
BE	Green, Yellow, Red	0
AF1	Green, Yellow, Red	1
AF2	Green, Yellow, Red	2
AF3	Green, Yellow, Red	3
AF4	Green, Yellow, Red	4
EF	Green, Yellow, Red	5
CS6	Green, Yellow, Red	6
CS7	Green, Yellow, Red	7

Working Principles

Simple Traffic Classification

Ruijie supports the following simple flow classification:

Simple traffic classification for DiffServ domains of VLAN networks

Simple traffic classification for DiffServ domains of MPLS networks

Simple traffic classification for DiffServ domains of IP networks

Uplink traffic mapping from DiffServ priorities to QoS

Downlink traffic mapping from QoS to DiffServ priorities

Applying simple traffic classification policies based on L3 interfaces or virtual templates

Complex Traffic Classification

Ruijie supports the following complex flow classification:

Complex traffic classification based on L2 information for VLAN networks

Complex traffic classification based on L2 information for MPLS networks

Complex traffic classification based on L2 information for IP networks

Traffic classification policies: associated user queues, priority re-marking, and QoS marking

Priority re-marking across DiffServ domains

Applying simple traffic classification policies based on L3 interfaces or virtual templates

Protocols and Specifications

RFC2474: Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers

RFC2597: Assured Forwarding PHB

RFC2598: Expedited Forwarding PHB

RFC2697: A Single Rate Three Color Marker

RFC2698: A Two Rate Three Color Marker

Default Configurations

The following table shows default traffic classification configurations.

Feature	Default
Complex traffic classification	Disabled
Complex traffic behaviors	None
Complex traffic classification polices	None
Simple traffic classification	Disabled
DiffServ domain in simple traffic classification	A default domain is created
Simple traffic classification policies	The default policy is consistent with the default domain

Configuring Complex Traffic Classification

Configuring Traffic Classifiers

Traffic classifiers are configured to distinguish the traffic of different users from one another so as to provide differentiated services for different users. Each traffic classifier may contain multiple matching rules, and the relationship between the matching rules is determined by the classifier type. If the classifier type is "and", all rules apply to the packet. If the rule type is "or", the packet can match any of the rules. If the classifier type is not specified, the "or" relationship applies between the matching rules. To configure traffic classifiers, perform the following steps:

Command	Purpose
Ruijie(config)# **traffic classifier** *classifier-name* [**and** | **or**]	Enter or create a traffic classifier.
Ruijie(config-traffic-classifier)# **if-match acl** *acl-name* **Or:** Ruijie(config-traffic-classifier)# **if-match dscp** *dscp-value* **Or:** Ruijie(config-traffic-classifier)# **if-match ip-precedence** *ip-precedence-value* **Or:** Ruijie(config-traffic-classifier)# **if-match any**	Set an IPv4 packet matching rule, which can be based on ACL, DSCP, or IP precedence, or any IPv4 packet.
Ruijie(config-traffic-classifier)# **if-match ipv6 acl** *ipv6-acl-number* **Or:** Ruijie(config-traffic-classifier)# **if-match ipv6 dscp** *dscp-value* **Or:** Ruijie(config-traffic-classifier)# **if-match ipv6 any**	Set an IPv6 packet matching rule, which can be based on ACL, DSCP, or any IPv6 packet.
Ruijie(config-traffic-classifier)# **if-match mpls-exp** *mpls-exp-value*	Set an MPLS packet matching rule, which can be based on MPLS EXP.
Ruijie(config-traffic-classifier)# **if-match cos** *cos-value* **Or:** Ruijie(config-traffic-classifier)# **if-match source-mac** *mac-address* **Or:** Ruijie(config-traffic-classifier)# **if-match destination-mac** *mac-address*	Set an Ethernet packet matching rule, which can be based on CoS, source MAC address, or destination MAC address.
Ruijie(config-traffic-classifier)#**exit**	Exit the traffic classifier configuration view.

Configuration example:

Create a traffic classifier and set an IPv4 packet matching rule based on an ACL:

```
Ruijie(config)#traffic classifier tc1
Ruijie(config-traffic-classifier)#if-match acl 100
Ruijie(config-traffic-classifier)#exit
```

Configuring Traffic Behaviors

Traffic behaviors determine traffic scheduling parameters after traffic is classified. To configure traffic behaviors, perform the following steps:

Command	Purpose
Ruijie(config)# **traffic behavior** *traffic-behavior-name*	Enter or create a traffic behavior.
Ruijie(config-traffic-behavior)#**user-queue** *user-queue-name* [**inbound | outbound**]	Set a user queue.
Ruijie(config-traffic-behavior)#**service-class** *service-class-value* **color** *color-value*	Set the service class and discard priority of packets.
Ruijie(config-traffic-behavior)#**remark dscp** *dscp-value* **Or:** Ruijie(config-traffic-behavior)#**remark ip-precedence** *ip-precedence-value*	Set the remark value of IPv4 packets.
Ruijie(config-traffic-behavior)#**remark ipv6 dscp** *dscp-value*	Set the remark value of IPv6 packets.
Ruijie(config-traffic-behavior)#**remark mpls-exp** *mpls-exp-value*	Set the remark value of MPLS packets.
Ruijie(config-traffic-behavior)#**remark cos** *cos-value*	Set the 802.1Q remark value of Ethernet packets.
Ruijie(config-traffic-behavior)#**sub-traffic-policy** *traffic-policy-name*	Set an associated sub-traffic policy.

Configuration example:

Create a traffic behavior.

```
Ruijie(config)#traffic behavior tb1
Ruijie(config-traffic-behavior)#user-queue uq1 inbound
Ruijie(config-traffic-behavior)#service-class ef color green
Ruijie(config-traffic-behavior)#remark dscp 40
```

Configuring Traffic Policies

Traffic policies associate traffic classifiers with traffic behaviors, so that classified traffic is scheduled according to users' configurations. To configure traffic policies, perform the following steps:

Command	Purpose
Ruijie(config)# **traffic policy** *traffic-policy-name*	Enter or create a traffic policy.
Ruijie(config-traffic-policy)# **classifier** *classifier-name* **behavior** *behavior-name* [**precedence** *precedence-value*]	Specify the traffic behavior for a traffic classifier and set the preference. The smaller the precedence value, the higher the preference.

Configuration example:

Create a traffic policy.

```
Ruijie(config)#traffic policy tp1
Ruijie(config-traffic-policy)#classifier tc1 behavior tb1 precedence 1
```

Applying Traffic Classification Polices

To apply traffic classification policies, perform the following steps:

Command	Purpose
Ruijie(config)# **interface** *interface-name*	Enter interface configuration mode.

Ruijie(config-if)# **traffic-policy** *traffic-policy-name* **{inbound | outbound} [link-layer | all-layer]**	Apply a traffic policy to the interface. You need to specify the layer parameter. By default, a policy takes effect for L3 and MPLS packets only. If the *link-layer* parameter is specified, the policy takes effect for 802.1P L2 packets only. If the *all-layer* parameter is specified, the policy takes effect for both L3 and L2 packets. If you specify the *link-layer* or *all-layer* parameter, the configured traffic policy is applicable to both the interface and all associated subinterfaces but not merely its subinterfaces. ATM interfaces and subinterfaces do not support the *link-layer* or *all-layer* parameter.

Configuration example:

Apply a traffic policy to an interface.

```
Ruijie(config)#int gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)#traffic-policy tp1 inbound
```

Displaying Configurations

Command	Purpose
show traffic classifier [*classifier-name*]	Show traffic classifier configurations in the system.
show traffic behavior [*behavior-name*]	Show traffic behavior configurations in the system.
show traffic policy [*policy-name*]	Show traffic policy configurations in the system.

Configuration example:

Show information about the interfaces of the port queue in the system.

```
Ruijie# show traffic classifier tc1
traffic classifier tc1 or
  if-match acl 1501
```

Configuring Simple Traffic Classification

Configuring DiffServ Domains and Traffic Policies

You need to first define DiffServ domains and specify traffic policies for the DiffServ domains during simple traffic classification. To configure DiffServ domains and traffic policies, perform the following steps:

Command	Purpose
Ruijie(config)# **diffserv domain {***ds-domain-name* **| default}**	Enter or create a DiffServ domain.
Ruijie(config-diffserv-domain)# **ip-dscp-inbound** *dscpvalue* **phb** *service-class color* **Or:** Ruijie(config-traffic-classifier)# **ip-dscp-outbound** *serviceclass color* **map** *dscp-value*	Configure an IP traffic policy.
Ruijie(config-diffserv-domain)# **mpls-exp-inbound** *exp* **phb** *service-class color* **Or:** Ruijie(config-diffserv-domain)# **mpls-exp-outbound** *service-class color* **map** *exp-value*	Configure an MPLS traffic policy.
Ruijie(config-diffserv-domain)# **8021p-inbound** *cos-value* **phb** *service-class color* **Or:** Ruijie(config-diffserv-domain)# **8021p-outbound** *service-class color* **map** *cos-value*	Configure an 802.1P traffic policy.
Ruijie(config-traffic-classifier)#**exit**	Exit the traffic classifier configuration view.

Configuration example:

Create a DiffServ domain named "out-ip" and set the mapping from IP DSCP to QoS.

Ruijie(config)# diffserv domain out-ip

```
Ruijie(config-diffserv-domain)# ip-dscp-inbound 34 phb ef green
```

```
Ruijie(config-diffserv-domain)#exit
```

Applying Traffic Classification Polices

To apply traffic classification policies, perform the following steps:

Command	Purpose
Ruijie(config)# **interface** *interface-name*	Enter interface configuration mode.
Ruijie(config-if)# **trust upstream { *ds-domain-name* | default }**	Apply a simple traffic classification policy to the interface.
Ruijie(config-if)# **trust 8021p**	Enable 802.1p simple traffic classification. This configuration is applicable to interfaces only. The configured traffic policy is applicable to both the interface and all associated subinterfaces but not merely its subinterfaces. This command is not available for ATM interfaces or subinterfaces.

Configuration example:

Apply a traffic policy of the DiffServ domain named "out-ip" to an interface.

```
Ruijie(config)#int gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)#trust upstream out-ip
```

Displaying Configurations

Command	Purpose
show diffserv domain diffserv-domain-name [8021p-inbound | 8021p-outbound | ip-dscp-inbound | ip-dscp-outbound |mpls-exp-inbound | mpls-exp-outbound]	Show DiffServ domain configurations.

Configuration example:

Show configuration information about the DiffServ domain named "ip-out".

```
Ruijie# show diffserv domain ipdscp
IP-DSCP map to Server-class and Color :
  0 --> be   green
  1 --> be   green
  2 --> be   green
  3 --> be   green
  4 --> be   green
  5 --> be   green
  6 --> be   green
  7 --> be   green
  8 --> af1  green
  9 --> be   green
 10 --> af1  green
 11 --> be   green
 12 --> af1  yellow
 13 --> be   green
 14 --> af1  red
 15 --> be   green
 16 --> af2  green
 17 --> be   green
 18 --> af2  green
 19 --> be   green
 20 --> af2  yellow
 21 --> be   green
 22 --> af2  red
 23 --> be   green
 24 --> af3  green
 25 --> be   green
 26 --> af3  green
 27 --> be   green
 28 --> af3  yellow
 29 --> be   green
 30 --> af3  red
 31 --> be   green
```

```
 32 --> af4   green
 33 --> be    green
 34 --> af4   green
 35 --> be    green
 36 --> af4   yellow
 37 --> be    green
 38 --> af4   red
 39 --> be    green
 40 --> ef    green
 41 --> be    green
 42 --> be    green
 43 --> be    green
 44 --> be    green
 45 --> be    green
 46 --> ef    green
 47 --> be    green
 48 --> cs6   green
 49 --> be    green
 50 --> be    green
 51 --> be    green
 52 --> be    green
 53 --> be    green
 54 --> be    green
 55 --> be    green
 56 --> cs7   green
 57 --> be    green
 58 --> be    green
 59 --> be    green
 60 --> be    green
 61 --> be    green
 62 --> be    green
 63 --> be    green

MPLS-EXP map to Server-class and Color :
  0 --> be    green
  1 --> af1   green
  2 --> af2   green
  3 --> af3   green
  4 --> af4   green
  5 --> ef    green
  6 --> cs6   green
  7 --> cs7   green

VLAN-Cos map to Server-class and Color :
  0 --> be    green
  1 --> af1   green
  2 --> af2   green
  3 --> af3   green
  4 --> af4   green
  5 --> ef    green
  6 --> cs6   green
  7 --> cs7   green

Server-class and Color map to IP-DSCP :
 be    green    -->  0
 be    yellow   -->  0
 be    red      -->  0
 af1   green    --> 10
 af1   yellow   --> 12
 af1   red      --> 14
 af2   green    --> 18
 af2   yellow   --> 20
 af2   red      --> 22
 af3   green    --> 26
 af3   yellow   --> 28
 af3   red      --> 30
 af4   green    --> 34
 af4   yellow   --> 36
 af4   red      --> 38
 ef    green    --> 46
```

```
 ef    yellow   --> 46
 ef    red     --> 46
 cs6   green    --> 48
 cs6   yellow   --> 48
 cs6   red     --> 48
 cs7   green    --> 56
 cs7   yellow   --> 56
 cs7   red     --> 56

Server-class and Color map to MPLS-EXP :
 be    green    -->  0
 be    yellow   -->  0
 be    red     -->  0
 af1   green    -->  1
 af1   yellow   -->  1
 af1   red     -->  1
 af2   green    -->  2
 af2   yellow   -->  2
 af2   red     -->  2
 af3   green    -->  3
 af3   yellow   -->  3
 af3   red     -->  3
 af4   green    -->  4
 af4   yellow   -->  4
 af4   red     -->  4
 ef    green    -->  5
 ef    yellow   -->  5
 ef    red     -->  5
 cs6   green    -->  6
 cs6   yellow   -->  6
 cs6   red     -->  6
 cs7   green    -->  7
 cs7   yellow   -->  7
 cs7   red     -->  7

Server-class and Color map to VLAN-CoS :
 be    green    -->  0
 be    yellow   -->  0
 be    red     -->  0
 af1   green    -->  1
 af1   yellow   -->  1
 af1   red     -->  1
 af2   green    -->  2
 af2   yellow   -->  2
 af2   red     -->  2
 af3   green    -->  3
 af3   yellow   -->  3
 af3   red     -->  3
 af4   green    -->  4
 af4   yellow   -->  4
 af4   red     -->  4
 ef    green    -->  5
 ef    yellow   -->  5
 ef    red     -->  5
 cs6   green    -->  6
 cs6   yellow   -->  6
 cs6   red     -->  6
 cs7   green    -->  7
 cs7   yellow   -->  7
 cs7   red     -->  7
```

Examples for Configuring Traffic Classification

Configuration Example 1

Networking Requirements

- Device requirements:

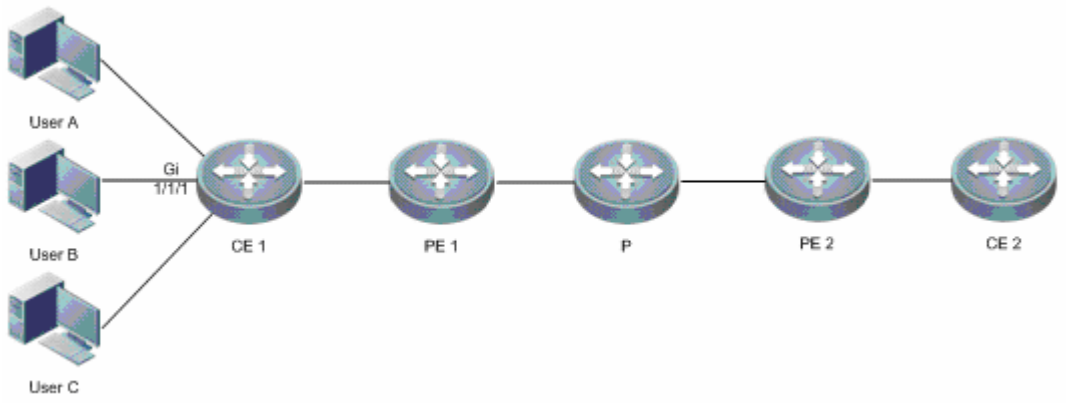
Four routers.

- Configuration requirements:

Two local users access an MPLS backbone network from a CE. The committed access rate of user A is 60 Mbps, and the peak access rate is 80 Mbps. The committed access rate of user B is 30 Mbps, and the peak access rate is 40 Mbps. The IP address of user A is 10.1.10.1, and that of user B is 10.1.10.2.

Network Topology

Figure 11 Network Topology for Complex Traffic Classification



Configuration Tips

Configure traffic classifiers to identify users.

Configure traffic behaviors to monitor and control user traffic.

Configuration Steps

Configure traffic classifiers:

```
# Configure a traffic classifier named "tc1".
Ruijie(config)#access-list 100 permit ip host 10.1.10.1 any
Ruijie(config)#traffic classifier tc1
Ruijie(config-traffic-classifier)#if-match acl 100
Ruijie(config-traffic-classifier)#exit
# Configure a traffic classifier named "tc2".
Ruijie(config)# access-list 110 permit ip host 10.1.10.2 any
Ruijie(config)#traffic classifier tc2
Ruijie(config-traffic-classifier)#if-match acl 110
Ruijie(config-traffic-classifier)#exit
```

Configure user queues:

```
# Configure a user queue named "uq1".
Ruijie(config)#user-queue uq1 inbound
Ruijie(config-user-queue)#cir 60000 pir 80000
Ruijie(config-user-queue)#exit
```

```
# Configure a user queue named "uq2".
Ruijie(config)#user-queue uq2 inbound
Ruijie(config-user-queue)#cir 30000 pir 40000
Ruijie(config-user-queue)#exit
```

Configure traffic behaviors:

```
#Configure a traffic behavior named "tb1".
Ruijie(config)#traffic behavior tb1
Ruijie(config-traffic-behavior)#user-queue uq1 inbound
Ruijie(config-traffic-behavior)#exit
```

```
#Configure a traffic behavior named "tb2".
Ruijie(config)#traffic behavior tb2
Ruijie(config-traffic-behavior)#user-queue uq2 inbound
Ruijie(config-traffic-behavior)#exit
```

Configure a traffic policy:

```
Ruijie(config)#traffic policy tp1
Ruijie(config-traffic-policy)#classifier tc1 behavior tb1
Ruijie(config-traffic-policy)#classifier tc2 behavior tb2
Ruijie(config-traffic-policy)#exit
```

Apply the traffic policy to an interface:

```
Ruijie(config)#int gigabitethernet 1/1/1
Ruijie(config-if-Gigabitethernet1/1/1)#traffic-policy tp1 inbound
```

Verification

Show traffic policy information:

```
Ruijie# show traffic policy tp1
traffic policy tp1
  classifier tc1 behavior tb1 precedence 1
  classifier tc2 behavior tb2 precedence 2
```

Configuration Example 2

Networking Requirements

- Device requirements:

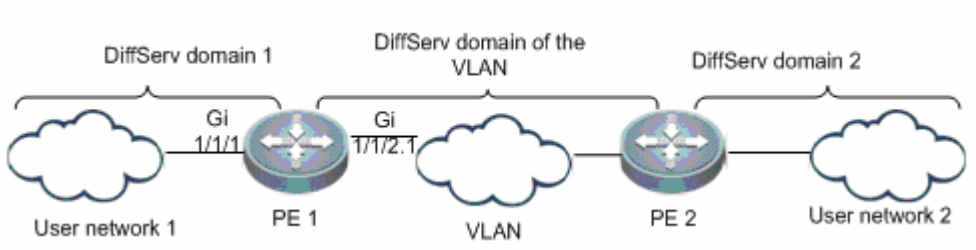
One Ethernet switch and two routers.

- Configuration requirements:

Two routers provide access services for the users of user network 1 and user network 2 respectively. The service priority of users of user network 1 must be able to be carried and transferred to user network 2 to implement DiffServ domain mapping across the VLAN. It is necessary to add HQOS configurations on PE 1.

Network Topology

Figure 12 User Network Interconnection Across a VLAN



Configuration Tips

Configure DiffServ domains on routers.

Apply simple traffic classification to the user networks and VLAN.

Configuration Steps

Create DiffServ domain policies:

```
# Configure a traffic classifier named "usera".
Ruijie(config)# diffserv domain usera
Ruijie(config-diffserv-domain)#ip-dscp-inbound 34 phb ef green
Ruijie(config-diffserv-domain)#ip-dscp-inbound 16 phb be green
# Configure a traffic classifier named "vlan".
Ruijie(config)# diffserv domain vlan
Ruijie(config-diffserv-domain)# 8021p-outbound ef green map 4
Ruijie(config-diffserv-domain)# 8021p-outbound be green map 1
```

Apply simple traffic classifiers to respective interfaces:

```
Ruijie(config)#int gigabitethernet 1/1/1
Ruijie(config-if-Gigabitethernet1/1/1)#trust upstream vlan
Ruijie(config-if-Gigabitethernet1/1/1)#exit

Ruijie(config)#int gigabitethernet 1/1/2.1
Ruijie(config-if-Gigabitethernet1/1/2.1)#trust upstream usera
Ruijie(config-if-Gigabitethernet1/1/2.1)#trust 8021p
Ruijie(config-if-Gigabitethernet1/1/2.1)#exit
```

Verification

Show DiffServ domain configurations:

```
Ruijie# show diffserv domain usera
IP-DSCP map to Server-class and Color:
  0 --> be   green
  1 --> be   green
  2 --> be   green
  3 --> be   green
  4 --> be   green
  5 --> be   green
  6 --> be   green
  7 --> be   green
  8 --> af1  green
  9 --> be   green
 10 --> af1  green
 11 --> be   green
 12 --> af1  yellow
 13 --> be   green
 14 --> af1  red
 15 --> be   green
 16 --> be   green
 17 --> be   green
 18 --> af2  green
 19 --> be   green
 20 --> af2  yellow
 21 --> be   green
 22 --> af2  red
 23 --> be   green
 24 --> af3  green
 25 --> be   green
 26 --> af3  green
 27 --> be   green
 28 --> af3  yellow
 29 --> be   green
 30 --> af3  red
 31 --> be   green
 32 --> af4  green
 33 --> be   green
 34 --> ef   green
 35 --> be   green
 36 --> af4  yellow
 37 --> be   green
 38 --> af4  red
 39 --> be   green
 40 --> ef   green
 41 --> be   green
 42 --> be   green
 43 --> be   green
 44 --> be   green
 45 --> be   green
 46 --> ef   green
 47 --> be   green
 48 --> cs6  green
 49 --> be   green
 50 --> be   green
 51 --> be   green
 52 --> be   green
 53 --> be   green
```

```
 54 --> be    green
 55 --> be    green
 56 --> cs7   green
 57 --> be    green
 58 --> be    green
 59 --> be    green
 60 --> be    green
 61 --> be    green
 62 --> be    green
 63 --> be    green
```

```
Ruijie# show diffserv domain vlan
Server-class and Color map to VLAN-CoS :
 be    green    -->  1
 be    yellow   -->  0
 be    red      -->  0
 af1   green    -->  1
 af1   yellow   -->  1
 af1   red      -->  1
 af2   green    -->  2
 af2   yellow   -->  2
 af2   red      -->  2
 af3   green    -->  3
 af3   yellow   -->  3
 af3   red      -->  3
 af4   green    -->  4
 af4   yellow   -->  4
 af4   red      -->  4
 ef    green    -->  4
 ef    yellow   -->  5
 ef    red      -->  5
 cs6   green    -->  6
 cs6   yellow   -->  6
 cs6   red      -->  6
 cs7   green    -->  7
 cs7   yellow   -->  7
 cs7   red      -->  7
```

Configuration Example 3

Networking Requirements

- Device requirements:

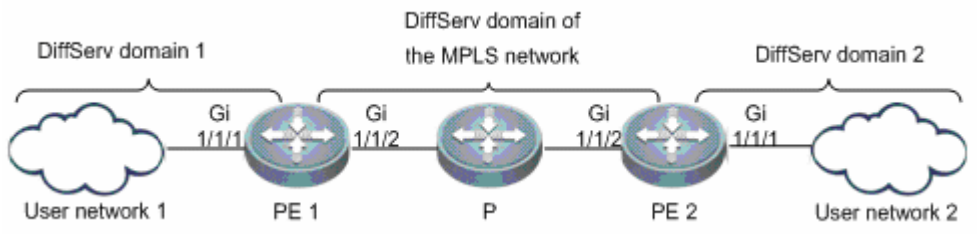
Five routers.

- Configuration requirements:

User network 1 and user network 2 access an MPLS backbone network from PE 1 and PE 2 respectively. The service priority of users of user network 1 must be able to be carried and transferred to user network 2 to implement DiffServ domain mapping across the MPLS network. It is necessary to add HQOS configurations on PE 1 and PE 2.

Network Topology

Figure 13 User Network Interconnection Across an MPLS Network



Configuration Tips

Configure DiffServ domains on routers.

Apply simple traffic classification to the user networks and MPLS network.

Configuration Steps

Configure PE 1 and create DiffServ domain policies:

```
# Configure a traffic classifier named "usera".
Ruijie(config)# diffserv domain usera
Ruijie(config-diffserv-domain)#ip-dscp-inbound 34 phb ef green
Ruijie(config-diffserv-domain)#ip-dscp-inbound 16 phb be green
# Configure a traffic classifier named "mpls".
Ruijie(config)# diffserv domain mplsa
Ruijie(config-diffserv-domain)# mpls-exp-outbound ef green map 4
Ruijie(config-diffserv-domain)# mpls-exp-outbound be green map 1
```

Configure PE1. Apply simple traffic classifiers to respective interfaces:

```
Ruijie(config)#int gigabitethernet 1/1/1
Ruijie(config-if-Gigabitethernet1/1/1)#trust upstream usera
Ruijie(config-if-Gigabitethernet1/1/1)#exit

Ruijie(config)#int gigabitethernet 1/1/2
Ruijie(config-if-Gigabitethernet1/1/2)#trust upstream mplsa
Ruijie(config-if-Gigabitethernet1/1/2)#exit
```

Configure PE 2 and create DiffServ domain policies:

```
# Configure a traffic classifier named "usera".
Ruijie(config)# diffserv domain userb
Ruijie(config-diffserv-domain)# ip-dscp-outbound ef green map
34Ruijie(config-diffserv-domain)# ip-dscp-outbound be green map 16
# Configure a traffic classifier named "mpls".
Ruijie(config)# diffserv domain mplsb
Ruijie(config-diffserv-domain)# mpls-exp-inbound 4 phb ef green
Ruijie(config-diffserv-domain)# mpls-exp-inbound 1 phb be green
```

Configure PE2. Apply simple traffic classifiers to respective interfaces:

```
Ruijie(config)#int gigabitethernet 1/1/1
Ruijie(config-if-Gigabitethernet1/1/1)#trust upstream userb
Ruijie(config-if-Gigabitethernet1/1/1)#exit

Ruijie(config)#int gigabitethernet 1/1/2
Ruijie(config-if-Gigabitethernet1/1/2)#trust upstream mplsb
Ruijie(config-if-Gigabitethernet1/1/2)#exit
```

Verification

Show DiffServ domain configurations on PE 1:

```
Ruijie# show diffserv domain usera
IP-DSCP map to Server-class and Color :
  0 --> be   green
  1 --> be   green
  2 --> be   green
  3 --> be   green
  4 --> be   green
  5 --> be   green
  6 --> be   green
  7 --> be   green
  8 --> af1  green
  9 --> be   green
 10 --> af1  green
 11 --> be   green
 12 --> af1  yellow
 13 --> be   green
 14 --> af1  red
 15 --> be   green
 16 --> be   green
 17 --> be   green
 18 --> af2  green
 19 --> be   green
 20 --> af2  yellow
```

```
 21 --> be   green
 22 --> af2  red
 23 --> be   green
 24 --> af3  green
 25 --> be   green
 26 --> af3  green
 27 --> be   green
 28 --> af3  yellow
 29 --> be   green
 30 --> af3  red
 31 --> be   green
 32 --> af4  green
 33 --> be   green
 34 --> ef   green
 35 --> be   green
 36 --> af4  yellow
 37 --> be   green
 38 --> af4  red
 39 --> be   green
 40 --> ef   green
 41 --> be   green
 42 --> be   green
 43 --> be   green
 44 --> be   green
 45 --> be   green
 46 --> ef   green
 47 --> be   green
 48 --> cs6  green
 49 --> be   green
 50 --> be   green
 51 --> be   green
 52 --> be   green
 53 --> be   green
 54 --> be   green
 55 --> be   green
 56 --> cs7  green
 57 --> be   green
 58 --> be   green
 59 --> be   green
 60 --> be   green
 61 --> be   green
 62 --> be   green
 63 --> be   green
Ruijie# show diffserv domain mplsa
Server-class and Color map to MPLS-EXP :
 be   green   -->  1
 be   yellow  -->  0
 be   red     -->  0
 af1  green   -->  1
 af1  yellow  -->  1
 af1  red     -->  1
 af2  green   -->  2
 af2  yellow  -->  2
 af2  red     -->  2
 af3  green   -->  3
 af3  yellow  -->  3
 af3  red     -->  3
 af4  green   -->  4
 af4  yellow  -->  4
 af4  red     -->  4
 ef   green   -->  4
 ef   yellow  -->  5
 ef   red     -->  5
 cs6  green   -->  6
 cs6  yellow  -->  6
 cs6  red     -->  6
 cs7  green   -->  7
 cs7  yellow  -->  7
 cs7  red     -->  7
```

Show DiffServ domain configurations on PE 2:

```
Ruijie# show diffserv domain userb
Server-class and Color map to IP-DSCP :
 be   green   --> 16
 be   yellow  -->  0
 be   red     -->  0
 af1  green   --> 10
 af1  yellow  --> 12
 af1  red     --> 14
 af2  green   --> 18
 af2  yellow  --> 20
 af2  red     --> 22
 af3  green   --> 26
 af3  yellow  --> 28
 af3  red     --> 30
 af4  green   --> 34
 af4  yellow  --> 36
 af4  red     --> 38
 ef   green   --> 34
 ef   yellow  --> 46
 ef   red     --> 46
 cs6  green   --> 48
 cs6  yellow  --> 48
 cs6  red     --> 48
 cs7  green   --> 56
 cs7  yellow  --> 56
 cs7  red     --> 56
Ruijie# show diffserv domain mplsb
MPLS-EXP map to Server-class and Color :
  0 --> be   green
  1 --> be   green
  2 --> af2  green
  3 --> af3  green
  4 --> ef   green
  5 --> ef   green
  6 --> cs6  green
  7 --> cs7  green
```

Configuring HQoS

Understanding HQoS

HQoS Overview

The traditional QoS offers different treatment to services and ensure QoS needs such as bandwidth and delay by classifying service flows and specifying policies for them. However, the existing user access network is complex, and there are a large number of access devices (such as Layer 2 switches and converters) that do not support complex QoS. Although egress devices of the user access network can ensure QoS for transmitted services as much as possible, they cannot ensure QoS based on the user and user group in a more refined manner.
Hierarchical QoS (HQoS) is different from the traditional QoS, which is specific to services. HQoS can provide QoS for data flows in the network by service, user, floor, and residential area. Service QoS provides quality service for multiple service flows of a single user. User QoS provides quality service for mulitple users on a floor, and so on for floor QoS and residential area QoS. HQoS can implement more refined service assurance for data aggregation devices to improve service quality for whole-network users.

Basic Concepts

FQ

The flow queue (FQ) indicates service queues of a user. Each user has eight FQs, which correspond to eight service priorities respectively (BE, AF1, AF2, AF3, AF4, EF, CS6, and CS7). The eight FQs can be configured with Priority Queuing (PQ), Weighted Fair Queuing (WFQ), or Low-priority Queuing (LPQ). Each FQ supports Weighted Random Early Detection (WRED) and traffic shaping.

UQ

The user here indicates one VLAN or VPN. Users can be divided based on the interface, sub-interface, or ACL. Each user has a user queue (UQ), which is aggregated by eight fixed FQs. You can limit the total bandwidth of each user by performing rate limiting to its UQ.

Note

If users belong to different line cards of a distributed device, the UQ function takes effect based on each line card.

GQ

Multiple users can be bound to one user group. Each user group has a group queue (GQ). You can control the traffic of a user group by performing traffic shaping to the GQ.

Note

If user groups belong to different line cards of a distributed device, the GQ function takes effect based on each line card.

VOQ

The Virtual Output Queuing (VOQ) are divided into four groups, which correspond to four service types respectively. In each service group, one VOQ queue is set for each destination device. VOQ scheduling is controlled by credit. Only queues with enough credit are scheduled. Credit is allocated by the destination device.

Destination Interface/Destination Device CQ

Each destination interface has eight queues, which correspond to eight service types respectively. The eight FQs can be configured with SP and WFQ. Each class queue (CQ) supports WRED and traffic shaping.

The destination device CQ can be regarded as an uplink destination interface CQ. They are the same in nature. The difference is that the packets of the destination device CQ are sent to boards instead of interfaces. Each destination device correspond to four queues, which correspond to four service types. The four queues are scheduled in SP mode.

LPQ

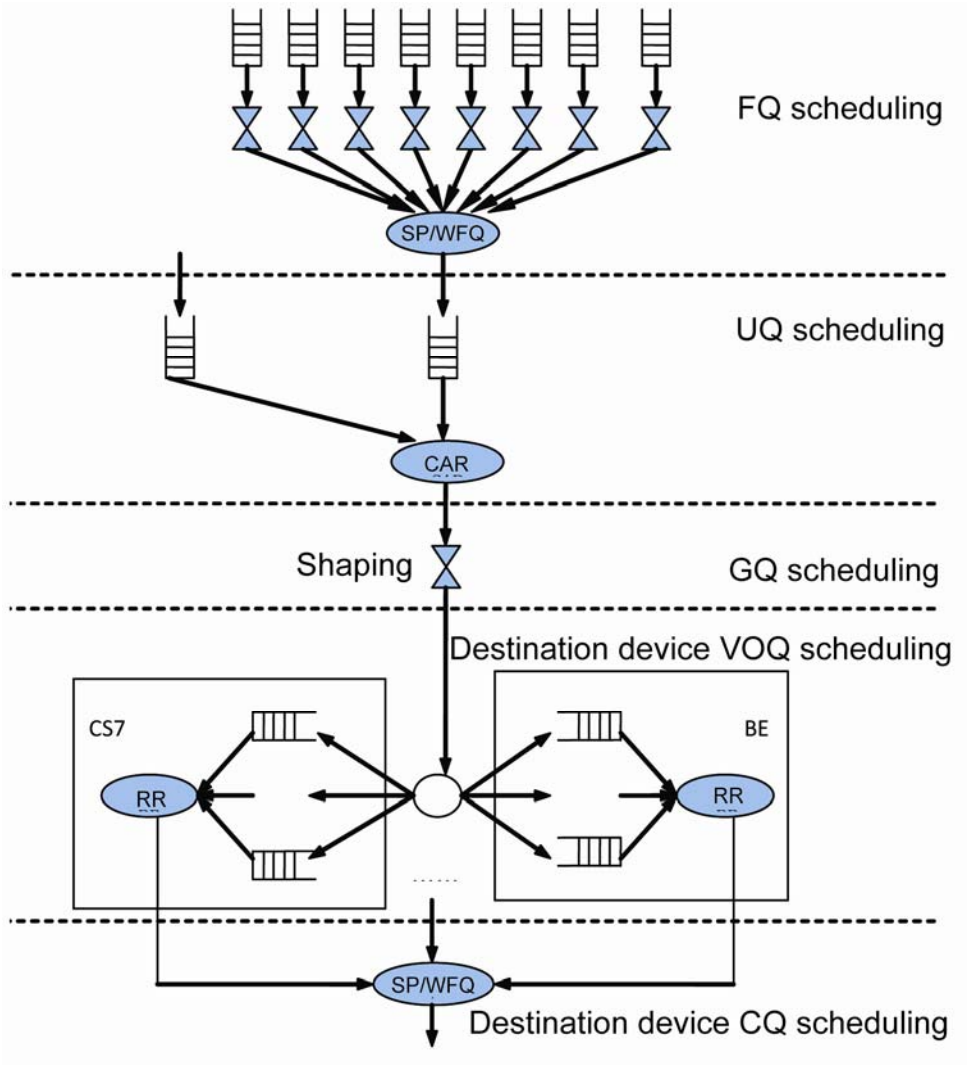
There are three scheduling mechanisms in HQoS: PQ, WFQ, and Low-priority Queue (LPQ), which descend in order of priority. In the case of congestion, PQ queues and WFQ queues can preempt the bandwidth of LPQ queues.

How HQoS Works

Uplink HQoS Scheduling

Uplink HQoS scheduling is divided into five levels: CQ > UQ > GQ > Destination device VOQ > Destination device CQ, as shown in the following figure:

Figure 14 Uplink HQoS scheduling process



Level 1 scheduling is FQ scheduling. The FQ is an entity queue, that is, the packets are cached in an FQ. FQ includes FQ WRED, FQ shaping, and FQ scheduling. WERD congestion avoidance is required before a packet enters a FQ. The system supports discarding priorities of three colors: red, yellow, and green. Red indicates the highest discarding priority, and green indicates the lowest one. Each FQ sets the minimum threshold, maximum threshold, and discarding probability for each discarding priority. The higher the discarding priority, the greater the maximum threshold and minimum threshold, and the greater the discarding probability of packets. Traffic shaping is performed via token bucket after WRED for FQ. Finally, FQ scheduling is performed by using Strict Priority (SP)+WFQ. SP includes PQ and LPQ. CS7, CS6, EF, AF, and BE are scheduled in sequence. Low-priority queues are scheduled only when there are no packets in high-priority queues. AF includes four types, which are scheduled according to their respective weights.

Level 2 scheduling is UQ scheduling. The UQ is a virtual queue, that is, the packets are not cached in a UQ. UQ scheduling is only an HQoS scheduling level. Each UQ includes eight FQs that share the bandwidth of the UQ. The UQ supports committed interface rate (CIR) only. Each UQ can invoke zero to one GQ.

Level 3 scheduling is GQ scheduling. The GQ is a virtual queue. Multiple UQs can be bound to a GQ for scheduling. The GQ supports traffic shaping only. If no UQ is bound to a GQ, GQ scheduling will be skipped.

Level 4 scheduling is VoQ scheduling. VoQ scheduling is the uplink traffic scheduling among line cards. The VoQ breaks into four groups by service priority, with one queue for each destination device in each group. When packets pass through UQ scheduling, they enter different VoQs based on their destination devices and priorities. VoQ scheduling is configured by the system, and no additional user configuration is required.

Level 5 scheduling is CQ scheduling. The CQ is a virtual queue, instead of an entity queue that caches packets. Each CQ, however, maintains information such as scheduling priority and weigh, and supports SP/WFQ scheduling. CQ scheduling for uplink HQoS is configured by the system, and no additional user configuration is required.

- CoS-based uplink HQoS processing:

Flows are classified based on configured flow classification rules, and are prioritized at eight levels.

The UQ, GQ, WRED parameters, and scheduling policies of packets are determined based on flow behavior rules. Then, packets are passed to corresponding FQs.

- FQ scheduling can be performed according to user configuration to avoid congestion.
- An FQ can be scheduled as a PQ, WFQ, or LPQ. The PQ and WFQ can preempt the bandwidth of the LPQ.

The remaining bandwidth for the GQ is checked. If the remaining bandwidth for the GQ is insufficient, the UQ included in the GQ is not scheduled. Otherwise, the UQ included in the GQ is scheduled. The bandwidth for the GQ is configurable.

The remaining bandwidth for the UQ is checked. If the remaining bandwidth for the UQ is insufficient, the FQ included in the UQ is not scheduled. Otherwise, the FQ is scheduled. The bandwidth for the UQ is configurable.

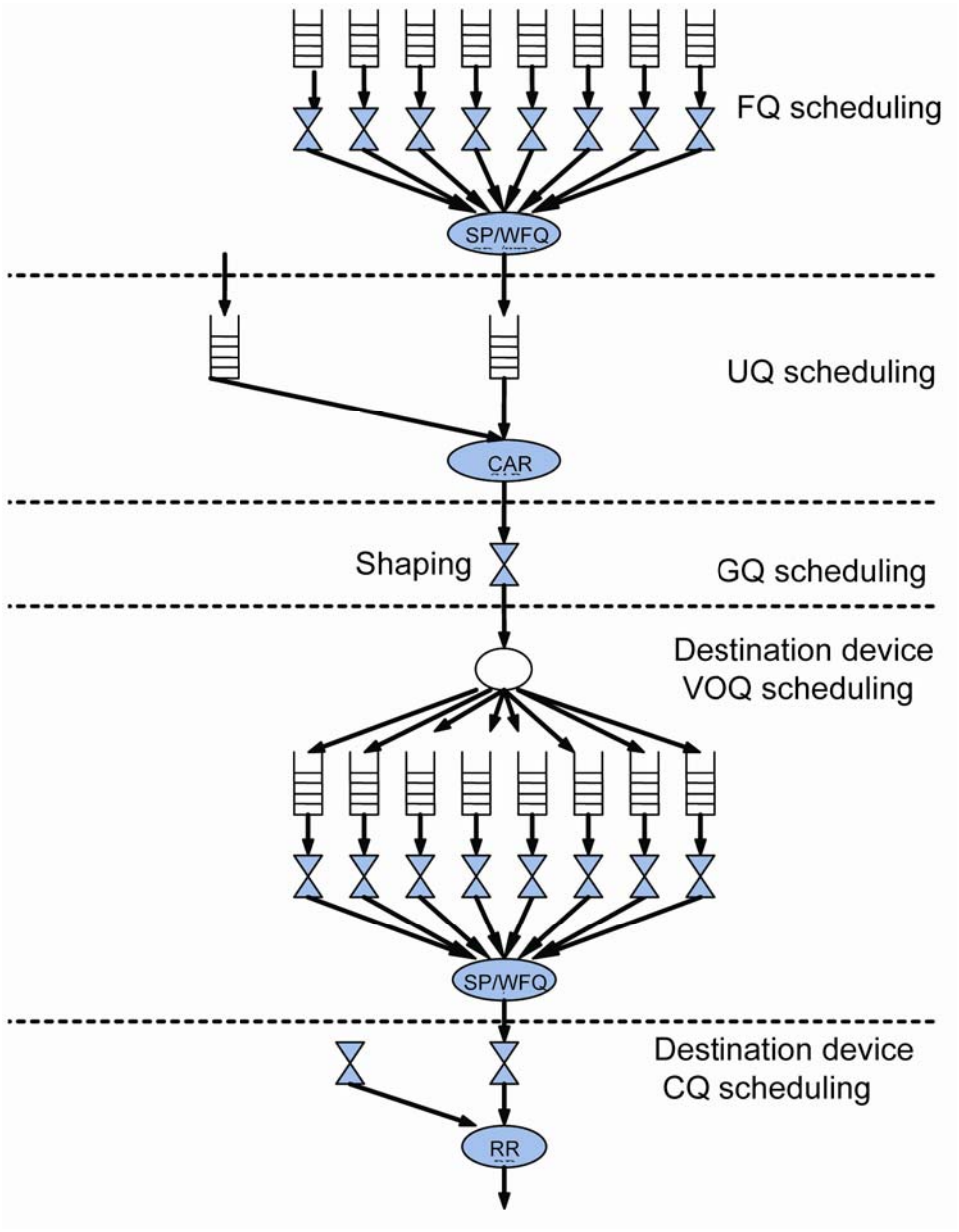
After scheduling, packets in the FQ enter the VoQs on destination devices or destination interfaces.

CQ scheduling is performed in SP mode among four queues. After scheduling, packets are forwarded.

Downlink HQoS Scheduling

Downlink HQoS scheduling is divided into five levels: FQ > UQ > GQ > Interface CQ > Destination interface, as shown in the following figure:

Figure 15 Downlink HQoS Scheduling Process



Level 1 FQ scheduling, level 2 UQ scheduling, and level 3 GQ scheduling are identical with those of uplink HQoS scheduling.

Level 4 scheduling is CQ scheduling. There are eight CQs on each interface, corresponding to eight service priorities. Different from the case of uplink HQoS scheduling, you can configure CQ congestion avoidance parameters and the traffic shaping value. The CQ is scheduled in SP + WFQ mode.

Level 5 scheduling is destination interface scheduling. The system polls interfaces for scheduling. Level 5 scheduling is configured by the system, and no additional user configuration is required.

Protocol Specifications

TR-059: A layered QoS model defined by the DSL Forum

Default Configuration

The following table describes the default HQoS configurations:

Function	Default
WRED queue lower threshold	20
WRED queue upper threshold	40
WRED queue discarding probability	100

Configuring CoS-based HqoS

Configuring a Traffic Classifier Rule

Configuring a traffic classifier rule is to distinguish between user flows to provide differentiated services for different users. Each traffic classifier rule can contain multiple match rules, the relationship among which is determined by the rule type. If the rule type is "and", the packet must match all rules; if the rule type is "or", the packet can match any one of the rules. If no rule type is specified, "or" rule type is adopted by default. Configure this function as follows:

Command	Purpose
Ruijie(config)# **traffic classifier** *classifier-name* [**and	or**]	Enters/Creates a traffic classifier rule.
Ruijie(config-traffic-classifier)# **if-match acl** *acl-number* Or: Ruijie(config-traffic-classifier)# **if-match dscp** *dscp-value* Or: Ruijie(config-traffic-classifier)# **if-match ip-precedence** *ip-precedence-value* Or: Ruijie(config-traffic-classifier)# **if-match any**	Sets IPv4 packet match rules. Supports matching packets based on ACL, DSCP, and IP precedence and matching all IPv4 packets (any).
Ruijie(config-traffic-classifier)# **if-match ipv6** *ipv6-acl-number* Or: Ruijie(config-traffic-classifier)# **if-match ipv6 dscp** *dscp-value* Or: Ruijie(config-traffic-classifier)# **if-match ipv6 any**	Sets IPv6 packet match rules. Supports matching packets based on ACL and DSCP, and matching all IPv6 packets (any).
Ruijie(config-traffic-classifier)# **if-match mpls-exp** *mpls-exp-value*	Sets MPLS packet match rules. Supports matching packets based on MPLS EXP.
Ruijie(config-traffic-classifier)# **if-match cos** *cos-value* Or: Ruijie(config-traffic-classifier)# **if-match source-mac** *mac-address* Or: Ruijie(config-traffic-classifier)# **if-match destination-mac** *mac-address*	Sets Ethernet packet match rules. Supports matching packets based on CoS, source MAC address, and destination MAC address.
Ruijie(config-traffic-classifier)#**exit**	Exits the traffic classifier rule configuration.

Configuration example:

Create a traffic classifier rule and set the IPv4 packet match rule to be based on ACL.

```
Ruijie(config)#traffic classifier tc1
Ruijie(config-traffic-classifier)#if-match acl 100
Ruijie(config-traffic-classifier)#exit
```

Configuring an FQ WRED Template

Configuring a WRED template is to configure congestion avoidance parameters, including upper threshold, lower threshold, and discarding probability, for packets in three colors. When the number of packets in a queue is smaller than the lower threshold, packets are not discarded. When the number of packets in a queue is larger than the lower threshold and smaller than the upper threshold, packets are discarded at certain probability. When the number of packets in a queue is larger than the upper threshold, packets are discarded. You can configure different WRED templates and apply them to different FQs.

Configure this function as follows:

Command	Purpose
Ruijie(config)# **wred** *wred-template-name*	Creates/Enters a WRED template.

Ruijie(config-wred)#**color green low-limit** *low-limit-threshold* **high-limit** *high-limit-threshold* **discard-percent** *discard-percent-value* Ruijie(config-wred)#**color yellow low-limit** *low-limit-threshold* **high-limit** *high-limit-threshold* **discard-percent** *discard-percent-value* Ruijie(config-wred)#**color red low-limit** *low-limit-threshold* **high-limit** *high-limit-threshold* **discard-percent** *discard-percent-value*	Sets the upper threshold, lower threshold, and probability for queues in three colors.
Ruijie(config- wred)#**exit**	Exits the WRED template configuration.

Configuration example:

Create a WRED template and set congestion avoidance parameters.

```
Ruijie(config)#wred wt1
Ruijie(config-wred)#color green low-limit 40 high-limit 60 discard-percent 10
Ruijie(config-wred)#color yellow low-limit 30 high-limit 50 discard-percent 10
Ruijie(config-wred)#color red low-limit 20 high-limit 40 discard-percent 10
Ruijie(config-wred)#exit
```

Configuring an FQ Template

Configuring an FQ template is to configure the scheduling mode (PQ, WFQ, and LPQ), traffic shaping value, and WRED parameters of eight kinds of PQs. PQ scheduling is performed on queues with the priority as ef, cs6, or cs7. WFQ scheduling is performed on queues with the priority as be, af1, af2, af3, or af4. Traffic shaping is not performed by default and the default discarding policy is tail discarding. You can configure multiple FQ templates and apply them to different FQs.

Configure this function as follows:

Command	Purpose
Ruijie(config)# **flow-queue** *flow-queue-template-name*	Enters/Creates an FQ template.
Ruijie(config-flow-queue)# **queue** *cos-value* {**pq** | **wfq weight** *weight-value* | **lpq**} [**shaping** *shaping-value*] [**wred** *wred-name*] [**depth** *depth-value*]	Set FQ scheduling parameters.
Ruijie(config- flow-queue)#**exit**	Exits the FQ template configuration.

Configuration example:

Create an FQ template and set FQ scheduling parameters.

```
Ruijie(config)#flow-queue fqt1
Ruijie(config-flow-queue)# queue be lpq
Ruijie(config-flow-queue)# queue af1 wfq weight 10 shaping 100000 wred wt1
Ruijie(config-flow-queue)# queue cs7 pq shaping wred wt1
Ruijie(config-flow-queue)#exit
```

Configuring an FQ Mapping Template

Configuring an FQ mapping template is to configure the mapping from eight kinds of PQs to CQs.

Configure this function as follows:

Command	Purpose
Ruijie(config)# **flow-mapping** *flow-mapping name*	Enters/Creates an FQ mapping template.
Ruijie(config-flow-mapping)# **map flow-queue** *cos-value* **to port-queue** *cos-value*	Sets the mapping from FQ to CQ.
Ruijie(config- flow-mapping)#**exit**	Exits the FQ mapping template configuration.

Configuration example:

Create a FQ mapping template and set the mapping from FQ to CQ.

```
Ruijie(config)#flow-mapping fmt1
Ruijie(config-flow-mapping)# map flow-queue af1 to port-queue ef
Ruijie(config-flow-mapping)#exit
```

Configuring a UQ

Configuring a UQ consists of configuring the CIR, configuring the FQ template, and associating a GQ.

Configure this function as follows:

Command	Purpose
Ruijie(config)# **user-queue** *user-queue-name* **inbound | outbound**	Enters/Creates a UQ.
Ruijie(config-user-queue)# **cir** *vir-value* **pir** *pir-value*	Sets UQ traffic shaping parameters. By default, the CIR of the UQ is 0.
Ruijie(config-user-queue)# **flow-queue** *flow-queue-template-name*	Sets UQ FQ scheduling parameters.
Ruijie(config-user-queue)# **user-group-queue** *user-group-queue-name*	Associates the UQ with a GQ.
Ruijie(config-user-queue)# **flow-mapping** *flow-rmap-name*	Sets an FQ mapping template.

Configuration example:

Create a UQ and set scheduling parameters.

```
Ruijie(config)#user-queue uq1 inbound
Ruijie(confg-user-queue)#cir 100000 pir 100000
Ruijie(config-user-queue)#flow-queue fqt1
Ruijie(config-user-queue)#user-group-queue ugq1
Ruijie(config-user-queue)#flow-mapping fmt1
```

Configuring a GQ

A GQ is a bundle of multiple UQs for centralized traffic shaping.

Configure this function as follows:

Command	Purpose
Ruijie(config)# **user-group-queue** *user-group-queue-name* [**inbound | outbound**]	Enters/Creates a GQ.
Ruijie(config-user-group-queue)# **shaping** *shaping-value*	Sets the traffic shaping value of the GQ.

Configuration example:

Create a GQ and set the traffic shaping value.

```
Ruijie(config)#user-group-queue ugq1 inbound
Ruijie(config-user-group-queue)#shaping 100000
```

Configuring a Traffic Behavior Rule

The traffic behavior rule determines traffic scheduling parameters after classification. Configure this function as follows:

Command	Purpose
Ruijie(config)# **traffic behavior** *traffic-behavior-name*	Enters/Creates a traffic behavior rule.
Ruijie(config-traffic-behavior)#**user-queue** *user-queue-name* [**inbound | outbound**]	Sets the UQ.
Ruijie(config-traffic-behavior)#**service-class** *service-class-value* **color** *color-value*	Sets the color of packets with different priorities.
Ruijie(config-traffic-behavior)#**remark dscp** *dscp-value* **Or:** Ruijie(config-traffic-behavior)#**remark ip-precedence** *ip-precedence-value* **Or:** Ruijie(config-traffic-behavior)#**remark mpls-exp** *mpls-exp-value*	Sets the remark value of IPv4 packets.
Ruijie(config-traffic-behavior)#**remark ipv6 dscp** *dscp-value*	Sets the remark value of IPv6 packets.
Ruijie(config-traffic-behavior)#**remark mpls-exp** *mpls-exp-value*	Sets the remark value of MPLS packets.

Ruijie(config-traffic-behavior)#**remark cos** *cos-value*	Sets the 802.1Q remark value of Ethernet packet.
Ruijie(config-traffic-behavior)#**sub-traffic-policy** *traffic-policy-name*	Sets a sub-traffic policy.

Configuration example:

Create a traffic behavior rule.

```
Ruijie(config)#traffic behavior tb1
Ruijie(config-traffic-behavior)#user-queue uq1 inbound
Ruijie(config-traffic-behavior)#service-class ef color green
Ruijie(config-traffic-behavior)#remark dscp 40
```

Configuring a Traffic Policy Rule

The traffic policy rule associates traffic classes and traffic behaviors, thus scheduling classified traffic according to user configurations. Configure this function as follows:

Command	Purpose
Ruijie(config)# **traffic policy** *traffic-policy-name*	Enters/Creates a traffic policy.
Ruijie(config-traffic-policy)# **classifier** *classifier-name* **behavior** *behavior-name* **precedence** *precedence-value*	Specifies a traffic behavior rule for a traffic class and sets the precedence. The smaller the value of the precedence, the higher the precedence is.

Configuration example:

Create a traffic policy.

```
Ruijie(config)#traffic policy tp1
Ruijie(config-traffic-policy)#classifier tc1 behavior tb1 precedence 1
```

Applying a Traffic Policy to an Interface

Configure this function as follows:

Command	Purpose
Ruijie(config)# **interface** *interface-name*	Enters the interface configuration mode.
Ruijie(config-if)# **traffic-policy** *traffic-policy-name* **[inbound | outbound] [link-layer | all-layer]**	To apply a traffic policy, the layer parameter needs to be specified. Only Layer 3 policies and MPLS take effect by default. The link-layer parameter specified takes effect to only 802.1P Layer 2 packets. The all-layer parameter specified takes effect to both Layer 2 and Layer 3 packets. The link-layer and all-layer parameters can be specified for main interfaces only. The parameters take effect to the main interface and its associated sub-interfaces after specified. They cannot be specified for sub-interfaces.

Configuration example:

Apply a traffic policy to an interface.

```
Ruijie(config)#int gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)#traffic-policy tp1 inbound
```

Configuring a CQ Template

Configuring an CQ template is to configure the scheduling mode (PQ, WFQ, and LPQ), traffic shaping value, and WRED parameters of eight kinds of PQs. PQ scheduling is performed on queues with the priority as ef, cs6, or cs7. WFQ scheduling is performed on queues with the priority as be, af1, af2, af3, or af4. Traffic shaping is not performed by default and the default discarding policy is tail discarding. You can configure multiple CQ templates and apply them to different interfaces. CQ scheduling takes effect on outbound traffic only.

Configure this function as follows:

Command	Purpose
Ruijie(config)# **port-queue** *port-queue-template-name*	Enters/Creates a CQ template.

Ruijie(config-port-queue)# **queue** *cos-value* {**pq** | **wfq weight** *weight-value* | **lpq**} [**shaping** *shaping-value*] [**wred** *wred-name*] [**depth** *depth-value*]	Sets CQ scheduling parameters.
Ruijie(config-port-queue-template)#**exit**	Exits the CQ template configuration.

Configuration example:

Create a CQ template and set CQ scheduling parameters.

```
Ruijie(config)#port-queue pqt1
Ruijie(config-port-queue)# queue be lpq outbound
Ruijie(config-port-queue)# queue af1 wfq weight 10 shaping 100000 wred pwt1
Ruijie(config-port-queue)# queue cs7 pq shaping wred pwt1
Ruijie(config-port-queue)#exit
```

Applying the CQ to an Interface

The CQ applied to an interface takes effect on outbound traffic only.

Configure this function as follows:

Command	Purpose
Ruijie(config)# **interface** *interface-name*	Enters the interface configuration mode.
Ruijie(config-if)# **port-queue** *port-queue-template-name* [**shaping** *shaping-value*]	Applies the CQ to an interface.

Configuration example:

Apply the CQ to an interface.

```
Ruijie(config)#int gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)#port-queue pqt1
```

Configuring a Static VoQ Credit Point

By default, the VoQ credit point of a device is calculated dynamically based on the processing capability of the device, FAP bandwidth, and flow control. This configuration is to specify a static credit point for the destination device, so that VoQ requests are not updated dynamically during VoQ scheduling.

Configure this function as follows:

Command	Purpose
Ruijie(config)# **credit** {*device-id credit-value*}	Specifies the VoQ credit point for the destination device.

Configuration example:

Set the VoQ credit point of the destination device with the ID as 4 to 10,000.

```
Ruijie(config)#credit 4 10000
```

Configuring System VoQ Scheduling

By default, system VoQ scheduling is disabled.

Configure this function as follows:

Command	Purpose
Ruijie(config)# **voq enable**	Enables system VoQ scheduling.

Configuration example:

Enable system VoQ scheduling.

```
Ruijie(config)#voq enable
```

Clearing Queue Statistics

Command	Function
clear port-queue statistics interface *interface-name*	Clears CQ statistics.

Command	Function
clear user-queue statistics ***user-queue-name*** **{inbound | outbound}** devid *devid*	Clears UQ statistics.
clear user-group-queue statistics *user-group-queue-name* **{inbound | outbound} devid** *devid*	Clears GQ statistics.
clear voq statistics *class-queue-priority* **devid** *devid*	Clears VoQ statistics.

Showing Configurations

Command	Function
show wred [*wred-name*]	Displays WRED configuration information on the system.
Show flow-queue [*flow-queue-name*]	Displays FQ configuration information
show user-queue statistics *user-group-queue-name* **{inbound | outbound} [devid *devid*]**	Displays UQ statistics.
show user-group-queue statistics *user-group-queue-name* **{inbound | outbound} [devid** *devid*]	Displays GQ statistics on the system.
show port-queue [*port-queue-name*]	Displays port-queue configuration information on the system.
show port-queue statistics [interface *interface*]	Displays port-queue statistics on the system.
show credit status [devid *devid*]	Displays credit system information.

Configuration example:

Display the port-queue information on a system interface.

```
Ruijie# show port-queue interface gigabitethernet 1/1/1
[be]
  Pass:     42900556 packets,   2745666258 bytes
  Drop:           0 packets,            0 bytes
  Que :           0 packets,            0 bytes,      2073046 balance,           0 token
[af1]
  Pass:     43401132 packets,   2608782540 bytes
  Drop:           0 packets,            0 bytes
  Que :           0 packets,            0 bytes,         8960 balance,           0 token
[af2]
  Pass:     45091586 packets,   2707371120 bytes
  Drop:           0 packets,            0 bytes
  Que :           0 packets,            0 bytes,      2069592 balance,           0 token
[af3]
  Pass:     43496828 packets,   2613966540 bytes
  Drop:           0 packets,            0 bytes
  Que :           0 packets,            0 bytes,      2092532 balance,           0 token
[af4]
  Pass:     45170464 packets,   2711553720 bytes
  Drop:           0 packets,            0 bytes
  Que :           0 packets,            0 bytes,      2092532 balance,           0 token
[ef]
  Pass:     45099831 packets,   2708775960 bytes
  Drop:           0 packets,            0 bytes
  Que :           0 packets,            0 bytes,           0 balance,           0 token
[cs6]
  Pass:     46002386 packets,   2761254360 bytes
  Drop:           0 packets,            0 bytes
  Que :           0 packets,            0 bytes,           0 balance,           0 token
[cs7]
  Pass:     41955096 packets,   2520579480 bytes
  Drop:           0 packets,            0 bytes
  Que :           0 packets,            0 bytes,           0 balance,           0 token
```

Typical HQoS Configuration Examples

Configuration Example 1

Networking Requirement

- Device requirement

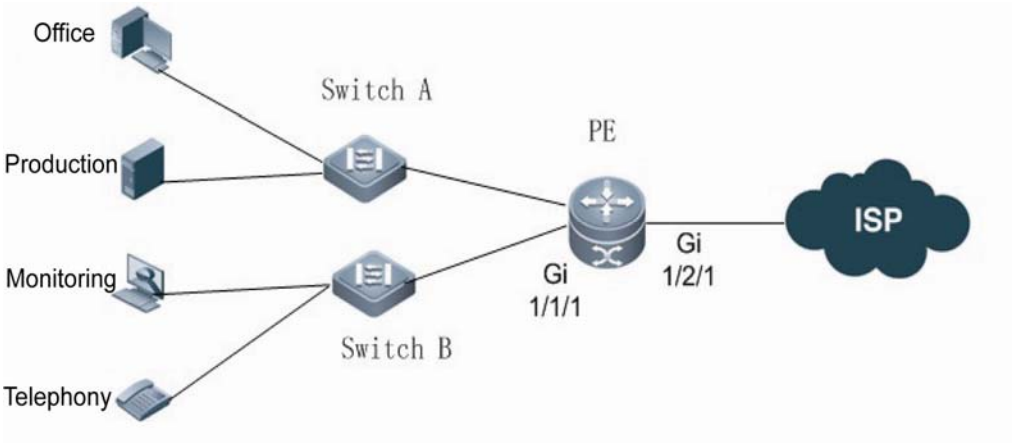
Two Ethernet switches and one router

- Configuration requirement

Each switch is connected to one user to provide two services. For user A, the CIR is 60 Mbit/s and peak bandwidth is 80 Mbit/s. For user B, the CIR is 30 Mbit/s and peak bandwidth is 40 Mbit/s. Both users are bound to a user group with the CIR as 90 Mbit/s and peak bandwidth as120 Mbit/s. Four services are identified by four IP addresses, that is, 10.1.10.1, 10.1.10.2, 10.1.20.1, and 10.1.20.2.

Networking Topology

Figure 16 HQoS Access Networking



Configuration Points

Configure traffic classification rules to distinguish between services.

Configure traffic behavior rules to perform traffic shaping on UQ and GQ.

Configuration Steps

Configure traffic classification rules.

```
# Configure traffic behavior rule tc1.
Ruijie(config)#access-list 100 permit ip 10.1.10.0 0.0.0.255  any
Ruijie(config)#traffic classifier tc1
Ruijie(config-traffic-classifier)#if-match acl 100
Ruijie(config-traffic-classifier)#exit
# Configure traffic behavior rule tc2.
Ruijie(config)#access-list 110 permit ip 10.1.20.0 0.0.0.255 any
Ruijie(config)#traffic classifier tc2
Ruijie(config-traffic-classifier)#if-match acl 110
Ruijie(config-traffic-classifier)#exit
```

Configure an FQ WRED template.

```
Ruijie(config)#wred-template wt1
Ruijie(config-wred-template)#color green low-limit 40 high-limit 60 discard-percent 10
Ruijie(config-wred-template)#color yellow low-limit 30 high-limit 50 discard-percent 10
Ruijie(config-wred-template)#color red low-limit 20 high-limit 40 discard-percent 10
Ruijie(config-wred-template)#exit
```

Configure FQ scheduling parameters.

```
Ruijie(config)#flow-queue-template fqt1
Ruijie(config-flow-queue-template)# queue be lpq
Ruijie(config-flow-queue-template)# queue af1 wfq weight 10 shaping 100 flow-wred wt1
Ruijie(config-flow-queue-template)# queue cs7 pq shaping shaping-percentage 20 flow-wred wt1
Ruijie(config-flow-queue-template)#exit
```

Configure an FQ mapping template.

```
Ruijie(config)#flow-mapping-template fmt1
Ruijie(config-flow-mapping-template)# map flow-queue af1 to port-queue ef
```

Configure a GQ.

```
Ruijie(config)#user-group-queue ugq1 inbound
Ruijie(config-user-group-queue)#shaping 120000
Ruijie(config-user-group-queue)#exit
```

Configure a UQ.

```
# Configure UQ uq1.
Ruijie(config)#user-queue uq1 inbound
Ruijie(confg-user-queue)#cir 60000 pir 80000
Ruijie(config-user-queue)#flow-queue-template fqt1
Ruijie(config-user-queue)#flow-mapping-template fmt1
Ruijie(config-user-queue)#user-group-queue ugq1
Ruijie(config-user-queue)#exit
# Configure UQ uq2.
Ruijie(config)#user-queue uq2 inbound
Ruijie(config-user-queue)#cir 30000 pir 40000
Ruijie(config-user-queue)#flow-queue-template fqt1
Ruijie(config-user-queue)#user-group-queue ugq1
Ruijie(config-user-queue)#exit
```

Configure traffic behavior rules.

```
# Configure traffic behavior rule tb1.
Ruijie(config)#traffic behavior tb1
Ruijie(config-traffic-behavior)#user-queue uq1 inbound
Ruijie(config-traffic-behavior)#exit
# Configure traffic behavior rule tb2.
Ruijie(config)#traffic behavior tb2
Ruijie(config-traffic-behavior)#user-queue uq2 inbound
Ruijie(config-traffic-behavior)#exit
```

Configure a traffic policy.

```
Ruijie(config)#traffic policy tp1
Ruijie(config-traffic-policy)#classifier tc1 behavior tb1
Ruijie(config-traffic-policy)#classifier tc2 behavior tb2
Ruijie(config-traffic-policy)#exit
```

Apply the policy to an interface.

```
Ruijie(config)#int gigabitethernet 1/1/1
Ruijie(config-if-Gigabitethernet1/1/1)#traffic-policy tp1 inbound
```

Configure a CQ WRED template.

```
Ruijie(config)# port-wred-template pwt1
Ruijie(config-port-wred-template)#color green low-limit 40 high-limit 60 discard-percent 10
Ruijie(config-port-wred-template)#color yellow low-limit 30 high-limit 50 discard-percent 10
Ruijie(config-port-wred-template)#color red low-limit 20 high-limit 40 discard-percent 10
Ruijie(config-port-wred-template)#exit
```

Configure a CQ.

```
Ruijie(config)#port-queue-template pqt1
Ruijie(config-port-queue-template)# queue be lpq outbound
Ruijie(config-port-queue-template)# queue af1 wfq weight 10 shaping 100000000 port-wred pwt1
Ruijie(config-port-queue-template)# queue cs7 pq shaping shaping-percentage 20 port-wred pwt1
Ruijie(config-port-queue-template)#exit
```

Apply the CQ to an interface.

```
Ruijie(config)#int gigabitethernet 1/2/1
Ruijie(config-if-Gigabitethernet 1/2/1)#port-queue pqt1 outbound
```

Verification

Display traffic policy statistics on an interface.

```
Ruijie#show user-queue statistics uq1 inbound devid 4
Ruijie#show user-queue statistics uq2 inbound devid 4
```

Display CQ statistics on an interface.

```
Ruijie# show port-queue interface gigabitethernet 1/2/1
```

Configuration Example 2

Networking Requirement

- Device requirement

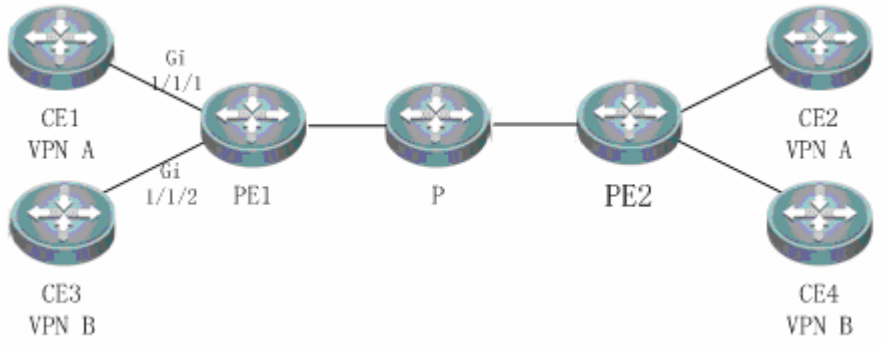
Seven routers

- Configuration requirement

Three routers constitute an MPLS backbone network. Two routers provide user access for VPN A, and two routers provide users access for VPN B. On each of the networks connected to CE1 and CE3, there is a multicast source with the multicast address as 232.0.0.1. For CE1, the CIR is 60 Mbit/s and peak bandwidth is 80 Mbit/s. For CE2, the CIR is 30 Mbit/s and peak bandwidth is 40 Mbit/s.

Networking Topology

Figure 17 HQoS Multicast Networking



Configuration Points

Configure traffic classification rules to distinguish between multicast addresses.

Configure traffic behavior rules to restrict the bandwidth of uplink multicast UQ.

Configuration Steps

Configure traffic classification rules.

```
# Configure traffic classification rule tc1.
Ruijie(config)#access-list 100 permit ip any host 232.0.0.1
Ruijie(config)#traffic classifier tc1
Ruijie(config-traffic-classifier)#if-match acl 100
Ruijie(config-traffic-classifier)#exit
# Configure traffic classification rule tc2.
Ruijie(config)#traffic classifier tc2
Ruijie(config-traffic-classifier)#if-match acl 100
Ruijie(config-traffic-classifier)#exit
```

Configure a UQ.

```
# Configure UQ uq1.
Ruijie(config)#user-queue uq1 inbound
Ruijie(confg-user-queue)#cir 60000 pir 80000
Ruijie(config-user-queue)#exit
# Configure UQ uq2.
Ruijie(config)#user-queue uq2 inbound
Ruijie(config-user-queue)#cir 30000 pir 40000
Ruijie(config-user-queue)#exit
```

Configure traffic behavior rules.

```
# Configure traffic behavior rule tb1.
Ruijie(config)#traffic behavior tb1
Ruijie(config-traffic-behavior)#user-queue uq1 inbound
Ruijie(config-traffic-behavior)#exit
# Configure traffic behavior rule tb2.
Ruijie(config)#traffic behavior tb2
Ruijie(config-traffic-behavior)#user-queue uq2 inbound
```

```
Ruijie(config-traffic-behavior)#exit
```

Configure a traffic policy.

```
Ruijie(config)#traffic policy tp1
Ruijie(config-traffic-policy)#classifier tc1 behavior tb1
Ruijie(config-traffic-policy)#exit

Ruijie(config)#traffic policy tp2
Ruijie(config-traffic-policy)#classifier tc2 behavior tb2
Ruijie(config-traffic-policy)#exit
```

Apply the policy to an interface.

```
Ruijie(config)#int gigabitethernet 1/1/1
Ruijie(config-if-Gigabitethernet1/1/1)#traffic-policy tp1 inbound

Ruijie(config)#int gigabitethernet 1/1/2
Ruijie(config-if-Gigabitethernet1/1/2)#traffic-policy tp2 inbound
```

Verification

Display traffic policy statistics on an interface.

```
Ruijie# show traffic policy tp1
Ruijie# show traffic policy t
```

RGOS Configuration Guide

V10.4(3b13)

Configuring IP Multicast

Configuring IP Multicast Routing

Overview

This chapter describes how to configure IPv4 multicast routing protocols. To obtain complete descriptions of multicast routing commands, see the "Multicast Routing Commands" section.

The traditional IP transmission only allows one host to transmit packets to a single host (unicast communication) or all hosts (broadcast communication). Multicast, however, allows one host to send the packets to some hosts (also known as group members).

The destination addresses of packets sent to the group member are Class-D network addresses (224.0.0.0–239.255.255.255). Multicast packets are UDP packets with best effort service. It does not provide reliable transmission and error control as TCP.

The multicast application consists of the sender and receiver. The sender can send multicast packets without needing to join a group. In contrast, the receiver can receive the multicast packets from the group only after joining the group.

Group members are dynamic. A host can join or leave a group at any time. Furthermore, there is no limit on the position or number of group members. A host can join more than one group simultaneously if necessary. Consequently, the active status and the number of members of a group vary from time to time.

Devices run a multicast routing protocol such as the Protocol-Independent Multicasting-Dense Mode (PIM-DM) and the Protocol-Independent Multicasting-Sparse Mode (PIM-SM) to maintain their routing tables to forward multicast messages, and use the Internet Group Management Protocol (IGMP) to learn the status of the members within a group on their directly attached subnets. A host can join or leave an IGMP group by sending IGMP Report messages.

IP multicast applies to one-to-many multimedia applications.

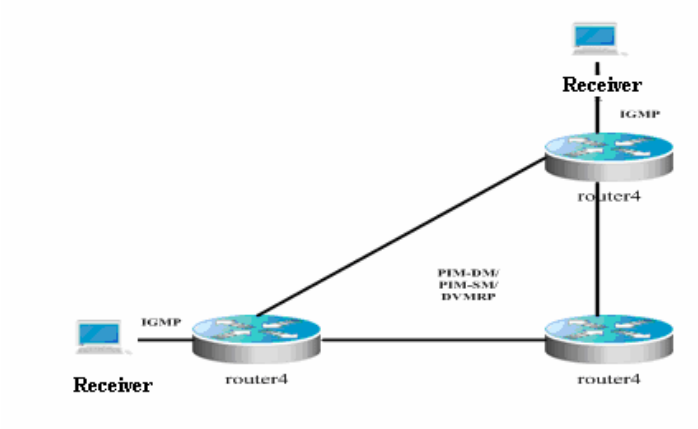
Implementation of IP Multicast Routing

Multicast routing protocols include:

- IGMP: Runs between the routers and the hosts to trace the relationship of group members.
- PIM-DM: A multicast routing protocol in dense mode, which runs between multicast devices to establish the multicast routing table for forwarding.
- PIM-SM: A multicast routing protocol in sparse mode, which runs between multicast devices to establish the multicast routing table for forwarding.
- DVMRP: Distance Vector Multicast Routing Protocol, which runs between multicast devices to establish the multicast routing table for forwarding.

Figure 1 shows IP multicast routing protocols used within the IP multicast environment.

Figure 1 IP Multicast Routing Protocols within the IP Multicast Environment



IGMP

To enable IP multicast, hosts and routers must support the IGMP protocol. This protocol is used by hosts to report their group memberships to multicast routers on the directly-connected network, allowing the multicast routers to determine how to forward multicast traffic.

By using the information obtained from IGMP, multicast routers create an interface-based multicast group member list. The list is activated only when at least one host on an interface is a member of the group. IGMPv1, IGMPv2 and IGMPv3 are currently supported.

IGMPv1

There are only two types of IGMP messages defined in IGMPv1:

- Membership query
- Membership report

A host sends a membership report to indicate that it is interest in joining a group, and the router sends membership queries periodically to ensure that the group has at least one host. When there is no hosts in that group, the device will delete it.

IGMPv2

In IGMPv2, there are only four types of IGMP messages:

- Membership query
- Version 1 membership report
- Version 2 membership report
- Leave group

IGMPv2 is basically the same as IGMPv1, except that IGMPv2 creates a Leave group message for hosts. For IGMPv2, hosts report leave messages to routers which then send queries to check whether there is a host in the multicast group. This makes joining and leaving a group more efficient.

In the multicast network running IGMP, a multicast router is dedicated for sending IGMP query messages. This router is called a querier which is selected through an election mechanism. At first, all routers are queriers. If a router receives a query message from another router with a lower IP address, it becomes a non-querier. Consequently, there is only one querier which has the lowest IP address among all multicast routers on the network.

If a querier is invalid, new querier will be elected. Non-queriers keep a timer for Other Querier Present Interval. Every time when a router receives a membership query packet, it resets the timer. If the timer expires, the router starts to send query messages and selects new querier again.

Queriers must periodically send membership queries to ensure that other routers on the network know that the querier still works. For this purpose, the querier maintains one query interval timer. When it sends membership query messages, this timer will be reset. When the interval timer times out, the querier sends another membership query.

When a new router appers, it sends a series of general query messages to solicit membership information. The number of general query packets depends on the Startup Query Count configured on the router. The initial general query interval is defined by the Startup Query Interval.

When a querier receives a leave group message from a host, it must send a group-specific membership query to see whether the host is the last one to leave the group. Before the querier stops forwarding packets to the group, it sends a series of such packets, the number of which is equal to the Last Member Query Count. The querier sends multiple group-specific membership queries to ensure that there is no member in the group. Such a query is sent every other the Last Member Query Interval seconds. When no response is received, the querier stops forwarding multicast packets to the group on the specified interface.

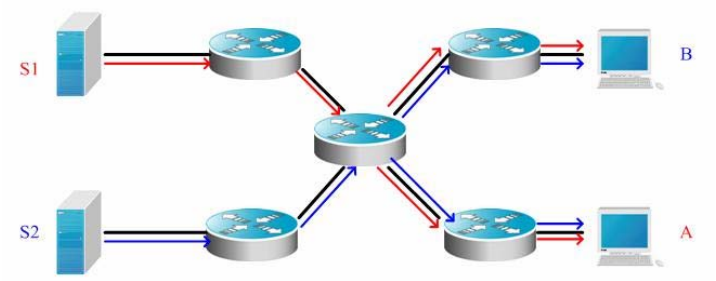
IGMPv3

Both IGMPv1 and IGMPv2 have the following defects:

- Lack of efficient measures to control multicast sources
- Difficult to establish multicast paths due to ignorance of multicast source locations.
- Difficult to find a unique multicast address. It is possible that multicast groups are using the same multicast address.

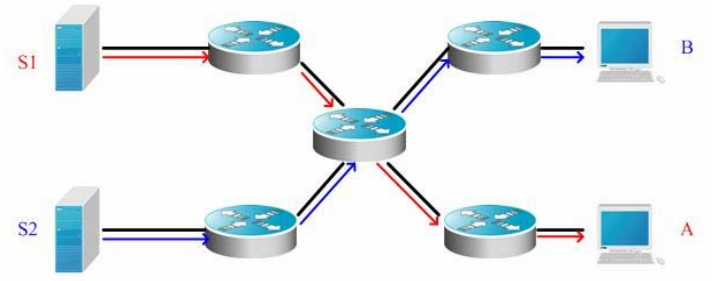
On the basis of IGMPv1 and IGMPv2, IGMPv3 provides an additional source filtering multicast function. In IGMPv1 or IGMPv2, hosts determines whether to join a group by group address and, once it joins the group, it receives multicast traffic forwarded from any source to that group address. In IGMPv3, hosts are enabled to report the multicast group they desire to join in and the multicast source from which they expect to receive traffic. A host specifies sources from which they want to receive multicast traffic through an INCLUDE list or an EXCLUDE list. Besides, IGMPv3 saves bandwidth by preventing unnecessary, illegal multicast data flows from occupying network bandwidth. It is particularly useful in the case where multiple multicast sources share one multicast address. IGMPv1 and IGMPv2 can also implement "source address filtering" in some sense, which, however, is performed on hosts receiving multicast traffic. As shown in the following diagram, two multicast sources (S1 and S2) send out traffic directed to the same multicast group address (G). This multicast traffic from S1 and S2 will be sent to all hosts receiving traffic from G. If host A only wants to receive multicast traffic from S1, it has to filter out traffic from S2 by running approriate client software.

Figure 2 Multicast traffic forwarded without source filtering



If multicast routers on the network support IGMPv3, host A wants to receive traffic from S1 only, it sends out an IGMPv3 packet in the form of “join G include S1”. host B wants to receive traffic from S2 only, it sends out an IGMPv3 packet in the form of “ join G include S2”. In this way, the traffic is forwarded as shown in Figure 3. This saves bandwidth.

Figure 3 Multicast traffic forwarded with source filtering



Based on IGMPv2, IGMPv3 adds the following two kinds of messages:

- Membership query
- Version 3 membership report

There are three types of membership query:

- General Query: used to learn information of all multicast members on an interface.
- Group-Specific Query: used to learn information of members of a specific group on an interface.
- Group-and-Source-Specific Query: a new type specified in IGMPv3 used to learn whether there is a member on an interface wants to receive group-specific multicast traffic from sources in the specified source list.

Membership report in IGMPv3 is different from that defined in IGMPv2. The IGMPv3 membership reports are always sent with an destination address of 224.0.0.22. Besides, an IGMPv3 membership report can contain one or more group records, containing a group address and an list of source addresses. Group records have the following types.

- IS_IN: indicates that the filter mode between a multicast group and the multicast source list is INCLUDE, that is, only multicast data sent from the specified multicast source list to the multicast group is received. If the specified multicast source list is empty, it indicates leaving the multicast group, which is equivalent to the leave packet in IGMPv2.
- IS_EX: indicates that the filter mode between a multicast group and the multicast source list is EXCLUDE, that is, only multicast data sent from the multicast sources not included in the specified multicast source list to the multicast group is received.
- TO_IN: indicates that the filter mode between a multicast group and the multicast source list is changed from EXCLUDE to INCLUDE.
- TO_EX: indicates that the filter mode between a multicast group and the multicast source list is changed from INCLUDE to EXCLUDE.

- ALLOW: indicates that multicast data from certain multicast sources are allowed. If the current relationship is INCLUDE, these multicast sources are added to the existing multicast source list. If the current relationship is EXCLUDE, these multicast sources are deleted from the existing multicast source list.
- BLOCK: indicates that multicast data from certain multicast sources are prohibited. If the current relationship is INCLUDE, these multicast sources are deleted from the existing multicast source list. If the current relationship is EXCLUDE, these multicast sources are added to the existing multicast source list.

For compatibility consideration, IGMPv3 can identify packets of IGMPv1 and IGMPv2.

PIM-DM

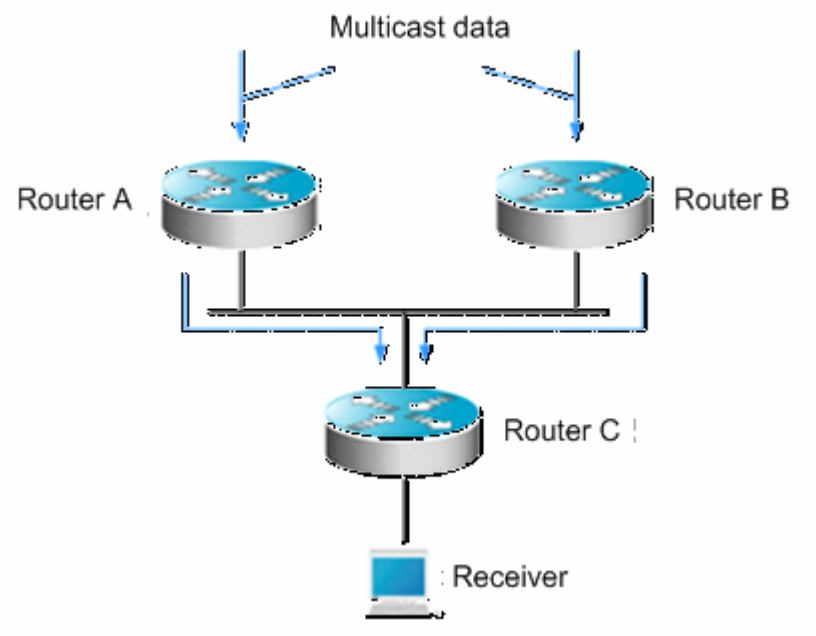
Protocol Independent Multicast-Dense Mode (PIM-DM) is a dense-mode multicast routing protocol, which is suitable for small-sized networks with densely distributed multicast members. As PIM-DM does not rely on any specific unicast routing protocol, it is called protocol independent multicast routing protocol. PIM-DM is defined in RFC 3973.

PIM-DM devices discover neighbors through Hello messages. After startup, a PIM-DM device sends a Hello message to each PIM-DM enabled interface periodically. The Hello message has a field of **Hello Hold Time**, which defines the maximum duration that a neighbor waits for the next message. If the neighbor does not receive another Hello message from the sender within this duration, this device will be removed from the adjacency list.

PIM-DM builds a shortest path tree (SPT) through flood and prune. PIM-DM assumes that when a multicast source begins to send a multicast packet, all the systems in the network need to receive this packet. As a result, this packet is forwarded to every system. The reverse path forwarding (RPF) check is performed for the packets received from the upstream interface. Those packets that fail to pass the check will be discarded. For the packets passing the check, the outgoing interface is computed based on the (S, G) pair of the packets, that is, source address and group address. If the outgoing interface is not null, an outgoing interface entry is created from the (S, G) pair and the multicast packet is forwarded through this outgoing interface. If the computed outgoing interface is null, a prune message is sent to the RPF neighbor, informing the upstream neighbor not to forward the multicast packets from the (S, G) pair to this interface. After the prune message is received on the upstream interface, the device marks the sending interface as pruned state and sets a pruned state timer. In this way, an SPT is created with the multicast source as its root.

PIM-DM uses the Assert mechanism to eliminate redundant routes.

Figure 4 Assert mechanism of PIM-DM



As shown in Figure-4, the multicast data arrives at Routers A and B at the same time, which forward the data to Router C. In this case, Router C receives duplicated data, which is not allowed. So there must be a mechanism to select Router A or B to forward the multicast data to Router C. This is the Assert mechanism of PIM-DM.

PIM-DM uses the state refresh message to update network state. The device directly connected to the multicast source sends the state refresh message to the downstream devices periodically to advertise the network topology changes. The devices receiving the message add their topology state to the state refresh message by modifying some fields, and then send it to the downstream devices. When the refresh message arrives at the leaf devices, the entire network state is updated.

PIM-DM uses the Graft mechanism to reestablish the connection with upstream devices. If the network topology of a downstream device in pruned state changes and the device needs to receive multicast data from a (S, G) pair, it sends the graft message to the upstream device. Upon receiving the graft message, the upstream device responds with a Graft-Ack message and forwards the multicast data to the downstream device again.

DVMRP

The Distance Vector Multicast Routing Protocol (DVMRP) is the first widely used multicast routing protocol in the Internet. It is also in dense mode. Like PIM-DM, DVMRP also uses the reverse path multicast mechanism to establish a distribution tree to forward multicast packets. The difference between the two protocols is that PIM-DM does not rely on specific unicast routing protocols and DVMRP replies on RIP.

A DVMRP device advertises itself, learns neighbor addresses and establishes adjacency through Probe packets. The DVMRP device establishes the adjacency relationship when the Probe packet received from a neighbor contains the IP address of the DVMRP device.

DVMRP neighbors exchange source route information by periodically sending Report packets. The information includes the source network mask and hop count. Such information is stored in the DVMRP routing table that is independent of the unicast routing table and used for RPF check during source tree creation.

DVMRP is also a multicast routing protocol in dense mode and creates SPTs for each multicast source. Initial multicast traffic is forwarded along the entire SPT, but DVMRP does not forward redundant paths. For the specified SPT, the device will send Prune packets to the upstream device after acknowledging that it does not need to receive multicast traffic. The device does not need to receive specified multicast traffic if no downstream neighbor exists and no multicast member information exists. As DVMRP is a multicast routing protocol in dense mode, multicast traffic is redistributed once pruning times out.

In addition, to enable the multicast receiver to join the SPT quickly, DVMRP supports the Graft and Graft-Ack mechanisms. The Graft mechanism adds the pruned paths to the SPT quickly, while the Graft-Ack mechanism avoids loss of Graft messages due to busy networks.

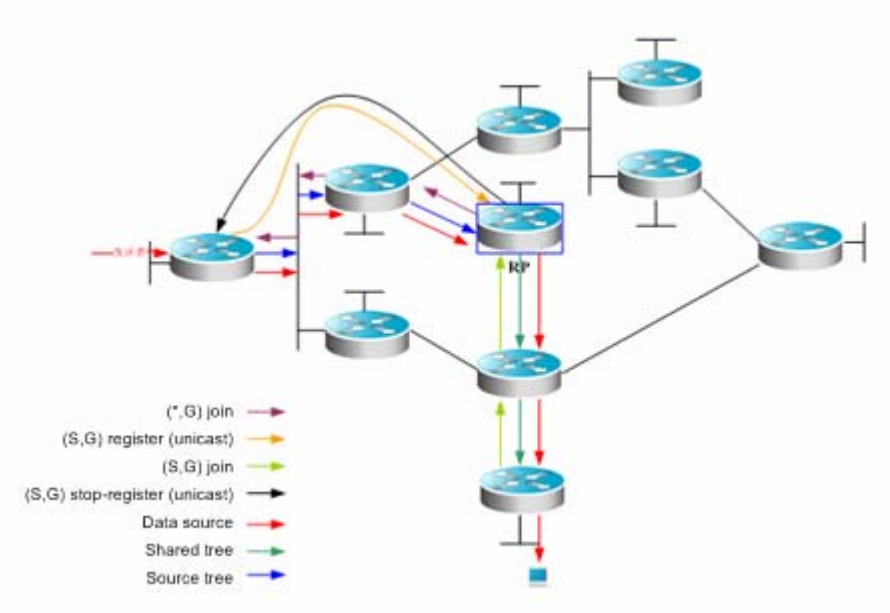
This product supports the complete DVMRP protocol.

PIM-SM

The Protocol Independent Multicast (PIM) is designed by the Inter-Domain Multicast Routing (idmr) working group. As its name implied, PIM does not rely on any specific unicast routing protocol. It can use a unicast routing table established by any unicast routing protocol to perform the RPF check function, instead of maintaining separate multicast routing tables to implement multicast forwarding. As PIM is not required to receive or distribute route updates, compared to other multicast routing protocols, it costs much less. PIM is designed to support shortest path trees (SPTs) and rendezvous point trees (RPTs) simultanenously and enable flexible conversion between them, so that their advantages can be used to improve multicast efficiency. There are two PIM modes: dense mode and sparse mode.

The Protocol Independent Multicast – Sparse Mode (PIM-SM) is a multicast routing protocol of sparse mode. In a PIM-SM domain, the PIM-SM-enabled device periodically sends Hello messages to discover adjacent PIM-SM devices and selects a designated router (DR) in a multi-access network. The DR is responsible for sending Join/Prune messages towards the root of themulticast distribution tree from its directly connected group member, or itsdirectly connected multicast source.

Figure 5 Explicit join mechanism of PIM-SM



PIM-SM forwards multicast data packets by establishing a multicast distribution tree. The multicast distribution tree is divided into two types: Shared Tree that takes the RP of the group G as the root and Shortest Path Tree that takes the multicast source as the root. PIM-SM establishes and maintains the multicast distribution tree by use of the explicit join/prune mechanism. As shown in Figure-5,

1) When the DR at the receiving end receives a report packet from the receiving end, it sends a (*.G)join packet towards the RP of group G to join the shared tree.
2) When the DR at the data source receives multicast data from the source host, it encapsulates the multicast data into a register message and unicasts it to the RP. Then the RP will forward the decapsulated data packets to group members along the shared tree.
3) The RP sends an (S, G)join packet to the first-hop device in the source direction to join the shortest path tree of this source. In this way, the source's packets are sent to the RP without encapsulation along its shortest path tree.
4) When the first multicast data reaches along the SPT, the RP sends the stop-register message to the DR at the source, notifying the DR of stopping register encapsulation. Afterwards, the DR at the source does not encapsulate register packets but sends them to the RP along its shortest path tree, which then forwards the packets to group members along the shared tree. When no multicast data is required, the DR at the receiving end multicasts the prune message to group G's RP hop by hop to prune the shared tree.

PIM-SM also offers a mechanism of selecting the root point (RP). One or more Candidate-BSRs are configured in a PIM-SM domain. PIM-SM selects a BSR by following a certain rule. There are also Candidate-RPs in a PIM-SM domain that unicast the packets including their IP addresses and available multicast groups to the BSR. The BSR will periodically generate a BSR message which includes a series ofcandidate RPs and corresponding multicast group addresses. The BSR messages are sent hop-by-hop within the entire domain. The device receives and saves these BSR messages. If the DR receives a report on the member relationship of a multicast group from its directly connected host but has no route entries of the multicast group, the DR will use a Hash algorithm to map the multicast group address to a candidate RP that can serve this group. Then, the DR multicasts the Join/Prune message to the RP hop-by-hop. If the DR receives multicast data packets from its directly connected host but has no route entries of the multicast group, the DR will usea Hash algorithm to map the multicast group address to a candidate RP that can serve this group. Then the DR encapsulates multicast data packets into a register message and unicasts it to the RP.

The main difference between PIM-SM and the flood/prune model-based PIM-DM is that PIM-SM is based on the explicit join model. In other words, the receiver sends the join message to the RP, while the router only forwards the packets of that multicast group on the outgoing interface that has joined a multicast group. PIM-SM uses the shared tree to forward multicast packets. Each group has a Rendezvous Point (RP). The multicast source sends data to the RP along the shortest path, and then the RP sends the data to the receivers along the shortest path. This is similar to CBT, but PIM-SM does not use the concept of core. One of the major advantages of PIM-SM is that it not only receives multicast messages through the shared tree but also provides a shared tree-to-SPT conversion mechanism. Such conversion reduces network delay and possible congestion on the RP, but it consumes enormous router resources. So it is suitable for the case where there are only a few multicast data sources and network groups.

PIM-SM uses the shared tree and SPT to distribute multicast frames. At this time, it is assumed that other devices don't want to receive these multicasts unless otherwise stated definitely. When a host joins a group, the equipment connected to the host must notify the root (or the RP) by using the PIM join message. This join message is transferred one after another through the routers to create a shared tree structure. Therefore, the RP records the transfer path and also the register message from the first hop router (DR) of the multicast source, and improves the shared tree upon these two messages. The branch/leaf messages are updated by periodically querying messages. With the shared tree, the multicast source first sends multicast packets to the RP, guaranteeing that all the receivers can receive them. The notation (*.G) represents a tree. The asterisk (*) represents all sources and G represents a specific multicast address. The prune message is also used in the shared tree. That is, the branch/leaf will send prune messages once it is not expecting to receive multicast frames.

PIMv2 BSR is a method of distributing group-to-RP messages to all devices without the need of setting an RP for them. BSR distributes mapping information by propagating BSR messages hop by hop. At first, BSR is selected among routers in the same process as selecting a root bridge based on priority level among layer 2 bridges. Each BSR checks the BSR messages and only forwards those having a priority higher than or equal to its own (higher IP address). The selected BSR sends its BSR message to the all-PIM-routers multicast group (224.0.0.13), where TTL is 1. After the adjacent PIMv2 router receives the message, it multicasts it while setting the TTL to 1. In this way, the BSR message is received by all devices hop by hop. Since the message contains the IP address of the BSR, the candidate BSR can know which router is the current BSR based on this message. The candidate RPs send candidate RP advertisements to announce in which address ranges they can become an RP. The BSR stores them in its local candidate RP cache. The BSP notifies all PIM routers of its local candidate RPs periodically. These messages reach various devices hop by hop in the same way.RPF Check

Multicast routing protocols depend on existing unicast route messages, MBGP routes or static multicast routes to create multicast routing entries. When creating multicast routing entries, multicast routing protocols run the Reverse Path Forwarding (RPF) check mechanism to ensure that multicast packets are transmitted along proper paths while avoiding loops.

RPF check is on the basis of unicast routes, MBGP routes or static multicast routes.

- The unicast routing table summarizes the shortest paths to each destination network segment.
- The MBGP routing table directly offers multicast routes.
- The multicast static routing table lists the RPF route messages that the user configures statically and manually.

RPF Check Process

The multicast routing protocol searches the unicast routing table, the MBGP routing table and the static multicast routing while performing an RPF check. The process is as follows:

1) First of all, select an optimal route from the unicast routing table, the MBGP routing table and the static multicast routing table, respectively.

- Select an optimal route from the unicast routing table for RPF check:
  - Use the IP address of the packet source as the destination address to search the unicast routing table and select an optimal unicast route.
  - If the unicast route has only one next hop, check whether multicast is enabled on the egress of the next hop.
    - If no, the unicast route is not suitable for RPF check.
    - If yes, the unicast route is suitable for RPF check and the egress serves as the RPF interface.
  - If the unicast route has more than one next hop, traverse all next hops and check whether multicast is enabled on the egress of one next hop.
    - If no, traverse the next hop.
    - If yes, the unicast route is suitable for RPF check and the egress serves as the RPF interface.
    - If no multicast is enabled on the egress after all next hops are traversed, there is no unicast route suitable for RPF check.
  - If no optimal route exists, there is no unicast route suitable for RPF check.
- Select an optimal route from the MBGP routing table for RPF check:
  - Use the IP address of the packet source as the destination address to search the MBGP routing table and select an optimal MBGP route.
  - The MBGP route has only one next hop. Check whether multicast is enabled on the egress of the next hop.
    - If no, the MBGP route is not suitable for RPF check.
    - If yes, the MBGP route is suitable for RPF check.
  - If no optimal route exists, there is no MBGP route suitable for RPF check.
- Select an optimal route from the static multicast routing table for RPF check:
  - Use the IP address of the packet source as the destination address to search the static multicast routing table and select an optimal static multicast route.
  - If the static multicast route has only one next hop, check whether multicast is enabled on the egress of the next hop.
    - If no, the static multicast route is not suitable for RPF check.
    - If yes, further check whether there is a unicast route available for RPF check.
      - If the next hop does not associate with the unicast protocol number, the static multicast route is suitable for RPF check.
      - If there is no unicast route available for RPF check, the static multicast route is suitable for RPF check.
      - If there is a unicast route available for RPF check, but the unicast protocol number is inconsistent with the one associated with the next hop of the static multicast route, the static multicast route is not suitable for RPF check.
      - If there is a unicast route available for RPF check, and the unicast protocol number is consistent with the one associated with the next hop of the static multicast route, the static multicast route is suitable for RPF check.
  - If the static multicast route has more than one next hop, traverse all next hops and check whether multicast is enabled on the egress of one next hop.
    - If no, traverse the next hop.
    - If yes, further check whether there is a unicast route available for RPF check.
      - If the next hop does not associate with the unicast protocol number, the static multicast route is suitable for RPF check. The outbound interface is the RPF interface.

- If there is no unicast route available for RPF check, the static multicast route is suitable for RPF check. The outbound interface is the RPF interface.
- If there is a unicast route available for RPF check, but the unicast protocol number is inconsistent with the one associated with the next hop of the static multicast route, traverse the next hop.
- If there is a unicast route available for RPF check, and the unicast protocol number is consistent with the one associated with the next hop of the static multicast route, the static multicast route is suitable for RPF check. The outbound interface is the RPF interface.
- If no multicast is enabled on the egress after all next hops are traversed, there is no static multicast route suitable for RPF check.

■ If no optimal route exists, there is no static multicast route suitable for RPF check.

2) Select one from these three optimal routes for RPF check.

■ If the longest match routing rule is configured, select the longest match route; if these three routes are of the same mask, select the one of the highest priority; if they are of the same priority, select the one in the order of static multicast route, MBGP route and unicast route.

■ If the longest match routing rule is not configured, select the one of the highest priority; if they are of the same priority, select the one in the order of static multicast route, MBGP route and unicast route.

Caution

The effectiveness of MBGP routes recurs on unicast routes rather than distance. The implementation of current MBGP protocols does not support equal-cost routes.

The effectiveness of static multicast routes recurs on unicast routes rather than distance.

If the static unicast route is selected as RPF route, the route must be configured with the next hop IP address. The PIM protocol will select RPF neighbors based on this next hop IP address. If the static unicast route is not configured with the next hop IP address, the PIM protocol cannot obtain RPF neighbors.

☑ For the commands including the VRF parameters, only the RSR20, RSR30, RSR50 and RSR50E devices support the VRF parameters.

Configuring IP Multicast Routing

Enabling IP Multicast Forwarding

Multicast data packets and protocol packets can be received and processed by related multicast protocols only after the multicast routing forwarding function is enabled.

Command	Function
Ruijie(config)# **ip multicast-routing** [**vrf** *vrf-name*]	Enables multicast routing forwarding. Enable multicast routing based on VRF if it is carried; Enable the default multicast routing globally if VRF is not carried.

Enabling IP Multicast Routing Protocols

Use the following commands to enable the IP multicast function on an interface.

Command	Function

Command	Function
Ruijie(config-if)# **ip pim dense-mode**	Enters the interface on which PIM-DM is to be enabled and enables PIM-DM in interface configuration mode. This command must be configured on a layer 3 interface.
Ruijie(config-if)# **ip pim sparse-mode**	Enters the interface on which PIM-SM is to be enabled and enables PIM-SM in interface configuration mode. This command must be configured on a layer 3 interface.
Ruijie(config-if)# **ip dvmrp enable**	Enters the interface on which DVMRP is to be enabled and enables DVMRP in interface configuration mode. This command must be configured on a layer 3 interface.

The following example shows how to configure PIM-DM on interface GE 0/3:

```
Ruijie(config)# ip multicast-routing
Ruijie(config)# interface  gigabitEthernet 0/3
Ruijie(config-if)# ip address 192.168.194.2 255.255.255.0
Ruijie(config-if)# ip pim dense-mode
```

Note If IPv4 multicast routing is enabled globally, enabling IP multicast routing protocols on an interface will also enable the IGMP function. Only the IP multicast routing protocols of one mode can be enabled on one interface.

Caution After the layer 3 multicasting is enabled on the Private VLAN and Super VLAN, if the multicast source exists in the sub-VLAN, one more route entry must be duplicated and the ingress is the sub-VLAN in which the multicast streams enter as the ingress validity check is required for multicast forwarding. As a result, one more multicast hardware entry is occupied, that is, multicast capacity is reduced by 1.

Enabling IGMP

The IGMP protocol is enabled with the enabling of IP multicast route forwarding and IP multicast routing protocols.

Configuring IP Multicast Routing

Configuring TTL Threshold

To limit the TTL of the data packets allowed to pass an interface, configure the TTL threshold.

Use the following command to configure the TTL threshold of multicast packets allowed to pass an interface. Use the **no** form of this command to restore the default value. The default value is **0**.

Command	Function

Command	Function
Ruijie (config-if) # **ip multicast ttl-threshold** *ttl-value*	Configures the TTL threshold of an interface. *ttl-value* ranges from 0 to 255.

Limiting the Number of Entries to Be Added to the IP Multicast Routing Table

Use the following command to limit the number of entries to be added to the IP multicast routing table in global configuration mode. Use the **no** form of this command to restore the default value. The default value is **1024**.

Command	Function
Ruijie (config) # **ip multicast route-limit** *limit* [*threshold*]	Limits the number of entries to be added to the IP multicast routing table. *limit* specifies the number of entries to be added to the multicast routing table. The range is from 1 to 2147483647. The default is 1024. *threshold* (optional) specifies the number of routes triggering alarm. The default is 2147483647.

Caution As the hardware is limited for different models, the routes exceeding the hardware entry threshold need to be forwarded through software, resulting in performance degrade.

Configuring IP Multicast Boundary for a Specific IP Group

Use the following command to set IP multicast boundary for a specific IP group in interface configuration mode. Use the **no** form of this command to restore the default value.

Command	Purpose
Ruijie (config-if) # **ip multicast boundary** *access-list* [**in** | **out**]	Sets IP multicast boundary for a specific IP group. Numerical standard ACL or name can be used to specify an IP group.

This command filters the IGMP, PIM-SM and PIM-DM packets associated with the IP group. Multicast packets will not flow in or out through the multicast boundary interface.

Note The ACL in this command supports matching of destination IP addresses, not group IP addresses or source IP addresses.

Configuring IP Multicast Static Route

IP static multicast route enables multicast packet forwarding through a path different from IP unicast path. RPF check is always performed for IP multicast packet forwarding. The real interface receiving packets is the expected one, namely the next hop interface of IP unicast route used to transmit to the sender. The check is reasonable when IP unicast topology is consistent with IP multicast topology. In some cases, however, it is better to make difference between IP unicast path and IP multicast path.

Static multicast route enables devices to execute RPF check according to configurations rather than the IP unicast routing table. Consequently, tunnel technology is used for IP multicast packet forwarding, not IP unicast packet forwarding. IP static multicast route is stored locally rather than be advertised or forwarded.

Use the following command to configure IP multicast static routes.

Command	Function
Ruijie (config) # **ip mroute** [**vrf** *vrf-name*] *source-address mask* { **fallback-lookup** { **global** | **vrf** *vrf-name* } | [**bgp** | **isis** | **ospf** | **static**] {*v4rpf-address* | *interface-type interface-number* } } [*distance*]	Configures IP multicast static route. The routing protocol type can be set. *distance*: In the range of 0 to 255

Caution To set the egress of the static multicast route not to be the next hop IP address, the egress must be a point-to-point interface.

Configuring Longest-Match-based Routing

Use the following command to configure longest-match-based routing.

Command	Function
Ruijie(config)# **ip multicast** [**vrf** *vrf-name*] **rpf longest-match**	Selects an optimal route from the static multicast, MBGP and unicast routing tables respectively in compliance with the RPF rules. Select the one with the longest mask matching from the three routes as the RPF route. If the three are of the same priority, select one in the order of multicast static route, MBGP route and unicast route.

The static multicast route, MBGP route and unicast route used for RPF check are elected from the static multicast routing table, MBGP routing table and unicast routing by RPF rules, respectively.

- By default, the one of highest priority is selected from these three routes. If they are of the same priority, select one in the order of static multicast route, MBGP route and unicast route.
- If the route selection based on the longest match has been configured, the one with the longest mask matching is selected from the three routes as the RPF route. If the masks of the three routes are the same, the one of the highest priority will be selected; if the three are of the same priority, a route is selected in the order of multicast static route, MBGP route and unicast route.

Configuring the Selection Method for PROXY in RPF Vector

Use the following commands to configure the selection method for proxy in RPF vector in global configuration mode.

Command	Function
ip multicast [**vrf** *vrf-name*] **rpf proxy** [**rd**] {**vector | disable**}	Configures the selection method for proxy. There are three selection methods for proxy: When the **rd** parameter is configured, the RPF Vector with RD information carried is used. This parameter takes effect only when the vrf is specified. When the **vector** parameter is configured, RFP Vector is used. When the **disable** parameter is configured, receiving RPF Vector is prohibited.
no ip multicast [**vrf** *vrf-name*] **rpf proxy** [**rd**] {**vector | disable**}	Deletes the selection method for proxy.

☑ Currently, this function is supported by RSR20. RSR30, RSR50 and RSR50E.

Configuring the Multicast Hardware Table Overflow Override Mechanism

This command deletes the hardware forwarding entry created earliest if the number of hardware forwarding table is full during creation of a new entry.

Command	Function
Ruijie(config)# **msf ipmc-overflow override**	Deletes the hardware forwarding entry created earliest and adds the new entry if the hardware forwarding table is full during creation of a new entry.

Monitoring and Maintaining IP Multicast Routing

Use the following command to show the IPv4 multicast forwarding table in privileged EXEC mode.

Command	Function
show ip mroute [**vrf** *vrf-name*] [*group-or-source-address* [*group-or-source-address*]] [**dense** | **sparse**] [**summary** | **count**]	Shows the IPv4 multicast forwarding table.

Use the following command to delete the IPv4 multicast forwarding table in privileged EXEC mode.

Command	Function
clear ip mroute [vrf *vrf-name***]** {***** **|** *v4group-address* [*v4source -address*]}	Deletes the IPv4 multicast forwarding table.

Use the following command to reset the IPv4 multicast forwarding table statistics in privileged EXEC mode.

Command	Function
clear ip mroute [vrf *vrf-name***] statistics** {* | *v4group-address* [*v4source-address*]}	Resets the IPv4 multicast forwarding table statistics.

Use the following command to show the IPv4 static multicast routing information in privileged EXEC mode.

Command	Function
show ip mroute [**vrf** *vrf-name*] **static**	Shows the IPv4 static multicast routing information.

Use the following command to show the IPv4 static multicast routing information in privileged EXEC mode.

Command	Function
show ip rpf [**vrf** *vrf-name*] { *source-address* [*group-address*] [**rd** *route-distinguisher*] } [**metric**]	Shows the RPF information of specific IPv4 source address.

☑ Only RSR20, RSR30, RSR50 and RSR50E support the parameters of **group address**, **rd** and **metric**.

Use the following command to show the IPv4 static multicast interface information in privileged EXEC mode.

Command	Function
show ip mvif [**vrf** *vrf-name*] [*interface-type interface-number*]	Shows the IPv4 multicast interface information.

Use the following command to show the IPv4 layer 3 multicast forwarding table in privileged EXEC mode.

Command	Function
show ip mrf [**vrf** *vrf-name*] **mfc**	Shows the IPv4 layer 3 multicast forwarding table.

Use the following command to show the operation of multicast core in privileged mode.

Command	Function
debug nsm mcast [**vrf** *vrf-name*] **all**	Shows the operation of multicast core.

Use the following command to show the communication between the core of IPv4 multicast and multicast protocols in privileged mode.

Command	Function
debug nsm mcast [**vrf** *vrf-name*] **fib-msg**	Shows the communication between the core of IPv4 multicast and multicast protocols.

Use the following command to show the operation on the interface of the core of IPv4 multicast in privileged mode.

Command	Function
debug nsm mcast [**vrf** *vrf-name*] **vif**	Shows the operation on the interface of the core of IPv4 multicast.

Use the following command to show the operation of interface and statistics of the core of IPv4 multicast in privileged mode.

Command	Function
debug nsm mcast [**vrf** *vrf-name*] **stats**	Shows the operation of interface and statistics of the core of IPv4 multicast.

Use the following command to show the packet forwarding on Layer 3 of IPv4 multicast in privileged mode.

Command	Function

debug ip mrf [**vrf** *vrf-name*] **forwarding**	Shows the packet forwarding on Layer 3 of IPv4 multicast.

Use the following command to show the operation of forwarding entries on Layer 3 of IPv4 multicast in privileged mode.

Command	Function
debug ip mrf [**vrf** *vrf-name*] **mfc**	Shows the operation of forwarding entries on Layer 3 of IPv6 multicast.

Use the following command to show the operation of forwarding events on Layer 3 of IPv4 multicast in privileged mode.

Command	Function
debug ip mrf [**vrf** *vrf-name*] **event**	Shows the operation of forwarding events on Layer 3 of IPv4 multicast.

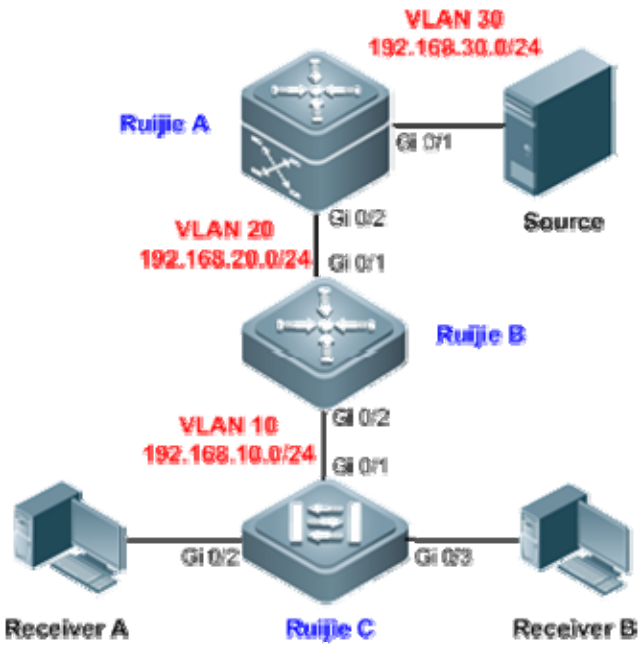
Configuration Examples

PIM-DM Configuration Example

Networking Topology

As shown in Figure 6, Ruijie A and Ruijie B are layer 3 devices; Ruijie C is a layer-2 access device, with downlink users belonging to VLAN 10. The multicast source belongs to VLAN 30, and resides in a network segment different from the multicast receivers.

Figure 6 Topology for multicast routing network



Networking Requirements

- IGMP is running between multicast source and multicast receiver to establish and maintain the membership of a multicast group. For a dense-mode multicast network, PIM-DM can be applied to realize layer-3 routing of multicast data, while IGMP Snooping can be applied on the layer-2 device to realize layer-2 forwarding of multicast data.
- Only hosts belonging to VLAN 10 can join the multicast group 225.0.0.0/8, and a host can join up to 200 multicast groups.
- PIM adjacency established between the edge multicast router (Ruijie B) and the downlink device by receiving PIM data packets should be avoided.

Configuration Tips

- Configure unicast routing protocol on the layer-3 devices (Ruijie A and Ruijie B in this example), and ensure the route connectivity between different network segments. Static route is configured in this example.
- On the layer-3 interface of multicast routing devices (SVI of VLANs 10, 20 and 30), configure PIM-DM to enable IGMP automatically (IGMPv2 is the default version).
- Configure IGMP Snooping on the layer-2 device (Ruijie C in this example). Here only the IVGL mode of IGMP Snooping is enabled, and detailed configurations are not provided here. For details, see *Configuring IGMP Snooping*.
- Configure multicast group access control on the layer-3 interface (SVI for VLAN 10 of Ruijie B) of multicast router to limit the range of multicast groups the downlink hosts can join. Configure the maximum number of IGMP group members on this interface (in this example, the maximum number is set to 200).
- Configure PIM neighbor filtering on the layer-3 interface of Ruijie B for connecting to the layer-2 device. By setting up filtering conditions for ACL, only the PIM packets from uplink neighbors can be received.

Configuration Steps

- Step 1: Configure SVI for each VLAN.

! On Ruijie A, create VLAN 20 and VLAN 30, and configure the SVI for VLAN 20 as 192.168.20.1/24 and the SVI for VLAN 30 as 192.168.30.1/24.

```
RuijieA#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
RuijieA(config)#vlan 20
RuijieA(config-vlan)#exit
RuijieA(config)#vlan 30
RuijieA(config-vlan)#exit
RuijieA(config)#interface vlan 20
RuijieA(config-if-VLAN 20)#ip address 192.168.20.1 255.255.255.0
RuijieA(config-if-VLAN 20)#exit
RuijieA(config)#interface vlan 30
RuijieA(config-if-VLAN 30)#ip address 192.168.30.1 255.255.255.0
RuijieA(config-if-VLAN 30)#exit
```

! On Ruijie B, create VLAN 10 and VLAN 20, and configure the SVI for VLAN 10 as 192.168.10.1/24 and the SVI for VLAN 20 as 192.168.20.2/24.

```
RuijieB#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
RuijieB(config)#vlan 10
RuijieB(config-vlan)#exit
RuijieB(config)#vlan 20
RuijieB(config-vlan)#exit
RuijieB(config)#interface vlan 10
RuijieB(config-if-VLAN 10)#ip address 192.168.10.1 255.255.255.0
RuijieB(config-if-VLAN 10)#exit
RuijieB(config)#interface vlan 20
RuijieB(config-if-VLAN 20)#ip address 192.168.20.2 255.255.255.0
RuijieB(config-if-VLAN 20)#exit
```

- Step 2: Configure the attributes of each port.

! On Ruijie A, configure Gi 0/1 as an access port belonging to VLAN 30 and Gi 0/2 as a trunk port.

```
RuijieA(config)#interface gigabitEthernet 0/1
RuijieA(config-if-GigabitEthernet 0/1)#switchport access vlan 30
RuijieA(config-if-GigabitEthernet 0/1)#exit
RuijieA(config)#interface gigabitEthernet 0/2
RuijieA(config-if-GigabitEthernet 0/2)#switchport mode trunk
RuijieA(config-if-GigabitEthernet 0/2)#exit
```

! On Ruijie B, configure Gi 0/1 and Gi 0/2 as trunk ports.

```
RuijieB(config)#interface range gigabitEthernet 0/1-2
RuijieB(config-if-range)#switchport mode trunk
RuijieB(config-if-range)#exit
```

! On Ruijie C, configure Gi 0/1 as a trunk port and Gi 0/2-3 as an access port belonging to VLAN 10.

```
RuijieC(config)#interface gigabitEthernet 0/1
RuijieC(config-if-GigabitEthernet 0/1)#switchport mode trunk
RuijieC(config-if-GigabitEthernet 0/1)#exit
RuijieC(config)#interface range gigabitEthernet 0/2-3
RuijieC(config-if-range)#switchport access vlan 10
RuijieC(config-if-range)#exit
```

- Step 3: Configure static route on the layer-3 device.

! On Ruijie B, configure the next-hop IP address for 192.168.30.0 as 192.168.20.1.

```
RuijieB(config)#ip route 192.168.30.0 255.255.255.0 192.168.20.1
```

! On Ruijie A, configure the next-hop IP address for 192.168.10.0 as 192.168.20.2.

```
RuijieA(config)#ip route 192.168.10.0 255.255.255.0 192.168.20.2
```

- Step 4: Enable multicast routing on the layer-3 interface.

! On Ruijie A, enable multicast routing globally, and enable PIM-DM on each interface.

```
RuijieA(config)#ip multicast-routing
RuijieA(config)#interface vlan 20
RuijieA(config-if-VLAN 20)#ip pim dense-mode
RuijieA(config-if-VLAN 20)#exit
RuijieA(config)#interface vlan 30
RuijieA(config-if-VLAN 30)#ip pim dense-mode
RuijieA(config-if-VLAN 30)#exit
```

! On Ruijie B, enable multicast routing globally, and enable PIM-DM on each interface.

```
RuijieB(config)#ip multicast-routing
RuijieB(config)#interface vlan 10
RuijieB(config-if-VLAN 10)#ip pim dense-mode
RuijieB(config-if-VLAN 10)#exit
RuijieB(config)#interface vlan 20
RuijieB(config-if-VLAN 20)#ip pim dense-mode
RuijieB(config-if-VLAN 20)#exit
```

- Step 5: Enable IGMP Snooping on the layer-2 device.

! In global configuration mode, configure IGMP Snooping to operate in IVGL mode.

```
RuijieC(config)#ip igmp snooping ivgl
```

- Step 6: Configure multicast group access control on the layer-3 interface and configure the maximum number of IGMP group members.

! On Ruijie B, create ACL to permit the IP address 225.0.0.0/8.

```
RuijieB(config)#ip access-list standard 1
RuijieB(config-std-nacl)#permit 225.0.0.0 0.255.255.255
RuijieB(config-std-nacl)#exit
```

! On the SVI for VLAN 10, configure multicast group access control and associate ACL.

```
RuijieB(config)#interface vlan 10
RuijieB(config-if-VLAN 10)#ip igmp access-group 1
```

! On the SVI for VLAN 10, configure the maximum number of allowed multicast groups as 200.

```
RuijieB(config-if-VLAN 10)#ip igmp limit 200
RuijieB(config-if-VLAN 10)#exit
```

- Step 7: Configure PIM neighbor filtering.

! On Ruijie B, create the ACL to deny all IP addresses.

```
RuijieB(config)#ip access-list standard 2
RuijieB(config-std-nacl)#deny any
RuijieB(config-std-nacl)#exit
```

! Configure PIM neighbor filtering on the SVI for VLAN 10 and associate ACL so that this interface does not receive PIM packets from other devices or establish adjacencies with them.

```
RuijieB(config)#interface vlan 10
RuijieB(config-if-VLAN 10)#ip pim neighbor-filter 2
RuijieB(config-if-VLAN 10)#exit
```

Verification

- Step 1: Display device configurations.

! Configurations on Switch A

```
RuijieA#show running-config
!
vlan 20
!
vlan 30
!
ip multicast-routing
!
interface GigabitEthernet 0/1
 switchport access vlan 30
!
interface GigabitEthernet 0/2
 switchport mode trunk
!
interface VLAN 20
 ip pim dense-mode
 no ip proxy-arp
 ip address 192.168.20.1 255.255.255.0
!
interface VLAN 30
 ip pim dense-mode
 no ip proxy-arp
 ip address 192.168.30.1 255.255.255.0
!
ip route 192.168.10.0 255.255.255.0 192.168.20.2
```

! Configurations on Switch B

```
SwtichB#show running-config
!
vlan 10
!
vlan 20
!
ip multicast-routing
!
ip access-list standard 1
 10 permit 225.0.0.0 0.255.255.255
!
ip access-list standard 2
 10 deny any
!
interface GigabitEthernet 0/1
 switchport mode trunk
!
interface GigabitEthernet 0/2
 switchport mode trunk
!
interface VLAN 10
 ip pim dense-mode
 ip pim neighbor-filter 2
 ip igmp access-group 1
 ip igmp limit 200
 no ip proxy-arp
 ip address 192.168.10.1 255.255.255.0
!
interface VLAN 20
 ip pim dense-mode
 no ip proxy-arp
 ip address 192.168.20.2 255.255.255.0
!
ip route 192.168.30.0 255.255.255.0 192.168.20.1
```

- Step 2: Display PIM-DM information of the interface (Ruijie A is used as an example).

```
RuijieA#show ip pim dense-mode interface detail
VLAN 20 (vif-id: 1):
  Address 192.168.20.1
  Hello period 30 seconds, Next Hello in 30 seconds
  Over-ride interval 2500 milli-seconds
  Propagation-delay 500 milli-seconds
  Neighbors:
    192.168.20.2
VLAN 30 (vif-id: 2):
```

```
Address 192.168.30.1
Hello period 30 seconds, Next Hello in 25 seconds
Over-ride interval 2500 milli-seconds
Propagation-delay 500 milli-seconds
Neighbors: none
```

The preceding information shows the ID and address of the PIM-DM enabled interface and the corresponding PIM-DM neighbor.

- Step 3: Display the next hop information of PIM-DM (Ruijie B is used as an example).

```
RuijieB#show ip pim dense-mode nexthop
Destination   Nexthop   Nexthop        Nexthop        Metric Pref
               Num      Addr           Interface
192.168.30.2    1      192.168.20.1    VLAN 20           0     1
```

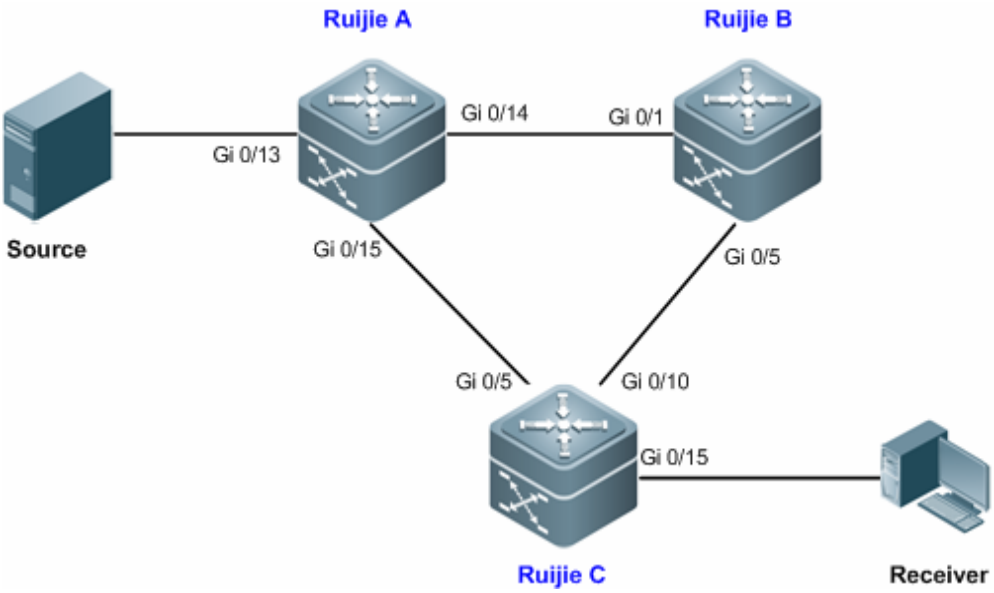
☑ This example applies to both layer-3 switches and routers. However, VLAN-related configuration commands are not supported on routers. Therefore, to establish the topology in this example on routers, directly replace the SVI interfaces with use common layer-3 interfaces.

PIM-SM Configuration Example (I)

Networking Topology

As shown in Figure 7, three layer-3 devices are interconnected through the routed ports. Multicast source and receiver are in different network segments.

Figure 7



The interface addresses of the devices are listed in the following table.

Device	Port Number	IP Address
Ruijie A	Gi 0/13	192.168.1.1/24
	Gi 0/14	192.168.2.1/24
	Gi 0/15	192.168.3.1/24
Ruijie B	Gi 0/1	192.168.2.2/24
	Gi 0/5	192.168.4.1/24
	Loopback1	10.1.1.1/24
Ruijie C	Gi 0/5	192.168.3.2/24
	Gi 0/10	192.168.4.2/24
	Gi 0/15	192.168.5.1/24

Networking Requirements

- IGMP is running between multicast source and multicast receiver to establish and maintain the membership of a multicast group. For a sparse-mode multicast network, PIM-SM can be applied to realize layer-3 routing of multicast data.
- Unauthenticated multicast source should be avoided from sending multicast data in the PIM-SM domain.

Configuration Tips

- Configure unicast routing protocols on the layer-3 devices, and ensure the route connectivity between different network segments. This example configures the OSPF protocol. For details, see *Configuring OSPF*.
- After enabling PIM-SM on each interface, IGMP will be enabled automatically (IGMPv2 is the default version).
- In the entire PIM-SM domain, at least one RP must be configured (serving all multicast groups by default) to act as the root node of shared tree (in this example, one interface of Ruijie B is configured as static RP).
- On the RP, configure address filtering of register messages (on Ruijie B in this example).

Configuration Steps

- Step 1: Configure the IP address on the interface of each device.

! Configure the IP address of Ruijie A's interface.

```
RuijieA#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
RuijieA(config)#interface gigabitEthernet 0/13
RuijieA(config-if-GigabitEthernet 0/13)#no switchport
RuijieA(config-if-GigabitEthernet 0/13)#ip address 192.168.1.1 255.255.255.0
RuijieA(config-if-GigabitEthernet 0/13)#exit
RuijieA(config)#interface gigabitEthernet 0/14
RuijieA(config-if-GigabitEthernet 0/14)#no switchport
RuijieA(config-if-GigabitEthernet 0/14)#ip address 192.168.2.1 255.255.255.0
RuijieA(config-if-GigabitEthernet 0/14)#exit
RuijieA(config)#interface gigabitEthernet 0/15
RuijieA(config-if-GigabitEthernet 0/15)#no switchport
RuijieA(config-if-GigabitEthernet 0/15)#ip address 192.168.3.1 255.255.255.0
RuijieA(config-if-GigabitEthernet 0/15)#exit
```

! Configure the IP address of Ruijie B's interface, and configure a Loopback interface as well.

```
RuijieB(config)#interface gigabitEthernet 0/1
RuijieB(config-if-GigabitEthernet 0/1)#no switchport
RuijieB(config-if-GigabitEthernet 0/1)#ip address 192.168.2.2 255.255.255.0
RuijieB(config-if-GigabitEthernet 0/1)#exit
RuijieB(config)#interface gigabitEthernet 0/5
RuijieB(config-if-GigabitEthernet 0/5)#no switchport
RuijieB(config-if-GigabitEthernet 0/5)#ip address 192.168.4.1 255.255.255.0
RuijieB(config-if-GigabitEthernet 0/5)#exit
RuijieB(config)#interface loopback 1
RuijieB(config-if-Loopback 1)#ip address 10.1.1.1 255.255.255.0
RuijieB(config-if-Loopback 1)#exit
```

! Configure the IP address of Ruijie C's interface.

```
RuijieC(config)#interface gigabitEthernet 0/5
RuijieC(config-GigabitEthernet 0/5)#no switchport
RuijieC(config-GigabitEthernet 0/5)#ip address 192.168.3.2 255.255.255.0
RuijieC(config-GigabitEthernet 0/5)#exit
RuijieC(config)#interface gigabitEthernet 0/10
RuijieC(config-GigabitEthernet 0/10)#no switchport
RuijieC(config-GigabitEthernet 0/10)#ip address 192.168.4.2 255.255.255.0
RuijieC(config-GigabitEthernet 0/10)#exit
RuijieC(config)#interface gigabitEthernet 0/15
RuijieC(config-GigabitEthernet 0/15)#no switchport
RuijieC(config-GigabitEthernet 0/15)#ip address 192.168.5.1 255.255.255.0
```

- Step 2: Interconnect devices and configure the corresponding OSPF protocol on the devices.

! Configure Switch A

```
RuijieA(config)#route ospf 1
RuijieA(config-router)#network 192.168.1.0 0.0.0.255 area 0
RuijieA(config-router)#network 192.168.2.0 0.0.0.255 area 0
RuijieA(config-router)#network 192.168.3.0 0.0.0.255 area 0
RuijieA(config-router)#exit
```

! Configure Ruijie B

```
RuijieB(config)#route ospf 1
RuijieB(config-router)#network 10.1.1.0 0.0.0.255 area 0
RuijieB(config-router)#network 192.168.2.0 0.0.0.255 area 0
RuijieB(config-router)#network 192.168.4.0 0.0.0.255 area 0
RuijieB(config-router)#exit
```

! Configure Ruijie C

```
RuijieC(config)#route ospf 1
RuijieC(config-router)#network 192.168.3.0 0.0.0.255 area 0
RuijieC(config-router)#network 192.168.4.0 0.0.0.255 area 0
RuijieC(config-router)#network 192.168.5.0 0.0.0.255 area 0
RuijieC(config-router)#exit
```

- Step 3: Globally enable multicast routing on the devices and enable PIM-SM on each interface.

! Configure Ruijie A

```
RuijieA(config)#ip multicast-routing
RuijieA(config)#interface gigabitEthernet 0/13
RuijieA(config-if-GigabitEthernet 0/13)#ip pim sparse-mode
RuijieA(config-if-GigabitEthernet 0/13)#exit
RuijieA(config)#interface gigabitEthernet 0/14
RuijieA(config-if-GigabitEthernet 0/14)#ip pim sparse-mode
RuijieA(config-if-GigabitEthernet 0/14)#exit
RuijieA(config)#interface gigabitEthernet 0/15
RuijieA(config-if-GigabitEthernet 0/15)#ip pim sparse-mode
RuijieA(config-if-GigabitEthernet 0/15)#exit
```

! Configurations on Ruijie B and Ruijie C (including the Loopback interface on Ruijie B) are the same as the preceding configurations.

- Step 4: Configure RP.

! Select the Loopback interface of Switch B as the static RP of PIM-SM domain. Note: Static RP must be configured identically on all PIM devices.

```
RuijieA(config)#ip pim rp-address 10.1.1.1
```

! Configurations on Ruijie B and Ruijie C are the same as the preceding configuration.

- Step 5: Configure address filtering of register messages on RP.

! On Ruijie B, create ACL to permit register messages with source IP address being 192.168.1.2 and group address range being 225.0.0.0/8–226.0.0.0/8.

```
RuijieB(config)#ip access-list extended 100
RuijieB(config-ext-nacl)#permit ip host 192.168.1.2 225.0.0.0 0.255.255.255
RuijieB(config-ext-nacl)#permit ip host 192.168.1.2 226.0.0.0 0.255.255.255
RuijieB(config-ext-nacl)#deny ip any any
RuijieB(config-ext-nacl)#exit
```

! Associate this ACL with the register message address filtering of RP.

```
RuijieB(config)#ip pim accept-register list 100
```

Verification

- Step 1: Display device configurations.

! Configurations on Ruijie A.

```
RuijieA#show running-config
!
ip pim rp-address 10.1.1.1
!
ip multicast-routing
!
interface GigabitEthernet 0/13
 no switchport
 ip pim sparse-mode
 no ip proxy-arp
 ip address 192.168.1.1 255.255.255.0
!
interface GigabitEthernet 0/14
 no switchport
 ip pim sparse-mode
 no ip proxy-arp
 ip address 192.168.2.1 255.255.255.0
!
interface GigabitEthernet 0/15
 no switchport
 ip pim sparse-mode
 no ip proxy-arp
 ip address 192.168.3.1 255.255.255.0
!
router ospf 1
 network 192.168.1.0 0.0.0.255 area 0
 network 192.168.2.0 0.0.0.255 area 0
 network 192.168.3.0 0.0.0.255 area 0
!
```

! Configurations on Ruijie B.

```
RuijieB#show running-config
!
ip pim rp-address 10.1.1.1
ip pim accept-register list 100
!
```

```
ip multicast-routing
!
ip access-list extended 100
 10 permit ip host 192.168.1.2 225.0.0.0 0.255.255.255
 20 permit ip host 192.168.1.2 226.0.0.0 0.255.255.255
 30 deny ip any any
!
interface GigabitEthernet 0/1
 no switchport
 ip pim sparse-mode
 no ip proxy-arp
 ip address 192.168.2.2 255.255.255.0
!
interface GigabitEthernet 0/5
 no switchport
 ip pim sparse-mode
 no ip proxy-arp
 ip address 192.168.4.1 255.255.255.0
!
interface Loopback 1
 ip pim sparse-mode
 ip address 10.1.1.1 255.255.255.0
!
router ospf 1
 network 10.1.1.0 0.0.0.255 area 0
 network 192.168.2.0 0.0.0.255 area 0
 network 192.168.4.0 0.0.0.255 area 0
```

! Configurations on Ruijie C.

```
RuijieC#show running-config
!
ip pim rp-address 10.1.1.1
!
ip multicast-routing
!
interface GigabitEthernet 0/5
 no switchport
 ip pim sparse-mode
 no ip proxy-arp
 ip address 192.168.3.2 255.255.255.0
!
interface GigabitEthernet 0/10
 no switchport
 ip pim sparse-mode
```

```
 no ip proxy-arp
 ip address 192.168.4.2 255.255.255.0
!
interface GigabitEthernet 0/15
 no switchport
 ip pim sparse-mode
 no ip proxy-arp
 ip address 192.168.5.1 255.255.255.0
!
router ospf 1
 network 192.168.3.0 0.0.0.255 area 0
 network 192.168.4.0 0.0.0.255 area 0
 network 192.168.5.0 0.0.0.255 area 0
```

- Step 2: Display PIM-SM interface information (Ruijie B is used as an example).

```
RuijieB#show ip pim sparse-mode interface detail
GigabitEthernet 0/1 (vif 1):
  Address 192.168.2.2, DR 192.168.2.2
  Hello period 30 seconds, Next Hello in 1 seconds
  Triggered Hello period 5 seconds
  Neighbors:
   192.168.2.1
GigabitEthernet 0/5 (vif 2):
  Address 192.168.4.1, DR 192.168.4.2
  Hello period 30 seconds, Next Hello in 10 seconds
  Triggered Hello period 5 seconds
  Neighbors:
   192.168.4.2
Loopback 1 (vif 3):
  Address 10.1.1.1, DR 10.1.1.1
  Hello period 30 seconds
  Triggered Hello period 5 seconds
  Neighbors:
```

The preceding information shows the IP address of each interface and the IP addresses of the DR and PIM-SM neighbor in the corresponding network segment.

- Step 3: Display current RP information (Ruijie B is used as an example).

```
RuijieB#show ip pim sparse-mode rp mapping
PIM Group-to-RP Mappings
Group(s): 224.0.0.0/4, Static
    RP: 10.1.1.1 , Static
        Uptime: 01:43:07
```

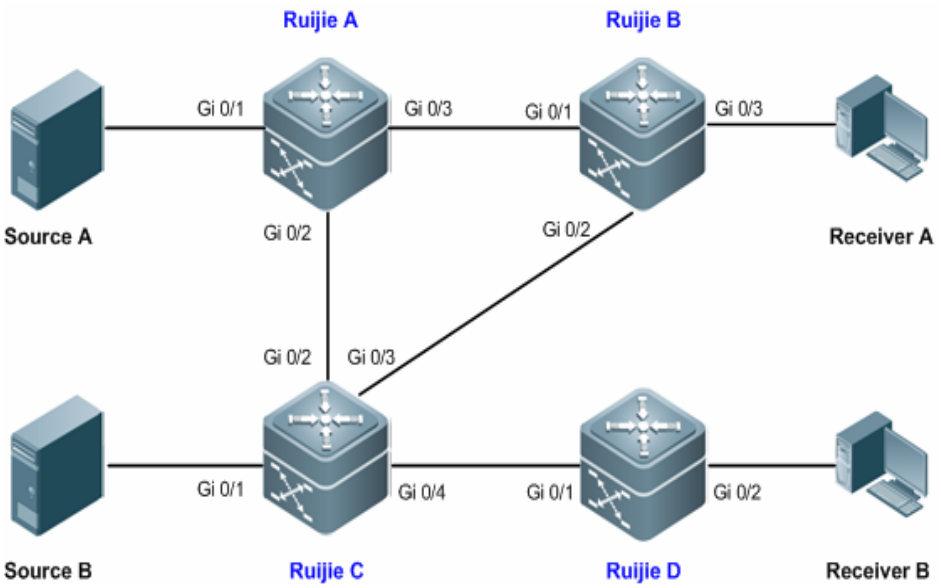
☑ This example applies to both layer-3 switches and routers. However, if you need to configure the switch port as a layer-3 port, you must run the **no switchport** command (not needed for routers).

PIM-SM Configuration Example (II)

Networking Topology

As shown in Figure 8, four layer-3 devices are interconnected through the routed ports. Multicast sources (Source A and Source B) and receivers (Receiver A and Receiver B) are in different network segments.

Figure 8



The interface addresses of each device are listed in the following table.

Device	Port Number	IP Address
Ruijie A	Gi 0/1	192.168.1.1/24
	Gi 0/2	192.168.2.1/24
	Gi 0/3	192.168.3.1/24
Ruijie B	Gi 0/1	192.168.3.2/24
	Gi 0/2	192.168.4.1/24
	Gi 0/3	192.168.5.1/24
	Loopback 1	10.1.1.1/24
	Loopback 2	10.1.2.1/24
Ruijie C	Gi 0/1	192.168.6.1/24
	Gi 0/2	192.168.2.2/24
	Gi 0/3	192.168.4.2/24
	Gi 0/4	192.168.7.1/24
	Loopback 1	10.1.3.1/24
Ruijie D	Gi 0/1	192.168.7.2/24
	Gi 0/2	192.168.8.1/24

Networking Requirements

- Multicast data forwarding between multicast routers is achieved through PIM-SM. One BSR in the PIM-SM domain is responsible for collecting and advertising RP information in the domain, while multiple candidate RPs serve different multicast groups to divert network traffic.
- The multicast router receives only BSM messages from a valid BSR.
- The BSR receives only advertisement packets from valid candidate RPs.

Configuration Tips

- Enable multicast routing on all multicast routers and enable PIM-SM multicast routing protocol on the interconnected interface. Note: Enabling PIM-SM will automatically enable IGMP.
- Specify one interface (Loopback 1 on Ruijie B) as the candidate BSR and two other interfaces (Loopback 2 on Ruijie B and Loopback 1 on Ruijie C) as the candidate RPs, and configure the multicast groups served by the candidate RPs.
- On the multicast router needing to filter BSM messages, configure the range of valid BSR (in this example, enable Ruijie C to permit only the BSM messages sent from Loopback 1 of Ruijie B).
- On BSR (Ruijie B in this example), configure the elected BSR to limit the valid C-RP address range and the multicast group range served.

Configuration Steps

- Step 1: Configure the interface IP addresses of each device.

! Configure Ruijie A

```
RuijieA#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
RuijieA(config)#interface gigabitEthernet 0/1
RuijieA(config-if-GigabitEthernet 0/1)#no switchport
RuijieA(config-if-GigabitEthernet 0/1)#ip address 192.168.1.1 255.255.255.0
RuijieA(config-if-GigabitEthernet 0/1)#exit
RuijieA(config)#interface gigabitEthernet 0/2
RuijieA(config-if-GigabitEthernet 0/2)#no switchport
RuijieA(config-if-GigabitEthernet 0/2)#ip address 192.168.2.1 255.255.255.0
RuijieA(config-if-GigabitEthernet 0/2)#exit
RuijieA(config)#interface gigabitEthernet 0/3
RuijieA(config-if-GigabitEthernet 0/3)#no switchport
RuijieA(config-if-GigabitEthernet 0/3)#ip address 192.168.3.1 255.255.255.0
RuijieA(config-if-GigabitEthernet 0/3)#exit
```

! Configurations on Ruijie B, Ruijie C and Ruijie D are the same as the preceding configurations.

! On Ruijie B, configure the IP address of Loopback 1 as 10.1.1.1/24 and the IP address of Loopback 2 as 10.1.2.1/24.

```
RuijieB(config)#interface loopback 1
RuijieB(config-if-Loopback 1)#ip address 10.1.1.1 255.255.255.0
RuijieB(config-if-Loopback 1)#exit
```

```
RuijieB(config)#interface loopback 2
RuijieB(config-if-Loopback 2)#ip address 10.1.2.1 255.255.255.0
RuijieB(config-if-Loopback 2)#exit
```

! On Ruijie C, configure the IP address of Loopback 1 as 10.1.3.1/24.

```
RuijieC(config)#interface loopback 1
RuijieC(config-Loopback 1)#ip address 10.1.3.1 255.255.255.0
RuijieC(config-Loopback 1)#exit
```

- Step 2: Interconnect devices and configure the corresponding OSPF protocol on the devices.

! Configure Ruijie A

```
RuijieA(config)#route ospf 1
RuijieA(config-router)#network 192.168.1.0 0.0.0.255 area 0
RuijieA(config-router)#network 192.168.2.0 0.0.0.255 area 0
RuijieA(config-router)#network 192.168.3.0 0.0.0.255 area 0
RuijieA(config-router)#exit
```

! Configurations on Ruijie B, Ruijie C and Ruijie D are the same as the preceding configurations.

Step 2: Enable multicast routing on each device and enable PIM-SM multicast routing protocol on each interface.

! Configure Ruijie A

```
RuijieA(config)#ip multicast-routing
RuijieA(config)#interface range gigabitEthernet 0/1-3
RuijieA(config-if-range)#ip pim sparse-mode
```

! Configurations on Ruijie B, Ruijie C and Ruijie D are the same as the preceding configurations. Note: PIM-SM must be enabled on the Loopback interface.

- Step 3: Configure the candidate BSR and candidate RP.

! On Ruijie B, configure Loopback 1 as the candidate BSR.

```
RuijieB(config)#ip pim bsr-candidate loopback 1 24
```

! On Ruijie B, create standard ACL to permit the address range of 225.0.0.0/8 to 226.0.0.0/8.

```
RuijieB(config)#ip access-list standard 1
RuijieB(config-std-nacl)#permit 225.0.0.0 0.255.255.255
RuijieB(config-std-nacl)#permit 226.0.0.0 0.255.255.255
RuijieB(config-std-nacl)#exit
```

! Configure Loopback 2 of Ruijie B as the candidate RP and associate the ACL.

```
RuijieB(config)#ip pim rp-candidate loopback 2 group-list 1
```

! On Ruijie C, create the standard ACL to permit the address range of 227.0.0.0/8 to 228.0.0.0/8.

```
RuijieC(config)#ip access-list standard 1
RuijieC(config-std-nacl)#permit 227.0.0.0 0.255.255.255
RuijieC(config-std-nacl)#permit 228.0.0.0 0.255.255.255
RuijieC(config-std-nacl)#exit
```

! On Ruijie C, configure Loopback 1 as the candidate RP and associate the ACL.

```
RuijieC(config)#ip pim rp-candidate loopback 1 group-list 1
```

- Step 4: Configure the range of valid BSR.

! On Ruijie C, create the standard ACL named "bsr_acl" to permit only packets with IP address being 10.1.1.1.

```
RuijieC(config)#ip access-list standard bsr_acl
RuijieC(config-std-nacl)#permit host 10.1.1.1
RuijieC(config-std-nacl)#exit
```

! On Ruijie C, configure the range of valid BSR and associate ACL "bsr_acl".

```
RuijieC(config)#ip pim accept-bsr list bsr_acl
```

- Step 5: Configure the elected BSR to limit the valid C-RP address range and the multicast group range served.

! On Ruijie B, create extended ACL named "rp_acl" to permit only packets with IP address being 10.1.3.1 and multicast address range being 227.0.0.0/8–228.0.0.0/8.

```
RuijieB(config)#ip access-list extended rp_acl
RuijieB(config-ext-nacl)#permit ip host 10.1.3.1 227.0.0.0 0.255.255.255
RuijieB(config-ext-nacl)#permit ip host 10.1.3.1 228.0.0.0 0.255.255.255
RuijieB(config-ext-nacl)#exit
```

! On Ruijie B, configure the elected BSR to limit the valid C_RP.

```
RuijieB(config)#ip pim accept-crp list rp_acl
```

Verification

- Step 1: Display device configurations.

! Configurations on Ruijie A.

```
RuijieA#show running-config
!
ip multicast-routing
```

```
!
interface GigabitEthernet 0/1
 no switchport
 ip pim sparse-mode
 no ip proxy-arp
 ip address 192.168.1.1 255.255.255.0
!
interface GigabitEthernet 0/2
 no switchport
 ip pim sparse-mode
 no ip proxy-arp
 ip address 192.168.2.1 255.255.255.0
!
interface GigabitEthernet 0/3
 no switchport
 ip pim sparse-mode
 no ip proxy-arp
 ip address 192.168.3.1 255.255.255.0
!
router ospf 1
 network 192.168.1.0 0.0.0.255 area 0
 network 192.168.2.0 0.0.0.255 area 0

 network 192.168.3.0 0.0.0.255 area 0
```

! Configurations on Ruijie B.

```
RuijieB#show running-config
!
ip pim accept-crp list rp_acl
ip pim bsr-candidate Loopback 1 24
ip pim rp-candidate Loopback 2 group-list 1
!
ip multicast-routing
!
ip access-list standard 1
 10 permit 225.0.0.0 0.255.255.255
 20 permit 226.0.0.0 0.255.255.255
!
ip access-list extended rp_acl
 10 permit ip host 10.1.3.1 227.0.0.0 0.255.255.255
 20 permit ip host 10.1.3.1 228.0.0.0 0.255.255.255
!
interface GigabitEthernet 0/1
 no switchport
```

```
 ip pim sparse-mode
 no ip proxy-arp
 ip address 192.168.3.2 255.255.255.0
!
interface GigabitEthernet 0/2
 no switchport
 ip pim sparse-mode
 no ip proxy-arp
 ip address 192.168.4.1 255.255.255.0
!
interface GigabitEthernet 0/3
 no switchport
 ip pim sparse-mode
 no ip proxy-arp
 ip address 192.168.5.1 255.255.255.0
!
interface Loopback 1
 ip pim sparse-mode
 ip address 10.1.1.1 255.255.255.0
!
interface Loopback 2
 ip pim sparse-mode
 ip address 10.1.2.1 255.255.255.0
!
router ospf 1
 network 10.1.1.0 0.0.0.255 area 0
 network 10.1.2.0 0.0.0.255 area 0
 network 192.168.3.0 0.0.0.255 area 0
 network 192.168.4.0 0.0.0.255 area 0
 network 192.168.5.0 0.0.0.255 area 0
```

! Configurations on Ruijie C.

```
RuijieC#show running-config
!
ip pim accept-bsr list bsr_acl
ip pim rp-candidate Loopback 1 group-list 1
!
ip multicast-routing
!
ip access-list standard 1
 10 permit 227.0.0.0 0.255.255.255
 20 permit 228.0.0.0 0.255.255.255
!
ip access-list standard bsr_acl
```

```
 10 permit host 10.1.1.1
!
interface GigabitEthernet 0/1
 no switchport
 ip pim sparse-mode
 no ip proxy-arp
 ip address 192.168.6.1 255.255.255.0
!
interface GigabitEthernet 0/2
 no switchport
 ip pim sparse-mode
 no ip proxy-arp
 ip address 192.168.2.2 255.255.255.0
!
interface GigabitEthernet 0/3
 no switchport
 ip pim sparse-mode
 no ip proxy-arp
 ip address 192.168.4.2 255.255.255.0
!
interface GigabitEthernet 0/4
 no switchport
 ip pim sparse-mode
 no ip proxy-arp
 ip address 192.168.7.1 255.255.255.0
!
interface Loopback 1
 ip pim sparse-mode
 ip address 10.1.3.1 255.255.255.0
!
router ospf 1
 network 10.1.3.0 0.0.0.255 area 0
 network 192.168.2.0 0.0.0.255 area 0
 network 192.168.4.0 0.0.0.255 area 0
 network 192.168.6.0 0.0.0.255 area 0
 network 192.168.7.0 0.0.0.255 area 0
```

! Configurations on Ruijie D.

```
RuijieD#show running-config
!
ip multicast-routing
!
interface GigabitEthernet 0/2
 no switchport
```

```
 ip pim sparse-mode
 no ip proxy-arp
 ip address 192.168.8.1 255.255.255.0
!
interface GigabitEthernet 0/11
 no switchport
 ip pim sparse-mode
 no ip proxy-arp
 ip address 192.168.7.2 255.255.255.0
!
router ospf 1
 network 192.168.7.0 0.0.0.255 area 0
 network 192.168.8.0 0.0.0.255 area 0
```

- Step 2: Display RPs in the PIM-SM domain and the corresponding service multicast information (Ruijie A is used as an example).

```
RuijieA#show ip pim sparse-mode rp mapping
PIM Group-to-RP Mappings
Group(s): 225.0.0.0/8
  RP: 10.1.2.1
    Info source: 10.1.1.1, via bootstrap, priority 192
         Uptime: 01:15:16, expires: 00:02:00
Group(s): 226.0.0.0/8
  RP: 10.1.2.1
    Info source: 10.1.1.1, via bootstrap, priority 192
         Uptime: 01:15:16, expires: 00:02:00
Group(s): 227.0.0.0/8
  RP: 10.1.3.1
    Info source: 10.1.1.1, via bootstrap, priority 192
         Uptime: 01:13:30, expires: 00:02:00
Group(s): 228.0.0.0/8
  RP: 10.1.3.1
    Info source: 10.1.1.1, via bootstrap, priority 192
         Uptime: 01:13:30, expires: 00:02:00
```

By limiting the multicast address range served by each candidate RP, the multicast sources in the PIM-SM domain can be limited. The receiver cannot receive multicast data sent from a multicast source that is not within the address range served (225.0.0.0/8–228.0.0.0/8).

In addition, invalid BSMs (the source address is not 10.1.1.1) are directly dropped on the device configured with valid BSR limitation. If invalid C_RP advertisement messages are sent to BSR, after valid C_RP limitation is configured, BSR will filter invalid C_RP advertisement messages.

☑ This example applies to both layer-3 switches and routers. However, if you need to configure the switch port as a layer-3 port, you must run the **no switchport** command (not needed for routers).

Configuring IGMP

IGMP Overview

IP multicast refers to a network technology that allows one or more sender (multicast source) to send one packet to more than one receiver simultaneously. The multicast source sends packets to a specific multicast group and only hosts joining the group can receive the packets. Multicast can save network bandwidth greatly because there is only a single packet transmitted on any link of the network, no matter how many receivers are deployed.

Multicast uses Class-D IP addresses specified by the Internet Assigned Numbers Authority (IANA). The four high-order bits of Class-D IP addresses are binary 1110. So, the range of multicast address is from 224.0.0.0 to 239.255.255.255. However, not all addresses in this range can be assigned to users. Some addresses are reserved for protocols or other use. For instance, the address 224.0.0.1 is assigned to all multicast hosts and 224.0.0.2 is assigned to all multicast routers.

Any hosts, no matter whether they are multicast group members or not, can be multicast sources. However, only multicast group members can receive multicast frames. A multicast group member is able to dynamically join or leave the group. Forwarding of multicast frames in the network is implemented by multicast routers running multicast routing protocols.

To enable IP multicast, hosts and routers must support the Internet Group Management Protocol (IGMP). This protocol is used by hosts to report their group memberships to multicast routers on the directly-connected network, allowing the multicast routers to determine how to forward multicast traffic. By using the information obtained from IGMP, multicast routers create an interface-based multicast group member list. The list is activated only when at least one host on an interface is a member of the group.

IGMPv1, IGMPv2 and IGMPv3 are currently supported. On the basis of IGMPv1, IGMPv2 adds a leave message for a host to actively request to leave a multicast group. IGMP behaviors includes behaviors of hosts and devices.

IGMPv1

There are only two types of IGMP messages defined in IGMPv1:

- Membership query
- Membership report

A host sends a membership report to indicate that it is interest in joining a group, and the router sends membership queries periodically to ensure that the group has at least one host. When there is no hosts in that group, the device will delete it.

IGMPv2

In IGMPv2, there are only four types of IGMP messages:

- Membership query
- Version 1 membership report
- Version 2 membership report
- Leave group

IGMPv2 is basically the same as IGMPv1, except that IGMPv2 creates a Leave group message for hosts. For IGMPv2, hosts report leave messages to routers which then send queries to check whether there is a host in the multicast group. This makes joining and leaving a group more efficient.

In the multicast network running IGMP, a multicast router is dedicated for sending IGMP query messages. This router is called a querier which is selected through an election mechanism. At first, all routers are queriers. If a router receives a query message from another router with a lower IP address, it becomes a non-querier. Consequently, there is only one querier which has the lowest IP address among all multicast routers on the network.

If a querier is invalid, new querier will be elected. . Non-queriers keep a timer for Other Querier Present Interval. Every time when a router receives a membership query packet, it resets the timer. If the timer expires, the router starts to send query messages and selects new querier again.

Queriers must periodically send membership queries to ensure that other routers on the network know that the querier still works. For this purpose, the querier maintains one query interval timer. When it sends membership query messages, this timer will be reset. When the interval timer times out, the querier sends another membership query.

When a new router appers, it sends a series of general query messages to solicit membership information. The number of general query packets depends on the Startup Query Count configured on the router. The initial general query interval is defined by the Startup Query Interval.

When a querier receives a leave group message from a host, it must send a group-specific membership query to see whether the host is the last one to leave the group. Before the querier stops forwarding packets to the group, it sends a series of such packets, the number of which is equal to the Last Member Query Count. The querier sends multiple group-specific membership queries to ensure that there is no member in the group. Such a query is sent every other the Last Member Query Interval seconds. When no response is received, the querier stops forwarding multicast packets to the group on the specified interface.

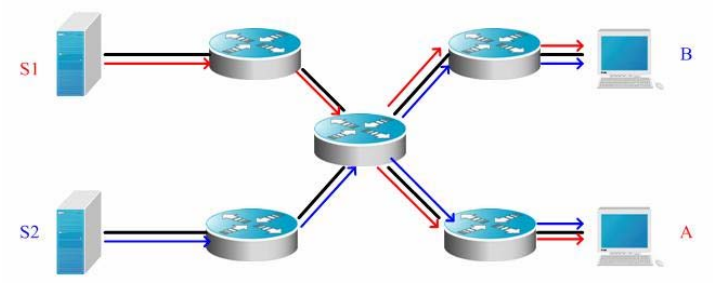
IGMPv3

Both IGMPv1 and IGMPv2 have the following defects:

- Lack of efficient measures to control multicast sources
- Difficult to establish multicast paths due to ignorance of multicast source locations.
- Difficult to find a unique multicast address. It is possible that multicast groups are using the same multicast address.

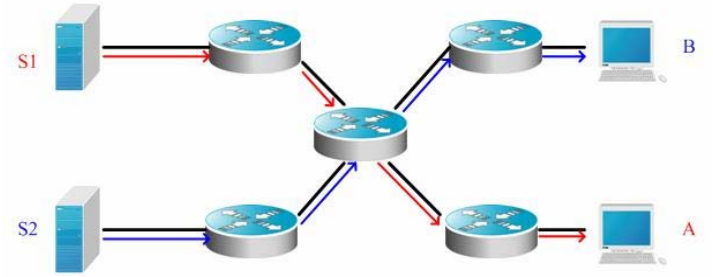
On the basis of IGMPv1 and IGMPv2, IGMPv3 provides an additional source filtering multicast function. In IGMPv1 or IGMPv2, hosts determines whether to join a group by group address and, once it joins the group, it receives multicast traffic forwarded from any source to that group address. In IGMPv3, hosts are enabled to report the multicast group they desire to join in and the multicast source from which they expect to receive traffic. A host specifies sources from which they want to receive multicast traffic through an INCLUDE list or an EXCLUDE list. Besides, IGMPv3 saves bandwidth by preventing unnecessary, illegal multicast data flows from occupying network bandwidth. It is particularly useful in the case where multiple multicast sources share one multicast address. IGMPv1 and IGMPv2 can also implement "source address filtering" in some sense, which, however, is performed on hosts receiving multicast traffic. As shown in the following diagram, two multicast sources (S1 and S2) send out traffic directed to the same multicast group address (G). This multicast traffic from S1 and S2 will be sent to all hosts receiving traffic from G. If host A only wants to receive multicast traffic from S1, it has to filter out traffic from S2 by running approriate client software.

Figure 9 Multicast traffic forwarded without source filtering



If multicast routers on the network support IGMPv3, host A wants to receive traffic from S1 only, it sends out an IGMPv3 packet in the form of “join G include S1”. host B wants to receive traffic from S2 only, it sends out an IGMPv3 packet in the form of “ join G include S2”. In this way, the traffic is forwarded as shown in Figure 2. This saves bandwidth.

Figure 10 Multicast traffic forwarded with source filtering



Based on IGMPv2, IGMPv3 adds the following two kinds of messages:

- Membership query
- Version 3 membership report

There are three types of membership query:

- General Query: used to learn information of all multicast members on an interface.
- Group-Specific Query: used to learn information of members of a specific group on an interface.
- Group-and-Source-Specific Query: a new type specified in IGMPv3 used to learn whether there is a member on an interface wants to receive group-specific multicast traffic from sources in the specified source list.

Membership Report in IGMPv3 is different from that defined in IGMPv2. The IGMPv3 membership reports are always sent with an destination address of 224.0.0.22. Besides, an IGMPv3 membership report can contain information of multiple groups.

IGMPv3 can identify membership report messages of IGMPv1 and IGMPv2 and leave group messges of IGMPv2.

IGMPv3 works the same way as IGMPv2. It is backward compatible with IGMPv1 and IGMPv2.

Caution

At most 1017 sources are allowed to forward traffic to a specific multicast group on Layer-3 interfaces of Ruijie’s switching routers. You can configure unicasting traffic from a specific allowed source. At most 1017 sources can be filtered from forwarding traffic to a specific multicast group on Layer-3 interfaces of Ruijie’s switching routers. You cannot configure unicasting traffic from the filtered sources.

IGMP Configuration Tasks

This section describes IGMP configuration tasks. Only some tasks are mandatory, and other tasks are optional depending on network requirements.


Caution All commands described in this section must be configured on layer-3 interfaces.

Default Configuration

The following table describes the default configuration of IGMP.

Feature	Default Setting
IGMP version	IGMPv2 is supported on all interfaces.
Query response interval	10 seconds
Query interval	125 seconds
Access to multicast group	All multicast groups are permitted.
Other querier present interval	255 seconds
Robustness variable	2
Last member query interval	1 second
Last member query count	2
IGMP	Disabled

Enabling IGMP

Use the following commands to enable IGMP in interface configuration mode.

Command	Function
Ruijie (config-if) # **ip pim** { **sparse-mode** | **dense-mode** }	Enables IGMP.
Ruijie (config-if) # **no ip pim** { **sparse-mode** | **dense-mode** }	Disables IGMP.

Configuring IGMP Version

Use the following commands to configure the IGMP version in interface configuration mode.

Command	Function
Ruijie (config-if) # **ip igmp version** { 1 | *2* | 3 }	Configures the IGMP version, version 2 by default.
Ruijie (config-if) # **no ip igmp version**	Restores to the default value.

Configuring Last Member Query Interval

After receiving a leave message from a multicast group, the querier sends a group-specific membership query to verify whether there is any member in the group. If no report is received during the last member query interval, the querier will regard the host that is leaving the group is the last member of that group, and then delete the information of the group. The default value of the last member query interval is 10, in units of 1/10 second. .

Use the following commands to configure the last member query interval in interface configuration mode.

Command	Function
Ruijie (config-if) # **ip igmp last-member-query-interval** *interval*	Configures the last member query interval. The *interval* specifies the range from 1 to 255. The unit is 1/10 second.
Ruijie (config-if) # **no ip igmp last-member-query-interval**	Restores to the default value.

Configuring Last Member Query Count

To prevent loss of group-specific membership query packets, it is required to send the packets for several times to ensure reliability. Therefore, you are advised to configure the last member query count to greater than 1.

Use the following commands to configure the last member query count in interface configuration mode.

Command	Function
Ruijie (config-if) # **ip igmp last-member-query-count** *count*	Configures the last member query count. The range is from 2 to 7. The default is 2.
Ruijie (config-if) # **no ip igmp last-member-query-count**	Restores to the default value.

Configuring General Query Interval

A querier sends general query messages at intervals to all hosts to verify the current membership. The destination address of the messages is the all-hosts group address, 224.0.0.1, Time To Live (TTL) is 1 and the default value is 125 seconds.

Use the following commands to configure the general query interval in interface configuration mode.

Command	Function
Ruijie (config-if) # **ip igmp query-interval** *seconds*	Configures the general query interval in seconds. The range is from 1 to 18000 seconds. The default is 125 seconds.
Ruijie (config-if) # **no ip igmp query-interval**	Restores to the default value.

Configuring the Max Response Time

The max response time is specified in the membership query message sent by the querier. Shortening this response time can allow the querier to know change of members earlier. However, it can also result in increase of the member reports diffusing in the network. Network administrators can consider a tradeoff between the two factors and then decide a proper value for the period, 10 seconds by default. Another consideration in configuring the response time is that it must be shorter than the query interval.

Use the following commands to configure the max response time in interface configuration mode.

Command	Function
Ruijie (config-if) # **ip igmp query-max-response-time** *seconds*	Configures the max response time in seconds. The range is from 1 to 25 seconds. The default value is 10 seconds.
Ruijie (config-if) # **no ip igmp query-max-response-time**	Restores to the default value.

Configuring Other Querier Present Interval

Once the timer times out, the querier considers that there is no other queriers on the network. This is helpful for the election of querier. You can reduce the value of this timer in the circumstance where the querier changes frequently to speed up response.

Use the following commands to configure the other querier present interval in interface configuration mode.

Command	Function
Ruijie (config-if) # **ip igmp query-timeout** *seconds*	Configures other querier present interval in seconds. The range is from 60 to 300 seconds. The default is 255 seconds.
Ruijie (config-if) # **no ip igmp query-timeout**	Restores to the default value.

Configuring Access Control to Multicast Groups

By default, hosts on an interface can join any multicast group. You can limit the range of multicast groups that hosts can join by configuring a standard IP ACL and applying it to the specific interface.

Use the following commands to create a standard access control list.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie (config) # **access-list** *access-list-num* **permit** *A.B.C.D A.B.C.D*	Defines an ACL.
Ruijie (config)# **interface** *interface-id*	Enters interface configuration mode.
Ruijie (config-if) # **ip igmp access-group** *access-list-name*	Applies the access control list to an interface. The *access-list-name* specifies the range of group addresses that hosts on the interface can join.
Ruijie (config-if) # **no ip igmp access-group**	Deletes the access control list.

Caution Suppose this command is associated with extended ACL. When the received IGMP report message is (S1,S2,S3…Sn,G), this command has to use an ACL entry to match the (0, G) message. Therefore you must explicitly configure an extended ACL with the (0,G) entry so that the (S1,S2,S3…Sn,G) message can be filtered.

Configuring Immediate-Leave Group

In IGMPv2, you can execute this command to r reduce the leave latency of multicast group members . After this command is enabled, a host leaves a multicast group as long as it sends a leave message, without waiting the querier to send a group-specific query message. This command is available only when there is only one receiver host on an interface.

Use the following commands to configure an immdiate-leave group list. .

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.

Command	Function
Ruijie (config) # **access-list** *access-list-num* **permit** *A.B.C.D A.B.C.D*	Defines an ACL.
Ruijie (config)# **interface** *interface-id*	Enters interface configuration mode.
Ruijie(config-if)# **ip igmp immediate-leave group-list** *access-list-name*	Creates an immediate-leave group list.
Ruijie (config-if) # **end**	Enters privileged EXEC mode.

Configuring join-group

This command configures a routeras a member of a multicast group. Use the **no** form of this command to remove the router from the multicast group.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie (config)# **interface** *interface-id*	Enters interface configuration mode.
Ruijie(config-if)# **ip igmp join-group** *group-address*	Configures a router to join a multicast group.
Ruijie (config-if) # **end**	Enters privileged EXEC mode.

Use the **no ip igmp join-group** *group-address* command to remove the router from the multicast group.

Configuring static-group

This command configures a statically joined group. Use the **no** form of this command to remove the statically joined multicast group.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie (config)# **interface** *interface-id*	Enters interface configuration mode.
Ruijie(config-if)# **ip igmp static-group** *group-address*	Configures a statically joined group.
Ruijie (config-if) # **end**	Enters privileged EXEC mode.

Use the **no ip igmp static-group** *group-address* command to remove the statically joined group. .

Configuring Limit on the Number of IGMP Group Members

Use this command to limit the number of IGMP group members globally. Membership messages that exceed the limit will not be cached or forwarded.

You can configure this command on each interface in interface or global configuration mode.

Command	Function
Ruijie(config) # **ip igmp limit** *number*	Limits the number of IGMP members in global configuration mode. The range depends on specific products.
Ruijie(config-if) # **ip igmp limit** *number*	Limits the number of IGMP members in interface

Command	Function
	configuration mode. . The range depends on specific products. By default, it is 1024.

Use the **no ip igmp limit** command to restore the default configuration.

Configuring IGMP PROXY - SERVICE

This command enables services on all the downlink mroute-proxy interfaces. After you configure this command on an interface, the interface becomes the uplink interface of the corresponding mroute-proxy service. Moreover, it associates all its downlink interfaces and maintains their propagated multicast group information.

Up to 32 proxy services can be configured using this command. The interface number with the IGMP Proxy enabled is limited by the multicast interface number supported by the device. Upon the receipt of query message, the proxy-service interface responds accordingly based on the member information that it maintains from the interfaces with mroute-proxy configured. Consequently, configuring proxy-service on an interface equals to performing host behaviors rather than router behaviors on the interface. Use the following command to configure IGMP proxy-service in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip igmp proxy-service**	Configures proxy-service on the interface.

Configuring IGMP MROUTE - PROXY

This command lets an interface to forward messages to its corresponding uplink interface. The uplink interface can forward IGMP messages received from its members only when it is set to a proxy-service interface.

Use the following command to configure IGMP mroute-proxy in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip igmp mroute-proxy** *interfacename*	Configures mroute-proxy on the interface. *interfacename* specifies the name of the uplink interface.

Enabling IGMP SSM-MAP

This command forcibly appends the relevant multicast source messages to the dynamically learned multicast group messages. It is usually used in conjunction with the **ip igmp ssm-map static** command.

Use the following command to enable IGMP SSM-MAP in global configuration mode.

Command	Function
Ruijie(config)# **ip igmp** [**vrf** *vrf-name*] **ssm-map enable**	Enables the SSM-MAP function under specified VRF.

Configuring IGMP SSM-MAP STATIC

This command is used in conjunction with the **ip igmp ssm-map enable** command. After this command is configured, the received messages whose version is earlier than version 3 will be mapped to the corresponding multicast source record.

Use the following command to configure IGMP SSM-MAP static in global configuration mode.

Command	Function

Command	Function
Ruijie(config)# **ip igmp** [**vrf** *vrf-name*] **ssm-map static** *access-list-num A.B.C.D*	Maps all groups matched ACL *access-list-num* under specified VRF to source address *A.B.C.D*.

Monitoring and Maintaining IGMP and Membership Information

Clearing the Dynamic Group Member Messages Obtained from the Response Message in the IGMP Cache

Use the following command to clear the dynamic group member messages obtained from the response message in the IGMP cache in privileged EXEC mode.

Command	Function
Ruijie# **clear ip igmp** [**vrf** *vrf-name*] **group**	Clears the dynamic group member messages obtained from the response message in the IGMP cache in the specified VRF.

Clearing All the Information on the Interface in IGMP Cache

Use the following command to clear all the information on the interface in IGMP cache in privileged EXEC mode.

Command	Function
Ruijie# **clear ip igmp** [**vrf** *vrf-name*] **interface** *interface-type interface-number*	Clears all the information on the interface in IGMP cache in the specified VRF.

Displaying the Status of All IGMP Group Members in the Directly-Connected Subnet

Use the following command to show the status of all IGMP group members in the directly-connected subnet in privileged EXEC mode.

Command	Function
Ruijie# **show ip igmp** [**vrf** *vrf-name*] **groups**	Shows the status of all IGMP groups under the specified VRF in the directly-connected subnet.
Ruijie# **show ip igmp** [**vrf** *vrf-name*] **groups detail**	Shows the details of all IGMP groups under the specified VRF in the directly-connected subnet.
Ruijie# **show ip igmp** [**vrf** *vrf-name*] **groups** *A.B.C.D*	Shows the status of the specified group under the specified VRF in the directly-connected subnet.
Ruijie# **show ip igmp** [**vrf** *vrf-name*] **groups** *A.B.C.D* **detail**	Shows the details of the specified group under the specified VRF in the directly-connected subnet.
Ruijie# **show ip igmp** [**vrf** *vrf-name*] **interface** *interface-type interface-number*	Shows the information of the specified interface under the specified VRF in the directly-connected subnet.
Ruijie# **show ip igmp** [**vrf** *vrf-name*] **groups** *interface-type interface-number* **detail**	Shows the details of all the groups of the specified interface under the specified VRF in the directly-connected subnet.
Ruijie# **show ip igmp** [**vrf** *vrf-name*] **groups** *interface-type interface-number A.B.C.D*	Shows the information of the specific group of the specified interface under the specified VRF in the directly-connected subnet.

Command	Function
Ruijie# **show ip igmp** [**vrf** *vrf-name*] **groups** *interface-type interface-number A.B.C.D* **detail**	Shows the details of the specific group of the specified interface under the specified VRF in the directly-connected subnet.

Displaying IGMP Interface Configuration

Use the following commands to show the IGMP interface configuration in privileged EXEC mode.

Command	Function
Ruijie# **show ip igmp** [**vrf** *vrf-name*] **interface** [*interface-type interface-number*]	Shows the configuration information of the IGMP interface in the specified VRF.
Ruijie# **show ip igmp** [**vrf** *vrf-name*] **interface**	Shows the configuration information of all the IGMP interfaces in the specified VRF.

Displaying IGMP SSM-MAP Configuration

Use the following commands to show the IGMP SSM-MAP configuration in privileged EXEC mode.

Command	Function
Ruijie# **show ip igmp** [**vrf** *vrf-name*] **ssm-mapping**	Shows the configuration information of IGMP SSM-MAP under the specified VRF.
Ruijie# **show ip igmp ssm-mapping** *A.B.C.D*	Shows the mapping information from IGMP SSM-MAP under the specified VRF to the multicast group *A.B.C.D*.

Displaying the Status of the IGMP Debugging Switch

Use the following command to show the status of the IGMP debugging switch in privileged EXEC mode.

Command	Function
Ruijie# **show debugging**	Shows the status of the IGMP debugging switch.

Turning on IGMP Debugging Switches

Use the following commands to turn on IGMP debugging switches to observe IGMP behaviors in privileged EXEC mode.

Command	Function
Ruijie# **debug ip igmp** [**vrf** *vrf-name*] **all**	Turns on all IGMP debugging switches in the specified VRF.
Ruijie# **debug ip igmp** [**vrf** *vrf-name*] **decode**	Turns on decode debugging switch in the specified VRF.
Ruijie# **debug ip igmp** [**vrf** *vrf-name*] **encode**	Turns on encode debugging switch in the specified VRF.
Ruijie# **debug ip igmp** [**vrf** *vrf-name*] **events**	Turns on event debugging switch in the specified VRF.
Ruijie# **debug ip igmp** [**vrf** *vrf-name*] **fsm**	Turns on final-state-machine debugging switch in the specified VRF.
Ruijie# **debug igmp** [**vrf** *vrf-name*] **tib**	Turns on tree debugging switch in the specified VRF.
Ruijie# **debug ip igmp** [**vrf** *vrf-name*] **warning**	Turns on warning debugging switch in the specified VRF.

Configuring PIM-DM

PIM-DM Overview

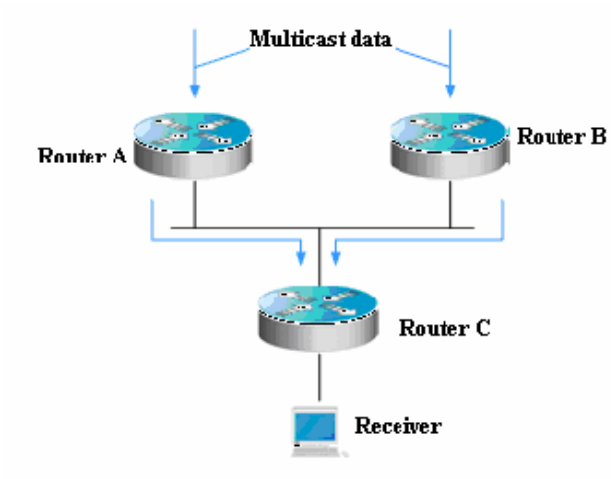
Protocol Independent Multicast-Dense Mode (PIM-DM) is a dense-mode multicast routing protocol, which is suitable for small-sized networks with densely distributed multicast members. As PIM-DM does not rely on any specific unicast routing protocol, it is called protocol independent multicast routing protocol. PIM-DM is defined in RFC 3973.

PIM-DM devices discover neighbors through Hello messages. After startup, a PIM-DM device sends a Hello message to each PIM-DM enabled interface periodically. The Hello message has a field of **Hello Hold Time**, which defines the maximum duration that a neighbor waits for the next message. If the neighbor does not receive another Hello message from the sender within this duration, this device will be removed from the adjacency list.

PIM-DM builds a shortest path tree (SPT) through flood and prune. PIM-DM assumes that when a multicast source begins to send a multicast packet, all the systems in the network need to receive this packet. As a result, this packet is forwarded to every system. The reverse path forwarding (RPF) check is performed for the packets received from the upstream interface. Those packets that fail to pass the check will be discarded. For the packets passing the check, the outgoing interface is computed based on the (S, G) pair of the packets, that is, source address and group address. If the outgoing interface is not null, an outgoing interface entry is created from the (S, G) pair and the multicast packet is forwarded through this outgoing interface. If the computed outgoing interface is null, a prune message is sent to the RPF neighbor, informing the upstream neighbor not to forward the multicast packets from the (S, G) pair to this interface. After the prune message is received on the upstream interface, the device marks the sending interface as pruned state and sets a pruned state timer. In this way, an SPT is created with the multicast source as its root.

PIM-DM uses the Assert mechanism to eliminate redundant routes.

Figure 11 Assert mechanism of PIM-DM



As shown in Figure-1, the multicast data arrives at Routers A and B at the same time, which forward the data to Router C. In this case, Router C receives duplicated data, which is not allowed. So there must be a mechanism to select Router A or B to forward the multicast data to Router C. This is the Assert mechanism of PIM-DM.

PIM-DM uses the state refresh message to update network state. The device directly connected to the multicast source sends the state refresh message to the downstream devices periodically to advertise the network topology changes. The devices receiving the message add their topology state to the state refresh message by modifying some fields, and then send it to the downstream devices. When the refresh message arrives at the leaf devices, the entire network state is updated.

PIM-DM uses the Graft mechanism to reestablish the connection with upstream devices. If the network topology of a downstream device in pruned state changes and the device needs to receive multicast data from a (S, G) pair, it sends the graft message to the upstream device. Upon receiving the graft message, the upstream device responds with a Graft-Ack message and forwards the multicast data to the downstream device again.

PIM-DM Configuration Tasks

The PIM-DM configuration tasks include the following items. However, only the first and second one are mandatory, and others are optional.

Enabling Multicast Routing

PIM-DM can forward multicast packets only after the multicast routing function is enabled.

Use the following command to enable or disable the multicast routing function in global configuration mode.

Command	Function
Ruijie (config) **# ip multicast-routing**	Enables multicast routing globally.
Ruijie (config) **# no ip multicast-routing**	Disables multicast routing globally.

Enabling PIM-DM

PIM-DM must be enabled on each interface. A device can exchange PIM-DM control messages with other devices, maintain and update the multicast routing table and forward multicast messages only after PIM-DM is enabled on the interface of the device.

Use the following commands to enable PIM-DM in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip pim dense-mode**	Enables the PIM-DM protocol on the interface.
Ruijie(config-if)**# no ip pim dense-mode**	Disables the PIM-DM protocol on the interface.

Caution

Enabling PIM-DM will take effect on an interface only after the multicast routing is enabled in global configuration mode.

When this command is configured, if the system displays "Failed to enable PIM-DM on <*interface name*>, resource temporarily unavailable, please try again", configure this command again.

When this command is configured, if the system displays "PIM-DM Configure failed! VIF limit exceeded in NSM!!!", the number of configured multicast interfaces reaches the threshold. If you still need to enable PIM-DM on the interface, remove some unnecessary PIM-DM, PIM-SM or DVMRP interfaces.

It is not recommended that different IPv4 multicast routing protocols be configured on different interfaces of a switch or router.

If the interface is of tunnel-type, only 4Over4 configuration tunnel, 4Over4 GRE tunnel, 4Over6 configuration tunnel and 4Over6 GRE tunnel support the IPv4 multicasting. The multicasting function can also be enabled on other tunnel interfaces that do not support IPv4 multicasting, but no error message will be displayed and no multicast packets will be received or sent.

Multicast tunnels can be created on Ethernet interfaces only. Nested tunnel and multicast data QoS/ACL are not supported.

Setting the Interval of Sending the Hello Message

After PIM-DM is enabled on an interface, the interface sends the Hello message to the interfaces of adjacent devices periodically. You can modify the interval according to the network situation.

Use the following command to configure the interval of sending the Hello message in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip pimquery-interval** *interval-seconds*	Sets the interval of sending the Hello message on the interface. *interval-seconds*: in the range of 1 to 65535 seconds
Ruijie(config-if)# **no ip pimquery-interval**	Restores the setting to the default value.

By default, the interval of sending the Hello message on the interface is 30 seconds.

Caution When the interval of sending the Hello message is updated, Hello hold time will be updated as 3.5 times of the Hello sending interval automatically. If the interval of sending Hello message multiplying 3.5 is larger than 65535, Hello hold time is updated to 65535.

Configuring Propagation Delay of Hello Message

Options can be added to Hello messages. The default value of **propagation-delay** in **LAN Prune Delay Option** is 500 milliseconds.

Use the following command to configure the propagation delay of Hello messages in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip pim propagation-delay** *interval-milliseconds*	Sets the propagation delay in the range of 1 to 32767 milliseconds.
Ruijie(config-if)# **no ip pim propagation-delay**	Restores the setting to the default value.

Configuring Override Interval of Hello Message

Options can be added to Hello messages. The default value of **override-interval** in **LAN Prune Delay Option** is 2500 milliseconds.

Use the following command to configure the override interval in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip pim override-interval** *interval-milliseconds*	Sets the override interval in the range of 1 to 65535 milliseconds.
Ruijie(config-if)# **no ip pim override-interval**	Restores the setting to the default value.

Configuring PIM-DM Neighbor Filtering

The neighbor filtering function can be configured on the interface to enhance network security. With neighbor filtering enabled, PIM-DM does not establish adjacency with the neighbor or deletes the established adjacency with the neighbor as long as a neighbor is denied by the access list.

Use the following command to configure the PIM neighbor filtering function in interface configuration mode.

Command	Function
Ruijie(config-if)#**ip pim neighbor-filter** *access-list*	Enables the PIM neighbor filtering function on the current interface.
Ruijie(config-if)#**no ip pim neighbor-filter** *access-list*	Disables the PIM neighbor filtering function on the current interface.

The PIM neighbor filtering function is disabled by default on an interface.

Note

ip pim neighbor-filter command description:
Only neighbor addresses permitted by the ACL can be the PIM neighbors of the current interface.

Configuring PIM-DM State Refresh

After PIM-DM is enabled on a device, if the RPF interface is directly connects to the multicast source (that is, the PIM interface is in the same network segment as the multicast source), the device periodically sends state refresh messages to downstream devices to update the entire network state. You can disable processing or forwarding of PIM state refresh messages in global configuration mode.

Use the following command to configure PIM-DM state refresh in global configuration mode.

Command	Function
Ruijie(config-if)**#no ip pim state-refresh disable**	Enables processing or forwarding PIM-DM state refresh messages.
Ruijie(config-if)**# ip pim state-refresh disable**	Disables processing or forwarding PIM-DM state refresh message.

The PIM-DM state refresh function is enabled by default.

Caution

Disabling the state refresh messages may cause the re-convergence of the converged PIM-DM multicast forward tree, resulting in unnecessary bandwidth waste and routing table flapping. Therefore, it is better not to disable the state refresh function in normal cases.

Configuring the Interval of Sending PIM-DM State Refresh Message

After PIM-DM is enabled on a device, if an interface is directly connected to the multicast source, the device periodically sends state refresh messages to downstream devices to update the entire network state. You can modify the interval of sending PIM state refresh message on an interface according to the network situation.

Use the following command to configure the interval of sending PIM state messages on the interface in interface configuration mode.

Command	Function
Ruijie(config-if)**#ip pim state-refresh origination-interval** *seconds*	Configures the interval of sending PIM state refresh messages on the current interface, in the range of 1 to 100 seconds.
Ruijie(config-if)**#no ip pim state-refresh origination-interval**	Restores the setting to the default value.

By default, the interval of sending PIM state refresh messages on the interface is 60 seconds.

Note

Only the devices directly connected to multicast source can periodically send the PIM state refresh message to the downstream interfaces. Therefore, if the devices are not directly connected to the multicast source, the interval of sending PIM state refresh messages configured on the downstream interface is invalid.

Monitoring and Maintaining PIM-DM

PIM-DM provides the following commands to monitor and maintain PIM-DM.

Displaying PIM-DM State

Command	Function
show ip pim dense-mode interface [*interface-type interface-number*] [**detail**]	Shows the PIM-DM information on the interface.
show ip pim dense-mode neighbor [*interface-type interface-number*]	Shows the PIM-DM neighbor information.
show ip pim dense-mode nexthop	Shows the next hop information of PIM-DM.
show ip pim dense-mode mroute [*group-or-source-address [group-or-source-address*]] [**summary**]	Shows the PIM-DM routing table.
show ip pim dense-mode track	Shows the number of PIM packets sent and received since the statistic beginning time.

For details about the preceding commands, see *PIM-DM Command References*.

Here are some examples of the commands:

3) **show ip pim dense-mode interface detail** command:

```
Ruijie# show ip pim dense-mode interface detail
FastEthernet 0/1 (vif-id: 3):
Address 10.10.10.10
Hello period 30 seconds, Next Hello in 15 seconds
Over-ride interval 2500 milli-seconds
Propagation-delay 500 milli-seconds
Neighbors:
10.10.10.1
FastEthernet 0/2 (vif-id: 2):
Address 50.50.50.50
Hello period 30 seconds, Next Hello in 2 seconds
Over-ride interval 2500 milli-seconds
Propagation-delay 500 milli-seconds
Neighbors:
50.50.50.1
```

In the preceding example, the IP address of FastEthernet 0/1 is 10.10.10.10, the Hello message sending interval is 30 seconds, the next Hello message is to be sent in 15 seconds, and the neighbor address is 10.10.10.1. The information about FastEthernet 0/2 is similar to that of FastEthernet 0/1.

4) **show ip pim dense-mode neighbor** command:

```
Ruijie# show ip pim dense-mode neighbor
Neighbor-Address Interface           Uptime/Expires    Ver
10.10.10.1      FastEthernet 0/1     00:19:29/00:01:21  v2
50.50.50.1      FastEthernet 0/2     00:22:09/00:01:39  v2
```

In the preceding example, the device has two neighbors. Neighbor 10.10.10.1 connects to FastEthernet 0/1 and has been alive for 19 minutes and 29 seconds, with the TTL to expire in one minute and 21 seconds. Neighbor 50.50.50.1 is similar.

5) **show ip pim dense-mode nexthop** command:

```
Ruijie# show ip pim dense-mode nexthop
Destination  Nexthop   Nexthop      Nexthop           Metric Pref
              Num      Addr        Interface
1.1.1.111      1       50.50.50.1   FastEthernet 0/2   0     1
```

In the preceding example, the next hop neighbor address to multicast source 1.1.1.111 is 50.50.50.1 and the egress is FastEthernet 0/2.

6) **show ip pim dense-mode mroute** command:

```
Ruijie# show ip pim dense-mode mroute
PIM-DM Multicast Routing Table
(1.1.1.111, 229.1.1.1)
MRT lifetime expires in 205 seconds
RPF Neighbor: 50.50.50.1, Nexthop: 50.50.50.1, FastEthernet 0/2
Upstream IF: FastEthernet 0/2
Upstream State: Pruned, PLT:200
Assert State: NoInfo
Downstream IF List:
FastEthernet 0/1:
```

```
Downstream State: NoInfo
Assert State: Loser, AT:170
```

The preceding example shows two entries: 1.1.1.111 and 229.1.1.1. The MRG aging time is 205 seconds, RPF neighbor is 50.50.50.1, the next hop is 50.50.50.1, and the egress to the next hop is FastEthernet 0/2. The upstream interface of these entries is FastEthernet 0/2 in Pruned state, indicating that there is no downstream forwarding egress. The downstream interface is FastEthernet 0/1 in NoInfo state. The Assert state of the interface is Loser. FastEthernet 0/1 is not a forwarding egress.

7) **show ip pim dense-mode track** command:

```
Ruijie# show ip pim dense-mode track
PIM packet counters
Elapsed time since counters cleared: 00:04:03

                          received    sent
Valid PIMDM packets:            1           8
Hello:                          1           8
Join/Prune:                  0          0
Graft:                          0            0
Graft-Ack:                      0            0
Assert:                      0            0
State-Refresh:               0            0
PIM-SM-Register:             0            0
PIM-SM-Register-Stop:           0            0
PIM-SM-BSM:                     0            0
PIM-SM-C-RP-ADV:                0            0
Unknown Type:                   0

Errors:
Malformed packets:           0
Bad checksums:               0
Unknown PIM version:            0
Send errors:                    0
```

Deleting PIM-DM State Information

Use the following command to delete the PIM-DM state information:

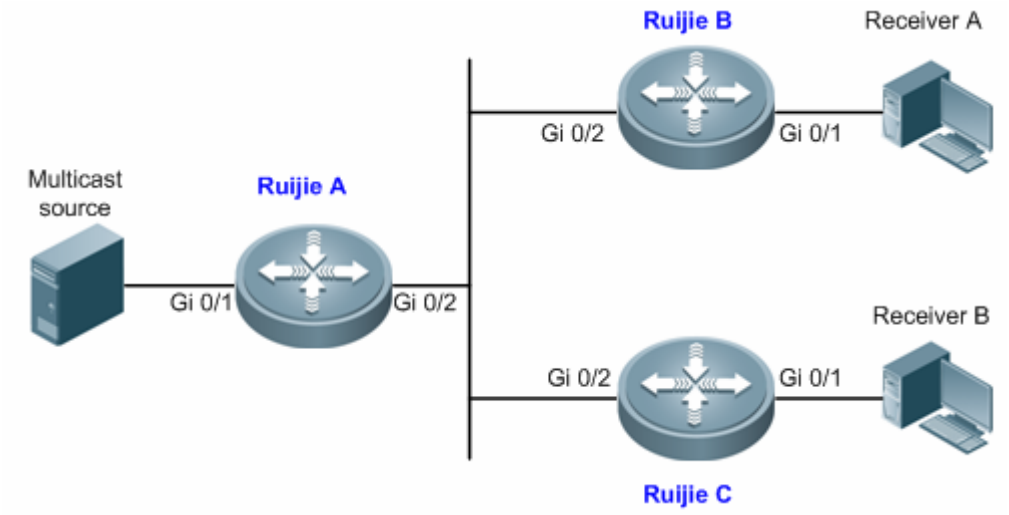
Command	Function
Ruijie**# clear ip pim dense-mode track**	Resets the start time of packet statistics and clears PIM packet counter.

PIM-DM Configuration Example

Configuration Requirements

Figure 12 shows the network topology. Ruijie A and the multicast source are in the same network, Ruijie B and receiver A are in the same network, and Ruijie C and receiver B are in the same network. Assume that the devices are properly connected to the hosts, and the IP addresses and unicast routes are configured.

Figure 12 Networking topology for PIM-DM configuration



Device Configuration

The following example shows how to configure PIM-DM on Ruijie A. The configurations on Ruijie B and Ruijie C are similar to those on Ruijie A.

- Step 1: Enable multicast routing.

```
Ruijie# configure terminal
Ruijie(config)# ip multicast-routing
```

- Step 2: Enable PIM-DM on the interface Gi 0/1.

```
Ruijie(config)# interface GigabitEthernet 0/1
Ruijie(config-if)# ip pim dense-mode
Ruijie(config-if)# exit
```

- Step 3: Enable PIM-DM on the interface Gi 0/2 and return to the privileged EXEC mode.

```
Ruijie(config)# interface GigabitEthernet 0/2
Ruijie(config-if)# ip pim dense-mode
Ruijie(config-if)# end
```

The configuration on Ruijie B and Ruijie C is similar to Ruijie A, that is, enable multicast routing and enable PIM-DM on each interface.

Note

Enabling PIM-DM will automatically enable IGMP on each interface.

This example applies to both layer-3 switches and routers. However, if you need to configure the switch port as a layer-3 port, you must run the **no switchport** command (not needed for routers).

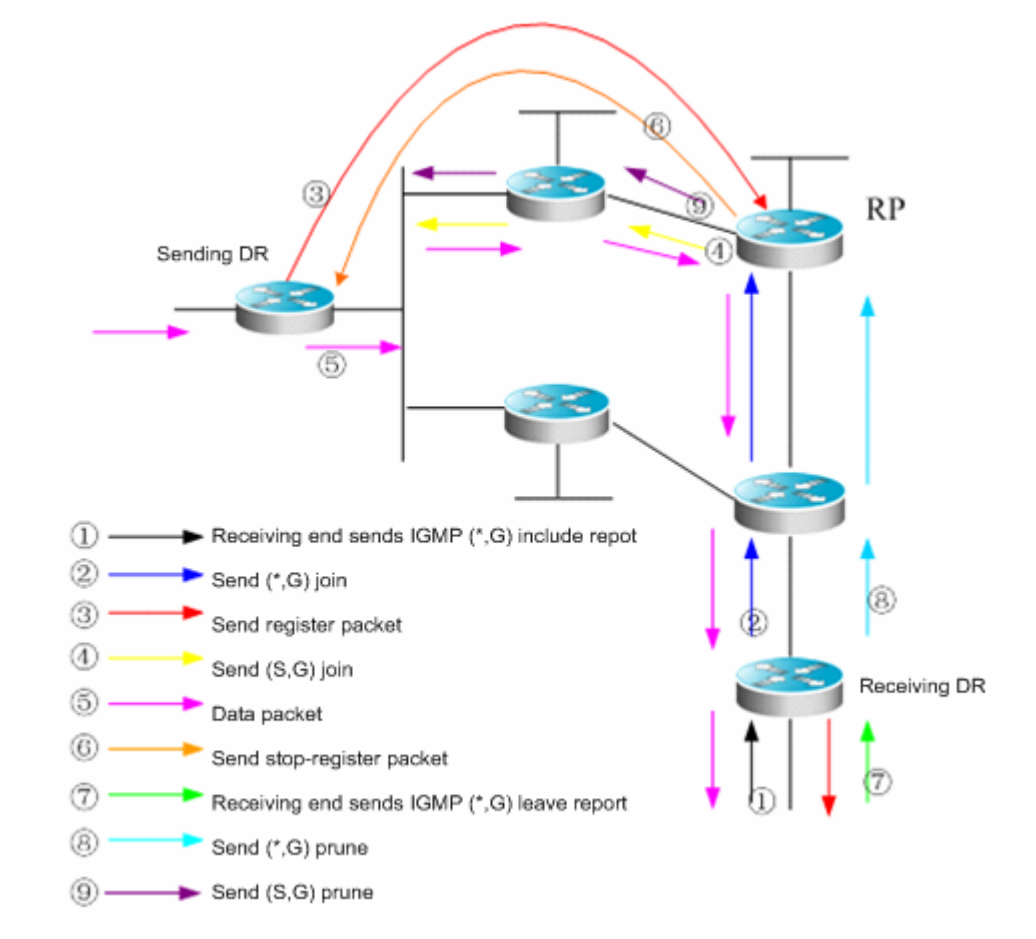
Configuring PIM-SM

PIM-SM Overview

The Protocol Independent Multicast (PIM) is designed by the Inter-Domain Multicast Routing (idmr) working group. As its name implied, PIM does not rely on any specific unicast routing protocol. It can use a unicast routing table established by any unicast routing protocol to perform the RPF check function, instead of maintaining separate multicast routing tables to implement multicast forwarding. As PIM is not required to receive or distribute route updates, compared to other multicast routing protocols, it costs much less. PIM is designed to support shortest path trees (SPTs) and rendezvous point trees (RPTs) simultanenously and enable flexible conversion between them, so that their advantages can be used to improve multicast efficiency. There are two PIM modes: dense mode and sparse mode.

The Protocol Independent Multicast – Sparse Mode (PIM-SM) is a multicast routing protocol of sparse mode. In a PIM-SM domain, the PIM-SM-enabled device periodically sends Hello messages to discover adjacent PIM-SM devices and selects a designated router (DR) in a multi-access network. The DR is responsible for sending Join/Prune messages towards the root of themulticast distribution tree from its directly connected group member, or itsdirectly connected multicast source.

Figure 13 Explicit Join/Prune mechanism of PIM-SM



PIM-SM forwards multicast data packets by establishing a multicast distribution tree. The multicast distribution tree is divided into two types: Shared Tree that takes the RP of the group G as the root and Shortest Path Tree that takes the

multicast source as the root. PIM-SM establishes and maintains the multicast distribution tree by use of the explicit join/prune mechanism. As shown in Figure-1,

8) The DR at the receiving end receives an IGMP (*,G)include report packet from the receiving end.
9) If the DR at the receiving end is not the RP of this group G, it will send a (*.G)join packet towards the RP. The upstream router receiving this (*.G)join packet will send it towards the RP. In this way, the (*.G)join packet is sent hop by hop until the RP of the group G receives the (*.G)join packet. It is indicated that the DR has joined the shared tree.
10) When the source host sends multicast data to the group, the source data is encapsulated into a register message and unicasted by the DR at the data source to the RP. Then the RP will forward the decapsulated data packets to group members along the shared tree.
11) The RP will send a (S, G)join packet to the DR in the direction of the source to join the shortest path tree of this source.
12) In this way, the source's packets are sent to the RP without encapsulation along its shortest path tree after the SPT from the RP to the DR at the source is established.
13) When the first multicast data reaches along the SPT, the RP will send the register - stop message to the DR at the source, notifying the DR of stopping register encapsulation. When the DR at the source received the register - stop message, it will not encapsulate register packets, but send them to the RP along its shortest path tree, which will forward them to group members along the shared tree.
14) When a receiving end needs no multicast data, it will send an IGMP leave message.
15) The DR at the receiving end multicasts the prune message to the group G's RP hop by hop to prune the shared tree. This prune message will finally arrive at the RP or a router with other (*G) receivers on the way to the RP. Therefore, the data packets will not be sent toward that receiving end.
16) If there is no downstream receiver on the RP, the RP will send the (S,G) prune packet toward the data source. As the (S, G) prune packets are sent to the DR at the source end one by one, the DR at the source end will prune the interface receiving the (S,G) prune packet. As a result, the data packets are filtered at the DR at the source end.

PIM-SM also offers a mechanism of selecting the root point (RP). One or more Candidate-BSRs are configured in a PIM-SM domain. PIM-SM selects a BSR by following a certain rule. There are also Candidate-RPs in a PIM-SM domain that unicast the packets including their IP addresses and available multicast groups to the BSR. The BSR will periodically generate a BSR message which includes a series ofcandidate RPs and corresponding multicast group addresses. The BSR messages are sent hop-by-hop within the entire domain. The device receives and saves these BSR messages. If the DR receives a report on the member relationship of a multicast group from its directly connected host but has no route entries of the multicast group, the DR will use a Hash algorithm to map the multicast group address to a candidate RP that can serve this group. Then, the DR multicasts the Join/Prune message to the RP hop-by-hop. If the DR receives multicast data packets from its directly connected host but has no route entries of the multicast group, the DR will usea Hash algorithm to map the multicast group address to a candidate RP that can serve this group. Then the DR encapsulates multicast data packets into a register message and unicasts it to the RP.

The main difference between PIM-SM and the flood/prune model-based PIM-DM is that PIM-SM is based on the explicit join model. In other words, the receiver sends the join message to the RP, while the router only forwards the packets of that multicast group on the outgoing interface that has joined a multicast group. PIM-SM uses the shared tree to forward multicast packets. Each group has a Rendezvous Point (RP). The multicast source sends data to the RP along the shortest path, and then the RP sends the data to the receivers along the shortest path. This is similar to CBT, but PIM-SM does not use the concept of core. One of the major advantages of PIM-SM is that it not only receives multicast messages through the shared tree but also provides a shared tree-to-SPT conversion mechanism. Such conversion reduces network delay and possible congestion on the RP, but it consumes enormous router resources. So it is suitable for the case where there are only a few multicast data sources and network groups.

PIM-SM uses the shared tree and SPT to distribute multicast frames. At this time, it is assumed that other devices don't want to receive these multicasts unless otherwise stated definitely. When a host joins a group, the equipment connected to the host must notify the root (or the RP) by using the PIM join message. This join message is transferred one after another through the routers to create a shared tree structure. Therefore, the RP records the transfer path and also the register message from the first hop router (DR) of the multicast source, and improves the shared tree upon these two messages. The branch/leaf messages are updated by periodically querying messages. With the shared tree, the multicast source first sends multicast packets to the RP, guaranteeing that all the receivers can receive them. The notation (*.G) represents a tree. The asterisk (*) represents all sources and G represents a specific multicast address. The prune message is also used in the shared tree. That is, the branch/leaf will send prune messages once it is not expecting to receive multicast frames.

PIMv2 BSR is a method of distributing group-to-RP messages to all devices without the need of setting an RP for them. BSR distributes mapping information by propagating BSR messages hop by hop. At first, BSR is selected among routers in the same process as selecting a root bridge based on priority level among layer 2 bridges. Each BSR checks the BSR messages and only forwards those having a priority higher than or equal to its own (higher IP address). The selected BSR sends its BSR message to the all-PIM-routers multicast group (224.0.0.13), where TTL is 1. After the adjacent PIMv2 router receives the message, it multicasts it while setting the TTL to 1. In this way, the BSR message is received by all devices hop by hop. Since the message contains the IP address of the BSR, the candidate BSR can know which router is the current BSR based on this message. The candidate RPs send candidate RP advertisements to announce in which address ranges they can become an RP. The BSR stores them in its local candidate RP cache. The BSP notifies all PIM routers of its local candidate RPs periodically. These messages reach various devices hop by hop in the same way.

☑ The VRF parameters only apply to RSR20, RSR30, RSR50 and RSR50E

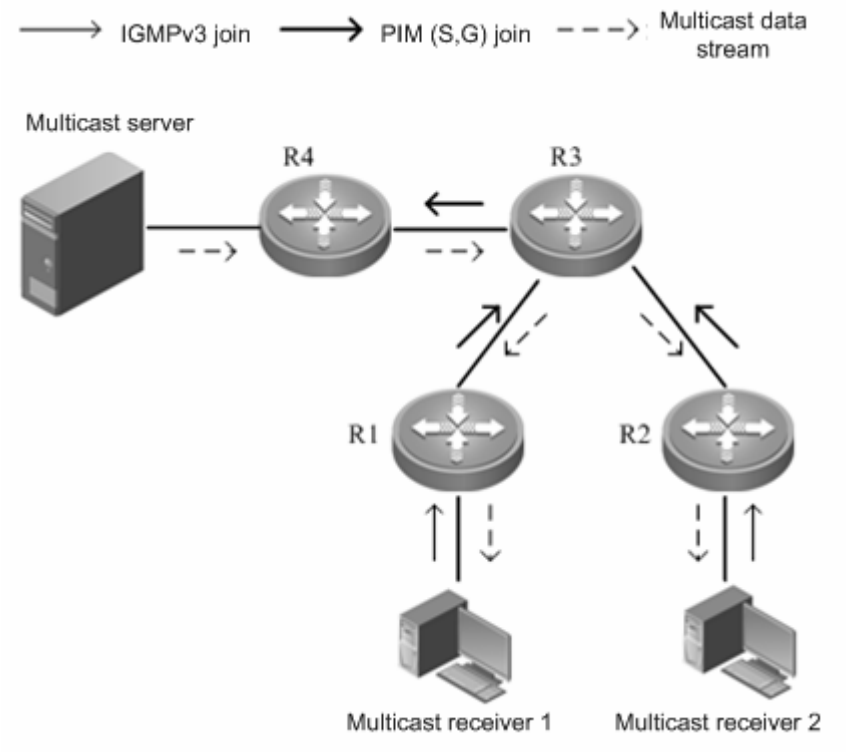
SSM Model

PIM-SM allows two multicast models,: Any-Source Multicast (ASM) and Source-Specific Multicast (SSM). In the ASM model, multicast receivers only specify a multicast group G to join but not a multicast source S. In the SSM model, multicast receivers can specify both a multicast source S and multicast group G.

The PIM-based SSM model provides implementation solutions for specified source multicast. It requires IGMPv3 to manage the membership between hosts and routers and PIM-SM to connect routers.

In the SSM model, multicast receivers have known the multicast source information (S, G) by some means such as accessing the server and accepting advertisements. Then, when a multicast receiver requests a multicast service, it can send IGMP(S, G) join directly to the last hop router. As shown in Figure 2, multicast receiver 1 sends the IGMP(S, G) join report to request the multicast service (S, G). The last hop router sends PIM (S, G) join to the multicast source hop by hop after receiving the IGMP (S, G) join from the multicast receiver. As shown in Figure 2, R1 sends the PIM(S, G) join to R3 after receiving the IGMP(S, G) join report from multicast receiver 1, and then R3 sends the PIM(S, G) join to R4. In this way, a shortest path tree from the multicast receiver to the multicast source is created.

Figure 14 SSM Model



Implementation of an SSM model requires that,

- The multicast receiver obtains the information about the multicast source (S, G) in advance through some channel; the multicast receiver initiates IGMP(S, G) join for the desired multicast services.
- IGMPv3 must be enabled on the interface of the last hop router connected to the multicast receiver. IGMPv1/IGMPv2 does not support the SSM.
- It is recommended that PIM-SSM be enabled on the routers on the way from the multicast receiver to the multicast source. AS PIM-SSM is compatible with PIM-SM, it is feasible to enable only PIM-SM.

Note With SSM enabled, the default group range of SSM is 232/8. The group range of SSM can be modified through commands or SSM can be disabled. For details, see the "Configuring SSM" section.

The SSM has the following features:

- In the SSM model, multicast receivers can obtain the information about the multicast source in advance through some channels, for example, advertisements or access to the specified server.
- The SSM model is a specific subset of PIM-SM. It only processes the PIM(S,G) join and PIM(S,G) prune messages and drops the RPT-related messages within the range of SSM, e.g. PIM(*,G) join/prune messages. It will respond immediately with the register - stop packet to the register packets within the range of SSM.
- In the SSM model, no PR or the election and distribution of RP messages is required. In the SSM, all the multicast distribution trees created are the shortest path trees (SPT).

Preparation before Configuring PIM-SM

Before configuring PIM-SM, enable a routing protocol such as OSPF to automatically discover routes.

PIM-SM Configuration Tasks

The PIM-SM configuration tasks cover the following items. However, only the first and second one are mandatory, and others are optional.

Enabling Multicast Routing

PIM-SM can forward multicast packets only after the multicast routing function is enabled.

Use the following command to enable the multicast routing function in global configuration mode.

Command	Function
ip multicast-routing [**vrf** *vrf-name*]	Enables multicast routing. If VRF is carried, multicast routing is enabled based on the VRF; if VRF is not carried, multicast routing is enabled globally.
no ip multicast-routing [**vrf** *vrf-name*]	Disables multicast routing.

Enabling PIM-SM

PIM-SM must be enabled on each interface. A device can exchange PIM-SM control messages with other devices, maintain and update multicast routing table, and forward multicast packets only after PIM-SM is enabled on its interface.

Use the following command to enable PIM-SM on the interface in interface configuration mode.

Command	Function
ip pim sparse-mode	Enables PIM-SM on the interface.
no ip pim sparse-mode	Disables PIM-SM on the interface.


Note PIM-SM can be enabled on an interface only after multicast routing is enabled in global configuration mode.


Note If the system prompts "Failed to enable PIM-SM on <*interface name*>, resource temporarily unavailable, please try again", run this command again.


Note If the system prompts "PIM-SM Configure failed! VIF limit exceeded in NSM!!!", the number of configured interfaces exceeds the upper limit of the multicast interfaces. Remove some unnecessary PIM-DM, PIM-SM or DVMRP interfaces.


Note

It is not recommended that different IPv4 multicast protocols be configured on different interfaces of a switch or router.


Note

If the interface is of tunnel-type, only 4Over4 configuration tunnel, 4Over4 GRE tunnel, 4Over6 configuration tunnel and 4Over6 GRE tunnel support the IPv4 multicasting. Multicast can be also enabled on other tunnel interfaces that do not support the multicasting, but no error message will be displayed and no multicast packets will be received or sent.


Note

The multicast tunnel can be created on the Ethernet interface only. Nested tunnel and multicast data QoS/ACL are not supported.

Configuring the Interval of Sending Hello Messages

After PIM-SM is enabled on the interface, the device periodically sends Hello messages to the interfaces of neighbors. You can set the interval of sending Hello messages according to the actual network situation.

Use the following command to configure the interval of sending the Hello message in interface configuration mode.

Command	Function
ip pim query-interval *interval-seconds*	Sets the interval of sending Hello messages, in seconds. *interval-seconds*: in the range of 1 to 65535 seconds
no ip pim query-interval	Restores the setting to the default value.

By default, the interval of sending Hello messages on the interface is 30 seconds.


Note

When the interval of sending Hello messages is updated, Hello hold time will automatically be updated to 3.5 times of the interval of sending Hello messages. If the result is greater than 65535, Hello hold time is updated to 65535.

Configuring Propagation-Delay in Hello Message Option

Options can be added to Hello messages. The default value of propagation-delay in LAN Prune Delay Option is 500 milliseconds.

Use the following command to configure the propagation delay of Hello messages in interface configuration mode.

Command	Function
ip pim propagation-delay *interval-milliseconds*	Sets the propagation delay in the range of 1 to 32767 milliseconds.
no ip pim propagation-delay	Restores the setting to the default value.

Note

Modifying propagation delay or prune deny delay will affect J/P-override-interval. As specified in the protocol, J/P-override-interval is less than the hold time of Join-Prune message; otherwise streams may be interrupted temporarily. This can be ensured by network administrators.

Configuring Override-Interval in Hello Message Option

Options can be added to Hello messages. The default value of override-interval in LAN Prune Delay Option **i**s 2500 milliseconds.

Use the following command to configure the override interval in interface configuration mode.

Command	Function
ip pim override-interval *interval-milliseconds*	Sets the override interval in the range of 1 to 65535 milliseconds.
no ip pim override-interval	Restores the setting to the default value, namely, 2500 milliseconds.

Note Modifying propagation delay or prune deny delay will affect J/P-override-interval. As specified in the protocol, J/P-override-interval must be less than the hold time of Join-Prune message; otherwise streams may be interrupted temporarily. This can be ensured by network administrators.

Configuring Neighbor-Tracking in Hello Message Option

The T bit of the LAN Prune Delay Option of the Hello message indicates whether to enable join restriction on the interface. When join restriction is enabled on the interface, the Join message to be sent from the interface to the upstream neighbor will be restricted, upon receipt of the Join message from its neighbor to the upstream neighbor. If this function is disabled, the Join message to be sent from the interface to the upstream neighbor will still be sent. Moreover, if join restriction is enabled on all downstream receivers, the upstream router can trace these receivers by received Join messages. By default, join restriction is enabled on the interface.

Use the following command to disable join restriction on the interface in interface mode.

Command	Function
ip pim neighbor-tracking	Disables join restriction on the interface.
no ip pim neighbor-tracking	Enables join restriction on the interface.

Configuring Triggered Hello Delay of Hello Messages

When a router starts or detects new neighbor, the device will send Hello messages after a random period of time to prevent congestion of Hello packets. This random interval can be calculated based on triggered hello delay, which is 5 seconds by default.

Use the following command to configure the triggered Hello delay in interface configuration mode.

Command	Function
ip pim triggered-hello-delay *interval-seconds*	Sets the triggered hello delay, in seconds. *interval-seconds*: in the range of 1 to 5 seconds
no ip pim triggered-hello-delay	Restores the setting to the default value.

Configuring PIM-SM Neighbor Filtering

You can filter neighbors on an interface to enhance network security. With this function enabled, when a neighbor is denied by an ACL, the PIM-SM will not establish the adjacency relationship with that neighbor or remove the currently established adjacency relationship with that neighbor.

Use the following command to configure PIM-SM neighbor filtering in interface configuration mode:

Command	Function
ip pim neighbor-filter *access-list*	Enables the PIM-SM neighbor filtering function on the interface.
no ip pim neighbor-filter *access-list*	Disables the PIM-SM neighbor filtering function on the interface.

By default, the PIM-SM neighbor filtering function is disabled on an interface.

Note

ip pim neighbor-filter command description:
When the associated ACL rule is permit, only the neighbor address in the ACL list can be used as the PIM neighbor of the current interface; when the associated ACL rule is deny, the neighbor address in the ACL list cannot be used as the PIM neighbor of the current interface.

Configuring the Priority of DR

This command is used to configure the priority of the designated router (DR). Higher weight means higher priority.

Use the following command to configure the DR priority in interface configuration mode.

Command	Function
ip pim dr-priority *priority-value*	Sets the DR priority. *priority-value*: in the range of 0 to 4294967294
no ip pim dr-priority	Restores the setting to the default value, namely 1.

Configuring Static RP

In a small network, you can configure static RP to use PIM-SM. All the devices in the PIM-SM domain have the same static RP configuration, ensuring no ambiguity of the PIM-SM multicast routes.

Use the following command to configure static RP in global configuration mode.

Command	Function
ip pim [**vrf** *vrf-name*] **rp-address** *rp-address* [*access-list*]	Configures the static RP address. *access-list*: supports the numerical ACL in the range of 1 to 99 and 1300 to 1999; also supports the named ACL. All multicast groups are permitted by default.
no ip pim [**vrf** *vrf-name*] **rp-address** *rp-address* [*access-list*]	Removes the static RP configuration.


Note If the static RP and the dynamic RP take effect at the same time, the dynamic RP takes precedence. .


Note The static RP address can be configured for multiple multicast groups (by ACL) or all multicast groups (not by ACL). However, a static RP address cannot be configured for several times.


Note If more than one static RP are configured for a multicast group, the one with the highest IP address takes effect.


Note Only the permitted addresses defined in the ACL are invalid multicast groups. By default, 0.0.0.0/0 refers to filtering all multicast groups (224/4).


Note After configuration, the static RP source address is inserted into the tree of group-based static RP group. Each static multicast group maintains the link table structure of a static RP group. The link tables are ordered in descending sequence by IP addresses. When a RP is selected for a group, the first element, namely, the RP with the highest IP address is firstly selected.


Note Deleting a static RP address deletes the address from all groups that has this address, and one address is selected from the existing tree structure as the RP address.

Configuring Candidate BSR

A globally unique BSR is elected from candidate BSRs configured on an interface in a PIM-SM domain. This BSR will collect and distribute RPs in the domain to ensure the uniqueness of RP mapping in the domain.

Use the following command to configure the candidate BSR in global configuration mode.

Command	Function
ip pim [**vrf** *vrf-name*] **bsr-candidate** *interface-type interface-number* [*hash-mask-length* [*priority-value*]]	Specifies an interface as a candidate BSR. The global BSR is elected through BSM message learning and competition. *hash-mask-length* ranges from 0 to 32, 10 by default. *priority-value* ranges from 0 to 255, 64 by default.
no ip pim [**vrf** *vrf-name*] **bsr-candidate** *interface-type interface-number*	Removes the configuration of a candidate BSR.

Configuring BSR Border

To restrict BSM flooding, you can set the BSR border on the interface so that BSM will be dropped immediately rather than being forwarded.

Use the following command to configure the BSR border in interface configuration mode.

Command	Function
ip pim bsr-border	Configures the BSR border on an interface.
no ip pim bsr-border	Removes the BSR border on an interface.

Ignoring RP Priorities in RP-SET

When an RP is selected for a multicast address, if several RPs can serve this multicast address, you can use this command to ignore the RP priority when comparing two RPs. If this command is not configured, the RP priority will be taken into account during comparison.

Command	Function
ip pim [**vrf** *vrf-name*] **ignore-rp-set-priority**	Ignores the RP priority in RP-Set.
no ip pim [**vrf** *vrf-name*] **ignore-rp-set-priority**	Considers the RP priority in RP-Set.

Configuring Candidate RP

Candidate RP advertisement is sent to the BSR at intervals and then propagated to all the PIM-SM devices in the domain, thus ensuring the uniqueness of RP mapping.

Use the following command to configure the candidate RP in global configuration mode.

Command	Function
ip pim rp-candidate *interface-type interface-number* [**priority** *priority-value*] [**interval** *interval-seconds*] [**group-list** *access-list*]	Configures the device as the candidate RP. When **priority** is default, *priority-value* ranges from 0 to 255, 192 by default. When **interval** is default, *interval-seconds* ranges from 1 to 16383, 60 seconds by default. When **group-list** is default, *access-list* permits all multicast groups by default, namely 224/4.
no ip pim rp-candidate *interface-type interface-number*	Removes the candidate RP configuration.

Note You can use the ACL to specify an interface as the candidate RP of a specific group. It should be noted that the group calculation is based on the permit ACE, not the deny ACE. The source range of the ACE is matched as a specific group range.

Checking Reachability of Register Messages

You can use this command to check whether an RP is reachable. With this command configured, the DR checks whether RP is reachable before sending a register packet, that is whether there is a route to the RP by checking the unicast and static multicast routing tables. If there is no such a route, no register packet will be sent.

Use the following command to check the RP reachability in global configuration mode.

Command	Function
ip pim [**vrf** *vrf-name*] **register-rp-reachability**	Checks whether a register packet can reach the destination device. No check is conducted by default.
no ip pim [**vrf** *vrf-name*] **register-rp-reachability**	Disables this function.

Note

If there is a static multicast route to the RP and the next hop of the route is reachable in the unicast routing table, PIM-SM considers that a route to the RP exists even if the RP is not reachable in the unicast routing table.

Configuring Address-based Filtering for Register Packets

You can use this command to filter the register packets that have arrived at an RP by the source address and group address contained in the packets. Otherwise, every reached register packet is permitted. With this command configured, only the register packets with the source addresses and group addresses permitted by the ACL can be processed.

Use the following command to configure address-based filtering for register packets in global configuration mode.

Command	Function
ip pim [**vrf** *vrf-name*] **accept-register list** *access-list*	Enables filter of register packets by source addresses and group addresses. *access-list* ranges from 100 to 199 and 2000 to 2699; also supports named ACL.
no ip pim [**vrf** *vrf-name*] **accept-register**	Disables filter of register packets by source addresses and group addresses.

Configuring Rate Limit on Sending Register Packets

Use this command to configure the rate of sending register packets by DR. Use the **no** form of this command to cancel the rate limit. This command configures the rate of sending register packets for each (S, G) state, not the register packets in the whole system.

Use the following command to configure the rate limit on sending RPs in global configuration mode.

Command	Function
ip pim [**vrf** *vrf-name*] **register-rate-limit** *rate*	Sets the maximum number of register packets sent per second. *rate*: in the range of 1-65535
no ip pim [**vrf** *vrf-name*] **register-rate-limit**	Removes the rate limit.

Configuring the Whole-Packet Method for Calculating the Register Packet Checksum

Use this command to calculate the whole PIM packet including the multicast data packet encapsulated when calculating the register packet checksum. Otherwise, the checksum of register packets is calculated using the default method specified by the protocol.

Use the following command to configure the whole-packet method for calculating the register packet checksum in global configuration mode.

Command	Function
ip pim [**vrf** *vrf-name*] **register-checksum-wholepkt** [**group-list** *access-list*]	Configures the whole-packet method for calculating the register packet checksum. group-list *access-list*: Apply this configuration to all multicast addresses by default.
no ip pim [**vrf** *vrf-name*] **register-checksum-wholepkt** [**group-list** *access-list*]	Removes the whole-packet method for calculating the register packet checksum. group-list *access-list*: By default, this configuration is removed for all the multicast addresses.

Note

Some devices from other vendors make checksum calculation of register packets based on the overall packets. This function is introduced in Ruijie's devices to be compatible with those devices.
If a device from those vendors serves as the RP and Ruijie's device serves as the source DR, you can use this command on the source DR; if the device from other vendors serves as the source DR and Ruijie's device serves as the RP, you can use this command on the RP.

Configuring the RP to Forward Multicast Packets to Downstream Interfaces after Decapsulating Register Packets

Use this command to decapsulate a register packet and forward its multicast packets. Without this command, the multicast packets in the register packet are not de-capsulated or forwarded.

Use the following command in global configuration mode.

Command	Function
ip pim [**vrf** *vrf-name*] **register-decapsulate-forward**	Decapsulates the register packet and forwards its multicast packets
no ip pim [**vrf** *vrf-name*] **register-decapsulate-forward**	Removes the configuration.

Note

Since the register packet is decapsulated and its multicast packets are forwarded through software, in case of decapsulation and forwarding of many register packets, this function incurs additional workload to CPU. So it is not recommended.

Limiting the Range of Legal BSRs

Use this command to limit the range of legal BSRs. Without this function, PIM-SM-enabled routers will receive all external BSM messages.

Use the following command in global configuration mode.

Command	Function
ip pim [**vrf** *vrf-name*] **accept-bsr list** *accept-bsr list*	Filters the BSM packet of BSR. The range is from 1 to 99, 1300 to 1999, or can be characters.
no ip pim [**vrf** *vrf-name*] **accept-bsr**	Removes the filtering of the BSM packet of BSR.

Note This command filters the BSR address field of the BSM message. If this address is denied by ACL, the BSM message is filtered.

Configuring the Electing BSR to Limit the Legal CRP Address Range and the Multicast Group Range It Serves

Use this command to configure the electing BSR to limit the legal CRP address range and the multicast group range it serves. Without this function, the electing BSR will receive all external advertisement messages of candidate RPs.

In this command, the *source* parameter of ACL rule specifies the C-RP address and the *destination* parameter specifies the multicast group range the C-RP serves. If both addresses are denied by ACL, the group of the C-RP will be filtered.

Use the following command in global configuration mode.

Command	Function
ip pim [**vrf** *vrf-name*] **accept-crp list** *accpet-crp list*	Enables the electing BSR to filter the candidate RP advertisement. The range is from 100 to 199, 2000 to 2699 or can be characters.
no ip pim [**vrf** *vrf-name*] **accept-crp**	Disables the electing BSR to filter the candidate RP advertisement.

Configuring the Electing BSR to Receive the C-RP-ADV Message Whose Prefix-count Is 0

Use this command to configure the electing BSR to receive the C-RP-ADV message whose prefix-count is 0. Without this command, the electing BSR will not process the C-RP-ADV packet whose prefix-count is 0.

With this function, the electing BSR considers that the C-RP supports all groups after receiving the C-RP-ADV message whose prefix-count is 0.

Use the following command in global configuration mode.

Command	Function

Command	Function
ip pim [**vrf** *vrf-name*] **accept-crp-with-null-group**	Configures the electing BSR to receive the C-RP-ADV message whose prefix-count is 0.
no ip pim [**vrf** *vrf-name*] **accept-crp-with-null-group**	Removes the configuration.

Configuring the Source IP Address of Register Packets

This command sets the source IP address of register packets sent from DR. With this command not configured or the **no** form of this command, the DR interface address connected to the multicast source is used as the source address of the register packet. If the address parameter of this command is used, the configured address must be reachable for unicast routes. If the interface parameter of this command is used, it is generally a loopback interface, but can also be other types. This interface address must have been advertised by the unicast route.

Use the following command in global configuration mode.

Command	Function
ip pim register-source { *local_address* | *Interface-type interface-number* }	Configures the source IP address used in RPs.
no ip pim register-source	Sets the RPF interface address as the source IP address of register packets.

Configuring Register Suppression Time

This command configures the registersuppression time. It will modify the register suppression time defined on the DR. If the **ip pim rp-register-kat command** is not configured, defining the register suppression time in the RP will change RP keepalive period.

Use the following command to configure the register suppression time in global configuration mode.

Command	Function
ip pim [**vrf** *vrf-name*] **register-suppression** *seconds*	Configures the register suppression time. *seconds* ranges from 1 to 65535 seconds.
no ip pim [**vrf** *vrf-name*] **register-suppression**	Sets the suppression time to 60 seconds.

Configuring the Probe Interval of Null Register Packet

The source DR can send Null-Register packet to the RP in a period of time before the registersuppression time expires. This period is called probe interval, 5 seconds by default.

Use the following command to configure the probe time of null register packets in global configuration mode.

Command	Function
ip pim [**vrf** *vrf-name*] **probe-interval** *interval-seconds*	Configures the probe time of null register packets. *interval-seconds*: in the range of 1 to 65535 seconds

Command	Function
no ip pim [**vrf** *vrf-name*] **probe-interval**	Restores the probe time to 5s.

Note

The probe time should be less than half of register suppression time. Moreover, the register suppression time times three and plus the probe time should not be greater than 65535 seconds; otherwise, the system displays a warning message.

Configuring the RP KAT Timer

Use this command to configure the keepalive time of the (S, G) state created by register packets on the RP in global configuration mode.

Command	Function
ip pim [**vrf** *vrf-name*] **rp-register-kat** *seconds*	Configures KAT timer. *seconds*: in the range of 1 to 65535 seconds
no ip pim [**vrf** *vrf-name*] **rp-register-kat**	Uses the default KAT value, namely, register suppression time times three and plus register probe time.

Note

The value of the timer should be greater than register suppression time of source DR times three and plus register probe time. Otherwise, the RP may timeout the (S, G) state before the source DR sends the register packet again, causing temporary interruption of the multicast stream.

Configuring the Interval of Sending the Join/Prune Message

By default, the Join/Prune message is sent at the interval of 60 seconds by default. Use this command to modify this interval. With this command not configured, the default sending interval of join/prune packets is 60 seconds.

Use the following command in global configuration mode.

Command	Function
ip pim [**vrf** *vrf-name*] **jp-timer** *seconds*	Sets the interval of sending the Join/Prune message. *interval-seconds*: in the range of 1 to 65535 seconds.
no ip pim [**vrf** *vrf-name*] **jp-timer** [*interval-seconds*]	Restores the setting to the default value, namely 60s.

Note

When the sending interval of the join/prune packets is configured, if the interval times3.5 is more than 65535, a warning message is displayed and the interval is changed to 65535/3.5 seconds.

Allowing the Last Hop Device to Switch from the Shared Tree to the Shortest Path Tree

With this command configured, when the first (S, G) packet is received, a PIM join message is triggered and a source tree is created. If the keyword **group-list** is defined, all the groups specified will switch to the source tree. Use the **no** form of this command to enable the device to switch back to the shared tree and send a prune message.

Use the following command in global configuration mode.

Command	Function
ip pim [**vrf** *vrf-name*] **spt-threshold** [**group-list** *access-list*]	If **group-list** is defined, allows the last hop device of a specific group to switch from the shared tree to the shortest path tree. If **group-list** is not defined, allows all multicast groups.
no ip pim [**vrf** *vrf-name*] **spt-threshold** [**group-list** *access-list*]	Disables this function.

Configuring MIB in Dense Mode

Use this command to configure MIB in dense mode; With this command not configured, MIB is in sparse mode.

Use the following command in global configuration mode.

Command	Function
ip pim mib dense-mode	Uses MIB in dense mode.
no ip pim mib dense-mode	Uses MIB in sparse mode,

Enabling SSM

In the SSM mode, multicast packets can be directly received from the multicast source instead of through the RP tree.

Use the following command in global configuration mode.

Command	Function
ip pim [**vrf** *vrf-name*] **ssm** { **default** | **range** *access-list* }	Enables SSM.
no ip pim [**vrf** *vrf-name*] **ssm**	Disables SSM.

Monitoring and Maintaining PIM-SM

PIM-SM provides the following commands to monitor and maintain PIM-SM.

Displaying PIM-SM Information

Use the following commands to show information about PIM-SM on the local device.

Command	Function
show debugging	Shows the status of the debugging switch.
show ip pim sparse-mode [**vrf** *vrf-name*] **bsr-router**	Shows BSR details.
show ip pim sparse-mode [**vrf** *vrf-name*] **interface** [*interface-type interface-number*] [**detail**]	Shows the PIM-SM information of the interface.
show ip pim sparse-mode [**vrf** *vrf-name*] **local-members** [*interface-type interface-number*]	Shows local IGMP information about a PIM-SM interface.
show ip pim sparse-mode [**vrf** *vrf-name*] **mroute** [*group-or-source-address* [*group-or-source-address*]] [**proxy**]	Shows information about a PIM-SM multicast routing table. With the parameter **proxy**, this command shows the RPF Vector information about PIM-SM entries.
show ip pim sparse-mode [**vrf** *vrf-name*] **neighbor** [**detail**]	Shows information about the PIM-SM neighbors.
show ip pim sparse-mode [**vrf** *vrf-name*] **nexthop**	Shows the next hop of PIM-SM from NSM.
show ip pim sparse-mode [**vrf** *vrf-name*] rp-**hash** *group-address*	Shows a specified group address. *group-address* corresponds to RP information.
show ip pim sparse-mode [**vrf** *vrf-name*] **rp mapping**	Shows information about all current RPs and the groups they serve.
show ip pim sparse-mode [**vrf** *vrf-name*] **track**	Shows the number of PIM packets sent and received from the start time of statistics till now

☑ The parameter **proxy** in the command **show ip pim sparse-mode mroute** is only supported by RSR20, RSR30, RSR50 and RSR50E.

Deleting Internal Information About PIM-SM

Use the following commands to delete internal information about PIM-SM on the local device.

Command	Function
clear ip mroute [**vrf** *vrf-name*] { * | *group_address* [*source_address*] }	Deletes a multicast routing table entry.
clear ip mroute [**vrf** *vrf-name*] **statistics** { * | *group_address* [*source_address*] }	Deletes the statistics of a multicast routing table entry.
clear ip pim sparse-mode [**vrf** *vrf-name*] **bsr rp-set** *	Deletes RP-SET.
clear ip pim sparse-mode [**vrf** *vrf-name*] **track**	Resets the start time of statistics and clears the PIM packet counter

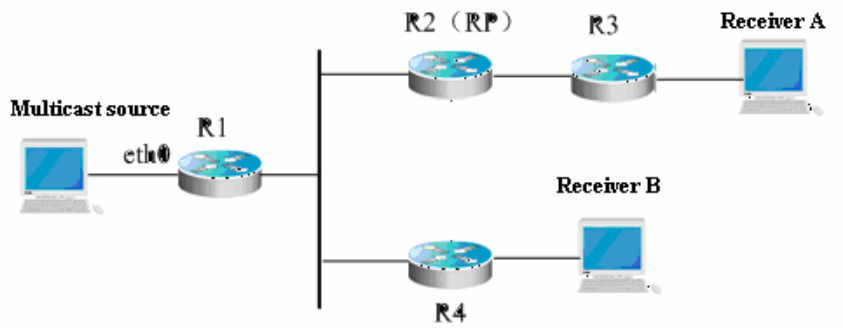
For details about the preceding commands, see *PIM-SM Commands*.

PIM-SM Configuration Example

Configuration Requirements

Figure 3 shows the network topology. R1 and the multicast source are in the same network. R2 will be set as an RP. R3 and receiver A are in the same network, and R4 and receiver B are in the same network. Assume that the devices connect to the host properly, IP addresses are configured on each interface, and IP unicast is enabled on each device.

Figure 15 Network topology for PIM-SM configuration



Device Configuration

Step 1: Enable multicast routing.

R1 is used as an example to show how to enable IP multicast routing. The configurations on R2, R3 and R4 are similar to R1.

```
Ruijie# configure terminal
Ruijie(config)# ip multicast-routing
```

Step 2: Enable PIM-SM on the interface.

The following shows how to enable PIM-SM on Gi 0/1 of R1. The configurations on interfaces of R1, R2, R3 and R4 are similar.

```
Ruijie(config)# interface GigabitEthernet 0/1
Ruijie(config-if)# ip pim sparse-mode
Ruijie(config-if)# end
```

Step 3: Configure the candidate BSR and the candidate RP.

Configure loopback 1 of R2 as C-BSR and C-RP.

```
Ruijie(config)# interface loopback 1
Ruijie(config-if)# ip address 100.1.1.1 255.255.255.0
Ruijie(config-if)# ip pim sparse-mode
Ruijie(config-if)# exit
Ruijie(config)# ip pim bsr-candidate loopback 1
Ruijie(config)# ip pim rp-candidate loopback 1
Ruijie(config-if)# end
```

After the receivers join the group and the multicast source sends multicast streams, you can use the **show** command provided by PIM-SM to monitor the running status.

Note Enabling PIM-DM will automatically enable IGMP on each interface.

Note This example applies to both layer-3 switches and routers. However, if you need to configure the switch port as a layer-3 port, you must run the **no switchport** command (not needed for routers).

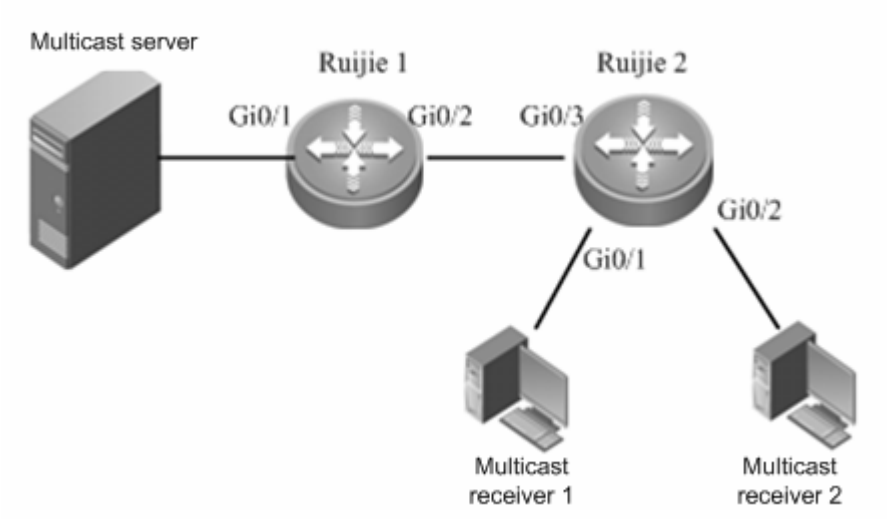
Enabling SSM based on PIM-SM

Networking Requirements

- The network must be interconnected on layer 3, for example, based on OSPF.
- The multicast receivers can obtain the information about the multicast source through some channels, depending on application software of hosts and deployment of network administrators.
- The PIM-SM protocol is applied within the network.

Networking Topology

Figure 16 Network topology for SSM configuration



Device name	Interface	IP address
Ruijie 1	Gi 0/1	2.2.2.1/24
	Gi 0/2	3.3.3.1/24
Ruijie 2	Gi 0/3	3.3.3.2/24
	Gi 0/1	4.4.4.1/24
	Gi 0/2	5.5.5.1/24

Configuration Steps

- Perform basic configuration on interfaces of Ruijie 1 and Ruijie 2.

Perform configurations on interfaces of Ruijie 1 and Ruijie 2 based on the IP addresses specified in the networking topology.

- Enable interworking on layer 3.

Enable OSPF on all interfaces of Ruijie 1 and Ruijie 2, implementing interworking on layer 3.

- Configure multicast on Ruijie 1 and Ruijie 2.

Firstly, enable the multicast routing on Ruijie 1 and Ruijie 2; secondly, enable PIM-SM on the interfaces of Ruijie 1 and Ruijie 2; at last, enable IGMPv3 on the interfaces where Ruijie 2 connects to the multicast receivers. Ruijie 2 is used as an example below.

Enable the multicast routing on Ruijie 2.

```
Ruijie(conf)#ip multicast-routing
```

Enable PIM-SM on all the interfaces of Ruijie 2. Interface Gi 0/1 is used as an example below:

```
Ruijie(conf-GigabitEthernet0/1)#ip pim sparse-mode
```

Enable IGMPv3 on the interfaces where Ruijie 2 connects to the multicast receivers. Interface Gi 0/1 is used as an example below:

```
Ruijie(conf-GigabitEthernet0/1)#ip igmp version 3
```

The configuration procedure for Ruijie 1 is similar to that for Ruijie 2.

- Enable the SSM function on Ruijie 1 and Ruijie 2.

Enable SSM on Ruijie 2. The default group range of SSM is used, namely 232/8.

```
Ruijie(conf)#ip pim ssm default
```

Enable SSM on Ruijie 1. The default group range of SSM is used, namely 232/8.

```
Ruijie(conf)#ip pim ssm default
```

Verification

- Multicast receivers 1 and 2 request the multicast service (2.2.2.2, 232.0.0.1) by sending IGMP (2.2.2.2, 232.0.0.1) join.

Protocol entry (2.2.2.2, 232.0.0.1) will be created on Ruijie 2. Use the **show ip pim sparse-mode mroute** command to view it.

```
Ruijie#show ip pim sparse-mode mroute
IP Multicast Routing Table
(*,*,RP) Entries: 0
(*,G) Entries: 0
(S,G) Entries: 1
(S,G,rpt) Entries: 1
FCR Entries: 0
REG Entries: 0

(2.2.2.2, 232.0.0.1)
```

```
RPF nbr: 3.3.3.1
RPF idx: GigabitEthernet0/3
SPT bit: 0
Upstream State: JOINED
kat expires in 175 seconds
  00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
30 31
Local
0.i  i  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
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```

As shown in the preceding information, the protocol entry (2.2.2.2, 232.0.0.1) has been created on Ruijie 2 and there are two multicast receivers.

- The multicast server sends data stream (2.2.2.2, 232.0.0.1).

Multicast forwarding table (2.2.2.2, 232.0.0.1) will be created on Ruijie 2. Use the **show ip mroute** command to view it.

```
Ruijie#show ip mroute

IP Multicast Routing Table
Flags: I - Immediate Stat, T - Timed Stat, F - Forwarder installed, R - RPT, S - SPT
Timers: Uptime/Stat Expiry
Interface State: Interface (TTL)

(2.2.2.2, 232.0.0.1), uptime 00:19:31, stat expires 00:02:53
Owner PIMSM, Flags: TFSs
  Incoming interface: GigabitEthernet 0/3
  Outgoing interface list:
     GigabitEthernet 0/1(1)
     GigabitEthernet 0/2(1)
```

As shown in the preceding information, the multicast forwarding table (2.2.2.2, 232.0.0.1) has been created on Ruijie 2. Multicast egresses Gi 0/1 and Gi 0/2 are connected to multicast receivers 1 and 2 respectively. The forwarding table has been marked with the flag “s", which indicates that the table is in the SSM model.

Configuring RMEF

RMEF Overview

IP multicast realizes efficient point-to-multipoint data transmission over IP networks. Since IP multicast can effectively save network bandwidth and reduce network load, it is widely applied in real-time data transmission, multimedia conferencing, data copying, gaming and simulation.

Ruijie Multicast Express Forward (RMEF) maintains a mirror image of control-plane multicast routing table at the express forwarding data plane, so that forwarding of multicast packets can be done at the express forwarding data plane, thus improving the performance and efficiency of multicast forwarding.

Configuring REMF

Enabling/disabling multicast express forwarding on the interface

Use the following commands to enable/disable multicast express forwarding on the interface in interface configuration mode.

Command	Function
Ruijie(config-if)# **ip ref**	Enables multicast express forwarding on the interface.
Ruijie(config-if)# **no ip ref**	Disables multicast express forwarding on the interface.

By default, multicast express forwarding is enabled on the interface.

Displaying RMEF Configuration and Status

Use the following commands to show RMEF configurations and statistics.

Command	Function
show ip ref mcast route [*ip address ip address*]	Shows the multicast express forwarding table. When no parameters are set, this command shows all table entries. When parameters are set (the first parameter is the IP address of the multicast source and the second one is the IP address of the multicast group), this command shows the table entries that match the two IP addresses.
show ip ref mcast info	Shows RMEF information, including the RMEF status, whether RMEF is enabled, number of express forwarding tables, and data packet uploading rate of RMEF in the case of no forwarding table or in data packet uploading process.
show ip ref mcast statistics	Shows statistics on the packets forwarded on the

Command	Function
interface *interface-type interface-number*	multicast express forwarding interface.
show ip ref mcast statistics mfc	Shows statistics on data packets forwarded on all multicast express forwarding entries.

Configuration Examples

The following examples show typical configurations on a router:

```
RSR20-04# config
```

! Enable multicast forwarding.

```
RSR20-04(config)# ip multicast-routing
```

! Enter the related interface and enable the multicast protocol.

```
RSR20-04(config)# interface fastEthernet 0/0
RSR20-04(config-if)# ip pim dense-mode
```

! Enable express forwarding on the interface.

```
RSR20-04(config-if)# ip ref
```

The following example shows how to debug multicast express forwarding:

! Display all multicast express forwarding tables.

```
Ruijie (config-if)# show ip ref mcast route
IP Multicast EF Routing Table
Interface State: Interface (Interface Index)
(30.1.1.2, 224.1.1.2)
 In_interface: GigabitEthernet 0/1.100(8)
 Hit: Yes
 To_cpu: No
 Oif_list: GigabitEthernet 0/2.100 (12)
```

! Display multicast express forwarding information.

```
Ruijie (config-if)# show ip ref mcast info
---------------------------------
IP RMEF is open
total RMEF MFC NUM = 1
to_cpu ratelimit PPS in one second = 10
no_mfc ratelimit PPS in one second = 10
---------------------------------
```

! Display multicast express forwarding statistics.

```
Ruijie (config-if)# show ip ref mcast statistics mfc
(30.1.1.2, 224.1.1.2)
```

```
In_interface: GigabitEthernet 0/1.100(8)
Match_PKTNUM: 17058555
Match_PKTBYTES: 1091747520
WRONG_IN_IF_PKTNUM: 0
TO_CPU_RESERVE_PACKET: 0
TO_CPU_DROP_PACKET: 0
Oif_list: GigabitEthernet 0/2.100(12)
```

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MPLS Configuration

MPLS Configuration

Note The term “router” and router icons in this chapter refer to routers in a generic sense and layer-3 switches running routing protocols.

Understanding MPLS

Multiprotocol Label Switching (MPLS) supports multiple network-layer protocols such as IP, IPv6, and IPX and is compatible with multiple link-layer technologies including ATM, frame relay, Ethernet, and PPP. MPLS forwards packets based on labels attached to them. It works at both the connectionless control plane and the connection-oriented data plane, thereby introducing connection-oriented attributes to connectionless IP networks. The MPLS technology was first introduced to enhance the forwarding rate of routing devices. However, with the development of hardware technologies and network processors, this competitive edge gradually loses its appeal. Because MPLS combines Layer 2 switching with Layer 3 routing technologies, it has unprecedented edges over other technologies in terms of addressing issues of virtual private networks (VPNs) and traffic engineering (TE). MPLS VPN is increasingly favored by carriers to address interconnection problems between companies and to provide various new services. It has already become an important means for carriers to provide value-added services over IP networks. At the same time, the MPLS TE technology also turns into a major method to reduce congestion and guarantee quality of service (QoS) on IP networks by managing network traffic. Therefore, the MPLS technology receives more and more attention and the MPLS applications gradually shift to MPLS VPN and TE applications.

- Basic Concept
- Different from incoming label map (ILM), FEC-to-NHLFE (FTN) maps each forwarding equivalence class (FEC) to a series of next hop label forwarding entries (NHLFEs) which indicates there are multiple paths. An FTN table is used when a label edge router (LER) encapsulates a label in an unlabeled packet before forwarding the packet.
- Label
- Label Distrubition Protocol
- MPLS Network
- An MPLS network comprises two basic components: Label Switching Routers (LSRs) and LERs. An LSR is located at the core of the MPLS network and runs the LDP signalling protocol to forward labeled packets. An LER classifies and labels incoming packets into FECs and encapsulates the labeled packets as MPLS packets for forwarding. The LER also removes the labels from outgoing MPLS packets and restores these packets to the original packets. On the MPLS network, packets with labels are forwarded along the label switched path (LSP) set up through LDP.

The MPLS architecture is divided into two parts: the forwarding unit (data plane) and control unit (control plane). The former forwards a packet by searching the label forwarding information base (LFIB) based on the label carried by the packet whereas the latter is responsible for creating and maintaining the LFIB between the connected MPLS nodes. Each MPLS node must run one or more routing protocols (including static routes) to exchange routing information with other MPLS nodes on the MPLS network. Therefore, in effect, each MPLS node is an IP router on the control plane. Similar to a conventional IP router, an MPLS node also uses unicast routing protocols (including static routes) to create and maintain a routing table. The difference is that the traditional router uses the routing table to create a forwarding table and the

MPLS node uses the routing table to exchange label binding information between each destination subnet and neighboring MPLS nodes. The protocol responsible for exchanging label binding information is LDP.

- MPLS Forwarding Behaviors
- The MPLS forwarding process is as follows (IP routing for example):

1) All LSRs (including LERs) run routing protocols such as Open Shortest Path First (OSPF) and Intermediate System to Intermediate System (IS-IS) to establish IP routing tables on LSRs and LERs.
2) LDP creates an LSP based on the IP routing tables.
3) The ingress LER receives an IP packet, analyzes the IP header, associates it with an FEC, labels the IP header with L1, and sends the labeled packet to the next-hop LSR along the LSP.
4) After receiving the packet, the next-hop LSR searches the next LSP based on the label on the stack top, replaces the label with a new label, and sends the packet to the next LSR of the LSP.
5) The subsequent LSRs repeats as step 4.
6) When the last but one LSR receives the labeled packet and looks up the LFIB, if the egress label is found to be an implicit label, it pops the label and forwards the pure IP packet to the last hop LSR; andif the egress label is an explicit null one, the LSR pops the label and forwards the packet by looking up the IP forwarding table based on the IP header..
7) If the last but one LSR pops the label, the egress LER receives the original IP packet and forwards the packet according to the IP routing table.

- LSP Establishment and Loop Detection
- MPLS Applications

Basic Concepts

- MPLS Node

MPLS-enabled nodes can identify MPLS signaling protocols (control protocols), support one or more Layer 3 routing protocols (including static routes), and forward packets based on MPLS labels. Generally, an MPLS node can forward original Layer 3 packets (such as IP packets).

- FEC

An FEC refers to a set of data packets that are forwarded in the same way, such as data packets that have the same prefix in their destination addresses. The FEC supports different classification methods for different applications. For example, the FEC classifies IP unicast routes based on the address prefixes. That is, one route corresponds to one FEC. All the packets in the same FEC are equally handled on the MPLS network.

- LSR

As a core device on an MPLS network, the LSR provides label switching and distribution functions. As specified in RFC 3031 for MPLS system, an LSR is also an MPLS node which is capable of forwarding original Layer 3 packets (such as IPv4 andIPv6 packets). Since MPLS can forward normal IP packets, LSRs also have this capability..

- LER

Located on the edge of an MPLS network, an LER classifies incoming traffic into different FECs, requests labels for these FECs, and restores outgoing traffic to the original packets by popping labels. The LER thus provides traffic classification, label mapping, and label removal functions.

- LSP

An FEC data stream is assigned with specific labels on different nodes and transmitted along the nodes according to the switching of assigned labels. The path where the data stream travels is an LSP. It is a collection of multiple LSRs. Therefore, an LSP can be considered as a tunnel that traverses the MPLS core network.

- NHLFE

An NHLFE table is used to store the next-hop information about MPLS packets. Typically, a next hop label forwarding entry contains the following information:

1) Next hop of data packets
2) Link layer encapsulation to use when forwarding data packets
3) Coding scheme for the label stack when forwarding data packets
4) Operations on the label stack of data packets, including:
   a) Replacing the label at the top of the label stack with a new label
   b) Popping the label off the stack top
   c) Pushing one or more labels
   d) Replacing the label at the top of the label stack with a new label and pushing one or more new labels on the label stack

- ILM

An ILM table is a label forwarding table where each incoming label is mapped to a series of NHLFEs (multiple NHLFEs indicate multiple paths). The ILM is used when an LSR receives and forwards MPLS packets with labels.

- FTN

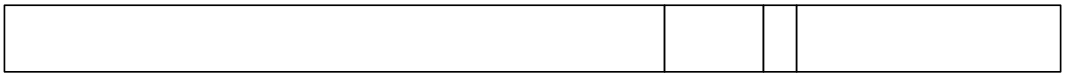
Different from ILM, FTN maps each FEC to a series of NHLFEs (multiple NHLFEs indicate multiple paths). An FTN table is used when an LER encapsulates labels to an unlabeled packet before forwarding the packet.

Label

A label is a short identifier with fixed length and of local significance. The label is distributed and transmitted only between two adjacent LSRs. As a result, it is valid only between the two LSRs. One label identifies one FEC. When arriving at the MPLS ingress, packets are classified into different FECs according to certain rules. Based on the FECs, the packets are encapsulated with different labels and then forwarded on the MPLS network based on the labels.

Label Format

Figure 1 MPLS label format



As shown in Figure-1, a label consists of four fields, which is described as follows:

- Label field

The label field is a 20-bit label value. The label value is an index for the label forwarding table. The Internal Engineering Task Force (IETF) classifies 0 to 15 as reserved labels and predefines their meanings:

Reserved Label	Description

0	IPv4 explicit null label. As specified in RFC 3032, label 0 must be placed at the bottom of the label stack, which means that the label must be popped before packets are forwarded according to destination IP addresses. RFC 4182 modifies the description of label 0 in RFC 3032. In RFC 4182, label 0 is popped directly upon receipt of a label 0 packet. The subsequent forwarding behavior is determined by the content behind the label 0. If another label follows, the packet is forwarded according to the label; if the packet is an IPv4 packet, it is forwarded based on the destination IP address.
1	Router alert label. This label is not allowed to be placed at the bottom of the label stack. When a receiving packet carries a router alert label, it must be sent to the local software module for processing. The actual forwarding of the packet must be based on the label behind the router alert label. Before the packet is forwarded, however, the router alert label must be pushed to the label stack again. This option is similar to the Router Alert Option of IP packets. You can use this option to configure each LSR to check MPLS packets.
2	IPv6 explicit null label. As specified in RFC 3032, label 2 must be placed at the bottom of the label stack. This means that the label must be popped before the packet is forwarded according to the destination IP address. RFC 4182 modifies the description of label 2 in RFC 3032. In RFC 4182, label 2 is popped directly upon reciept of a label 2 packet. The subsequent forwarding behavior is based on the content behind the label2. If another label follows, the packet is forwarded according to the label; if it is an IPv6 packet, it is forwarded according to the destination IP address.
3	Implicit null label. This label can be distributed by LDP but can never be transmitted in the label stacks of MPLS packets. When an LSR exchanges MPLS packets, if the label on the top of the label stack has a value of 3, it can be popped but should not be replaced with another label. The implicit null label is used in the Penultimate Hop Popping (PHP) function.
4 to 15	Reserved by the IETF for future use.

- Exp field

The Exp field is currently used to store the QoS information about MPLS. This field contains 3 bits.

- S mark

The S mark field indicates the stack bottom. It contains one bit. If multiple labels exist, the S bit of the label at the stack bottom is set to **1** and the S bits of other labels are **0**. If only one label exists, the S bit is set to 1.

- TTL

Time to Live. This field contains 8 bits. It is similar to the TTL value in an IP packet header. When a label is first added to an IP packet, the TTL value can be copied from the TTL field (or HopLimit of IPv6) of the IP packet header. The TTL value of the outer (stack top) label then decreases by one at every label switching. When MPLS runs on ATM links, the label encoding methods are different and no TTL field exists. For methods and solutions, refer to RFC 3032.

Label Stack

An MPLS packet can contain several labels to form a label stack. The label after the link layer header is the top label and the label before the IP header is the bottom label. An LSR exchanges labels based on the top label. When multiple labels exist, each label must be complete and contain 32 bits. A label stack supports multiple layers of labels to be carried in an MPLS packet. The purpose is to enable the MPLS technology to support hierarchical network systems and LSP tunnels.

Operation Methods of Labels

The following lists basic label operations on MPLS nodes:

- Push

Insert a label between the link layer header and the network layer header on an ingress LER or add a new label to the stack top of an MPLS packet on an intermediate LSR.

- Pop

Remove labels off packets on the egress LER to restore the IP packets or remove the top label on an intermediate LSR to reduce layers of a label stack.

- Swap

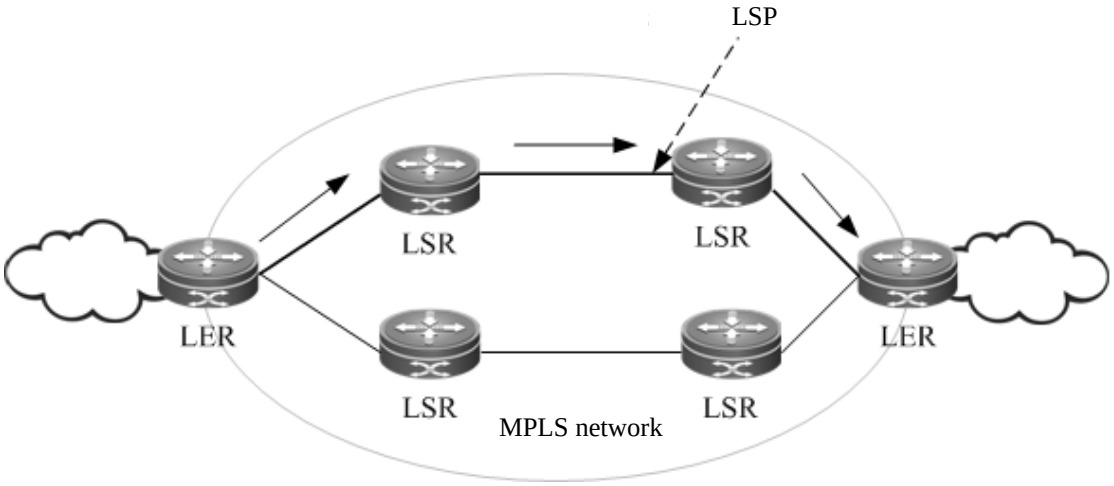
Replace the top label in the label stack of a packet based on the ILM during forwarding of the packet.

LDP

As an emerging network system, MPLS also has its own signaling protocols or "routing protocols". One of the basic concepts in the MPLS system is that two LSRs must reach consensus on the meaning of labels used for traffic transmission. This consensus is realized through a series of processes, that is, LDP. Through LDP, one LSR can notify the other LSR of the label binding. The MPLS system architecture does not assume that there is only a single LDP. Some MPLS systems use independent distribution protocols, such as LDP defined in RFC 3036 by the IETF; other MPLS systems support the distribution of labels by extending existing protocols in piggybacking mode, such as MP-BGP and RSVP. You can choose different LDPs for MPLS networks based on different application scenarios.

MPLS Network

Figure 2

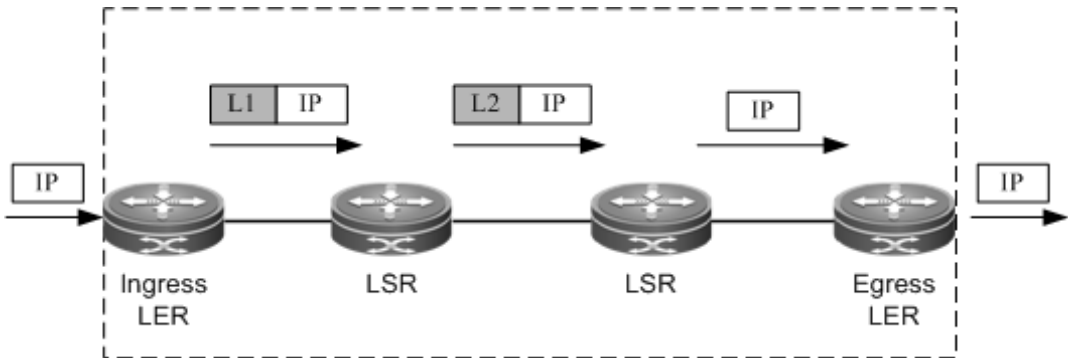


An MPLS network comprises two basic components: Label Switching Routers (LSRs) and LERs. An LSR is located at the core of the MPLS network and runs the LDP signalling protocol to forward labeled packets. An LER classifies and labels incoming packets into FECs and encapsulates the labeled packets as MPLS packets for forwarding. The LER also removes the labels from outgoing MPLS packets and restores these packets to the original packets. On the MPLS network, packets with labels are forwarded along the label switched path (LSP) set up through LDP.

The MPLS architecture is divided into two parts: the forwarding unit (data plane) and control unit (control plane). The former forwards a packet by searching the label forwarding information base (LFIB) based on the label carried by the packet whereas the latter is responsible for creating and maintaining the LFIB between the connected MPLS nodes. Each MPLS node must run one or more routing protocols (including static routes) to exchange routing information with other MPLS nodes on the MPLS network. Therefore, in effect, each MPLS node is an IP router on the control plane. Similar to a conventional IP router, an MPLS node also uses unicast routing protocols (including static routes) to create and maintain a routing table. The difference is that the traditional router uses the routing table to create a forwarding table and the MPLS node uses the routing table to exchange label binding information between each destination subnet and neighboring MPLS nodes. The protocol responsible for exchanging label binding information is LDP.

MPLS Forwarding Behaviors

Figure 3 Forwarding process of MPLS packets that support PHP



The following takes traditional IP routing services as an example to show the MPLS forwarding process:

- Enable traditional routing protocols (OSPF or IS-IS) on all LSRs (including LERs) and create IP routing tables on the LSRs and LERs.
- Set up an LDP LSP based on the IP routing table.
- Upon receipt of an IP packet, the ingress LER analyzes the IP packet header and maps it to an FEC. The ingress LER then adds the label L1 to the packet and sends the labeled packet to the next hop LSR along the LSP.
- The next-hop LSR receives the labeled packet, searches the LSP based on the label on the stack top, and then forwards the packet to the next-hop LSR along the LSP after replacing the label with a new one.
- The intermediate LSRs perform the same actions as step 4.
- Upon receipt of the labeled packet, the PHP LSR searches the label forwarding table and pops the label after learning that the outgoing label is the implicit null label 3. The PHP LSR then forwards the original IP packet to the last-hop LSR. If the outgoing label is the explicit null label, the PHP LSR pops the label and directly sends the original packet based on the routes of the IP header in the IP forwarding table.
- If the label is popped on the PHP LSR, the last-hop egress LER receives the original IP packet and forwards it according to the IP routing table.

LSP Establishment and Loop Detection

A virtual MPLS connection is an LSP. One FEC data stream is assigned with different labels on different MPLS nodes and forwarded according to the labels. The path that the data stream travels is an LSP that consists of a series of LSRs. Data streams of the same FEC pass through the same LSP.

- LSP Establishment
- LSP Loop Control

LSP Establishment

The LSP establishment is the process of binding an FEC to a label and notifying adjacent LSRs of the binding. This process is completed by LDP. RFC 3036 stipulates the protocol specifications of LDP, the interactive process of LSRs, and the message formats.

LDP detects adjacent LSRs by sending Hello messages periodically. The LDP Hello messages are encapsulated using the User Datagram Protocol (UDP) and use the well-known port 646 as the destination port. The destination address of these packets is 224.0.0.2, the multicast address of all routers in the subnet. The discovery of an adjacent LSR triggers the creation of LDP sessions. An LDP session is created in the following two steps:

- Establish a transmission connection. The connection is established after the completion of TCP three-way handshakes that do not require any interaction of LDP messages.
- Initialize the session. Both parties exchange their initialization information to negotiate and determine the LDP session parameters such as the label distribution mode, Keepalive duration, and the maximum length of Protocol Data Unit (PDU).

After the LDP session is created and both parties enter the operational state, the two parties can exchange label messages to distribute and manage labels, and create an LSP for each FEC.

During the process of LSP establishement, two label distribution modes are used: Downstream on Demand (DOD) and Downstream Unsolicited (DU). In DOD mode, an LSR responds to a label binding message only after it receives a label request from an adjacent LSR. In DU mode, the LSR voluntarily sends label binding messages to its adjacent LSRs without receiving any request.

During the LSP establishment, two label control methods are used: independent and ordered control. In independent control mode, each LSR announces to its adjacent devices the binding of labels and FECs at any required time. In independent DOD mode, one LSR can immediately answer an upstream label mapping request without waiting for the label mapping from the next hop device. In independent DU mode, one LSR can announce the label mapping of an FEC at any time deemed as proper for swapping the label of the FEC.

In ordered control mode, one LSR binds an FEC to a label and sends the binding upstream only when the FEC has the next-hop label mapping or the LSR is the egress of the FEC. Otherwise, the LSR does not bind the FEC to a label, or send the binding to an upstream LSR until receiving the label mapping of the FEC from a downstream LSR. In ordered control and DU mode, one LSR announces the label to an upstream LSR only when the LSR is the egress of the FEC or the LSR receives the label distributed by a downstream LSR. If the label distribution mode of the downstream LSR is DOD, the LSR, either in DOD or DU mode, passes on the label request from an upstream LSR to downstream devices.

LSP Loop Control

During the LSP setup process, the loop detection mechanism must be provided to ensure timely detection of any loops formed by the LSP. The maximum number of hops and path vector can be used to avoid LSP loops.

When the maximum number of hops is used, the message that transmits label binding information records the number of bypassing LSRs. The number increases by one after passing an LSR. If the number exceeds the specified maximum value, the system considers that a loop occurs and terminates the LSP.

When the path vector is used, the message that transmits label binding information records IDs of bypassing LSRs. The ID of an LSR is recorded to the vector table of the message after each LSR. Upon receipt of a label binding message, an LSR checks whether its ID is included in the vector table. If not, the LSR adds its ID to the record when distributing the message; if yes, the LSR considers that a loop occurs and terminates the LSP.

MPLS Applications

Thanks to the combination of Layer 2 switching and Layer 3 routing technologies, the MPLS technology improves the forwarding rate of packets. With the development of the Application-Specific Integrated Circuit (ASIC) technologies, the forwarding rate is no longer a bottleneck in network development. As a result, the edges of MPLS in enhancing forwarding rates are not remarkable. Due to the innate advantage of combining Layer 2 switching and Layer 3 routing technologies, however, MPLS still has unprecedented edges over other technologies in terms of VPNs and TE. In this context, MPLS receives more and more attention. The MPLS applications also gradually shift to the application areas of MPLS VPN and MPLS TE.

Configuring MPLS


Caution

1. LDP is a topology-driven protocol. To ensure normal operation of LDP, enable IPv4 routing protocols and ensure their normal operations.
2. To enable the router MPLS express forwarding function and improve the forwarding performance of routers, use the **ip ref** command in interface configuration mode.

Enabling MPLS Forwarding Globally

Use the **mpls ip** command to enable a device to support MPLS forwarding in configuration mode. By default, MPLS forwarding is disabled on a device. After MPLS forwarding is enabled, the device first forwards packets according to their labels. When the label forwarding fails, the device attempts to forward packets based on their IP addresses.

Use the **no mpls ip** command to disable MPLS forwarding.

Command	Function
Ruijie(config)# **mpls ip**	Enables MPLS forwarding globally.
Ruijie(config)# **no mpls ip**	Disables MPLS forwarding globally.


Caution

This command is not applicable to controlling switch chip forwarding.

Enabling LDP Globally

Use the **mpls router ldp** [*vrf-name*] command to enable LDP for a VRF instance in global configuration mode and enter LDP configuration mode.

Use the **no mpls router ldp** [*vrf-name*] command to disable LDP for a VRF instance.

Command	Function
Ruijie(config)# **mpls router ldp** [*vrf-name*]	Enables LDP for a VRF instance and enters LDP configuration mode.
Ruijie(config-mpls-router)# **ldp router-id interface loopback** *id* [**force**]	Configures the LDP router ID. The loopback address is generally used as the router ID.
Ruijie(config)# **no mpls router ldp** [*vrf-name*]	Disables LDP for a VRF instance.

Caution

1. After LDP is enabled globally, use the **mpls ip** command to enable LDP for an interface in interface configuration mode.
2. If *vrf-name* is not specified, LDP is globally enabled for all VRF instances.
3. You are required to specify the router ID for an LDP when enabling LDP.

Enabling Label Switching on an Interface

By default, interfaces do not forward MPLS packets. To enable MPLS forwarding on a device, use the **mpls ip** command in global configuration mode. To explicitly enable MPLS forwarding on a specified interface, use the **label-switching** command. When enabling the label forwarding function of an interface, adjust the maximum transmission unit (MTU) of the interface based on service types to facilitate the transmission of large packets.

Command	Function
Ruijie(config-if-*type ID*)# **label-switching**	Enables MPLS forwarding on an interface.
Ruijie(config-if-*type ID*)# **no label-switching**	Disables MPLS forwarding on an interface.

- ☑ To enable the MPLS express forwarding function of a router and to improve the forwarding performance, use the **ip ref** command in interface configuration mode
- ☑ If label forwarding is enabled on a switch on a VLAN, there must be only one member port. Otherwise, packets cannot be flooded on the VLAN.
- ☑ When unknown unicast packets or broadcast packets enter the switch through a port, these packets (including packets of VLANs with label forwarding disabled) cannot be forwarded if label forwarding is enabled on a VLAN where the port belongs to. You are advised to enable label forwarding on routing ports.

Note

After the MPLS packet forwarding is disabled on a public network interface, packet forwarding from the AC to the PW is not affected.

Enabling LDP on an Interface

After LDP is enabled globally, use the **mpls ip** command to enable LDP on an interface in interface configuration mode.

Command	Function
Ruijie(config-if-*type ID*)# **mpls ip**	Enables LDP on an interface.
Ruijie(config-if-*type ID*)# **no mpls ip**	Disables LDP on an interface.

Caution

After LDP is enabled in interface configuration mode, LDP does not take effect on an interface if the **mpls router ldp** command is not used in global configuration mode. To enable LDP on the interface, you must also use the **label-switching** command to enable MPLS forwarding on the interface.

Configuring MPLS MTU on an Interface (Optional)

By default, values of the MPLS MTU and the MTU are the same for an interface. The MPLS MTU determines whether MPLS packets must be fragmented during forwarding. The MPLS MTU indicates the overall length of MPLS encapsulation and encapsulated (such as IP) layers.

Use the **no mpls mtu** command to restore the default value of the MPLS MTU on an interface.

Command	Function
Ruijie(config-if-*type ID*)# **mpls mtu** *bytes*	Configures the MPLS MTU on an interface.
Ruijie(config-if-*type ID*)# **no mpls mtu**	Restores the default value of the MPLS MTU on an interface.

Caution The MPLS MTU on an interface cannot exceed the actual size of packets transmitted on the interface. For switches that forward packets based on ASIC, this configuration is invalid. These switches forward packets based on the MTU configured on interfaces and directly discard packets that exceed the MTU rather than performing fragmentation. To adjust the MTU of an interface, use the **mtu** command in interface configuration mode. Fragmentation is supported by only process forwarding and router forwarding. In actual applications, you must adjust the MTU value to avoid performance degradation caused by fragmentation.

Fragmenting MPLS Packets (Optional)

By default, MPLS packets that exceed the MPLS MTU on an interface are fragmented as IP fragmentations. The fragmented IP packets are still encapsulated with the original labels and transmitted along the original LSP.

Use the **no mpls ip fragment** command to directly discard packets that must be fragmented.

Command	Function
Ruijie(config)# **no mpls ip fragment**	Directly discards MPLS packets that exceed the MPLS MTU on an interface.
Ruijie(config)# **mpls ip fragment**	Restores the default value to fragment packets that exceed the MPLS MTU on an interface.

Caution This command is valid only for the encapsulated IP packets.

Handling ICMP Error Messages (Optional)

ICMP error messages (such as typical MPLS TTL timeout messages) generated during the forwarding of MPLS packets are forwarded along the LSP of the label stack by default. To provide different processing methods for MPLS packets with different numbers of labels, use the **mpls ip icmp-error pop** *labels* command. For ICMP error messages with the forwarding label stack not greater than the specified number of labels, they are forwarded through routes on the IP routing table where the FEC of the stack top label is stored. For ICMP error messages with the forwarding label stack greater than the specified number of labels, they are forwarded along the LSP of the original label stack.

Command	Function

Ruijie(config)# **mpls ip icmp-error pop** *labels*	Controls the handling of ICMP error messages generated by labeled MPLS packets.
Ruijie(config)# **no mpls ip icmp-error pop**	Restores the default value.

Configuring the MPLS TTL Replication Function (Optional)

There are two modes for handling the TTL of encapsulated and de-encapsulated IP (or MPLS) packets on an MPLS network:

- TTL replication mode: This is the default working mode. The procedure is as follows: When a label is pushed, the label TTL copies the TTL of the existing IP or MPLS header to the TTL field of the label. When a label is popped out, the TTL is copied back from the outer label to the inner IP packet or MPLS packet.
- TTL non-replication mode: In this mode, the TTL is not copied. The procedure is as follows: When a label is pushed, the TTL value of the label is directly set to 255. When a label is popped out, the original TTL value of the inner IP packet or MPLS packet is exposed and retained.

Use the **mpls ip ttl propagate** { **public** | **VPN** } command to configure the TTL replication function for packets sent and forwarded by a device.

Command	Function
Ruijie(config)# [**no**] **mpls ip ttl propagate public**	Enables or disables the TTL replication function for MPLS packets sent by the device.
Ruijie(config)# [**no**] **mpls ip ttl propagate VPN**	Enables or disables the TTL replication function for MPLS service packets forwarded by the device.

After the TTL replication function is enabled on an MPLS network, you can use the Tracert tool on a CE to track all the LSRs that the packets pass through in the MPLS domain. If the TTL non-replication mode is configured on PEs, the entire LSP of the packets is considered as only one hop.

Caution After TTL replication is enabled, the TTL of the inner header is not copied but retained if it is smaller than the TTL of the outer header.

Verifying the MPLS Information

To view MPLS information and verify the configuration results, use the **show** commands in privileged mode.

- Displaying MPLS information

Display the utilization information about the label space and the interfaces enabled with MPLS. You can verify whether the configurations are accurate based on the information.

Command	Function
Ruijie# **show mpls summary**	Displays basic MPLS information.

- Displaying the MPLS forwarding table

Display contents of MPLS forwarding entries and MPLS forwarding entries added to an MPLS application protocol (such as LDP and MP-BGP).

Command	Function

Ruijie# **show mpls forwarding-table** [**summary** | [[*ip-address/mask* | **label** *label* | **interface** *interface-name* | **next-hop i***p-address*] | [**ftn** [**ip** | **vc**] | **ilm** [**ip** | **vc**]] | { **vrf** *vrf-name* | **global** } [**ftn** | **ilm**]] [**frr**] [**detail**]]	Displays the information about the MPLS forwarding table.

- Displaying the utilization of the label pool

Command	Function
Ruijie# **show mpls label-pool**	Displays information about the utilization of the MPLS label pool.

- Check the LSP connectivity.

Command	Function
Ruijie# **ping mpls ipv4** *ip-address/mask* [**repeat** *repeat*] [**ttl** *time-to-live*] [**timeout** *timeout*] [**size** *size*] [**interval** *mseconds*] [**source** *ip-address*] [**destination** *ip-address*] [**force-explicit-null**] [**pad** *pattern*] [**reply mode** { **ipv4** | **router-alert** }] [**dsmap**] [**flags fec**] [**verbose**]	Checks the LSP connectivity.
Ruijie# **traceroute mpls ipv4** *ip-address/mask* [**timeout** *timeout*] [**ttl** *ttl*] [**source** *ip-address*] [**destination** *ip-address*] [**force-explicit-null**] [**reply mode** { **ipv4 | router-alert** }] [**flags fec**] [**verbose**]	Checks the LSR nodes that the LSP passes through.

Configuring Optional LDP Parameters (Optional)

You can modify the default LDP parameter settings as required. To modify LDP parameters, use the commands in LDP configuration or interface configuration mode.

Configuring Parameters for an LDP Session

Configuring the LDP Router ID

The LDP router ID, expressed in the format of IP addresses, uniquely identifies one LSR in a domain. By default, the system router ID is used as the LDP router ID, that is, the LSR ID. The value of an LDP router ID must be globally unique. In addition, the LDP router ID must be reachable to other LSRs because LDP uses the LDP router ID as the transport address by default. To modify the LSR ID, use the **ldp router-id** command.

Command	Function
Ruijie(config-mpls-router)# **ldp router-id interface** *interface-name* [**force**]	Specifies the address of an interface as the LDP router ID of the LSR. **force** indicates that the current configurations immediately take effect.
Ruijie(config-mpls-router)# **no ldp router-id**	Restores the default value. The system router ID is used as the LDP router ID.

Configuring transport-address

By default, the LSR ID is used as the global transport address. As an option, you can choose the main address of an interface or specify an IP address as the transport address to set up an LDP session on the interface. The following shows two configuration methods.

Use the following commands to configure the transport address of an interface.

Command	Function
Ruijie(config-if-*type ID*)# **mpls ldp transport-address** { **interface** | *ip-address*}	Configures the transport address for LDP sessions on an interface.
Ruijie(config-if-*type ID*)# **no mpls ldp transport-address**	Deletes the configuration on the interface. By default, the global transport address is used. If no global transport address is configured, the LSR ID is used as the transport address.

Use the following commands to globally configure a transport address for all LDP sessions in LDP configuration mode.

Command	Function
Ruijie(config-mpls-router)# **transport-address** { **interface** | *ip-address* | *interface-name* }	Configures a global transport address for LDP sessions.
Ruijie(config-mpls-router)# **no transport-address**	Removes the global setting and restores the LSR ID as the transport address.

Caution

1. When you specify an IP address as the transport address, ensure that the address is reachable to other directly connected LSRs; otherwise, the LDP session cannot be set up.
2. If transport addresses are configured on an interface and globally, the basic LDP session set up on the interface prefers the transport address configured for the interface.
3. The configured transport address is valid only for the basic LDP session. The LDP session set up through extended mechanisms use the LSR ID as the transport address.

Configuring the Time Interval for Hello Packets

LDP periodically sends Hello packets to detect LDP peers. By default, the interval for sending Hello packets in the basic LDP discovery mechanism is 5 seconds. You can freely set the interval that ranges from 1 to 65535 seconds in interface mode.

Command	Function
Ruijie(config-if-type ID)# mpls ldp hello-interval seconds	Sets the interval for sending Hello packets in the basic LDP discovery mechanism.
Ruijie(config-if-type ID)# no mpls ldp hello–interval	Restores the default interval for sending Hello packets in the basic LDP discovery mechanism.

The default interval for sending Hello packets in the extended LDP discovery mechanism is 10 seconds. To modify the interval, use the **discovery target-hello** *interval* command.

Command	Function
Ruijie(config-mpls-router)# **discovery target-hello interval** *seconds*	Sets the interval for sending Hello packets in the extended LDP discovery mechanism.
Ruijie(config-mpls-router)# **no discovery target-hello interval**	Restores the default interval for sending Hello packets in the extended LDP discovery mechanism.

Configuring the Hold Time of Hello Packets

After an LDP peer is detected by periodically sent Hello packets, the local LDP device retains the peer for a period of time although no Hello packet is received from the peer, and considers that the peer expires after this period. This period of time is called the hold time of Hello packets. The default hold time of Hello packets is 15 seconds. You can freely set the interval that ranges from 1 to 65535 seconds in interface mode. The value 65535 indicates an indefinite hold time.

Command	Function
Ruijie(config-if-*type ID*)# **mpls ldp hello-holdtime** *seconds*	Sets the hold time of Hello packets.
Ruijie(config-if-*type ID*)# **no mpls ldp hello-holdtime**	Restores the default hold time of Hello packets.

The default hold time of Hello packets in the extended LDP discovery mechanism is 45 seconds. To modify this value, use the **discovery target-hello** *holdtime* command.

Command	Function
Ruijie(config-mpls-router)# **discovery target-hello holdtime** *seconds*	Sets the hold time of Hello packets in the extended LDP discovery mechanism.
Ruijie(config-mpls-router)# **no discovery target-hello holdtime**	Restores the default hold time of Hello packets in the extended LDP discovery mechanism.

Configuring the Hold Time of Keepalive Packets

After an LDP peer is detected by periodically sent Hello packets and an LDP session is set up in TCP mode, the local LDP device retains the peer for a period of time although no Keepalive packet is received from the peer. The local LDP device considers that the peer expires and voluntarily terminates the LDP session after this period. This period of time is called the hold time of Keepalive packets. The default hold time of Keepalive packets for the session set up in the basic discovery mechanism is 45 seconds and that for the session set up in the extended discovery mechanism is 180 seconds. You can freely set the value at the range of 15 to 65535. The interval for sending Keepalive packets is one third of the hold time of Keepalive packets.

Command	Function
Ruijie(config-if-*type ID*)# **mpls ldp keepalive–holdtime** *seconds*	In interface mode, sets the hold time of Keepalive packets for the session set up in the basic discovery mechanism.
Ruijie(config-if-*type ID*)# **no mpls ldp keepalive–holdtime**	Restores the default hold time of Keepalive packets for the session set up in the basic discovery mechanism.
Ruijie(config-mpls-router)# **targeted-session holdtime** *seconds*	In LDP mode, sets the hold time of Keepalive packets for the session set up in the extended discovery mechanism.
Ruijie(config-mpls-router)# **no targeted-session holdtime**	Restores the default hold time of Keepalive packets for the session set up in the extended discovery mechanism.

Configuring the Maximum Number of Repeated Label Requests

When an LDP device requests labels, it waits for a period of time to start another attempt if no label is detected due to various reasons. The default number of repeated requests is indefinite. You can freely set the value that ranges from 0 to 255 in interface mode.

Command	Function
Ruijie(config-mpls-router)# **mpls ldp max-label-requests** *times*	Sets the maximum number of repeated LDP label requests.

Ruijie(config-mpls-router)# **no mpls ldp max-label-requests**	Restores the default number of repeated LDP label requests.

Configuring the Maximum PDU

The messages exchanged between LDP devices are all contained in PDUs. You can freely set the value of the PDU that ranges from 256 to 4096 in interface mode. The default PDU value is 4096.

Command	Function
Ruijie(config-mpls-router)# **mpls ldp max-pdu** *max-pdu*	Sets the maximum PDU.
Ruijie(config-mpls-router)# **no mpls ldp max-pdu**	Restores the default PDU (4096).

Configuring the Extended LDP Discovery Mechanism

The basic discovery mechanism is used to detect the local LDP peers. That is, set up a local LDP session with the directly connected LSR. The extended discovery mechanism is used to detect the remote LDP peers. That is, set up a remote LDP session with the non-directly connected LSR.

Command	Function
Ruijie(config-mpls-router)# **neighbor** *ip-address*	Creates an extended LDP peer.
Ruijie(config-mpls-router)# **no neighbor** *ip-address*	Deletes an extended LDP peer.

Configuring LDP Loop Detection

Configuring the Loop Detection Mode

LDP provides two methods to detect loops: maximum number of hops and path vector. By default, loop detection is disabled for LDP.

In the loop detection based on the maximum number of hops, a packet carries both label information and the number of hops. The number increases by one every time the packet passes an LSR. When the number exceeds a preconfigured maximum value, the device considers that a loop occurs on the LSP.

In the loop detection based on the path vector, the packet carries the LSR ID apart from the label information. At each hop, an LSR first checks whether the number of LSRs in the path vector list exceeds the preset maximum number in the path vector list. If yes, a loop occurs. If no, the LSR continues to check whether its LSR ID exists in the path vector list of the LDP message. If yes, a loop occurs; if no, the LSR adds its own LSR ID to the path vector list.

Command	Function
Ruijie(config-mpls-router)# **loop-detection**	Enables loop detection.
Ruijie(config-mpls-router)# **no loop-detection**	Disables loop detection.

Configuring the Maximum Number of Hops

In interface mode, you can set the maximum number of hops allowed in loop detection mode. By default, the number is 254. You can set the value at the range of 1 to 255. If loop detection is enabled and the number of hops in an LDP message is detected to exceed the preset value, the LSR considers that a loop occurs.

Command	Function
Ruijie(config-if-*type ID*)# **mpls ldp max-hop-count** *number*	Sets the maximum number of hops in loop detection.

Ruijie(config-if-*type ID*)# **no mpls ldp max-hop-count**	Restores the default value of the maximum number of hops in loop detection.

Configuring the Maximum Number in the Path Vector List

In interface mode, you can set the maximum number of LSRs included in the path list of the loop detection based on path vector. By default, the number is 254. You can set the number at the range of 0 to 254. The number means the maximum number of LSRs that can be carried in the path vector list. After loop detection is enabled, an LSR considers that a loop occurs if the LSR detects its own LSR ID in the path vector list or the number of LSR IDs in the path vector list exceeds the preset value.

Command	Function
Ruijie(config-mpls-router)# **mpls ldp max-path-vector** *number*	Sets the maximum number in the path vector list of loop detection.
Ruijie(config-mpls-router)# **no mpls ldp max-path-vector**	Restores the default value of the maximum number in the path vector list of loop detection.

Configuring the LDP Working Mode

Configuring the LDP Label Distribution Control Mode

The LDP label distribution control mode specifies when an LSR notifies its neighbors of the binding between labels and FECs. There are two control modes: independent control and ordered control.

In independent control mode, the LSR can announce the binding of labels and FECs to its neighbors at any required time. In ordered control mode, an LSR binds an FEC to a label and sends the binding upstream only when the FEC has the next-hop label mapping or the LSR is the egress LSR of the FEC.

By default, LDP uses the independent control mode. To configure the LDP control mode, use the **lsp-control-mode** command.

Command	**Function**
Ruijie(config-mpls-router)# **lsp-control-mode** { **independent** | **orderd** }	Configures the label distribution control mode.
Ruijie(config-mpls-router)# **no lsp-control-mode**	Restores the default label distribution control mode.

Configuring the LDP Label Distribution Mode

The LDP label distribution mode specifies how an LSR notifies its neighbors of the binding between labels and FECs. There are two modes: DOD and DU.

In DOD mode, a downstream LSR responds to a label binding message only after receiving a label request from an upstream LSR. In DU mode, one LSR voluntarily sends label binding messages to its upstream LSRs according to certain triggering policies. If the upstream and downstream LSRs use different label distribution modes, the DU mode is used if the LSRs are connected to each other through Ethernet.

By default, LDP works in DU mode. You can use the **mpls ldp distribution-mode** command in interface mode to set the label distribution mode on an interface.

Command	**Function**
Ruijie(config-if-*type ID*)# **mpls ldp distribution-mode { du | dod }**	Configures the label distribution mode.

Ruijie(config-if-*type ID*)# **no mpls ldp distribution-mode**	Restores the default label distribution mode (DU).

Configuring the LDP Label Retention Mode

The label retention mode specifies whether an LSR should retain the label binding learnt from a label mapping message if the message is not sent from the next hop of the corresponding FEC or the message does not match any existing IP route. There are two label retention modes: conservative and liberal modes.

When the preceding situations occur, the liberal mode retains the binding of the FEC and label from the neighbor whereas the conservative mode does not retain the binding information.

The conservative label retention mode uses and maintains a small number of labels. The LSR should re-obtain the label values in case of route changes, prolonging responses. The liberal label retention mode, however, responds rapidly to route changes but unnecessary label mappings are also distributed and maintained.

By default, LDP uses the liberal label retention mode.

Use the **label-retention-mode** command to configure the label retention mode.

Command	Function
Ruijie(config-mpls-router)# **label-retention-mode** { **liberal | conservation** }	Configures the label retention mode.
Ruijie(config-mpls-router)# **no label-retention-mode**	Restores the default label retention mode.

Configuring Label Merging

If an LSR binds several incoming labels for a FEC but uses the same outgoing label for all packets in the FEC, it indicates that the LSR is capable of label merging. You can enable or disable label merging through LDP configurations.

By default, label merging is enabled for LDP.

Use the **label-merge** command to enable or disable label merging.

Command	Function
Ruijie(config-mpls-router)# **label-merge**	Enables label merging.
Ruijie(config-mpls-router)# **no label-merge**	Disables label merging.

Configuring the Transmission Mode of Label Release Messages

When an FEC becomes invalid, LDP sends label release messages to downstream devices to cancel the label bound to the FEC. Each LDP device on the LSR determines whether to transmit the messages to downstream devices based on the transmission mode of label release messages.

By default, an LDP device does not send label release messages received from an upstream device to downstream devices.

Use the **propagate-release** command to configure the transmission mode of label release messages.

Command	Function
Ruijie(config-mpls-router)# **propagate-release**	Configures a device to send label release messages to downstream devices.
Ruijie(config-mpls-router)# **no propagate-release**	Configures a device not to send label release messages to downstream devices.

Configuring Label Control Policies

Configuring Label Distribution Policies

By default, LDP assigns labels to all valid IGP routes (excluding BGP routes). In some special situations, you may only want to assign labels to some routes or to certain LDP peers to reduce the number of labels and the number of LSPs to lessen device and network burdens.

Command	Function
Ruijie(config-mpls-router)# **advertise-labels for host-routes**	Configures the device to assign labels to only host routes that satisfy the mask length of 32 bits in the route forwarding table. By default, the mask length of routes is not restricted.
Ruijie(config-mpls-router)# **advertise-labels for bgp-routes** [**acl** *acl-name*]	Configures the device to assign labels to BGP routes. By default, LDP does not assign labels to BGP routes.
Ruijie(config-mpls-router)# **advertise-labels for default-route**	Configures the device to assign labels to default routes. By default, LDP assigns implicit null label 3 to default routes.
Ruijie(config-mpls-router)# **advertise-labels for acl** *prefix-access-list* [**to** *peer-access-list*]	Configures the device to assign labels to FECs that match ACL rules and specify the device to assign labels only to LDP peers that match the rules.

Caution

1. By default, LDP assigns labels to only IGP routes. To assign labels to BGP routes, use the **advertise-labels for bgp-routes** command.
2. By default, LDP does not set up an LSP for default routes.

Configuring Label Reception Policies

By default, LDP can receive all label binding information sent from all neighbors. In certain situations, you may need to control the device to receive only some binding information about FECs and labels from certain neighbors. In this case, use the **neighbor** *ip-address* **labels accept** command.

Command	Function
Ruijie(config-mpls-router)# **neighbor** *ip-address* **labels accept** *acl-name*	Configures a label reception policy.

Configuring Policies for Distributing Explicit Null Labels

By default, LDP assigns implicit null labels to the FEC (such as direct routes) with the local device as the egress. You can use the **explicit-null** command to assign explicit null labels to all direct routes or routes that match certain ACL rules. To restore the default setting, use the **no explicit-null** command.

Command	Function
Ruijie(config-mpls-router)# **explicit-null** [**for** *prefix_acl* **| to** *peer_acl*]	Configures a device to assign explicit null labels to all direct routes or routes that match certain ACL rules.
Ruijie(config-mpls-router)# **no explicit-null**	Restores the default setting.

Caution

1. For an FEC with the local device as the egress, the device cannot assign explicit null labels to the FEC if the corresponding LSP is a tunnel that carries L2VPN or L3VPN services.
2. Configure this function only for the global LDP instance. This function is not supported by the VRF instance.

Configuring the LDP MD5 Authentication

To enhance the reliability of LDP sessions, you can configure the MD5 authentication for the TCP connections used by the LDP sessions. To configure the MD5 authentication for TCP connections between a device and its peer, use the **neighbor** *ip-address* **password** [**0 | 7**] *pwd-string* command. To restore the default setting,use the **no neighbor** *ip-address* **password** [**0 | 7**] *pwd-string* command.

Command	Function
Ruijie(config-mpls-router)# **neighbor** *ip-address* **password** [**0 | 7**] *pwd-string*	Configures a device to adopt the MD5 authentication for the TCP connections with its peer.
Ruijie(config-mpls-router)# **no neighbor** *ip-address* **password**	Restores the default setting.

Verifying the LDP Information

- Displaying LDP attributes

Use the **show mpls ldp parameters** [all **| vrf** *vrf-name*] command to view information about LDP attributes, including the LSR ID, transport address, loop detection mechanism, label distribution control mode, label retention mode, the interval and hold time of Hello packets with extended peers, and the interval and hold time of Keepalive packets with extended peers. You can verify the information to check whether the configurations are correct. By default, the LDP attributes of the default VRF are displayed. If **all** is chosen, the LDP attributes of all VRFs are displayed; if *vrf-name* is specified, the LDP attributes of a specified VRF are displayed.

Command	Function
Ruijie# **show mpls ldp parameters** [**all | vrf** *vrf-name*]	Displays information about LDP attributes.

- Displaying information about an interface enabled with LDP

Use the **show mpls ldp interface** [**all** | **vrf** *vrf-name* | *interface-name*] command to display the LDP status of interfaces in all or a specified VRF. You can also query the LDP status of specific interfaces. By default, the interface LDP status of interfaces in the default VRF is displayed. If **all** is chosen, the LDP status of interfaces in all VRFs is displayed; if *vrf-name* is specified, the LDP status of interfaces in a specified VRF is displayed; if *interface-name* is specified, the LDP status of the specified interface is displayed.

Command	Function
Ruijie# **show mpls ldp interface** [**all | vrf** *vrf-name* **|** *interface-name*]	Displays information about the interface enabled with LDP.

- Displaying the binding between FECs and labels

Use the **show mpls ldp bindings** [**all** |**vrf** *vrf-name*] | [*ip-address*/*mask* | **label** *label*] | [**remote** | **local**] command to display the binding information between FECs and labels. You can also use this command to view the LDP working status, to check whether an FEC is properly bound to a label, or query the specific label value bound to an FEC. When using this

command, you can filter the display information based on the VRF, address prefix, label value, remote binding, or local binding.

Command	Function
Ruijie# **show mpls ldp bindings** [**all | vrf** *vrf-name*] | [*ip-address/mask* | **label** *label* **|** [**remote | local**]	Displays the binding between FECs and labels.

- Displaying LDP neighbors

Use the **show mpls ldp neighbor** [**all** | **vrf** *vrf-name*] [*ip-address*] [**detail**] command to view the LDP neighbors of all or a specified VRF, including the TCP connection port, LDP status, statistics about packets received and transmitted, and the voluntary LDP discovery party of the local and remote LDP devices. If parameter **detail** is added, detailed information about LDP neighbors is displayed.

Command	Function
Ruijie# **show mpls ldp neighbor** [**all | vrf** *vrf-name*] | [**detail**]	Displays information about LDP neighbors.

- Displaying information about discovered LDP neighbors

Use the **show mpls ldp discovery** [**all** | **vrf** *vrf-name*] | [**detail**] command to display ports where LDP neighbors are discovered and information about the neighbors. If parameter **detail** is added, detailed information about LDP neighbors is displayed.

Command	Function
Ruijie# **show mpls ldp discovery** [**all | vrf** *vrf-name*] **|** [**detail**]	Displays information about discovered LDP neighbors.

- Reseting the LDP session

Use the **clear mpls ldp neighbor** command to reset an LDP session and set up a new session.

Command	Function
Ruijie# **clear mpls ldp neighbor** [**all** | **vrf** *vrf-name*] [*| *ip-address*]	Resets an LDP session and sets up a new session.

Configuring Static MPLS Forwarding

To support basic MPLS forwarding functions, you can also use static configurations other than LDP. To configure basic MPLS forwarding functions in static mode, perform the following configuration procedures:

- (Mandatory) Enable MPLS forwarding globally.
- (Mandatory) Enable MPLS forwarding on an interface.
- (Mandatory) Configure a static LSP.

Caution LDP is not required when configuring a static LSP. As a result, IPv4 routes are also not required. If no IPv4 route exists on the network, the static LSP can still take effect as long as the physical network is reachable.

For configuration procedures to enable MPLS forwarding globally or on an interface, refer to the basic procedures for configuring MPLS forwarding.

Configuring a Static LSP

The configuration of an MPLS network in static mode centers around the static LSP. The other configurations are the same as those of LDP. To configure a static LSP, perform the following steps:

- Configure a static FTN on the ingress LSR.
- Configure a static ILM on the intermediate LSR.
- Configure a static ILM on the PHP LSR.


Note

Label values 16 to 1024 are reserved for static LSPs. You can select only from these label values when configuring static LSPs.

☑ On a router, use the **ip ref** command on the label forwarding interface to enable MPLS fast forwarding to improve forwarding performance of the router.

Configuring a Static FTN on the Ingress LSR

On the ingress LSP, set up an FTN entry for the FEC, that is, bind the FEC to a label.

Use the **mpls static ftn** command to configure a static FTN in global configuration mode. The syntax of the command is as follows:

Command	Function
Ruijie(config)# **mpls static ftn** *ip-address / mask* **out-label** *label* **nexthop** *interface nexthop-ip*	Adds a global FTN.
Ruijie(config)# **no mpls static ftn** *ip-address/mask*	Deletes a global FTN.

For example, to configure a global FTN that binds label 16 to FEC 192.168.1.0/24 and supports the next hop of the LSP as 192.168.10.10 and the outgoing interface as GigabitEthernet 2/1, run the following command:

```
Ruijie(config)# mpls static ftn 192.168.1.0/24 out-label 16 GigabitEthernet 2/1 192.168.10.10
```

To delete the TFN, run the following command. In this case, you are required to only enter the FEC. Other parameters are not required.

```
Ruijie(config)# no mpls static ftn 192.168.1.0/24
```

Configuring a Static ILM on the Intermediate LSR

An intermediate LSR forwards labels for incoming labeled packets. In this case, you are required to configure ILM forwarding entries to map incoming labels to outgoing ones. Use the **mpls static ilm in-label** command to configure a static ILM in global configuration mode. The syntax of the command is as follows:

Command	Function
Ruijie(config)# **mpls static ilm in-label** *in_label* **forward-action swap-label** *swap_label* **nexthop** *interface nexthop-ip* **fec** *ip-address/mask*	Adds a global ILM.
Ruijie(config)# **no mpls static ilm in-label** *in_label*	Deletes a global ILM.

For example, to configure a global ILM that maps the incoming label 16 to the outgoing label 17 and supports the next hop of the LSP as 192.168.11.11, the outgoing interface as GigabitEthernet 2/2, and the FEC of the LSP as 192.168.1.0/24, run the following command:

```
Ruijie(config)# mpls static ilm in-label 16 forward-action swap-label 17 nexthop
GigabitEthernet 2/2 192.168.11.11 fec 192.168.1.0/24
```

To delete the ILM, run the following command:

```
Ruijie(config)# no mpls static ilm in-label 16
```

Configuring a Static ILM on the PHP LSR

Because the second but last hop is required to perform PHP, its ILM entries must be different from those on other intermediate LSRs. That is, the outgoing label in the ILM of the PHP LSR on the LSP should be an implicit null label (3).

Note For information about the PHP, refer to related materials.

For example, you are required to configure a global ILM on the PHP LSR of the LSP. The LSR is required to pop out the incoming label 17 and send the packets from GigabitEthernet 2/2. The next hop address is 192.168.12.12 and the corresponding FEC is 192.168.1.0/24. Run the following command:

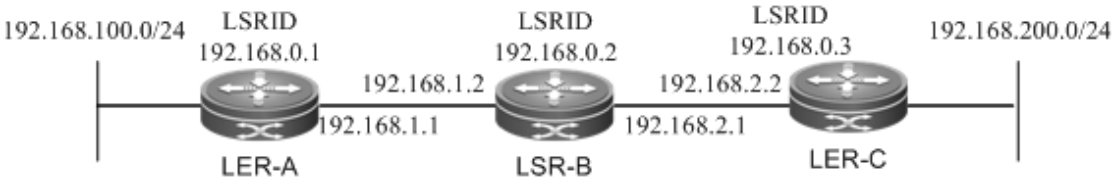
```
Ruijie(config)# mpls static ilm in-label 17 forward-action swap-label 3 nexthop GigabitEthernet
2/2 192.168.11.11 fec 192.168.1.0/24
```

To delete the ILM, run the following command:

```
Ruijie(config)# no mpls static ilm in-label 17
```

Example for Configuring Basic MPLS Functions

Figure 4



As shown in the preceding figure, three MPLS devices are deployed to construct an MPLS network. The following section introduces the setup of an LSP through LDP and the setup of a static LSP to show the MPLS configuration procedures.

Setting Up an LSP Through LDP

LDP works only with IPv4 routes. Here, OSPF is enabled to set up IPv4 routes. Before the following configuration, ensure that you have created a loopback interface (Loopback 0) and assigned an IP address, which also serves as the router ID, to the loopback interface on each device.

Configurations on LER_A:

Command	Function

Command	Function
Ruijie(config)# **mpls ip**	Enables MPLS forwarding globally. (Note: This command is not applicable to switch chip forwarding.)
Ruijie(config)# **mpls router ldp**	Enables LDP and enters LDP mode.
Ruijie(config-mpls-router)# **ldp router-id interface loopback** 0 **force**	Configures the LDP router ID. The loopback address is generally used as the router ID.
Ruijie (config-mpls-router)# **exit**	Exits LDP mode and enters global configuration mode.
Ruijie(config)# **interface gigabitEthernet** *2/2*	Enters interface mode of GigabitEthernet 2/2.
Ruijie(config-if-GigabitEthernet 2/2)# **mpls ip**	Enables LDP on the interface.
Ruijie(config-if-GigabitEthernet 2/2)# **label-switching**	Enables MPLS on the interface.
Ruijie(config-if-GigabitEthernet 2/2)# **ip ref**	Enables MPLS fast forwarding on the interface of a router.
Ruijie(config-if-GigabitEthernet 2/2)# **exit**	Exits interface mode and enters global configuration mode.
Ruijie (config)# **router ospf** *10*	Enables OSPF and enters OSPF mode.
Ruijie (config-router)# **network** *192.168.100.0 0.0.0.255* **area 0** Ruijie (config-router)# **network** *192.168.0.1 0.0.0.0* **area 0** Ruijie (config-router)# **network** *192.168.1.0 0.0.0.255* **area 0**	Adds routing information to OSPF.
Ruijie(config-router)# **end**	Ends the configuration.

Configurations on LER_B:

Command	Function
Ruijie (config)# **mpls ip**	Enables MPLS forwarding globally. (Note: This command is not applicable to switch chip forwarding.)
Ruijie (config)# **mpls router ldp**	Enables LDP and enters LDP mode.
Ruijie(config-mpls-router)# **ldp router-id interface loopback** *0* **force**	Configures the LDP router ID. The loopback address is generally used as the router ID.
Ruijie (config-mpls-router)# **exit**	Exits LDP mode and enters global configuration mode.
Ruijie (config)# **interface gigabitEthernet** *2/1*	Enters interface mode of GigabitEthernet 2/1.
Ruijie(config-if-GigabitEthernet 2/1)# **mpls ip**	Enables LDP on the interface.
Ruijie(config-if-GigabitEthernet 2/1)# **label-switching**	Enables MPLS on the interface at the public network side.
Ruijie(config-if-GigabitEthernet 2/2)# **ip ref**	Enables MPLS fast forwarding on the interface of a router.
Ruijie(config-if-GigabitEthernet 2/1)# **exit**	Exits interface mode and enters global configuration mode.
Ruijie (config)# **router ospf** *10*	Enables OSPF and enters OSPF mode.
Ruijie (config-router)# **network** *192.168.1.0 0.0.0.255* **area** *0* Ruijie (config-router)# **network** *192.168.2 .0 0.0.0.255* **area** *0* Ruijie (config-router)# **network** *192.168.0.2 0.0.0.0.0* **area** *0*	Adds routing information to OSPF.
Ruijie (config-router)# **end**	Ends the configuration.

Configurations on LER_C:

Command	Function
Ruijie (config)# **mpls ip**	Enables MPLS forwarding globally. (Note: This command is not applicable to switch chip forwarding.)
Ruijie (config)# **mpls router ldp**	Enables LDP and enters LDP mode.
Ruijie(config-mpls-router)# **ldp router-id interface loopback** *0* **force**	Configures the LDP router ID. The loopback address is generally used as the router ID.
Ruijie (config-mpls-router)# **exit**	Exits LDP mode and enters global configuration mode.
Ruijie (config)# **interface gigabitEthernet** *2/1*	Enters interface mode of GigabitEthernet 2/1.
Ruijie(config-if-GigabitEthernet 2/1)# **mpls ip**	Enables LDP on the interface.
Ruijie(config-if-GigabitEthernet 2/1)# **label-switching**	Enables MPLS on the interface at the public network side.
Ruijie(config-if-GigabitEthernet 2/2)# **ip ref**	Enables MPLS fast forwarding on the interface of a router.
Ruijie(config-if-GigabitEthernet 2/1)# **exit**	Exits interface mode and enters global configuration mode.
Ruijie (config)# **router ospf** *10*	Enables OSPF and enters OSPF mode.
Ruijie (config-router)# **network** *192.168.200.0 0.0.0.255* area *0* Ruijie (config-router)**# network** *192.168.0.3 0.0.0.0* **area** *0* Ruijie (config-router)# **network** *192.168.2.0 0.0.0.255* **area** *0*	Adds routing information to OSPF.
Ruijie (config-router)# **end**	Ends the configuration.

Configuring a Static LSP

You can configure a static LSP without IPv4 routes.

For example, set up two LSPs between interface 1 at the 192.168.100.0/24 network segment on LER_A and interface 2 at the 192.168.200.0/24 network segment on LER_C to connect the two network segments. You need to configure one LSP from LER_A to LER_C and the other LSP from LER_C to LER_A. This is because the LSP is uni-directional.

☑ On a router, you must use the **ip ref** command on the label forwarding interface to enable MPLS fast forwarding to improve forwarding performance of the router.

Configurations on LER_A:

Command	Function
Ruijie (config)# **mpls ip**	Enables MPLS forwarding globally. (Note: This command is not applicable to switch chip forwarding.)
Ruijie (config)# **interface gigabitEthernet** *2/2*	Enters interface mode of GigabitEthernet 2/2.
Ruijie(config-if-GigabitEthernet 2/2)# **label-switching**	Enables MPLS on the interface at the public network side.
Ruijie(config-if-GigabitEthernet 2/2)# **ip ref**	Enables MPLS fast forwarding on the interface of a router.
Ruijie(config-if-GigabitEthernet 2/2)# **exit**	Exits interface mode and enters global configuration mode.

Command	Function
Ruijie (config)# **mpls static ftn** *192.168.200.0/24* **out-label** *16* **nexthop gigabitEthernet** *2/2 192.168.1.2*	Creates an FTN that binds 192.168.200.0/24 to label 16. Specifies the next hop of the FTN as 192.168.1.2 and the outgoing interface as GigabitEthernet 2/2.
Ruijie(config-router)# **end**	Ends the configuration.

Configurations on LER_B:

Command	Function
Ruijie (config)# **mpls ip**	Enables MPLS forwarding globally. (Note: This command is not applicable to switch chip forwarding.)
Ruijie (config)# **interface gigabitEthernet** *2/1*	Enters interface mode of GigabitEthernet 2/1.
Ruijie(config-if-GigabitEthernet 2/1)# **label-switching**	Enables MPLS on the interface at the public network side.
Ruijie(config-if-GigabitEthernet 2/1)**# ip ref**	Enables MPLS fast forwarding on the interface of a router.
Ruijie(config-if-GigabitEthernet 2/1)# **exit**	Exits interface mode and enters global configuration mode.
Ruijie (config)# **interface gigabitEthernet** *2/2*	Enters interface mode of GigabitEthernet 2/2.
Ruijie(config-if-GigabitEthernet 2/2)# **label-switching**	Enables MPLS on the interface at the public network side.
Ruijie(config-if-GigabitEthernet 2/1)**# ip ref**	Enables MPLS fast forwarding on the interface of a router.
Ruijie(config-if-GigabitEthernet 2/2)# **exit**	Exits interface mode and enters global configuration mode.
Ruijie (config)# **mpls static ilm in-label** *16* **forward-action swap-label** *3* **nexthop gigabitEthernet** *2/2 192.168.2.2* **fec** *192.168.200.0/24*	Creates an ILM that maps the incoming label 16 to the outgoing label 3 (implicit null label) on GigabitEthernet 2/2. Specifies the next hop address as 192.168.2.2 and the FEC as 192.168.200.0/24.
Ruijie (config)# **mpls static ilm in-label** *17* **forward-action swap-label** *3* **nexthop gigabitEthernet** *2/1 192.168.1.1* **fec** *192.168.100.0/24*	Creates an ILM that maps the incoming label 17 to the outgoing label 3 (implicit null label) on GigabitEthernet 2/1. Specifies the next hop address as 192.168.1.1 and the FEC as 192.168.100.0/24.
Ruijie (config-router)# **end**	Ends the configuration.

Because LER_B is the PHP LSR for the FEC 192.168.100.0/24, the incoming label 17 is mapped to the outgoing label 3 (implicit null label). The outgoing interface is GigabitEthernet 2/1.

Similarly, because LER_B is the PHP LSR for the FEC 192.168.200.0/24, the incoming label 16 is also mapped to the outgoing label 3 (implicit null label). The outgoing interface is GigabitEthernet 2/2.

Configurations on LER_C:

Command	Function
Ruijie (config)# **interface gigabitEthernet** *2/1*	Enters interface mode of GigabitEthernet 2/1.
Ruijie(config-if-GigabitEthernet 2/1)# **label-switching**	Enables MPLS on the interface at the public network side.
Ruijie(config-if-GigabitEthernet 2/1)# **ip ref**	Enables MPLS fast forwarding on the interface of a router.
Ruijie(config-if-GigabitEthernet 2/1)# **exit**	Exits interface mode and enters global configuration mode.
Ruijie (config)# **mpls static ftn** *192.168.100.0/24* **out-label** *17* **nexthop gigabitEthernet** *2/1 192.168.2.1*	Creates an FTN that binds 192.168.200.0/24 to label 17. Specifies the next hop of the FTN as 192.168.2.1 and the outgoing interface as GigabitEthernet 2/1.
Ruijie (config-router)# **end**	Ends the configuration.

After the preceding configurations, packets destined for the 192.168.200.0/24 network segment on LER_A are sent out through GigabitEthernet 2/2 on LER_A and pushed with label 16. After arriving at the GigabitEthernet 2/1 interface on LER_B, these packets with label 16 are then transformed to IP packets and sent out through GigabitEthernet 2/2 on LER_B. After these IP packets destined for the 192.168.200.0/24 network segment arrives at LER_C, LER_C selects routes based on the destination IP address and sends out the packets from GigabitEthernet 2/1.

BGP/MPLS IP VPN Configuration

Understanding the BGP/MPLS IP VPN

Overview

In traditional VPNs, private network data streams are generally transmitted over public networks through Generic Routing Encapsulation (GRE), Layer 2 Tunneling Protocol (L2TP), and Point-to-Point Tunneling Protocol (PPTE). As another implementation of a VPN, a BGP/MPLS IP VPN can be considered as a VPN between Layer 2 and Layer 3. A label switched path (LSP) is a tunnel that is set up through MPLS LDP on the public network. In an MPLS VPN, the different branches of private networks at different locations are connected to form one network through LSPs. The MPLS VPN also supports interworking between different VPNs. The implementation of the VPN through MPLS has natural advantages. For VPN users, the workload is largely reduced because no special VPN devices are required to construct the VPN. Instead, the VPN users can directly use traditional routers. For carriers, the MPLS VPN can be easily expanded.

As a highly effective technical platform for IP backbone networks, MPLS provides VPNs with flexible and scalable technical foundations.

The L3VPN based on BGP/MPLS IP VPN has the following features:

- The VPN tunnels are set up on the provider edge (PE) devices of network service providers rather than the customer edge (CE) devices. The VPN routes are also transmitted between PEs. In this manner, users are not required to maintain VPN information.
- Existing routing protocols are directly utilized. The setup of VPN tunnels and route advertising are dynamically implemented, facilitating the expansion of VPNs.
- Address overlapping is supported. Different VPN users can use the same address space.
- On the network of service providers, VPN services are exchanged by label switching rather than traditional route distribution.
- The L3VPN is as secure as user dedicated lines.

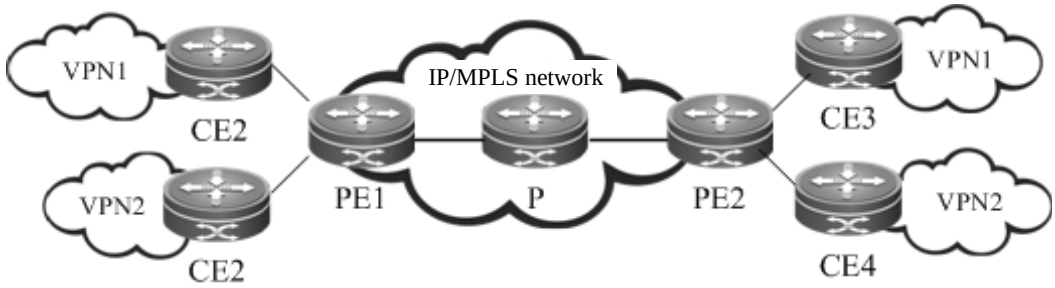
The BGP/MPLS IP VPN provides the following functions:

- Adopts the LDP to set up LSPs on the backbone network. This process is generally performed on the provider's network and completed when the topology becomes stable.
- Forwards data packets based on the pushed labels and the local mapping table.
- Supports MP-BGP and extended BGP attributes to transmit VPN routes and carry VPN attributes and labels.
- Manages VPN routes to set up multiple routing tables and maintain VPN routes.

Components of the BGP/MPLS IP VPN

A BGP/MPLS IP VPN model consists of three components, as shown in the following figure.

Figure 5 Basic components of the VPN



- CE

Located at a customer edge, a CE logically belongs to a user VPN. One interface on the CE is directly connected to a PE device. The CE can be a host, router or switch that may not support MPLS. As shown in the figure, CE1, CE2, CE3, and CE4 are CE devices.

- PE

A PE is an edge device on the SP backbone network. It can be a router, an ATM switch, or an FR switch, as shown by PE1 and PE2 in the figure. A PE logically belongs to the service provider and is directly connected to a CE. You can connect one PE to multiple CEs. The PE is mainly responsible for receiving the VPN information from CEs and transmitting the information to other PEs, or receiving the VPN information from other PEs and distributing it to the CEs. The PEs should support MPLS.

- P

The provider router (P) is a core device on the SP backbone network, as shown by P1, P2, and P3 in the figure. The P is not connected to CEs. It is responsible for routing and rapid forwarding. As a device on the core MPLS backbone network, the P should support MPLS. The P knows the routes to any destination on the backbone network but does not know the routes to a VPN.

VRF

- VRF

The VPN routing and forwarding table (VRF) is used to solve the conflicts of local routes. Each connection between a PE and a CE is associated with a VRF. One PE can have several VRFs to exchange route information with CEs. You can consider a VRF as a virtual router. Each virtual router should be connected to a CE to receive route information from the CE or advertise the VPN route information to the CE. The VRF solves the conflicts of local routes due to the adoption of the same address space by different VPNs. One VRF includes:

5) An independent routing table

6) A group of interfaces that belong to the VRF

7) A group of routing protocols that are used in the VRF

The VRF has two important attributes: route distinguisher (RD) and route-target (RT) attributes.

- RD

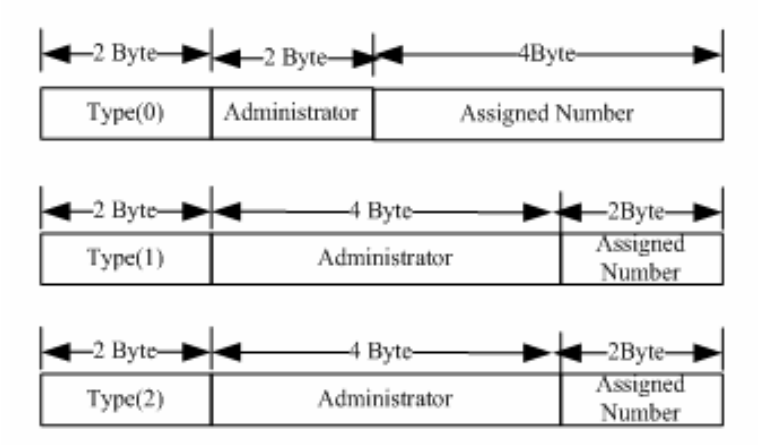
The RD is introduced to solve the conflict of routes during the transmission.

You can consider the RD as a distinguisher. If different VPNs use the same network address and advertise their route information on the backbone network through BGP, BGP chooses and advertises only the best route from the overlapped addresses. As a result, some VPNs cannot obtain their route information. If the RD values are added to the overlapped addresses, BGP identifies the same network addresses based on the different RDs carried in the VPN information. In this manner, each VPN can obtain its own route information. The RD only serves as a distinguisher to distinguish the same network addresses. If address overlapping does not exist for different VPNs, you can configure no RD values.

Generally, a unique RD value is specified for one VPN. In this manner, different VPNs have different RDs, facilitating the transmission of route information on the backbone network. The RD value is generally defined as xx: xx, such as RD 1: 100, where 1 stands for the AS number of the backbone network and 100 is a number specified by the user. One VPN route can carry only one RD value.

The RD consists of three fields: type, administrator, and assigned number. Based on the value of the type field, the encoding formats are classified into the following three types:

Figure 6 RD structure.



8) When Type = 0, the administrator field has two bytes and is marked by the AS number that must be a public AS number. The assigned number has four bytes and is managed by the service provider.

9) When Type = 1, the administrator field has four bytes and uses an IPv4 address that must be a global IP address. The assigned number has two bytes and is managed by the service provider.

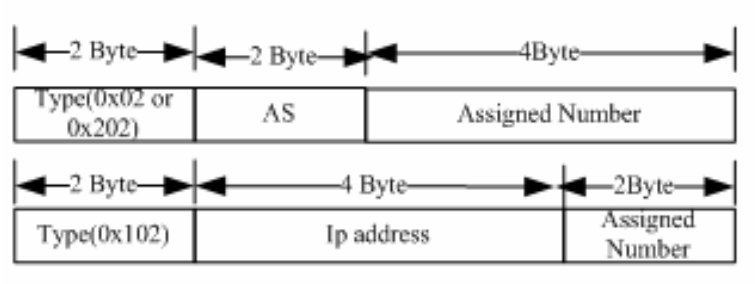
10) When Type = 2, the administrator field has four bytes and is marked by the four-byte AS number. The assigned number has two bytes and is managed by the service provider.

- Route-Target

The introduction of the RT attribute is to let the VRF choose its route selection mode. The RT attributes are classified into route-target export and route-target import. A PE receives routes from a CE and adds route-target export to the VPN routes and then advertises the VPN routes to other PEs. The PE determines whether to import the routes received from other PEs to the VRF based on the route-target import. One principle is that when a PE receives a VPN route, the PE imports the route to the VRF only when at least one RT attribute carried in the route is the same as the import RT in the VRF of the PE. In this manner, you can flexibly control the distribution of VPN routes. One VPN route can carry multiple RT values.

The BGP extended community attribute defines the RT encoding structure, as shown in the following figure.

Figure 7 RT structure



The definition of RT is similar to that of RD. For 0x02 and 0x202, the AS number must be a public one. For 0x102, the IPv4 address must be a global one rather than a private address.

MP-BGP

The VPN route information is transmitted on the backbone network through BGP. The export RT attribute is carried in the BGP extended community attribute. The traditional BGP4, however, transmits only IPv4 routes and cannot carry the VPN route that includes RDs. Therefore, the BGP is extended to introduce new attributes. One of the biggest advantages of BGP is its scalability. The Multi-Protocol (MP-BGP) is a new attribute introduced to the original BGP to support multiple protocols. The MP-BGP can carry VPN information. In this manner, the VPN route takes up the form of RD + IP address prefix. By adding RDs to VPN routes exchanged between PEs, the MP-BGP allows VPN users to change the IPv4 routes to VPN-IPv4 routes and transmit the routes on the backbone network.

Protocol Specification

- IETF RFC 4364: BGP/MPLS IP Virtual Private Networks (VPNs)

Configuring the BGP/MPLS IP VPN

☑ On a router, you must use the **ip ref** command on the interface to enable MPLS fast forwarding to improve forwarding performance of the router.

Default Configuration

BGP/MPLS L3 VPN is disabled by default.

Function	Default Setting
Basic BGP/MPLS L3 VPN functions	Disabled
VPN label distribution mode	Distributing labels to each VRF
Inter-AS VPN	Disabled
CSC VPN	Disabled
MPLS VPN over GRE	Disabled

Configuring the Basic BGP/MPLS IP VPN

To configure basic BGP/MPLS IP VPN functions, perform the following configurations:

- Configuring an MPLS Network (Mandatory)

- Configuring a VPN Routing Instance (Mandatory)
- Configuring PEs to Transmit VPN Routes (Mandatory)
- Configuring Route Exchange Between PEs and CEs (Mandatory)
- Configuring VPN Label Distribution Mode (Optional)
- Configuring Import and Export Policies for VPN Routes (Optional)
- No import VPN route-target community //Import extended community attribute list (not configured)
-

Configuring an MPLS Network

To use MPLS on the backbone network, you must configure the MPLS LDP on the P and PE to set up public tunnels. This means that you must configure LDP on MPLS devices and enable MPLS on each interface.

Use the following commands to configure an MPLS network.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **mpls ip**	Enables MPLS globally. Caution This command is not available on a switch chip.
Ruijie(config)# **mpls router ldp**	Enables LDP and enters LDP configuration mode.
Ruijie(config-mpls-router)# **ldp router-id interface loopback** *id* [**force**]	Configures the LDP router ID. The IP address of the loopback interface is generally used as the router ID.
Ruijie(config-mpls-router)# **exit**	Exits LDP configuration mode.
Ruiije(config)# **interface** *type ID*	Enters interface configuration mode.
Ruijie(config-if-*type ID*)# **ip address** *ip-address mask*	Assigns an IP address to the interface.
Ruijie(config-if-*type ID*)# **label-switching**	Enables MPLS on the interface at the public network side.
Ruijie(config-if-*type ID*)# **ip ref**	☑ In case of a router, enables MPLS fast forwarding on the interface.
Ruijie(config-if-*type ID*)# **mpls ip**	Enables LDP on the interface.
Ruijie(config-if-*type ID*)# **show running-config**	Displays existing configuration information.

Configure an MPLS network.

```
Ruijie# configure terminal
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)#interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-gigabitethernet 1/1)# no switchport
```

```
Ruijie(config-if-gigabitethernet 1/1)# ip address 192.168.10.1 255.255.255.0
Ruijie(config-if-gigabitethernet 1/1)# label-switching
Ruijie(config-if-gigabitethernet 1/1)# mpls ip
```

Configuring a VPN Routing Instance

A VPN routing instance is the VRF that is configured on PEs. The CE and P devices do not have VRFs.

The configuration of a VRF includes defining the VRF, assigning RD and RT values to the VRF, and associating the VRF with an interface.

Use the following commands to configure a VPN routing instance.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **ip vrf** *vrf-name*	Creates a VRF and enters VRF configuration mode.
Ruijie(config-vrf)# **rd** *rd-value*	Sets the RD value.
Ruiije(config-vrf)# **route-target {both | export | import}** *rt-value*	Sets the RT value.
Ruijie(config-vrf)# **exit**	Exits VRF configuration mode.
Ruijie(config)# **interface type** *ID*	Enters interface configuration mode.
Ruijie(config-if-*type ID*)# **ip vrf forwarding** *vrf-name*	Associates the interface with the VRF.
Ruijie(config-if-*type ID*)# **ip address** *address mask*	Assigns an IP address to the interface.
Ruijie(config-if-*type ID*)# **ip ref**	☑ In case of a router, enables MPLS fast forwarding on the interface.
Ruijie(config-if-*type ID*)# **show running-config**	Displays existing configuration information.

Configure a VRF and bind it to interface Gigabitethernet 1/1.

```
Ruijie(config)# ip vrf vpn1
Ruijie(config-vrf)# rd 100: 1
Ruijie(config-vrf)# route-target both 100: 1
Ruijie(config-vrf)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-gigabitethernet 1/1)# no switchport
Ruijie(config-if-gigabitethernet 1/1)# ip vrf forwarding vpn1
Ruijie(config-if-gigabitethernet 1/1)# ip address 192.168.10.1
255.255.255.0
```

Caution

If an RD value is specified for the VRF on a PE or the BGP VRF function is enabled on the PE, the RD value cannot be modified or deleted. In this case, you can only delete the VRF and create the VRF again to set the RD value.

Two different VRFs on the same PE cannot be assigned the same RD.

If you enter the **ip vrf forwarding** *vrf-name* command, the IP address assigned to the interface earlier is deleted. In this case, you need to redefine the IP address in interface configuration mode.

Configuring PEs to Transmit VPN Routes

PEs transmit route information to each other through BGP. Because a PE needs to transmit VPN route information rather than common IPv4 route information to another PE, you need to enter VPN address family configuration mode to configure the PE to transmit VPN routes to the peer PE.

Use the following commands to configure the PE to transmit VPN routes to another PE.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *asn-num*	Creates a BGP domain and enters BGP configuration mode.
Ruijie(config-router)# **neighbor** *ip-address* **remote-as** *asn-number*	Configures a BGP session.
Ruijie(config-router)# **neighbor** *ip-address* **update-source** *interface-name*	Sets the interface address used to set up the MP-IBGP session as the source address. The address of the loopback interface is generally used as the source address.
Ruijie(config-router)# **address-family vpnv4**	Enters the VPN address family.
Ruijie(config-router-af)# **neighbor** *ip-address* **activate**	Activates the BGP session to exchange VPN routes.
Ruijie(config-router-af)# **show running-config**	Displays existing configuration information.

Set up an MP-BGP session with the neighboring PE at 1.1.1.1.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 1
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
```

Configuring Route Exchange Between PEs and CEs

Running BGP Between PEs and CEs to Transmit Route Information

To configure a BGP session with a CE, you need to enter VRF address family configuration mode on the PE and then configure the routing protocol with the CE.

Use the following commands on the PE to configure BGP.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *pe-asn-num*	Creates a BGP domain and enters BGP configuration mode.
Ruijie(config-router)# **address-family ipv4 vrf** *vrf-name*	Configures and enters BGP VRF address family configuration mode.
Ruiije(config-router-af)# **neighbor** *ip-address* **remote-as** *ce-asn-num*	Sets up an EBGP session with a CE.
Ruijie(config-router-af)# **show running-config**	Displays existing configuration information.

Set up an EBGP session with the neighboring CE at 192.168.10.2.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf vrf1
Ruijie(config-router)# neighbor 192.168.10.2 remote-as 2
```

Caution If no RD is specified for the VRF, you will be reminded that no RD value is configured when you use the **address-family ipv4 vrf vrf-name** command to enter the specified VRF address family. As a result, you cannot enter the address family.

Use the following commands on the CE to configure a PE peer.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *ce-asn-num*	Creates a BGP domain and enters BGP configuration mode.
Ruiije(config-router)# **neighbor** *ip-address pe-asn*	Sets up an EBGP session with a PE.
Ruijie(config-router)# **show running-config**	Displays existing configuration information.

Set up an EBGP session with the PE at 192.168.10.1.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 2
Ruijie(config-router)# neighbor 192.168.10.1 remote-as 1
```

Configuring OSPF Between PEs and CEs to Transmit Route Information

To run OSPF between a PE and a CE, you must configure an OSPF instance for the VRF on the PE. The VRF then uses the OSPF instance to exchange route information between the PE and the CE. By redistributing BGP routes, OSPF sends the VPN routes received from other PEs to the CE. At the same time, by redistributing OSPF routes, BGP sends the VPN route information that is distributed to the PE by the CE to other PE peers.

Use the following commands on the PE to configure OSPF.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router ospf** *ospf-id* **vrf** *vrf-name*	Creates an OSPF instance and enters OSPF configuration mode.
Ruijie(config-router)# **network** *prefix mask* **area** *area-id*	Configures an OSPF link.
Ruiije(config-router)# **redistribute bgp subnets**	Configures OSPF to redistribute BGP routes.
Ruiije(config-router)# **exit**	Exits OSPF configuration mode.
Ruijie(config)# **router bgp** *asn*	Enables BGP and enters BGP configuration mode.
Ruijie(config-router)# **address-family ipv4 vrf** *vrf-name*	Enters BGP VRF configuration mode.
Ruijie(config-router-af)# **redistribute ospf** *ospf-id*	Redistributes OSPF routes.
Ruijie(config-router-af)# **show running-config**	Displays existing configuration information.

Run OSPF between a PE and a CE to distribute VPN routes.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10 vrf vrf1
Ruijie(config-router)# network 192.168.10.0 255.255.255.0 area 0
Ruijie(config-router)# redistribute bgp subnets
Ruijie(config-router)# exit
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf vrf1
Ruijie(config-router-af)# redistribute ospf 10
```

Configuring RIP Between PEs and CEs to Transmit Route Information

The PE and CE run RIP. The VRF on the PE can exchange route information between the PE and the CE. RIP redistributes BGP routes and transmits VPN routes from other PEs to the CE. Meanwhile, BGP redistributes RIP routes and transmits VPN routes distributed by the CE to the PE to other PE peers.

Use the following commands on the PE to configure RIP.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router rip**	Creates a RIP instance and enters RIP configuration mode.
Ruiije(config-router)# **address-family ipv4 vrf** *vrf-name*	Enters RIP VRF address family configuration mode.
Ruijie(config-router)# **version 2**	Configures the version of RIP.
Ruiije(config-router-af)# **network** *network-number* [*wildcard*]	Configures RIP on the PE and CE.
Ruiije(config-router-af)# **redistribute bgp**	Configures RIP to redistribute BGP routes.
Ruiije(config-router-af)# **exit**	Exits address family configuration mode.
Ruijie(config)# **router bgp** *asn*	Configures BGP and enters BGP configuration mode.
Ruijie(config-router)# **address-family ipv4 vrf** *vrf-name*	Enters BGP VRF configuration mode.

Command	Function
Ruijie(config-router-af)# **redistribute rip**	Redistributes OSPF routes.
Ruijie(config-router)# **show running-config**	Displays existing configuration information.

Run RIP between a PE and a CE to distribute VPN routes.

```
Ruijie# configure terminal
Ruijie(config)# router rip
Ruijie(config-router)# address-family ipv4 vrf vrf1
Ruijie(config-router-af)# version 2
Ruijie(config-router-af)# network 192.168.10.0
Ruijie(config-router-af)# redistribute bgp
Ruijie(config-router-af)# exit-address-family
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf vrf1
Ruijie(config-router-af)# redistribute rip
```

Transmitting Route Information Between a PE and a CE Through Static Configurations

In simple network environments, you can generally configure static routes. Use the following commands to configure a static route.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **ip route vrf** vrf-name prefix mask interface-name nexthop	Configures a static route.
Ruijie(config)# **router bgp** *asn*	Enters BGP configuration mode.
Ruijie(config-router)# **address-family ipv4 vrf** *vrf-name*	Enters BGP VRF address family configuration mode.
Ruijie(config-router-af)# **redistribute static**	Redistributes static routes.
Ruijie(config-router)# **show running-config**	Displays existing configuration information.

Configure a static route on the PE to distribute VPN routes.

```
Ruijie# configure terminal
Ruijie(config)# ip router vrf vrf1 192.168.20.0 255.255.255.0 gigabitEthernet 2/3 192.168.10.2
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf vrf1
Ruijie(config-router-af)# redistribute static
```

Configuring VPN Label Distribution Mode (Optional)

RFC 4364 describes two label distribution modes for L3VPN applications: route-based label distribution and VRF-based label distribution. The advantage of the former is rapid forwarding that allows a device to forward packets to the next hop by searching the ILM table. The disadvantage, however, is the large capacity of the ILM table. The advantage of the latter is the reduced capacity of the ILM table. This is because one label is assigned to each VRF and all routes in the VRF thus share the label. The disadvantage is the lower forwarding efficiency because it requires two times of table searching. The device should first locate the VRF of the packets based on the ILM table and then forward the packets by searching routes in the VRF based on the destination IP address.

An L3VPN adopts VRF-based label distribution mode by default. You can run the **alloc-label** command in VRF configuration mode to change default label distribution mode. You can also choose different distribution modes for different VRFs.

To configure label distribution mode, enter privileged EXEC mode and use the following commands.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **ip vrf** *vrf-name*	Creates a VRF and enters VRF configuration mode.
Ruijie(config-vrf)# alloc-label per-vrf	Assigns one label to all routes in the VRF. When distributing VPN routes, MP-BGP uses the same label for all routes.
Ruijie(config-vrf)# **alloc-label per-route**	Assigns one label to each route in the VRF. When distributing VPNv4 routes, MP-BGP uses a different label for each route.
Ruijie(config-vrf)# **show running-config**	Displays existing configuration information.


Caution When you change label distribution mode, MP-BGP cancels all routes advertised in the VPN and advertises the routes again.
VRF-based label distribution mode is adopted by default. In this case, a PE first pops out the received packets with labels and then chooses routes to forward the packets based on the IP routing table.
Configuring Import and Export Policies for VPN Routes (Optional)

In most situations, you can define the route-target import attribute in VRF configuration mode to determine the routes to be imported into the VRF and define the route-target export attribute to determine the RTs to be carried in the routes. These configurations are effective for all routes. In certain application scenarios that require accurate policy-based control on the import and export of VPN routes, however, you need to adopt policies.

Enter privileged EXEC mode and use the following commands to configure import and export policies.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **ip vrf** *vrf-name*	Creates a VRF and enters VRF configuration mode.

Ruijie(config-vrf)# **import map** *routemap-name*	Sets the policy to import VPNv4 routes from the remote end to the local VPN routes based on the rules defined in the route map.
Ruijie(config-vrf)# **export map** *routemap-name*	Sets the extended community attribute to export VPNv4 routes from the local end to the remote end based on the rules defined in the route map.
Ruijie(config-vrf)# **show running-config**	Displays existing configuration information.

Caution The rules defined by using the **import map** command take effect after the import extended community attribute defined in the VRF. That is, VPN routes received from the remote end can be further filtered by using the rules defined with the **import map** command only after the routes match the extended community attribute defined by the **route-target import** command in the VRF.

Configure a route map for importing VPN routes with the RT of 100:1 to vrf1.

```
Ruijie# configure terminal
Ruijie(config)# ip extcommunity-list 1 permit rt 100: 1
Ruijie(config)# route-map IN-RT-FILTER
Ruijie(config-route-map)# match extcommunity 1
Ruijie(config-route-map)# exit
Ruijie(config)# ip vrf vrf1
Ruijie(config-vrf)# rd 100: 2
Ruijie(config-vrf)# route-target export 100: 30
Ruijie(config-vrf)# import map IN-RT-FILTER
Ruijie(config-route-map)# end
Ruijie# show ip vrf detail vrf1
VRF vrf1: default RD : 100: 2
Interfaces:
Vlan 1 //Interface bound to the VRF
Export VPN route-target communities: //Export extended community attribute list
RT : 100: 30
No import VPN route-target community //Import extended community attribute list (not
configured)
import-map: IN-RT-FILTER//Import policy
```

Configuring a Static L3VPN FTN and ILM (Optional)

In most situations, MP-BGP assigns labels to private routes and a public LSP is generated by running LDP on a public network. You can also configure a static LSP to assign labels to private routes and set up private LSPs.

To configure an FTN for the L3VPN on the PE, enter privileged EXEC mode and use the following commands.

Command	**Function**
Ruijie# **config terminal**	Enters global configuration mode.

Ruijie(config)# **mpls static l3vpn-ftn** *vrf-name ip-address/mask* **out-label** *out-label* **remote-pe** *ip-address*	Configures a static private FTN that specifies the egress of the FEC as another PE. In this case, you must specify the private label and the egress PE. The address of the egress PE is then used to configure the public LSP.
Ruijie(config)# **mpls static l3vpn-ftn** *vrf-name fec-prefix/fec-mask* **local-forward nexthop** *interface-name nexthop-ip*	Configures a static private FTN that specifies the egress of the FEC as the local PE. In this case, you must specify the outgoing interface on the local PE and the next-hop address (the outgoing interface and the next hop are generally in another VRF). You can use this command when the local PE has several VRFs that belong to the same VPN.
Ruijie# **show running-config**	Displays existing configuration information.

To configure an ILM for the L3VPN on the PE, enter privileged EXEC mode and use the following commands.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **mpls static ilm in-label** *in-label* **forward-action pop-l3vpn-nexthop** *vrf-name* **nexthop** *interface-name nexthop-ip-address* **fec** *ip-address/mask*	Configures an ILM entry for the L3VPN on the PE. You need to specify the incoming label, the outgoing interface, and the next-hop address.
Ruijie# **show running-config**	Displays existing configuration information.

Caution The configured static private FTN and ILM take effect only after the corresponding public LSP is set up. To set up the public LSP, see the "Configuring an MPLS Network" section. You can set up a public LSP through LDP or static configurations.

Configuring an Inter-AS VPN

On an actual network, different sites of VPN users may be located on different ASs and mutual communication is required between these sites. In this case, the VPN routes should be exchanged between different ASs. This technology is called the inter-AS VPN.

RFC 4364 introduces three inter-AS VPN schemes:

- OptionA: VRF-to-VRF mode
- OptionB: single-hop MP-EBGP mode
- OptionC: multi-hop MP-EBGP mode

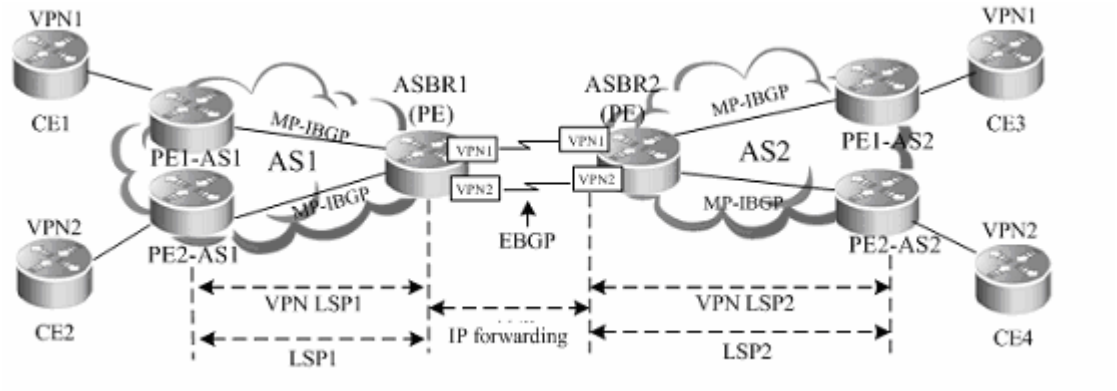
OptionA: VRF-to-VRF Mode

Also referred to as VRF back-to-back, VRF-to-VRF mode is easy to implement. The autonomous system boundary router (ASBR) of an AS sets up a VRF for each inter-AS VPN to bind an interface to the VRF. The VRFs on ASBRs then exchange VPN routes through the interface.

The purpose of creating a VRF and binding an interface to it is as follows:

- To receive VPN routes from the local AS
- To set up an EBGP connection between the VRF and the VRF of another AS to exchange IPv4 routes

Figure 8 VRF-to-VRF inter-AS VPN



As shown in the preceding figure, the VRFs between the ASBRs set up common EBGP sessions to exchange IPv4 routes and the ASBRs and PEs set up MP-IBGP sessions to exchange VPN routes. For the VRF on an ASBR, the other VRF, with which the EBGP session is set up, is equivalent to a CE. This configuration scheme is similar to the common intra-domain configuration scheme. The ASBRs and PEs set up MP-IBGP sessions to exchange VPN routes. The VRFs of ASBRs set up EBGP sessions in BGP VRF address family configuration mode to exchange IPv4 routes.

- Characteristics and limitations

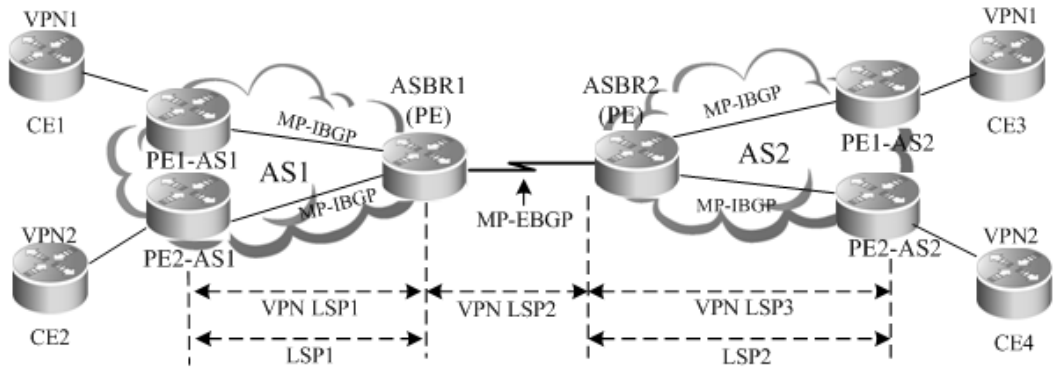
VRF-to-VRF mode is easy to implement by directly using MP-IBGP. The service deployment is also simple. This scheme, however, requires an interface (generally a logical sub-interface) for each inter-AS VPN on an ASBR. The number of bound interfaces at least should be equal to the number of inter-AS VPNs. You should configure an interface for each VPN on the ASBR, complicating network expansion. In addition, the separate creation of sub-interfaces for each VPN imposes high requirements on ASBRs. As a result, this scheme is generally applicable to networks with a small number of inter-AS VPNs.

The configuration of OptionA is similar to that of a BGP/MPLS IP VPN and is not described here.

OptionB: Single-Hop MP-EBGP Mode

In the OptionA scheme, you need to configure a VRF for each VPN on an ASBR and bind an interface to the VRF. This is because VPN routes cannot be directly transmitted between EBGP peers and can only be carried through MP-IBGP. If the VPN routes can be directly transmitted between EBGP peers, you are not required to configure VRFs on the ASBR. This is clearly a better implementation mode. In this case, the OptionB scheme extends MP-IBGP and allows the direct distribution of VPN routes between ASBRs. This is called single-hop EBGP, as shown in the following topology.

Figure 9 OptionB inter-AS VPN



- Characteristics and limitations

The advantage of this MP-EBGP scheme is that you are not required to configure a sub-interface for each site of VPN users on an ASBR. You are also not required to set up an inter-AS LSP. The VPN routes are directly transmitted between single-hop MP-EBGP neighbors. The VPN route information, however, is maintained and spread by the ASBRs between ASs. If a large number of VPN routes exist, the ASBRs are faced with heavy pressure. Because the ASBRs also generally assume tasks of forwarding IP packets on the public network, high requirements are imposed on these devices. In addition, the ASBRs cancel the RT filtering function for received VPN routes. The VPN routes on PEs may be spread to the ASBRs in another AS. This may lead to the leakage of VPN routes. As a result, the SPs, who exchange VPN routes, must reach trust agreements on route exchange. The ASBRs should trust each other and implement corresponding route filtering policies. The OptionB scheme is applicable to networks with lots of inter-AS VPN services.

OptionB has two schemes:

- The ASBR does not change the next hop of a VPN route.
- The ASBR changes the next hop of a VPN route.

The following describes the configuration procedures of the two schemes.

Scheme 1: Next Hop Unchanged

When an ASBR receives VPN routes sent from the ASBR in another AS and sends the routes to the MP-IBGP neighbors in the local AS, the next hop of the routes is not changed. This mode is called the "OptionB Next Hop Unchanged Scheme". In this mode, the PEs and ASBRs in an AS still set up MP-IBGP sessions to exchange VPN routes and the two ASBRs set up MP-EBGP sessions to directly exchange VPN routes. When sending routes to an MP-IBGP neighbor, the ASBR does not change the next hop of the VPN routes received from the MP-EBGP neighbor. This requires that the PE in the AS should have a route to the next hop address (that is, the ASBR in another AS). For this purpose, you can configure the local ASBR to redistribute routes destined for the other ASBR to the IGP protocol in the local AS. In this manner, the address of the ASBR in another AS becomes reachable and you can set up an LSP through LDP.

The configuration procedure is as follows:

11) Configuring route exchange between PEs and CEs

12) Configuring an IGP and MPLS signaling protocol in an AS

13) Configuring an ASBR to cancel the default RT filtering function

14) Configuring PEs and ASBRs in the same AS to exchange VPN route information

15) Setting up an MP-EBGP session between ASBRs

16) Configuring route map rules to filter VPN routers (optional)

17) Configuring an IGP to redistribute ASBR routes of another AS

- Configuring route exchange between PEs and CEs

This procedure is similar to configuring route exchange between PEs and CEs and is not described here.

- Configuring an IGP and MPLS signaling protocol in an AS

This procedure is similar to configuring an MPLS network and is not described here.

- Configuring an ASBR to cancel the default RT filtering function

By default, a PE rejects a VPN route sent by another PE (or ASBR), if the route is not imported by any VRF on the PE. Therefore, you should disable the default filtering on an ASBR so that the ASBR can receive all VPN routes from others PEs (or ASBRs), no matter whether these routes are imported into the local VRF or not.

Enter privileged EXEC mode and use the following commands.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *asn-number*	Enables BGP and enters BGP configuration mode.
Ruijie(config-router)# **no bgp default route-target filter**	Disables RT filtering.
Ruijie(config-router)# **show running-config**	Displays existing configuration information.

Disable RT filtering.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 2
Ruijie(config-router)# no bgp default route-target filter
```

- Configuring PEs and ASBRs in the same AS to exchange VPN route information

This procedure is similar to configuring PEs to transmit VPN routes and is not described here.

- Setting up an MP-EBGP session between ASBRs

Set up directly-connected single-hop MP-EBGP sessions between inter-AS ASBRs to distribute VPN routes.

Enter privileged EXEC mode and use the following commands.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *asn-number*	Enables BGP and enters BGP configuration mode.
Ruijie(config-router)# **neighbor** *asbr-address* **remote-as** *asbr-asn-number*	Configures an ASBR EBGP session.
Ruijie(config-router)# **address-family vpnv4**	Enters the BGP VPN address family.
Ruijie(config-router-af)# **neighbor** *asbr-address* **activate**	Enables the VPN route exchange with the peer.
Ruijie(config-router-af)# **show running-config**	Displays existing configuration information.

Configure an EBGP neighbor at 20.20.20.2 and activate the VPN address family.

```
Ruijie# configure terminal
```

```
Ruijie(config)# router bgp 2
Ruijie(config-router)# neighbor 20.20.20.2 remote-as 1
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 20.20.20.2 activate
```


Caution

You must run the **label-switching** command on the interface that connects two ASBRs to enable MPLS on the interface so that the links between the ASBRs can forward MPLS packets.

☑ On a router, use the **ip ref** command on the interface to enable fast forwarding to improve forwarding performance.


Caution

If the ASBRs do not use directly connected addresses to set up an MP-EBGP session but use the loopback address with a 32-bit mask as the source address to set up an MP-EBGP session, you must use the **neighbor ebgp-multihop** command to enable multi-hop EBGP. At the same time, you must configure static routes on the ASBR to the loopback address on the peer, enable LDP or configure a static FTN (with an outgoing label as 3, indicating that the ASBR is the second to last hop).

■ Configuring route map rules to filter VPN routes (optional)

In view of the AS security in actual applications, you can generally configure policies on ASBRs to send or receive only certain VPN routers. You can realize this purpose by filtering the RT extended community attributes of VPN routes. In addition, all VPN routes are saved because the default RT filtering function is disabled on the ASBR. In this case, you can configure VPN routing policies to receive only inter-AS VPN routes sent from the local AS, lessening the capacity pressure of the ASBR.

To configure a filtering policy, enter privileged EXEC mode and use the following commands.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **ip extcommunity-list standard** *extcommunity-name* | *extcommunity-number* {**permit**|**deny**} **rt** *rt-value*	Creates a rule for the extended community attribute list.
Ruijie(config)# **show ip extcommunity-list** [*list-number*|*list-name*]	Verifies the configured rule for the extended community attribute list.
Ruijie(config)# **route-map** *route-map-name* **permit** [*number*]	Creates a route map rule and enters route map configuration mode.
Ruijie(config-route-map)# **match extcommunity** *extcommunity-name*|*extcommunity-number*	Sets the RT matching rule for a route map.
Ruijie(config-route-map)# **show route-map** route-map-name	Displays the route map rule.
Ruijie(config-route-map)# **exit**	Exits route map configuration mode.
Ruijie(config)# **router bgp** *as-num*	Enables BGP and enters BGP configuration mode.
Ruijie(config-router)# **address-family vpnv4**	Enters the VPN address family.

Command	Function
Ruijie(config-router-af)# **neighbor** *peer-address* **route-map** *route-map-name* **in**	Filters the VPN routes received from the ASBR in another AS.
Ruijie(config-router-af)# **neighbor** *peer-address* **route-map** *route-map-name* **out**	Filters the VPN routes sent to the ASBR in another AS.
Ruijie(config-router-af)# **show running-config**	Displays existing configuration information.

Configure an ASBR to receive VPN routes with an RT value of 100:1 from the MP-IBGP peer at 1.1.1.1.

```
Ruijie# configure terminal
Ruijie(config)# ip extcommunity-list standard RT permit rt 100:1
Ruijie(config)# show ip extcommuniy-list RT
Named extended community standard list RT
permit rt 100:1
Ruijie(config)# route-map RT-IN permit
Ruijie(config-route-map)# match extcommunity RT
Ruijie(config-route-map)# show route-map RT-IN
route-map map, permit, sequence 10
  Match clauses:
  extcommunity (extcommunity-list filter):RT
  Set clauses:
  Policy routing matches: 0 packets, 0 bytes
Ruijie(config-route-map)# exit
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 100
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# neighbor 1.1.1.1 route-map RT-IN in
Ruijie(config-router-af)# end
```

- Configuring an IGP to redistribute ASBR routes of another AS

Because the ASBR does not change the next hop of VPN routes sent to the IBGP peer, the next hop address of VPN routes learned by the PEs in the local AS is the ASBR address in another AS. Therefore, you must configure the PEs to learn the route to the next hop address. For the single-hop directly-connected MP-EBGP session where BGP is enabled to carry labels (through IPv4 routes or VPN routes), MP-BGP supports the automatic generation of a host route with a 32-bit mask and FTN entry (with the outgoing label 3) on the ASBR. In this manner, the tunnel egress is not terminated on the local ASBR. Therefore, as long as the ASBR redistributes the host route to the IGP in the local AS, the PEs can learn routes to the ASBR in the other AS.

Enter privileged EXEC mode and use the following commands.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router** *igp*	Enables an IGP that can be OSPF, RIP, or IS-IS.
Ruijie(config-router)# **redistribute connected subnets**	Redistributes directly connected subnet routes.

Ruijie(config-router)# **show running-config**	Displays existing configuration information.

Configure OSPF on an ASBR to redistribute the directly connected subnet routes.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 1
Ruijie(config-router)# redistribute connected subnets
```

Scheme 2: Next Hop Changed

When an ASBR receives VPN routes sent from the ASBR in another AS and sends the routes to the PEs in the local AS, the next hop of the routes is changed. This mode is called the "OptionB Next Hop Changed Scheme". In this mode, the PEs and ASBRs in the same AS can set up MP-IBGP sessions to exchange VPN routes. Two ASBRs can set up MP-EBGP sessions to exchange VPN routes. Upon receipt of a VPN route from another ASBR neighbor, an ASBR changes the next hop to its own address when advertising the route to the MP-IBGP peer in the AS.

The configuration procedure is as follows:

18) Configuring route exchange between PEs and CEs

19) Configuring an IGP and MPLS signaling protocol in an AS

20) Configuring an ASBR to cancel the default RT filtering function

21) Setting up an MP-IBGP session between an ASBR and PE and changing the next hop address to its own address

22) Setting up an MP-EBGP session between ASBRs

23) Configuring route map rules to filter VPN routes (optional)

- Configuring route exchange between PEs and CEs

This procedure is similar to configuring route exchange between PEs and CEs and is not described here.

- Configuring an IGP and MPLS signaling protocol in an AS

This procedure is similar to configuring an MPLS network and is not described here.

- Configuring an ASBR to cancel the default RT filtering function

This procedure is similar to configuring an ASBR to cancel the default RT filtering function in Scheme 1 and is not described here.

- Setting up an MP-IBGP session between an ASBR and PE and changing the next hop address to its own address

By default, an ASBR does not change the next hop of the VPN route received from an MP-EBGP peer when the ASBR sends the route to the MP-IBGP peer. You can configure the ASBR to forcibly change the next hop of the VPN route to the ASBR address in the local AS. In this manner, the PEs in the local AS are not required to learn the address of the peer ASBR. This is the major difference with Scheme 1 (Next Hop Unchanged Scheme).

Enter privileged EXEC mode and use the following commands.

Command	**Function**
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *asn-num*	Enables BGP and enters BGP configuration mode.

Ruijie(config-router)# **neighbor** *pe-address* **remote-as** *asn-num*	Sets up an IBGP session with a PE.
Ruijie(config-router)# **neighbor** *pe-address* **update-source** *interface-name*	Specifies the local loopback interface as the source address to set up an IBGP session.
Ruijie(config-router)#**address-family vpnv4**	Enters BGP VPN address family configuration mode.
Ruijie(config-router-af)# **neighbor** *pe-address* **activate**	Enables the VPN route exchange with the peer.
Ruijie(config-router-af)# **neighbor** *pe-address* **next-hop-self**	Sets the ASBR to change the next hop to its own address when sending VPN routes to the IBGP neighbor.
Ruijie(config-router-af)# **show running-config**	Displays existing configuration information.

Set up an MP-IBGP session, activate the VPN address family, and change the next hop address to the ASBR address.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 1
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# neighbor 1.1.1.1 next-hop-self
Ruijie(config-router-af)# end
```

- Setting up an MP-EBGP session between ASBRs

This procedure is similar to setting up an MP-EBGP session between ASBRs in Scheme 1 and is not described here.

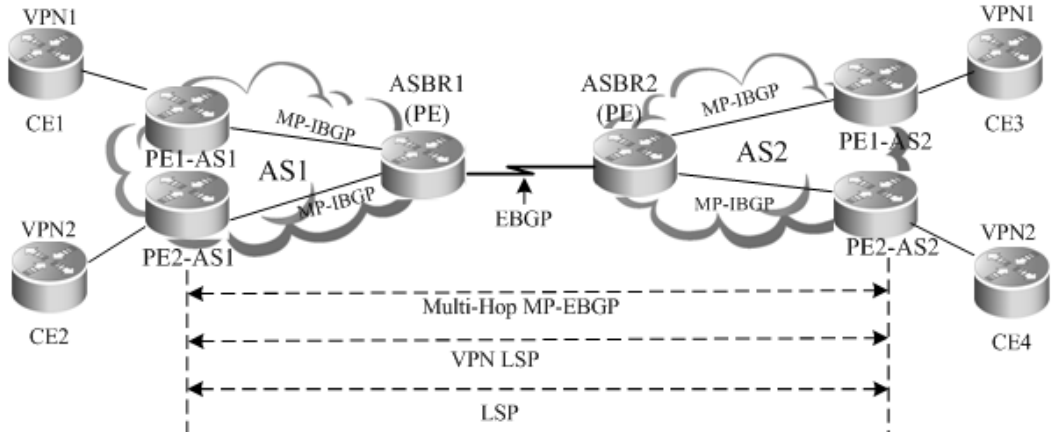
- Configuring route map rules to filter VPN routes (optional)

This procedure is similar to configuring route map rules to filter VPN routers (optional) in Scheme 1 and is not described here.

OptionC: Multi-Hop MP-EBGP Mode

Both OptionA and OptionB can meet the networking requirements of inter-AS VPNs. In these two schemes, ASBRs are required to maintain and advertise VPN routes. If a large number of inter-AS VPN routes should be advertised in each AS, the ASBRs may become the bottleneck of further network expansion. To solve this problem, a third scheme is developed, that is, the multi-hop MP-EBGP. In multi-hop MP-EBGP mode, the PEs in different ASs set up multi-hop MP-EBGP sessions to directly exchange VPN routes. As a result, the ASBRs are not required to maintain or advertise VPN routes.

Figure 10 Multi-hop MP-EBGP



- Characteristics and limitations

In multi-hop MP-EBGP mode, only PEs rather than ASBRs are required to store VPN information. This incurs complex configurations. This scheme is applicable to networks to be deployed with inter-AS VPN services on a large scale.

In terms of implementation principle, OptionC is further classified into two modes:

24) Enabling label distribution for IPv4 routes only between EBGP neighbors.

25) Enabling label distribution for IPv4 routes between EBGP and IBGP neighbors.

To facilitate expansion in OptionC, each AS is generally deployed with a route reflector (RR). The RRs of two ASs set up multi-hop MP-EBGP sessions to exchange VPN routes. Judged from deployment, OptionC can be referred to as the scheme of "Setting Up a Multi-Hop MP-EBGP Session Between RRs".

The following describes the configuration procedures of these schemes.

Scheme 1: Enabling Label Distribution for IPv4 Routes Only Between EBGP Neighbors

In this scheme, the IGP (such as OSPF or RIP) that runs on an ASBR is required to redistribute BGP routes so that each device in the AS can have routes to the PE in another AS. In the AS, you can use LDP to assign labels to the routes to the PE in another AS and set up an LSP. On the directly connected ASBRs of the two ASs, enable label distribution for IPv4 routes. In this manner, BGP serves as the MPLS signaling protocol to assign labels to the routes to the PE in another AS and set up an inter-AS LSP.

The configuration procedure is as follows:

26) Configuring route exchange between PEs and CEs in each AS

27) Configuring an IGP and MPLS signaling protocol in an AS

28) Setting up an EBGP session between ASBRs to distribute labels for IPv4 routes

29) Configuring an ASBR to redistribute inter-AS PE routes learned from EBGP to the IGP

30) Configuring a multi-hop MP-EBGP session

- Configuring route exchange between PEs and CEs

This procedure is similar to configuring route exchange between PEs and CEs and is not described here.

- Configuring an IGP and MPLS signaling protocol in an AS

This procedure is similar to configuring an MPLS network and is not described here.

- Setting up an EBGP session between ASBRs to enable label distribution for IPv4 routes

Set up an EBGP session between inter-AS ASBRs and enable label distribution of IPv4 routes. To import PE routes to BGP, you can use the **network** command in BGP IPv4 address family configuration mode or run commands to redistribute IGP routes. In view of the AS security in actual applications, you are generally required to configure IPv4 route distribution policies on ASBRs. By configuring route map rules, you can control the routes sent to neighbors and specify whether the routes carry labels. Similar control is available for receiving routes.

Enter privileged EXEC mode and use the following commands.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *asn-num*	Enables BGP and enters BGP configuration mode.
Ruijie(config-router)# **neighbor** *asbr-address* **remote-as** *asbr-asn-num*	Sets up an EBGP session with an ASBR.
Ruijie(config-router)#**address-family ipv4**	Enters BGP IPv4 address family configuration mode.
Ruijie(config-router-af)# **neighbor** asbr-address **send-label**	Configures the device to exchange labeled IPv4 routes with the ASBR peer in another AS.
Ruijie(config-router-af)# **network** *pe-address* **mask** *mask*	(Optional) Configures PE addresses to be imported into the BGP routing table in the local AS, that is, host routes of each PE in the AS.
Ruijie(config-router-af)# **neighbor** *asbr-address* **route-map** *routemap-name* **out**	(Optional) Configures a route distribution policy to control the routes sent to neighbors and specify whether the routes can carry labels, by defining a route map rule.
Ruijie(config-router-af)# **neighbor** *asbr-address* **route-map** *routemap-name* **in**	(Optional) Configures a route distribution policy to receive only labeled routes by defining a route map rule.
Ruijie(config-router-af)# **show running-config**	Displays existing configuration information.

Caution You must run the **label-switching** command on the interface that connects two ASBRs to enable MPLS on the interface so that the links between the ASBRs can forward MPLS packets.

☑ On a router, use the **ip ref** command on the interface to enable fast forwarding to improve forwarding performance.

Caution If the ASBRs do not use directly connected addresses to set up an MP-EBGP session but use the loopback address with a 32-bit mask as the source address to set up an MP-EBGP session, you must use the **neighbor ebgp-multihop** command to enable multi-hop EBGP. At the same time, you must configure static routes on the ASBR to the loopback address on the peer, enable LDP or configure a static FTN (with an outgoing label as 3, indicating that the ASBR is the second to last hop).

Set up an EBGP session between ASBRs, enable label distribution for IPv4 routes, and run the **network** command to import PE routes to BGP.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
```

```
Ruijie(config-router)# neighbor 20.20.20.2 remote-as 2
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 20.20.20.2 send-label
Ruijie(config-router-af)# network 10.10.10.10 mask 255.255.255.255
Ruijie(config-router-af)# end
```

In actual applications, an ASBR is generally required to distribute labels for PE routes for only inter-AS VPN services. For this purpose, you can use the route map rules defined by the **set mpls-label** command.

The **set mpls-label** command sets labels for routes. You can create a route map rule to distribute only inter-AS PE routes to the peer ASBR and set labels for the routes. Set route map rules and then run the **neighbor** *peer-address* **route-map** *rmap_name* **out** command in BGP IPv4 address family configuration mode to associate the rules with the route map.

The following example creates a route map to assign an MPLS label to the route with a prefix as 1.1.1.1/32, to assign a common IPv4 route without a label to the route with a prefix as 1.1.1.2/32, and not to send neighbors routes that fail to match acl1 and acl2.

```
Router(config)# ip access-list standard acl1
Router(config-std-nacl)# permit host 1.1.1.1
Router(config-std-nacl)# exit
Router(config)# ip access-list standard acl2
Router(config-std-nacl)# permit host 1.1.1.2
Router(config-std-nacl)# exit
Router(config)# route-map out-as permit 10
Router(config-route-map)# match ip address acl1
Router(config-route-map)# set mpls-label
Router(config-std-nacl)# exit
Router(config)# route-map out-as permit 20
Router(config-route-map)# match ip address acl2
Router(config)# router bgp 100
Router(config-router)# neighbor 30.30.30.2 remote-as 100
Router(config-router)# neighbor 30.30.30.2 route-map out-as out
```

Similarly, to receive only labeled IPv4 routes, you can run the **match mpls-label** command in route map mode. Set route map rules and then run the **neighbor** *peer-address* **route-map** *rmap_name* **in** command to associate the rules with the route map.

The following example creates a route map to receive labeled IPv4 routes from only the BGP peer at 30.30.30.2 and reject other routes.

```
Router(config)# route-map match-mpls
Router(config-route-map)# match mpls-label
Router(config)# router bgp 100
Router(config-router)# neighbor 30.30.30.2 remote-as 100
Router(config-router)# neighbor 30.30.30.2 route-map match-mpls in
```

- Configuring an ASBR to redistribute inter-AS PE routes learned from EBGP to the IGP

When an ASBR learns a route to the PE in another AS from the peer ASBR, the ASBR should advertise the route to other PEs in the local AS. The ASBR should also set up an LSP to the PE in another AS. In this manner, the ASBR can

redistribute routes learned from EBGP to the IGP and at the same time, enable LDP to distribute labels for BGP routes and then set up an LSP to the PE in another AS.

Enter privileged EXEC mode and use the following commands.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router** *igp*	Enters IGP configuration mode.
Ruijie(config-router)# **redistribute bgp subnets [route-map** *routemap-name*]	Redistributes BGP routes. Route filtering by using route map rules is optional.
Ruijie(config-router)# **exit**	Exits IGP configuration mode.
Ruijie(config)# **mpls router ldp**	Enters LDP configuration mode.
Ruijie(config-mpls-router)# **ldp router-id interface loopback** *0* force	Configures the LDP router ID. The loopback address is generally used as the router ID.
Ruijie(config-mpls-router)# **advertise-labels for bgp-routes [acl** *acl-name*]	Distributes labels for BGP routes. Filtering based on ACL rules is optional.
Ruijie(config-mpls-router)# **show running-config**	Displays existing configuration information.

Caution By default, LDP distributes labels for only IGP routes and does not distribute labels for BGP routes. To distribute labels for BGP routes, you can run the **advertise-labels for bgp-routes** command.

Configure an IGP and MPLS signaling protocol in an AS.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 1
Ruijie(config-router)# redistribute bgp subnets
Ruijie(config-router)# exit
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# advertise-labels for bgp-routes
Ruijie(config-mpls-router)# end
```

When an IGP redistributes the learned BGP routes in the OptionC scheme, you can run the **redistribute bgp subnets route-map** *routemap-name* command in IGP configuration mode to control the BGP routes to be redistributed to the IGP. In LDP configuration mode, you can run the **advertise-labels for bgp-routes acl** *acl-name* command to control the labels distributed for BGP routes.

Configure ACL rules and route map routes so that:

- The IGP redistributes only routes 1.1.1.1 and 2.2.2.2.
- The LDP assigns labels to only routes 1.1.1.1 and 2.2.2.2.

The configuration procedure is as follows:

```
Router(config)# ip access-list extended 101
Router(config-ext-nacl)# permit ip host 1.1.1.1 any
```

```
Router(config-ext-nacl)# permit ip host 2.2.2.2 any
Router(config-ext-nacl)# exit
Router(config)# route-map pe-routes
Router(config-route-map)# match ip address 101
Router(config-route-map)# exit
Router(config)# router ospf 1
Router(config-router)# redistribute bgp subnets route-map pe-routes
Router(config-route-map)# exit
Router(config)# mpls router ldp
Router(config-mpls-router)# advertise-labels for bgp-routes acl 101
```

- Configuring a multi-hop MP-EBGP session

In the earlier steps, the inter-AS LSP is already set up. At this time, you can directly set up a multi-hop MP-EBGP session on the PE to be deployed with inter-AS VPN services with the PE in another AS. The session can then exchange VPN routes.

To configure a multi-hop MP-EBGP session, enter privileged EXEC mode and use the following commands.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *asn-num*	Enables BGP and enters BGP configuration mode.
Ruijie(config-router)# **neighbor** *ebgp-peer-address* **remote-as** *ebgp-asn-num*	Sets up a multi-hop EBGP session with the PE in another AS.
Ruijie(config-router)# **neighbor** *ebgp-peer-address* **update-source** *interface-name*	Configures the device to use the loopback address to set up a neighbor relation with the EBGP peer.
Ruijie(config-router)# **neighbor** *ebgp-peer-address* **ebgp-multihop**	Configures multi-hop attributes.
Ruijie(config-router)#**address-family vpnv4**	Enters BGP VPN address family configuration mode.
Ruijie(config-router-af)# **neighbor** *ebgp-peer-address* **activate**	Enables the VPN route exchange with the peer.
Ruijie(config-router-af)# **exit**	Exits the BGP VPN address family.
Ruijie(config-router)# **address-family ipv4**	Enters BGP IPv4 address family configuration mode.
Ruijie(config-router-af)# **no neighbor** *ebgp-peer-address* **activate**	Disables the IPv4 route exchange.
Ruijie(config-router)# **show running-config**	Displays existing configuration information.

Caution

The exchange of IPv4 routes is not required in a multi-hop MP-EBGP session. At least the routes of the two addresses used to set up the BGP session should be avoided. Otherwise, a PE has two routes to the PE in another AS. One route is advertised by the ASBR in the local AS and the other is advertised by the multi-hop EBGP session. According to the BGP specification, the EBGP route has a higher priority over the IBGP route by default. As a result, BGP chooses the route advertised by the multi-hop BGP, resulting in continuous flapping of routes on the PE to the PE in another AS. The VPN routes are thus not reachable.

Set up a multi-hop EBGP session.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 2
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruijie(config-router)# neighbor 1.1.1.1 ebgp-multihop
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# exit
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# no neighbor 1.1.1.1 activate
Ruijie(config-router-af)# end
```

Scheme 2: Enabling Label Distribution for IPv4 Routes Between EBGP and IBGP Neighbors

In Scheme 1 (Enabling Label Distribution for IPv4 Routes Only Between EBGP Neighbors), the IGP and LDP in one AS are required to maintain the PE routes from another AS. That is, inter-AS PE routes should be advertised to each device in the AS. In view of the AS security in actual applications, the PE routes of another AS are generally not advertised to each device in the local AS. Instead, these routes should be owned by the BGP protocol so that the routes can be transparent to the IGP and LDP in the local AS. You can enable label distribution for IPv4 routes between EBGP and IBGP neighbors.

This scheme differs from Scheme 1 in that the IGP on an ASBR is not required to redistribute BGP routes and that the LDP is not required to assign labels to BGP routes, though the LDP is still responsible for the setup of an LSP in the local AS. The setup of an inter-AS LSP, however, requires label distribution for IPv4 routes between both IBGP and EBGP neighbors. The PEs are also required to push three consecutive layers of labels.

The configuration procedure is as follows:

31) Configuring route exchange between PEs and CEs in each AS

32) Configuring an IGP and MPLS signaling protocol in an AS

33) Setting up an IBGP session between a PE and an ASBR to distribute labels for IPv4 routes

34) Setting up an EBGP session between ASBRs to distribute labels for IPv4 routes

35) Configuring a multi-hop MP-EBGP session

- Configuring route exchange between PEs and CEs

This procedure is similar to configuring route exchange between PEs and CEs and is not described here.

- Configuring an IGP and MPLS signaling protocol in an AS

This procedure is similar to configuring an MPLS network and is not described here.

- Setting up an IBGP session between a PE and an ASBR to distribute labels for IPv4 routes

This scheme differs from Scheme 1 mainly in this configuration procedure. In this scheme, the PE routes that are learned by EBGP from another AS are not redistributed to the IGP in the local AS. Instead, the IBGP session between an ASBR and a PE is used to transmit the PE routes of another AS and BGP is used to assign labels to the PE routes.

Enter privileged EXEC mode and use the following commands.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *asn-number*	Enables BGP and enters BGP configuration mode.
Ruijie(config-router)# **neighbor** *peer-address* **remote-as** *asn-number*	Sets up an IBGP session with an ASBR (PE).
Ruijie(config-router)# **neighbor** *peer-address* **update-source** *interface-name*	Configures the device to use the loopback address as the source address to set up the BGP session with an ASBR (PE) peer.
Ruijie(config-router)# **address-family ipv4**	Enters the IPv4 address family.
Ruijie(config-router-af)# **neighbor** *peer-address* **send-label**	Configures the device to exchange labeled IPv4 routes with an ASBR (PE) peer.
Ruijie(config-router-af)# **show running-config**	Displays existing configuration information.

Caution Before you enable label distribution for IPv4 routes for an IBGP session with an IBGP peer, run the **neighbor update-source** command to specify the source address of the IBGP session. This source address must be the address of the loopback interface; otherwise, the inter-AS LSP cannot be set up.

Configure a PE to set up an MP-IBGP session with the ASBR at 10.10.10.2.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 10.10.10.2 remote-as 1
Ruijie(config-router)# neighbor 10.10.10.2  update-source loopback 0
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 10.10.10.2 activate
Ruijie(config-router-af)# neighbor 10.10.10.2 send-label
Ruijie(config-router-af)# exit
```

Configure an ASBR to set up an MP-IBGP session with the PE at 10.10.10.1 in the local AS.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 10.10.10.1 remote-as 1
Ruijie(config-router)# neighbor 10.10.10.1 update-source loopback 0
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 10.10.10.1 send-label
Ruijie(config-router-af)# end
```

- Setting up an EBGP session between ASBRs to enable label distribution for IPv4 routes

This procedure is similar to the corresponding procedure in Scheme 1 and is not described here.

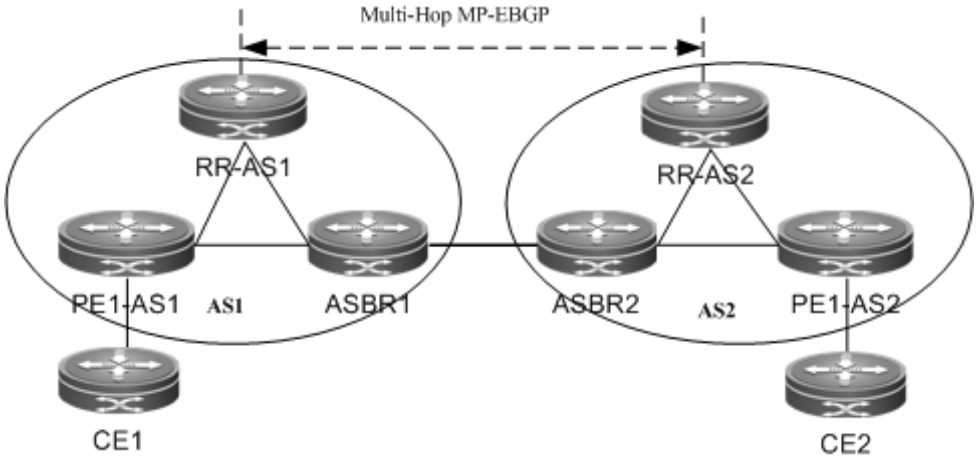
- Configuring a multi-hop MP-EBGP session

This procedure is similar to the corresponding procedure in Scheme 1 and is not described here.

Scheme 3: Setting Up a Multi-Hop MP-EBGP Session Between RRs

In the traditional OptionC scheme, the inter-AS VPN sites should be connected in full mesh mode. The addition of a single VPN site requires the setup of MP-MBGP connections with the PEs in other ASs, hindering the expansion of VPN sites. In this case, you can deploy an RR in each AS to solve this problem. Set up multi-hop MP-EBGP sessions between the RRs to exchange VPN routes.

Figure 11 Setting up a multi-hop MP-EBGP session between RRs in OptionC mode



As shown in the preceding figure, the RRs in the two ASs set up a multi-hop MP-EBGP session to exchange VPN routes. The configuration procedure is as follows:

36) Configuring route exchange between PEs and CEs in each AS

37) Configuring an IGP and MPLS signaling protocol in an AS

38) Setting up an MP-IBGP session between the RR and the PE and enabling label distribution for IPv4 routes

39) Setting up an IBGP session between the RR and the ASBR and enabling label distribution for IPv4 routes

40) Setting up an EBGP session between ASBRs to distribute labels for IPv4 routes

41) Configuring a multi-hop MP-EBGP session

- Configuring route exchange between PEs and CEs

This procedure is similar to configuring route exchange between PEs and CEs and is not described here.

- Configuring an IGP and MPLS signaling protocol in an AS

This procedure is similar to configuring an MPLS network and is not described here.

- Setting up an MP-IBGP session between the RR and the PE and enabling label distribution for IPv4 routes

Configure a PE to set up an MP-IBGP session with the RR to transmit VPN routes. At the same time, enable label distribution for IPv4 routes for the session.

Enter privileged EXEC mode and use the following commands.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *asn-number*	Enables BGP and enters BGP configuration mode.

Command	Function
Ruijie(config-router)# **neighbor** *peer-address* **remote-as** *asn-number*	Sets up the IBGP session.
Ruijie(config-router)# **neighbor** *peer-address* **update-source** *interface-name*	Uses the address of the loopback address as the source address to set up an IBGP session.
Ruijie(config-router)# **address-family ipv4**	Enters the IPv4 address family.
Ruijie(config-router-af)# **neighbor** *peer-address* **Activate**	Enables IPv4 route exchange.
Ruijie(config-router-af)# **neighbor** *peer-address* **send-label**	Enables label distribution for IPv4 routes.
Ruijie(config-router-af)# n**eighbor** *peer-address* **route-reflector-client**	Configures all PE peers as the clients of the IPv4 RR.
Ruijie(config-router-af)# **exit**	Exits the IPv4 address family.
Ruijie(config-router)# **address-family vpnv4**	Enters the VPN address family.
Ruijie(config-router-af)# **neighbor** *peer-address* **Activate**	Enables the VPN route exchange with the peer.
Ruijie(config-router-af)# **neighbor** *peer-address* **route-reflector-client**	Configures all PE peers as the clients of the VPN RR.
Ruijie(config-router-af)# **show running-config**	Displays existing configuration information.

Set up an MP-IBGP session between the RR and the PE. The configuration on the RR is as follows:

```
Ruijie# configure terminal
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 10.10.10.1 remote-as 1
Ruijie(config-router)# neighbor 10.10.10.1 update-source loopback 0
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 10.10.10.1 activate
Ruijie(config-router-af)# neighbor 10.10.10.1 send-label
Ruijie(config-router-af)# neighbor 10.10.10.1 route-reflector-client
Ruijie(config-router-af)# exit
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 10.10.10.1 activate
Ruijie(config-router-af)# neighbor 10.10.10.1 route-reflector-client
Ruijie(config-router-af)# end
```

- Setting up an IBGP session between the RR and the ASBR and distributing labels for IPv4 routes

Set up an MP-IBGP session between the ASBR and the RR to receive routes from the RR to the PEs in the local AS and send routes from the RR to the PEs in another AS. At the same time, enable label distribution for IPv4 routes for the session.

Enter privileged EXEC mode and use the following commands.

Command	Function
Ruijie# config terminal	Enters global configuration mode.
Ruijie(config)# **router bgp** *asn-number*	Enables BGP and enters BGP configuration mode.

Ruijie(config-router)# **neighbor** *peer-address* **remote-as** *asn-number*	Sets up the IBGP session.
Ruijie(config-router)# **neighbor** *peer-address* **update-source** interface-name	Uses the address of the loopback address as the source address to set up an IBGP session.
Ruijie(config-router)# **address-family ipv4**	Enters the IPv4 address family.
Ruijie(config-router-af)# **neighbor** *peer-address* **activate**	Enables IPv4 route exchange.
Ruijie(config-router-af)# **neighbor** *peer-address* **send-label**	Enables label distribution for IPv4 routes.
Ruijie(config-router)# **show running-config**	Displays existing configuration information.

Note For the IBGP session between an RR and an ASBR, you are generally not required to set the ASBR as the client of the RR unless the ASBR also serves as a PE.

Set up an IBGP session between the RR and the ASBR. The configuration on the RR (the configuration on the ASBR is similar) is as follows:

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 10.10.10.2 remote-as 1
Ruijie(config-router)# neighbor 10.10.10.2 update-source loopback 0
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 10.10.10.2 activate
Ruijie(config-router-af)# neighbor 10.10.10.2 send-label
Ruijie(config-router-af)# end
```

- Setting up an EBGP session between ASBRs to enable label distribution for IPv4 routes

This procedure is similar to the corresponding procedure in Scheme 1 and is not described here.

- Configuring a multi-hop MP-EBGP session

Set up a multi-hop MP-EBGP session between the RRs of two ASs to exchange inter-AS VPN routes. At the same time, disable the transmission of IPv4 routes for the session. The PE routes are advertised to another AS through the ASBR.

Enter privileged EXEC mode and use the following commands.

Command	**Function**
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *asn-number*	Enables BGP and enters BGP configuration mode.
Ruijie(config-router)# **neighbor** *rr-address* **remote-as** ebgp-asn-numbe	Sets up the EBGP session.
Ruijie(config-router)# **neighbor** *rr-address* **update-source** *interface-name*	Uses the address of the loopback address as the source address to set up an EBGP session.
Ruijie(config-router)# **neighbor** *rr-address* **ebgp-multihop**	Configures multi-hop EBGP attributes.

Ruijie(config-router)# **address-family ipv4**	Enters the IPv4 address family.
Ruijie(config-router-af)# **no neighbor** *rr-address* **activate**	Disables IPv4 route exchange for the session.
Ruijie(config-router-af)# **exit**	Exits the IPv4 address family.
Ruijie(config-router)# **address-family vpnv4**	Enters the VPN address family.
Ruijie(config-router-af)# **neighbor** *rr-address* **Activate**	Enables the device to exchange VPN routes with the RR in another AS.
Ruijie(config-router-af)# **neighbor** *rr-address* **next-hop-unchanged**	(Optional) Configures the device not to change the next hop when advertising VPN routes to the peer.
Ruijie(config-router)# **show running-config**	Displays existing configuration information.

Caution

By default, the device changes the next hop of a route to its own address when advertising the route to an EBGP peer. Upon receipt of the VPN route, the PE site in another AS considers the next hop of the route as the RR. As a result, all inter-AS VPN traffic is transmitted through the RR. This is generally not the optimal forwarding path and has high requirements on the forwarding performance of the RR. To avoid the preceding situation, you can run the **neighbor next-hop-unchanged** command in VPNv4 address family configuration mode to configure the device not to change the next hop of a VPNv4 route sent to the BGP peer when you set up a multi-hop MP-EBGP session on the RR.

The exchange of IPv4 routes is not required in a multi-hop MP-EBGP session. At least the routes of the two addresses used to set up the BGP session should be avoided. Otherwise, a PE has two routes to the PE in another AS. One route is advertised by the ASBR in the local AS and the other is advertised by the multi-hop EBGP session. According to the BGP specification, the EBGP route has a higher priority over the IBGP route by default. As a result, BGP chooses the route advertised by the multi-hop BGP, resulting in continuous flapping of routes on the PE to the PE in another AS. The VPN routes are thus not reachable.

Configure an RR to set up a multi-hop MP-EBGP session with the RR in another AS.

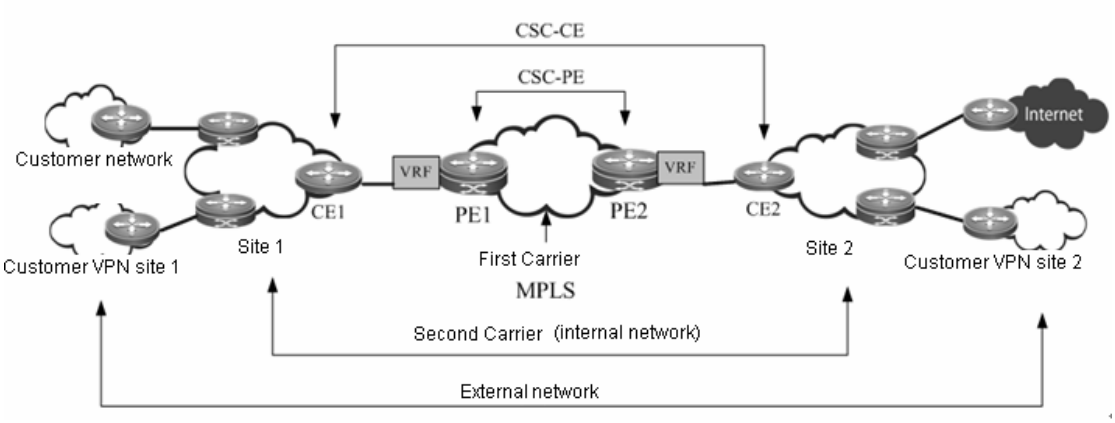
```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 30.30.30.2 remote-as 2
Ruijie(config-router)# neighbor 30.30.30.2 update-source loopback 0
Ruijie(config-router)# neighbor 30.30.30.2 ebgp-multihop
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# no neighbor 30.30.30.2 activate
Ruijie(config-router-af)# exit
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 30.30.30.2 activate
Ruijie(config-router-af)# neighbor 30.30.30.2 next-hop-unchanged
Ruijie(config-router-af)# end
```

Configuring Carrier's Carrier (CSC)

In a basic MPLS VPN, each site is a traditional IP network with a simple network structure. However, in there are some special VPN users. For example, a VPN user is also a service provider who leases the VPN service of an MPLS VPN

service provider and then provides specific services for users. In this case, the MPLS VPN service provider is called a provider carrier or first carrier, while the VPN user who is also a service provider is called a customer carrier or second carrier. This networking model is called carrier's carrier (CSC).

Figure 12 Model of Carrier's Carrier



Basic Concepts

- First carrier

The first carrier is also called a provider carrier, who provides MPLS VPN services for second carriers. In order to support second carriers to provide services for their users, the PE device of the first carrier must support CSC. The first carrier PE that provides services for second carriers is also called a CSC-PE.

- Second carrier

The second carrier is also called a customer carrier, who leases the MPLS L3VPN service from the first carrier in order to build its own intranet and then provide services for users. The second carrier CE connected to the first carrier is also called a CSC-CE.

- Internal route

The internal routes refer to the routes inside the network of the second carrier, namely, the intranet routes. The internal routes are used to guarantee the intercommunication of the second carrier's own network. Such routes must be jointly maintained by the first carrier PE and the second carrier.

- External route

Because the second carrier is a service provider, its network may be connected to multiple third-party networks. The route between the second carrier and the third-party network is called an external route. If the second carrier provides traditional IP services for users, the external routes include routes of user networks; if the second carrier is connected to the Internet, the external routes include Internet routes; if the second carrier provides MPLS VPN services for users, the external routes include user VPN routes.

Generally, there are tremendous external routes. To maintain good scalability, the first carrier will not maintain external routes, and external routes will be maintained independently by the second carrier.

- VPN tunnel

A VPN tunnel is an LSP tunnel established between VPN devices. In the CSC model, the LSP tunnel between second carrier devices is the VPN tunnel.

Working Principle

PE-CE Route and Label Distribution

To achieve good scalability, the number of routes to be maintained by the first carrier must be reduced. Therefore, the CSC model hands over external route maintenance to the second carrier, while the external traffic must use the VPN tunnel to traverse the first carrier. To support the CSC model, the first carrier PE must support VPN tunnels.

To support VPN tunnels, the first carrier PE (CSC-PE) and the second carrier CE (CSC-CE) must distribute the label binding information to each other. Depending on whether the CSC-PE and CSC-CE are in the same AS, the following routing protocols may be used to exchange internal routes and distribute labels for the internal routes:

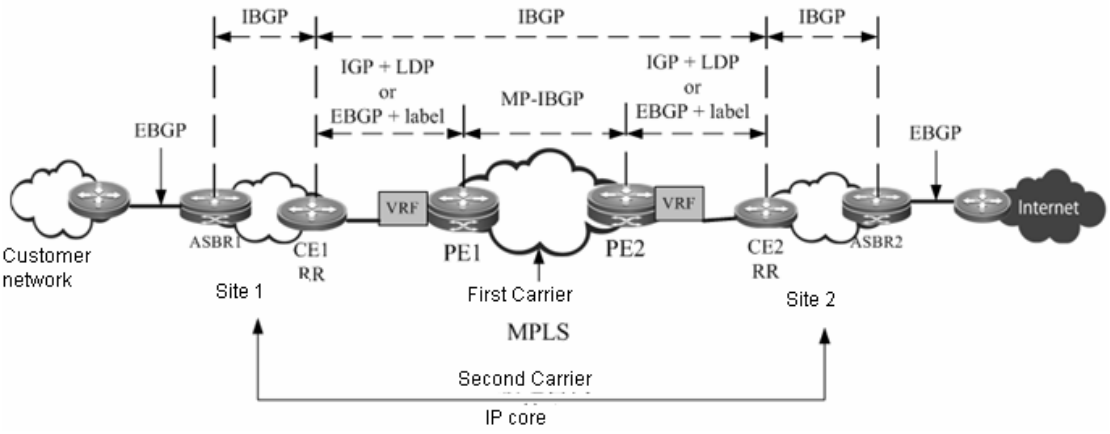
- If the CSC-PE and CSC-CE are in the same AS, IGP is generally used to exchange internal routes, and LDP is used to exchange label binding information.
- If the CSC-PE and CSC-CE are in different ASs, EBGP is generally used to exchange internal routes, and EBGP is enabled to perform label distribution for IPv4 routes and label distribution for internal routes.

Typical Application Scenarios

The second carrier can be an ordinary ISP or an MPLS service provider. Depending on the type of the second carrier network and the services provided by the second carrier for users, there are following typical application scenarios:

- Scenario I: IP core second ISP

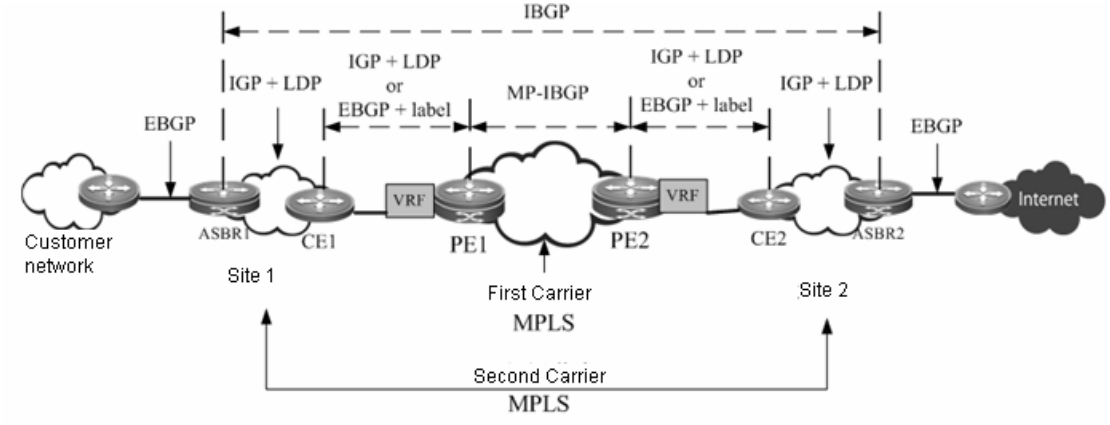
Figure 13 Scenario I: IP core second ISP



As shown in the figure, the second carrier is the IP core and provides network access services for users. IBGP neighbor relations are established between ASBR1, ASBR2, CE1 and CE2 to exchange external routes. CE1 and CE2 are RRs to reflect external routes between different sites. The Internet-access traffic of users flows from ASBR1 into the second carrier network and then flows out of the second carrier network from ASBR2. When the traffic flows from CE1 to CE2, the traffic is forwarded in the VPN LSP tunnel.

- Scenario II: MPLS core second ISP

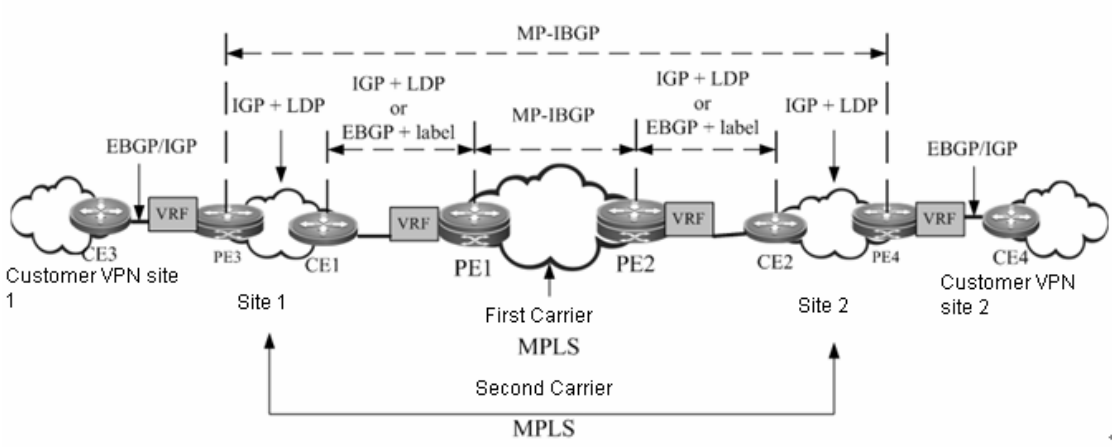
Figure 14 Scenario II: MPLS core second ISP



As shown in the figure, the second carrier is the MPLS core and provides network access services for users. An IBGP neighbor relation is established between ASBR1 and ASBR2 to exchange external routes. The Internet-access traffic of users flows from ASBR1 into the network of the second carrier and then flows out of the second carrier network from ASBR2. When the traffic flows from ASBR1 to ASBR2, the traffic is forwarded in the VPN LSP tunnel.

- Scenario III: MPLS core second VPN provider

Figure 15 Scenario III: MPLS core second VPN provider



As shown in the figure, the second carrier is the MPLS core and provides MPLS L3VPN services for users. An MP-IBGP neighbor relation is established between PE3 and PE4 to exchange user VPN routes. The VPN LSP between PE3 and PE4 acts as the external tunnel of a user VPN.

Configuration Steps

The CSC configuration includes:

- Configuring basic BGP/MPLS IP VPN functions for the first carrier
- Configuring the first carrier to enable CSC
- Configuring the second carrier
- Configuring user access for the second carrier

Configuring Basic BGP/MPLS IP VPN Functions for the First Carrier

The configuration of basic BGP/MPLS IP VPN functions includes:

42) Configuring an MPLS network

43) Configuring a VRF

44) Configuring an MP-IBGP neighbor

45) Configuring route exchange between PEs and CEs

- Configuring an MPLS network

The configuration in this section is similar to "Configuring an MPLS Network" in the "Configuring Basic BGP/MPLS IP VPN Functions" section.

- Configuring a VRF

The configuration in this section is similar to "Configuring a VPN Routing Instance" in the "Configuring Basic BGP/MPLS IP VPN Functions" section.

Caution The CSC configuration requires "per-route" label allocation for each VRF. Therefore, you need to run the **alloc-label per-route** command in VRF configuration mode to select the label allocation mode.

- Configuring an MP-IBGP neighbor

The configuration in this section is similar to "Configuring PEs to Transmit VPN Routes" in the "Configuring Basic BGP/MPLS IP VPN Functions" section.

- Configuring route exchange between PEs and CEs

The configuration in this section is similar to "Configuring Route Exchange Between PEs and CEs" in the "Configuring Basic BGP/MPLS IP VPN Functions" section.

Caution In Scenario I: In the network of the IP core second ISP, if the PE and CE use EBGP to exchange internal routes, because the external routes are exchanged using BGP and the CE is the route reflector, a route map needs to be configured for the PE and CE to filter external routes and avoid leaking external routes into the PE of the first carrier.

Configuring the First Carrier to enable CSC

Enable CSC on the first carrier PE. Depending on the protocol used for exchanging routes between a PE and a CE, the following two cases may apply:

46) The PE and CE use LDP to distribute labels.

47) The PE and CE use EBGP to distribute labels.

- The PE and CE use LDP to distribute labels.

If the PE and CE use IGP to exchange routes, run the following commands on the PE and CE respectively to configure the PE and CE to use LDP to distribute labels.

Use the following commands on the PE.

Command	Function

Command	Function
Ruijie(config)# **mpls router ldp** *vrf-name*	Enables LDP (PE) for the VRF.
Ruijie(config-mpls-router)# **ldp router-id interface** *interface-name* **force**	Configures the router ID of LDP.
Ruijie(config-mpls-router)# **advertise-labels for bgp-routes** [**acl** *acl-name*]	Configures LDP to distribute labels for BGP routes. LDP does not assign labels to BGP routes by default.
Ruijie(config-mpls-router)# **exit**	Exits LDP instance configuration mode.
Ruijie(config)# **interface** *interface-name*	Configures the interface connecting the CE.
Ruijie(config-if)# **label-switching**	Enables MPLS forwarding on the interface.
Ruijie(config-if)# **mpls ip**	Enables LDP on the interface.
Ruijie(config-if)# **ip ref**	☑ In case of a router, enables fast forwarding on the interface (not applicable to a switch).
Ruijie(config-if)# **end**	Exits interface configuration mode.
Ruijie# **show running**-config	Displays existing configuration information.
Ruijie# **show mpls ldp bindings vrf** *vrf-name*	Displays LDP label binding information under this VRF instance.

Use the following commands on the CE.

Command	Function
Ruijie(config)# **mpls router ldp**	Enables LDP (CE).
Ruijie(config-mpls-router)# **ldp router-id interface** *interface-name* **force**	Configures the router ID of LDP.
Ruijie(config-mpls-router)# **exit**	Exits LDP instance configuration mode.
Ruijie(config)# **interface** *interface-name*	Configures the interface connecting the PE.
Ruijie(config-if)# **label-switching**	Enables MPLS forwarding on the interface.
Ruijie(config-if)# **mpls ip**	Enables LDP on the interface.
Ruijie(config-if)# **end**	Exits interface configuration mode.
Ruijie# **show running-config**	Displays existing configuration information.
Ruijie(config-if)# **ip ref**	In case of a router, enables fast forwarding on the interface (not applicable to a switch).
Ruijie# **show mpls ldp bindings**	Displays LDP label binding information.

- The PE and CE use EBGP to distribute labels.

If the PE and CE use EBGP to exchange routes, run the following commands on the PE and CE respectively to configure the PE and CE to use EBGP to distribute labels.

Use the following commands on the PE.

Command	Function

Command	Function
Ruijie(config)# **interface** *interface-name*	Configures the interface connecting the CE.
Ruijie(config-if)# **ip ref**	☑ In case of a router, enables fast forwarding on the interface (not applicable to a switch).
Ruijie(config-if)# **label-switching**	Enables MPLS on the interface.
Ruijie(config-if)# **router bgp** *asn*	Enters BGP configuration mode.
Ruijie(config-router)# **address-family ipv4 vrf** *vrf-name*	Enters IPv4 address family configuration mode.
Ruijie(config-router-af)# **neighbor** {*peer-address* | *peer-group-name*} **send-label**	Enables BGP to carry labels for IP routes.
Ruijie(config-router-af)# **end**	Returns to privileged EXEC mode.
Ruijie# **show running-config**	Displays existing configuration information.
Ruijie# **show bgp vpnv4 unicast vrf** *vrf-name* labels	Displays BGP label information.

Use the following commands on the CE.

Command	Function
Ruijie(config)# **interface** *interface-name*	Configures the interface connecting the PE.
Ruijie(config-if)# **label-switching**	Enables MPLS on the interface.
Ruijie(config-if)# **ip ref**	☑ In case of a router, enables fast forwarding on the interface (not applicable to a switch).
Ruijie(config-if)# **router bgp** *asn*	Enters BGP configuration mode.
Ruijie(config-router)# **address-family ipv4**	Enters IPv4 address family configuration mode.
Ruijie(config-router-af)# **neighbor** {*peer-address* | *peer-group-name*} **send-label**	Enables BGP to carry labels for IP routes.
Ruijie(config-router-af)# **end**	Returns to privileged EXEC mode.
Ruijie# **show running-config**	Displays existing configuration information.
Ruijie# **show ip bgp labels**	Displays BGP label information.

Configuring the Second Carrier

Before the configuration, configure IGP for the second carrier network in order to guarantee the connectivity of the second carrier network. Depending on the application scenarios of the second carrier, different configuration schemes will be adopted:

- Scenario I: IP core second ISP
- Scenario II: MPLS core second ISP
- Scenario III: MPLS core second VPN provider

The Second Carrier Provides Internet Services Based on IP Core

In Scenario I, IBGP neighbor relations are established between ASBRs and CEs to exchange external routes. CEs are RRs to reflect external routes between different sites. The configuration task includes:

48) Configuring an intra-site BGP session

49) Configuring a BGP session between CSC-CEs of different sites

50) Configuring route map filtering

- Configuring an intra-site IBGP session

Use the following commands to configure an IBGP session between an intra-site ASBR and a CSC-CE, and configure the CSC-CE as an RR.

Command	Function
Ruijie(config)# **router bgp** *asn*	Configures a BGP router.
Ruijie(config-router)# **neighbor** {*peer-address* | *peer-group-name*} **remote-as** *asn*	Configures a BGP neighbor.
Ruijie(config-router)# **neighbor** {*peer-address* | *peer-group-name*} **route-reflector-client**	Configures the CSC-CE as the RR client.
Ruijie(config-router)# **neighbor** {*peer-address* | *peer-group-name*} **update-source** *interface-name*	Configures a BGP source address.
Ruijie(config-router)# **neighbor** {*peer-address* | *peer-group-name*} **next-hop-self**	For the ASBR, changes the next hop to the router itself when configuring the router to advertise BGP routes.

- Configuring an IBGP session between CSC-CEs of different sites

Use the following commands to set up a fully meshed IBGP session between CSC-CEs of different sites to exchange external routes of different sites.

Command	Function
Ruijie(config)# **router bgp** *asn*	Configures BGP.
Ruijie(config-router)# **neighbor** {*peer-address* | *peer-group-name*} **remote-as** *asn*	Configures a BGP neighbor.
Ruijie(config-router)# **neighbor** {*peer-address* | *peer-group-name*} **update-source** *interface-name*	Configures a BGP source address.
Ruijie(config-router)# **neighbor** {*peer-address* | *peer-group-name*} **route-reflector-client**	(Optional) Configures the CSC-CE of a peer site as the RR client.
Ruijie(config-router)# **exit**	Exits BGP configuration mode.
Ruijie(config)# **recursive-route lookup lsp**	Enables resolution of the next hop of a BGP route to an LSP tunnel.

- Configuring route map filtering

When BGP is used to exchange internal routes, because the CSC-CE is responsible for propagating both external routes and internal routes, you must guarantee that only the EBGP session between the CSC-CE and the CSC-PE can propagate internal routes, and that the IBGP session between CSC-CEs and between the CSC-CE and the ASBR can only propagate external routes; otherwise, routing loops or chaos may occur. To achieve this goal, you must run **neighbor route-map {in | out}** on the IBGP neighbor and EBGP neighbor to filter the corresponding routes, and the AS-path filtering rule is generally used. You can also use other rules.

Use the following commands to configure route map filtering.

Command	Function
Ruijie(config)# **ip as-path access-list** *access-list-number* {**permit** | **deny**} *regex*	Configures an AS-path ACL.
Ruijie(config)# **route-map** *route-map-name* {**permit** | **deny**} *sequence-number*	Configures a route map.
Ruijie(config-route-map)# **match as-path** *access-list-number*	Matches the AS-path ACL.
Ruijie(config-route-map)# **exit**	Returns to global configuration mode.
Ruijie(config)# **router bgp** *asn*	Configures a BGP router.
Ruijie(config-router)# **neighbor** {*peer-address* | *peer-group-name*} **route-map** *route-map-name* {**in** | **out**}	Applies the route map to a BGP neighbor.

The Second Carrier Provides Internet Services Based on MPLS

In Scenario II, the second carrier network is an MPLS core in which IBGP neighbor relations are established between ASBRs to exchange external routes. There is no need to propagate external routes via the CSC-CE. The configuration task includes:

51) Configuring an intra-site MPLS network

52) Configuring an inter-site IBGP session

- Configuring an intra-site MPLS network

The configuration of the intra-site MPLS network of the second carrier is similar to "Configuring an MPLS Network" in the "Configuring Basic BGP/MPLS IP VPN Functions" section.

Note: You need to enable LDP on the CSC-CE in order to set up sessions with other intra-site devices to build an MPLS network. If the CSC-CE and CSC-PE use BGP to exchange routes, you must run **advertise-labels for bgp-routes** on the CSC-CE to enable LDP to distribute labels for BGP routes.

- Configuring an IBGP session between ASBRs of different sites

Use the following commands to configure the BGP session between the local ASBR and the ASBR of a peer site in order to exchange external routes.

Command	Function
Ruijie(config)# **router bgp** *asn*	Configures BGP.
Ruijie(config-router)# **neighbor** {*peer-address* | *peer-group-name*} **remote-as** *asn*	Configures a BGP neighbor.
Ruijie(config-router)# **neighbor** {*peer-address* | *peer-group-name*} **update-source** *interface-name*	Configures a BGP source address.
Ruijie(config-router)# **neighbor** {*peer-address* | *peer-group-name*} **next-hop-self**	Changes the next hop to the router itself when configuring the ASBR router to advertise external routes.
Ruijie(config-router)# **exit**	Exits BGP configuration mode.
Ruijie(config)# recursive-route lookup lsp	Enables resolution of the next hop of a BGP route to an LSP tunnel.


Note

To reduce the configuration cost of a fully meshed IBGP session, you can configure the RR role inside the site. The intra-site ASBR can set up a BGP session with the RR, while an inter-site BGP session can only be set up between RRs.

The Second Carrier Provides VPN Services Based on MPLS Core

In Scenario III, the second carrier network is an MPLS core in which MP-IBGP neighbor relations are established between second carrier PEs to exchange user VPN routes. The configuration task includes:

53) Configuring an intra-site MPLS network

54) Configuring an MP-IBGP neighbor

- Configuring an intra-site MPLS network

The configuration of the intra-site MPLS network of the second carrier is similar to "Configuring an MPLS Network" in the "Configuring Basic BGP/MPLS IP VPN Functions" section.


Note

You need to enable LDP on the CSC-CE in order to set up sessions with other intra-site devices to build MPLS network. If the CSC-CE and CSC-PE use BGP to exchange routes, you must run **advertise-labels for bgp-routes** on the CSC-CE to allow LDP to distribute labels for BGP routes.

- Configuring PEs of each site to establish MP-IBGP neighbors

Configure PEs of each site to set up MP-IBGP sessions between intra-site PEs of the second carrier and between PEs of different sites in order to transmit VPN routes served by the second carrier. The configuration of the second carrier PE is similar to the PE configuration in the "Configuring Basic BGP/MPLS IP VPN Functions" section.


Note

To reduce the configuration cost of a fully meshed MP-IBGP session, you can configure the RR role inside the site. Intra-site PEs can set up an MP-IBGP session with the RR, while an inter-site MP-IBGP session can only be set up between RRs.

Configuring User Access for the Second Carrier

The configuration in this section relates to the services provided by the second carrier, and is irrelevant to the CSC model. If the second carrier provides IP services for users, see the "Configuring IP Routes" section. If the second carrier provides MPLS VPN services for users, see the "Configuring the MPLS VPN" section.

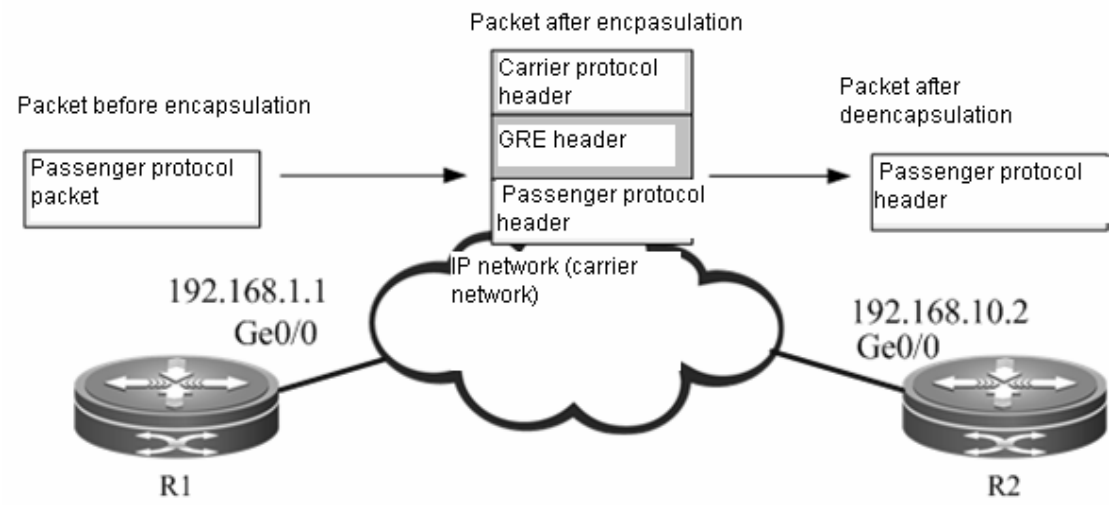
Configuring the MPLS VPN over GRE

☑ Currently, only router products of Ruijie support the MPLS VPN over GRE feature. This feature is not supported by Ruijie's switch products.

Basic Concepts

The traditional MPLS VPN uses an LSP as the public tunnel, that is, VPN traffic flows from an upstream PE to a downstream PE by means of label switching. This requires the carrier's core network to fully support MPLS. For certain considerations or due to certain limitations, if the carrier's core network cannot fully support MPLS, the MPLS VPN over GRE can provide a mechanism to allow the carrier to use a GRE tunnel as a hop on the LSP tunnel to guarantee the integrity of the public LSP.

Figure 16 GRE tunnel



- GRE tunnel

GRE provides a mechanism to encapsulate the packets of one protocol (passenger protocol) into another protocol (carrier protocol). The encapsulated packets consist of: carrier protocol header, GRE header and original passenger protocol header. After being encapsulated by the carrier protocol, the passenger protocol packets can be forwarded in the carrier network. After the encapsulated packets reach the destination address of the carrier protocol, the destination device will decapsulate the packets and then forward the packets according to the inner-layer passenger protocol used by packets. Such an encapsulation technology allows passenger protocol packets to traverse a heterogeneous carrier network and reach the destination device. It is a tunnel encapsulation technology.

- Passenger protocol

The passenger protocol is the protocol being encapsulated during the process of GRE encapsulation. In the application scenario of MPLS VPN over GRE, the passenger protocol refers to packets carrying MPLS labels.

- Carrier protocol

The carrier protocol is the protocol used to encapsulate the passenger protocol during the process of GRE encapsulation. In the application scenario of MPLS VPN over GRE, the carrier protocol is generally IPv4.

- Source address and destination address

While encapsulating the passenger protocol, you need to know the source address and destination address of the carrier protocol, so that the encapsulated packets can be forwarded on the carrier network. The abovementioned source address and destination address are the source address and destination address of a GRE tunnel.

- Tunnel endpoint

When packets are transported on the tunnel, one device carries out carrier protocol encapsulation and another device carries out decapsulation. The passenger protocol information can only be known and processed by these two devices, while other carrier network devices between the two devices are unaware of the existence of the passenger protocol. These two devices are the endpoints of the GRE tunnel.

Working Principle

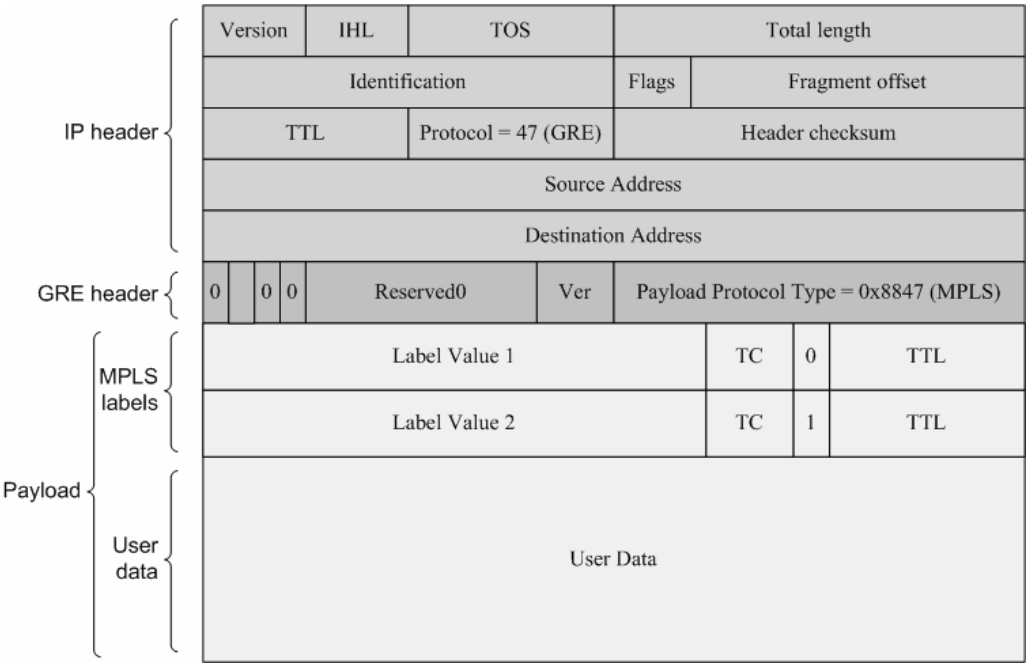
In the traditional MPLS VPN, private-network traffic carrying an inner-layer VPN label and an outer-layer public-network label reaches the peer PE by means of label switching. When a non-MPLS network exists in the backbone network, the LSP will become discontinuous. The GRE tunnel can help MPLS packets traverse a non-MPLS domain and realize a continuous LSP.

The GRE tunnel is a tunneling mechanism in an IP network and support GRE with MPLS as the passenger protocol, so that two devices on both sides of the IP network can exchange MPLS packets. Considering the GRE tunnel as a point-to-point logical link, devices at both ends of the tunnel directly establish IGP neighbor relations and LDP neighbor relations on this link to distribute routes and labels for the LSP, while the GRE tunnel becomes one hop of the LSP.

MPLS as a Passenger Protocol

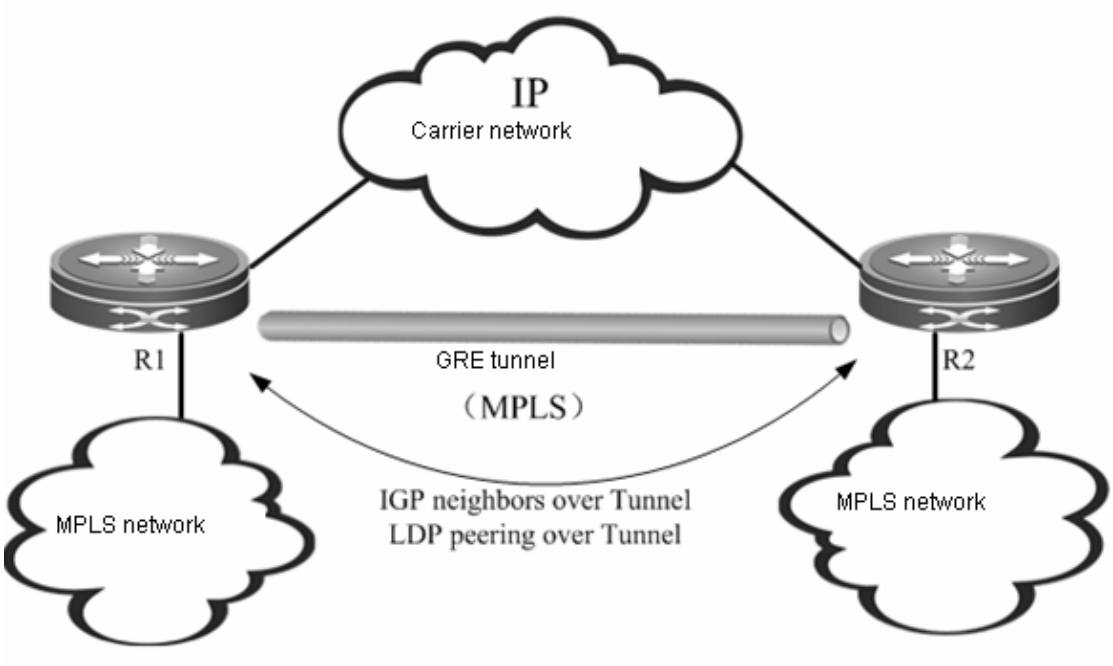
MPLS is used as the GRE tunnel of the passenger protocol so that two devices interconnected through a non-MPLS network can forward MPLS packets to each other. After a label operation at one end of the tunnel, MPLS packets are GRE-encapsulated and then transported over the carrier network to the other end of the tunnel; label switching is then carried out after packet decapsulation at the other end of the tunnel. The following figure shows the format of encapsulated packets with IPv4 being the carrier protocol and MPLS being the passenger protocol.

Figure 17 MPLS as the passenger protocol



GRE Tunnel as a Point-To-Point Link

Figure 18 GRE tunnel link



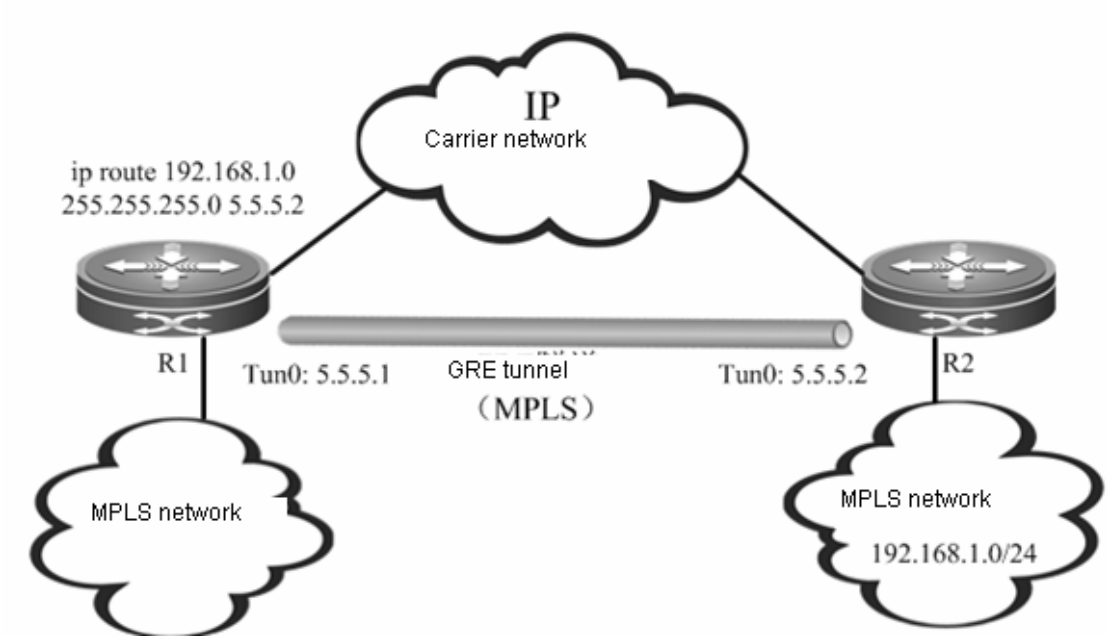
As shown in the figure, R1 and R2 are connected to an MPLS network respectively, while both routers are interconnected via a carrier network (IP). The GRE tunnel allows both endpoints (R1 and R2) to use the carrier network (IP) to transmit MPLS packets, so that two separated MPLS networks can be connected. The GRE tunnel is the point-to-point logical link between R1 and R2. It bypasses the carrier network (IP) and becomes one part of the MPLS network, so that the MPLS networks at both ends of the tunnel can maintain continuity. Considering the GRE tunnel as a point-to-point link, the IGP protocol can run on the link, while LDP can also distribute labels between R1 and R2.

Introduction of Tunnel Traffic

In either the carrier network (IP) or the MPLS network, traffic forwarding is driven by routers. Therefore, a dynamic routing protocol needs to be run in the carrier network (IP) and MPLS network. There are two possible schemes: single routing instance and dual routing instances.

- Single routing instance

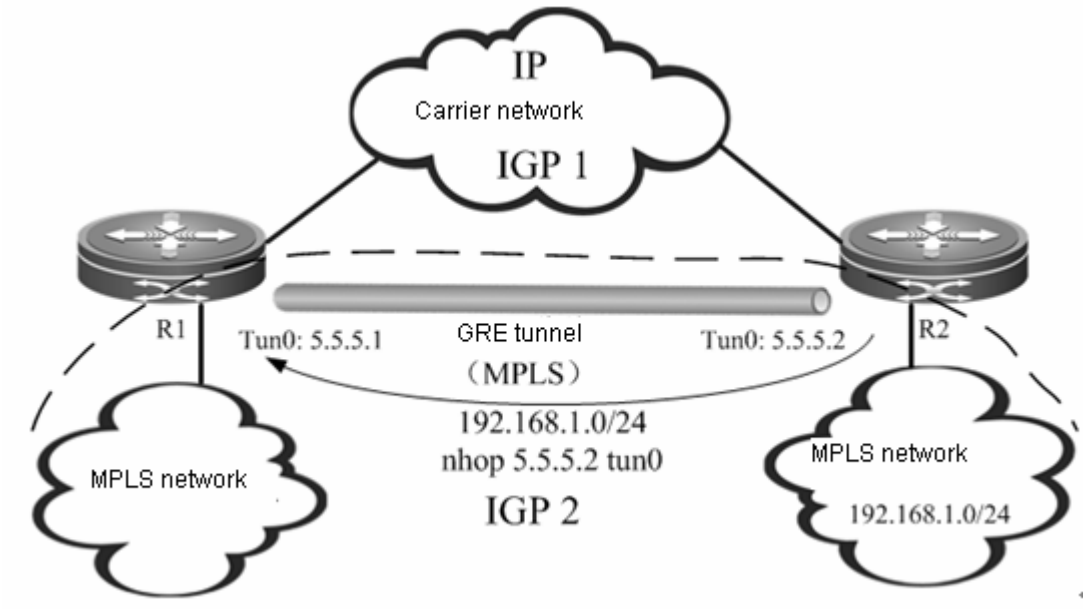
Figure 19 Single routing instance



In this scheme, the MPLS network and carrier network (IP) are in the same routing instance, and the entire network is in the plane form, as shown in Figure 15. By default, because the metric value of the GRE tunnel is far greater than that of an ordinary link, no traffic will be introduced into the GRE tunnel (which means that the GRE tunnel is not the next-hop egress interface of any route). Therefore, you must configure static routes in order to introduce MPLS traffic into the GRE tunnel. The static routes must be configured in this scheme, and the number of static routes depends on the number of route prefixes to be introduced into the GRE tunnel. The scalability is not satisfactory.

- Dual routing instances

Figure 20 Dual routing instances

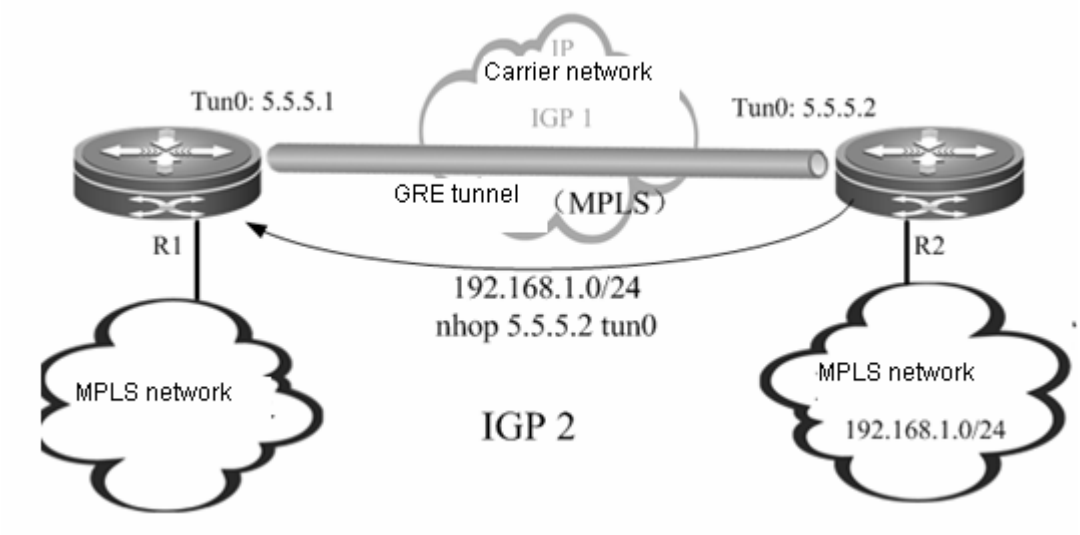


In this scheme, there are two different routing instances on each endpoint device of the GRE tunnel, as shown in Figure 16. One routing instance participates in route exchange in the carrier network (IP), while the other routing instance will participate in the route exchange in the MPLS network (including the GRE tunnel link). At this time, R1 learns the route to

the remote MPLS network through the GRE tunnel, with the egress interface being the GRE tunnel. The traffic can be introduced into the GRE tunnel without configuring any static route.

Dual routing instances are actually dividing the network into different layers. As the upper-layer network, the MPLS network (including the GRE tunnel) acts as the backbone network running consistent IGP instances, supporting MPLS and providing MPLS VPN services. As the bottom-layer network, the carrier network (IP) is the local network between R1 and R2 and runs independent IGP instances. If the GRE tunnel is the "layer-3 interface" between R1 and R2, the IP network and the IGP instance between R1 and R2 will be the "layer-2 network" and "layer-2 link protocol" between R1 and R2, as they guarantee the link state of the GRE tunnel. The relation can be indicated in Figure 17.

Figure 21 Dual IGP instances

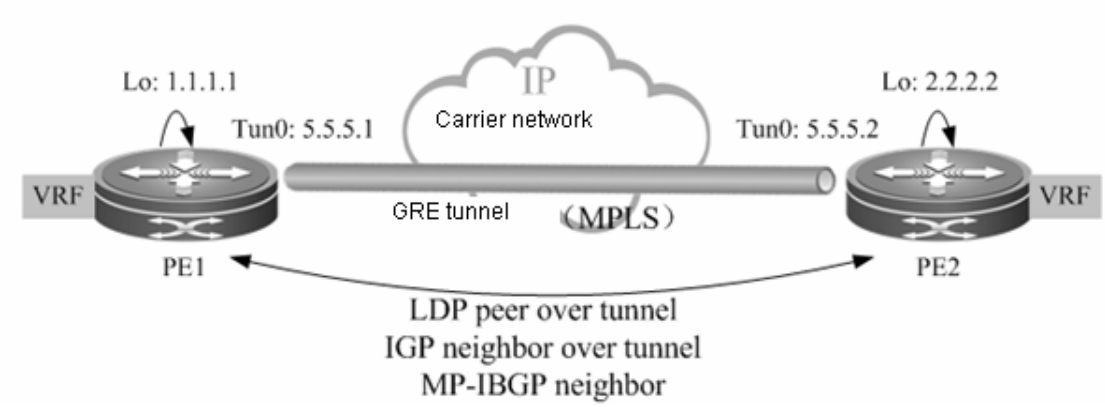


The scheme of dual routing instances divides the network into different layers and boasts better scalability. The following example is mainly based on this scheme.

Typical Applications

- Establishing a GRE tunnel between PEs

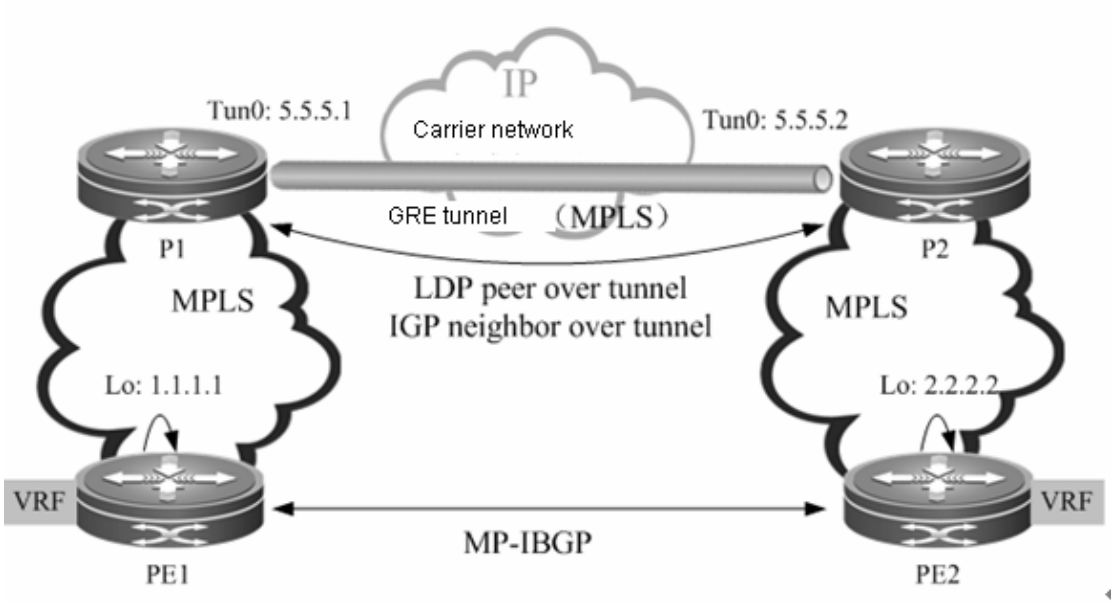
Figure 22 Scenario I: PE-PE



As shown in Figure 18, the core network between PEs is completely an IP network. The GRE tunnel is established between two PEs, and the LSP between PE1 and PE2 has only one hop.

- Establishing a GRE tunnel between Ps

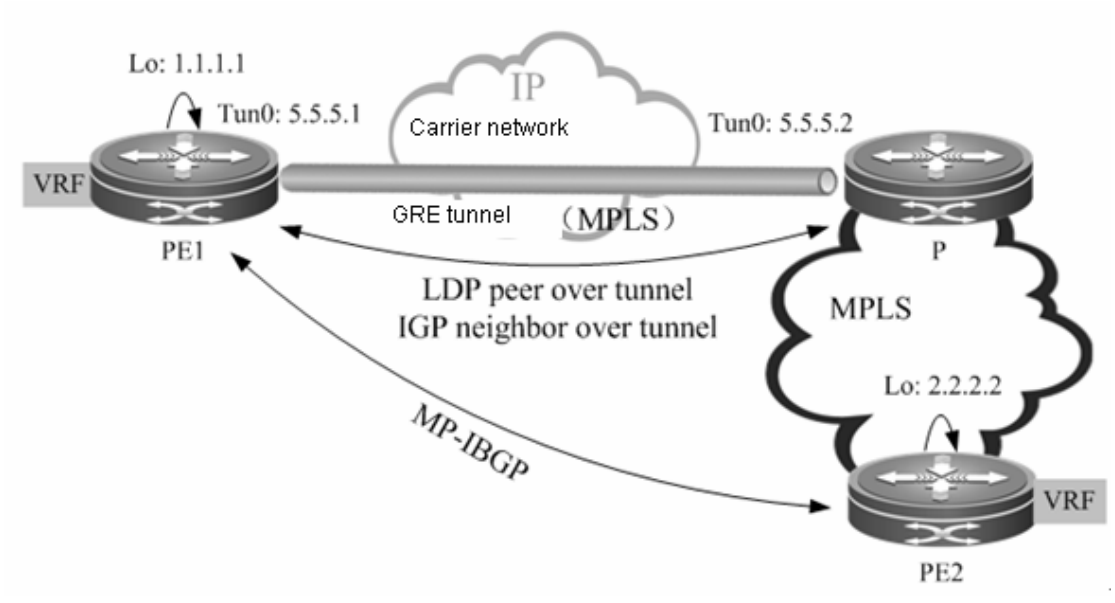
Figure 23 Scenario II: P-P



As shown in Figure 19, PE1 and PE2 are in two MPLS domains. P1 and P2 are interconnected through an IP network. The GRE tunnel is established between P1 and P2. The public LSP between PE1 and PE2 goes through P1 and P2, and the GRE tunnel between P1 and P2 is one hop of the LSP.

- Establishing a GRE tunnel between P and PE

Figure 24 Scenario III: P-PE



As shown in Figure 20, the network between PE1 and P does not support MPLS. The LSP is connected by establishing a GRE tunnel between PE1 and P.

Protocol Specification

- RFC 4023: Encapsulating MPLS in IP or GRE.

- RFC 4797: Use of Provider Edge to Provider Edge (PE-PE) Generic Routing Encapsulation (GRE) or IP in BGP/MPLS IP Virtual Private Networks.

Configuration Steps

The configuration of the MPLS VPN over GRE includes:

- Creating a tunnel interface
- Configuring an IGP route
- Configuring an MPLS network
- Configuring an MPLS VPN

Creating a Tunnel

Use the following commands to create a GRE tunnel (interface).

Command	Function
Ruijie(config)# **interface tunnel** *tunnel-id*	Creates a tunnel interface.
Ruijie(config)# **tunnel mode gre ip**	Configures the tunnel as a GRE in IP tunnel.
Ruijie(config-if)# **ip address** *ip-address address-mask*	Configures an address for the tunnel interface.
Ruijie(config-if)# **tunnel source** {*ip-address* | *interface-name*}	Configures the source address of the GRE tunnel.
Ruijie(config-if)# **tunnel destination** *ip-address*	Configures the destination address of the GRE tunnel.
Ruijie(config-if)# **no shutdown**	Enables the interface.

Configuring a Route to Introduce Traffic into the Tunnel

There are two ways to introduce traffic into the tunnel:

55) Configuring IGP

56) Configuring a static route

- Configuring IGP

Generally, multiple OSPF processes are used to create different routing instances. One OSPF process learns the route to the destination address of the tunnel, so that the tunnel interface is up if the route is reachable. Another OSPF process runs OSPF on the GRE tunnel to set up a session in order to learn the route to the destination address of the PE. For the configuration steps of multiple OSPF processes, see the "Configuring the Unicast Routing Protocol" section.

- Configuring a static route

Use the following command to configure a static route directly: Configure the tunnel interface as the egress of the host route to the specified PE address.

Command	Function
Ruijie(config)# **ip route** ip-address address-mask **tunnel** tunnel-id	Configures a static route.

Caution

If a static route is used to introduce traffic into the tunnel, the destination address of the tunnel cannot be the route prefix of the static route, that is, the address of the specified PE and the destination address of the tunnel must be different. This is because the state of the tunnel interface depends on the route to the destination address of the tunnel, while the static route will cause the route to the destination address to rely on the state of the tunnel interface, thus leading to the state flapping of the tunnel interface.

Configuring the Tunnel Interface to Enable MPLS

Use the following commands to enable LDP on the tunnel interface and enable MPLS forwarding.

Command	Function
Ruijie(config)# **mpls ip**	Enables MPLS globally. ☑ This command is not available on a switch chip.
Ruijie(config)# **mpls router ldp**	Enables LDP globally.
Ruijie(config-mpls-router)# **ldp router-id interface** *interface-name*	Configures the router ID of LDP.
Ruijie(config-mpls-router)# **exit**	Exits LDP configuration mode.
Ruijie(config)# **interface tunnel** *tunnel-id*	Enters tunnel interface configuration mode.
Ruijie(config-if)# **ip ref**	☑ In case of a router, enables fast forwarding (not applicable to a switch).
Ruijie(config-if)# **mpls ip**	Enables LDP on the interface.
Ruijie(config-if)# **label-switching**	Enables MPLS forwarding on the interface.
Ruijie(config-if)# **exit**	Exits interface configuration mode.

☑ Currently, only router products support the MPLS VPN over GRE-in-IPv4 tunnel. This feature is not supported by switch products.

Configuring the MPLS VPN

The configuration of the MPLS VPN includes:

- Configuring a VRF
- Configuring an MP-IBGP
- Configuring route exchange between PEs and CEs

For details, see the "Configuring Basic BGP/MPLS IP VPN Functions" section.

Configuring the OSPF VPN Extension

Understanding the L3VPN OSPF VPN Extension

PE-CE OSPF Feature

OSPF is a widely used IGP protocol. In most of the existing application schemes, VPN users generally select OSPF as the interior routing protocol. If OSPF is used between a PE and a CE, you do not need to run other routing protocols, thus simplifying CE configuration and management.

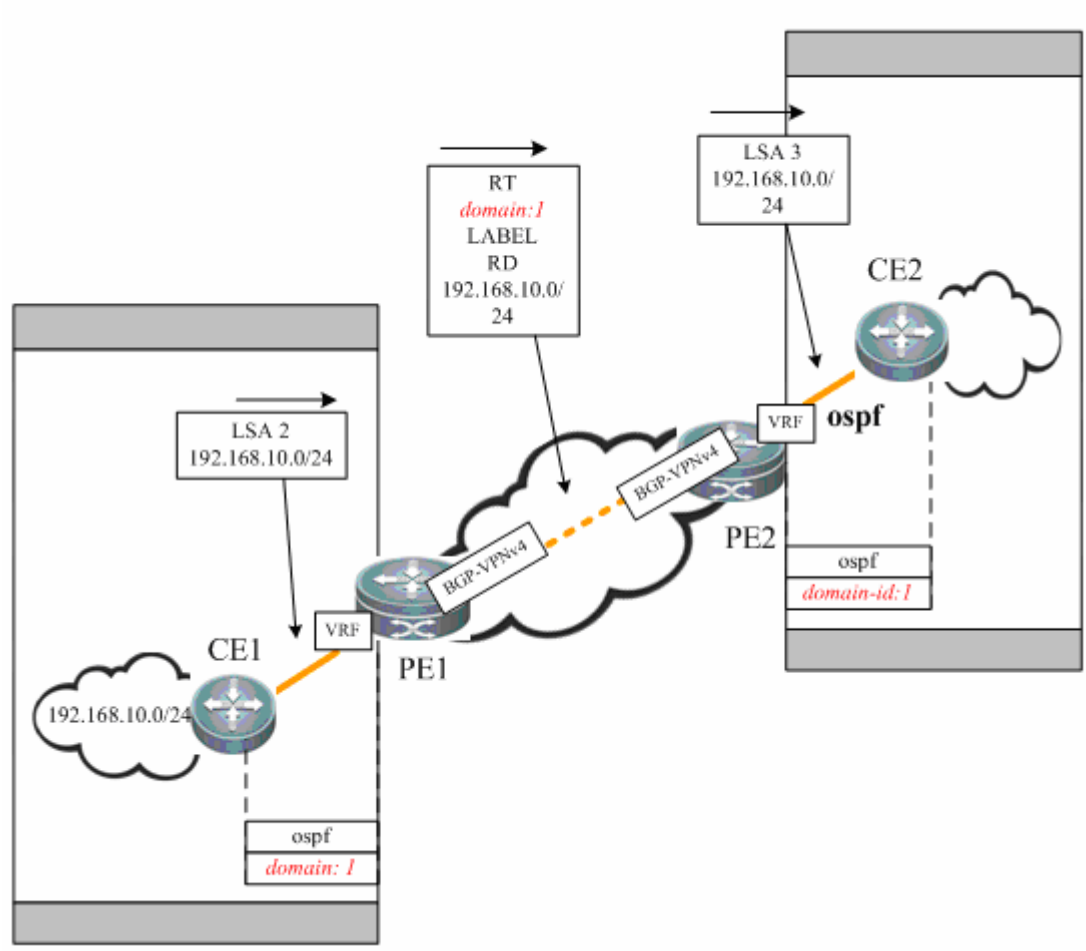
The PE-CE OSPF feature is described from the following four aspects.

- Domain ID

A domain ID refers to the OSPF domain to which the route belongs. When the CE has learned an OSPF route from an intra-VPN site, this route will be advertised to a PE in type-1, type-2 or type-3 link state advertisements (LSAs) and redistributed to BGP to form a VPN route. Meanwhile, the domain ID will also be redistributed to BGP together with the route and advertised as the extended community attribute in the VPN route. When other PEs receive this VPN route and redistribute it to the VRF OSPF instance, the domain ID will also be redistributed to the corresponding VRF OSPF instance together with this route. If the VRF OSPF instance confirms that the domain ID contained in the route is the same as the domain ID of this VRF OSPF instance, the route will be advertised to the CE as an internal route. Contrarily, if the VRF OSPF instance confirms the domain ID contained in the route is different from the domain ID of this VRF OSPF instance, the route will be advertised to the CE as an external route.

As shown in the following figure, for a route that belongs to the same OSPF domain, CE1 advertises the route to PE1 in a type-2 LSA and then a VPN route is formed and advertised to PE2. PE2 receives this route and redistributes it to the VRF OSPF instance. Because the VRF OSPF instance shares the same domain ID with this VPN route, this site will eventually be advertised to VPN sites in the form of an internal route.

Figure 25

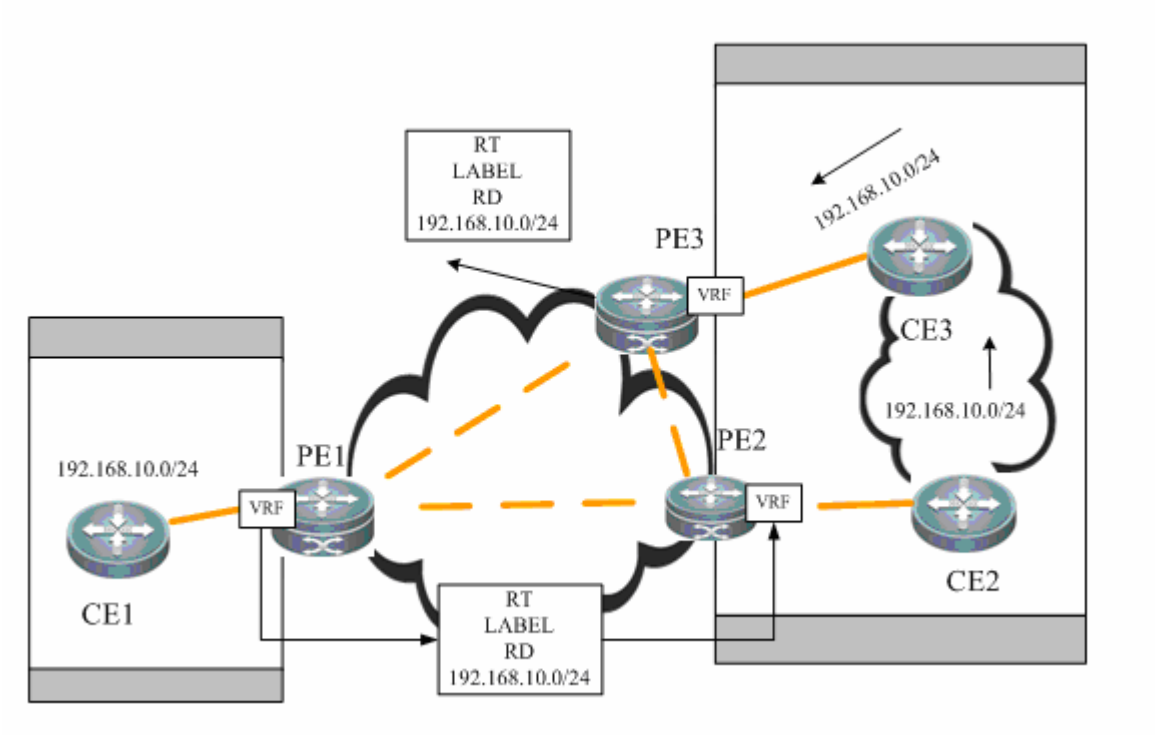


- DN bit

A DN bit is a loop detection technique when OSPF is run between the PE and the CE. In a certain scenario, running OSPF between the PE and the CE may cause loops. For example, when multiple PEs are connected to one VPN site, if one PE advertises the VPN route learned to the VPN site, and the route is further advertised to another PE by running OSPF inside the VPN site and then propagated, a routing loop may take place.

As shown in the following figure: The route from 192.168.10.0/24 is advertised by PE1 to PE2 and PE3. CE2 advertises the route to CE3 through OSPF. The route is then advertised to PE3 and redistributed to the BGP protocol of PE3. PE3 selects the route redistributed by OSPF and converts this route into a VPN-IPV4 route before advertising the route, thus causing a routing loop.

Figure 26



To avoid such potential loop, when the PE advertises a type-3, type-5 or type-7 LSA to the CE, it will set a DN bit in an optional field of the LSA. When other PEs receive any LSA containing a DN bit in the optional field, the OSPF protocol on the PE does not allow this LSA to participate in OSPF route computation.

- VPN route tag

A VPN route tag is another loop detection technique. When OSPF is run between the PE and the CE, the corresponding VRF OSPF instance on the PE will by default have a route tag called "VPN route tag". The VRF OSPF instance on the PE imports the VPN route and converts the route into a type-5 or type-7 LSA. When LSA is advertised to CE, this LSA will carry a VPN route tag. In the circumstance in which one VPN site is connected with multiple PEs, if a PE receives a type-5 or type-7 LSA that carries a VPN route tag and this VPN route tag is the same as the that of the OSPF instance, this LSA will not participate in OSPF route calculation.

- PE-CE inter-area deployment

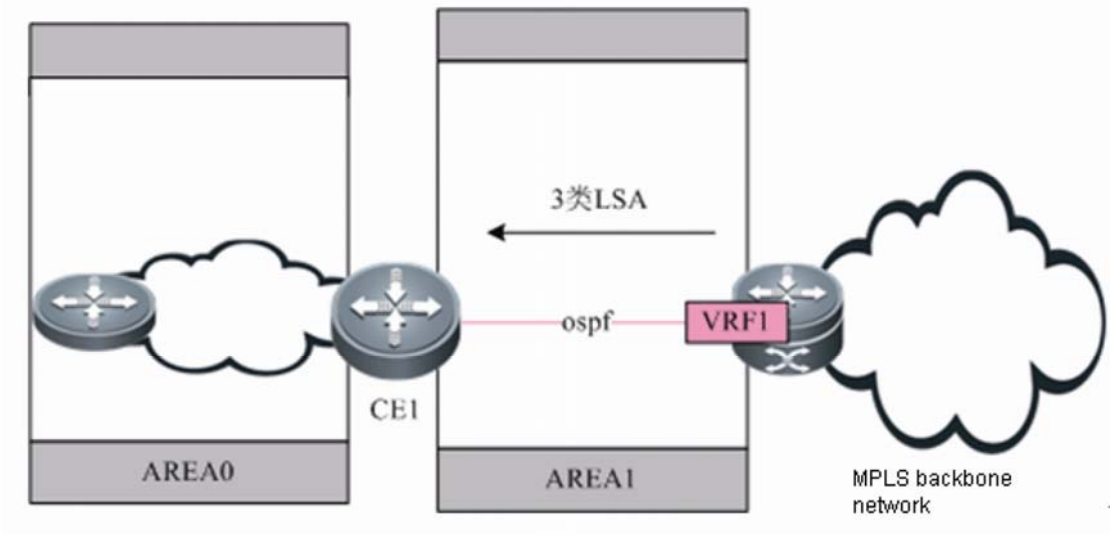
Under normal circumstances, the link between the PE and the CE can be in any OSPF area. However, if the link between the PE and the CE falls into a non-zero area, the PE is an area border router (ABR) to the OSPF area where the CE is located. This may cause some problems because the OSPF protocol acting as an ABR device has the following features:

57) The ABR only calculates the type-3 LSA in the backbone area.

58) The ABR only forwards the type-3 LSA in the backbone area to a non-backbone area.

As shown in the following figure, if the link between the PE and the CE is in a non-zero area, the PE will redistribute the VPNv4 route advertised by MP-BGP to OSPF and restore it to a type-3 LSA to be advertised to CE1. CE1 will not calculate the non-backbone area LSAs. Therefore, these LSAs will not be advertised to routers in Area 0, and intra-VPN sites may fail to learn the route to other sites. Therefore, pay special attention when deploying a non-zero area between the PE and the CE.

Figure 27

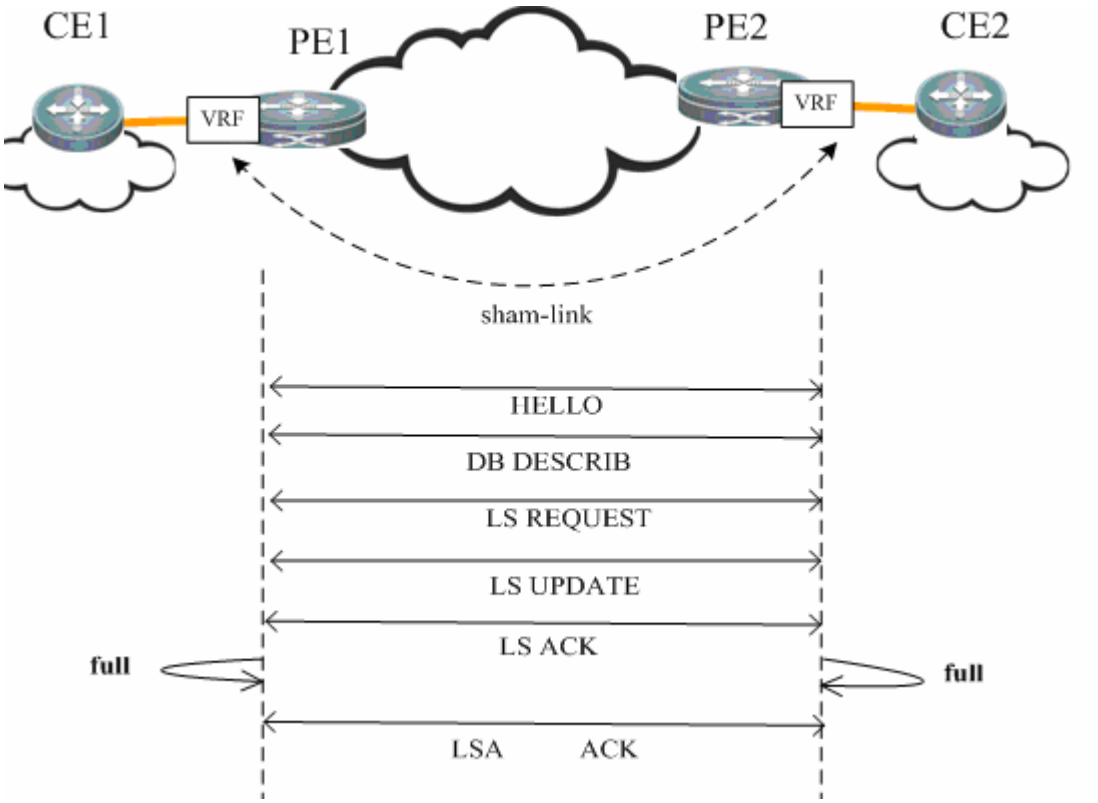


Generally, in L3VPN applications, if OSPF is run between the PE and the CE to exchange VPN routes, it is suggested not to deploy the backbone area at an intra-VPN site. In practice, if intra-VPN routers other than the PE sites also fall into the backbone area, there must be at least one router at this intra-VPN site to connect to the PE, and the link between the CE and the PE must belong to Area 0, so that intra-area routes and external routes can be propagated between the PE and the VPN site.

Sham Link

A sham link is not a real link. It refers to a "virtual link" established between the VRFs of two PEs. The sham link is the same as the normal OSPF link. With its own OSPF interface, it can send OSPF protocol packets, establish neighbors, and send LSAs. When LSAs are flooded over the sham link, all OSPF route types will not be changed, as shown in the following figure.

Figure 28



The purpose of establishing a sham link between VRF OSPF instances on different PEs is as follows:

- The approach of using MP-IBGP to carry a private route will only propagate the route, and the restoration after reaching the peer PE is only to import the original OSPF route information as far as possible, during which the OSPF topology information cannot be truly communicated. By establishing an OSPF link through a sham link, all OSPF instances inside each site can be truly connected and work out complete topology information.
- Different sites in the same VPN exchange information via the MPLS backbone network, but a link is established between VPN sites so that VPN sites can still communicate via this link when the MPLS backbone network fails. This link is called the "backdoor link". If two sites of VPN users fall into the same OSPF area and there is a "backdoor link" connecting these two sites, routes will be exchanged via both the MPLS backbone network and the "backdoor link". Because the routes exchanged via the MPLS backbone network are inter-area routes and the routes exchanged via the "backdoor link" are intra-area routes, and the intra-area routes are apparently superior to inter-area routes, the route forwarding between two sites will hence use the backdoor link. This goes against the purpose of establishing the "backdoor link". Therefore, the sham link must be used in such applications.

Protocol Specification

- RFC 4576 and RFC 4577 specify the mechanism to realize L3VPN OSPF.

Default Configuration

Function	Default Setting
domain-tag	AS number of local BGP
domain-id	Default value: NULL; default type: 0x0005

Function	Default Setting
capability vrf-lite	The PE-CE OSPF feature is supported by the VRF OSPF instance by default.
extcommunity-type	In the OSPF instance extended community attribute carried by BGP, the default type of route-id is 0x0107, and the default type of route-type is 0x0306.

Configuring a Domain ID (Optional)

The domain ID is used to indicate the domain to which the OSPF instance belongs. Generally, all VRF OSPF instances belonging to the same VPN must use the same domain ID.

Use the following commands to configure the domain ID.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router ospf** *ospf-id* **vrf** *vrf-name*	Creates an OSPF instance and enters OSPF configuration mode.
Ruijie(config-router)# **domain-id** {*ip-address* [secondary] | **null | type** {0005|0105|0205|8005} **value** *hex-value* **[secondary]**}	(Optional) Configures the domain ID of the OSPF instance. The OSPF domain ID is 0 by default.
Ruijie(config-router)# **show running-config**	Displays existing configuration information.

☑ Supported by RSR20 series running 10.4(3) or later versions

☑ Supported by RSR30 series running 10.4(3) or later versions

☑ Supported by RSR50 series running 10.4(3) or later versions

☑ Supported by RSR50E series running 10.4(3) or later versions

Note

This command is only applicable to an OSPF instance associated with a VRF.

A VRF OSPF instance can be configured with multiple domain IDs, but there is only one primary domain ID. Others are secondary domain IDs. The only primary domain ID is configured with the **domain-id** *value* command, while multiple secondary domain IDs are configured with the **domain-id** *value* **secondary** command. OSPF routes are advertised when converted into VPN routes, and VPN routes only contain the primary domain ID.

You can use the **domain-id** *ip-address* command or the **domain-id type {0005|0105|0205|8005}** *value* command to configure the primary and secondary domain IDs.

Different VRF OSPF instances can have the same domain ID. However, VRF OSPF instances in the same VPN must be configured with the same domain ID in order to guarantee the correctness of route advertisements.

Configure the primary domain ID and secondary domain ID of the VRF OSPF protocol to 4.4.4.4 and 5.5.5.5 respectively.

```
Ruijie# configure terminal
```

```
Ruijie(config)# router ospf 10 vrf vrf1
Ruijie(config-router)# domain-id 4.4.4.4
Ruijie(config-router)# domain-id 5.5.5.5 secondary
Ruijie(config-router)# domain-id type 0005 value 010101010101 secondary
```

Configuring a VPN Route Tag (Optional)

Use the following commands to configure a VPN route tag.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# r**outer ospf** *ospf-id* **vrf** *vrf-name*	Creates an OSPF instance and enters OSPF configuration mode.
Ruijie(config-router)# **domain-tag** *value*	(Optional) Configures a VPN route tag (1 to 4294967295) for the OSPF instance.
Ruijie(config-router)# **show running-config**	Displays existing configuration information.

☑ Supported by RSR20 series running 10.4(3) or later versions

☑ Supported by RSR30 series running 10.4(3) or later versions

☑ Supported by RSR50 series running 10.4(3) or later versions

☑ Supported by RSR50E series running 10.4(3) or later versions

Note

This command is only applicable to an OSPF instance associated with a VRF.

If the domain tag of a VRF is not configured manually, the default value is the AS number of the local BGP protocol.

In an L3VPN, if one VPN site is connected with multiple PEs, the VPN route learned by a PE through MP-BGP will be advertised to a VPN site in a type-5 or type-7 LSA. The route may also be learned by other PEs connecting to this VPN site and then advertised, hence causing a loop. To avoid such loop, the same VPN route tag must be configured on the PE for VRF OSPF instances connected to the same VPN site.

When a VRF OSPF instance sends a type-5 or type-7 LSA to the VPN site, this LSA will also carry the VPN route tag. When other PEs receive such type-5 or type-7 LSA containing the VPN route tag, if such route tag is the same as the route tag of the corresponding OSPF instance, this LSA will not participate in OSPF route computation.

Generally, OSPF instances associated with the same VPN must be configured with the same VPN route tag.

Configure the domain tag of the VRF OSPF protocol to 10.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10 vrf vrf1
Ruijie(config-router)# domain-tag 10
```

Configuring a Sham Link (Optional)

The sham link is mainly used in the scenario where there is a backdoor link between VPN sites. If you still expect to transmit VPN data via the MPLS backbone network, you can establish a sham link between the VRF OSPF instances of two PEs. Both instances can establish OSPF neighbors through this sham link and distribute LSA packets over the sham link.

Use the following commands to configure a sham link.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router ospf** *ospf-id* **vrf** *vrf-name*	Creates an OSPF instance and enters OSPF configuration mode.
Ruijie(config-router)# **area area-id sham-link** *source-address destination-address* [**cost** *number*] [**dead-interval** *seconds*] [**hello-interval** *seconds*] [**retransmit-interval** *seconds*] [**transmit-delay** *seconds*] [**authentication** [**message-digest** | **null**]] [[**authentication-key [0|7]** *key*] | [**message-digest-key** *key-id* **md5 [0|7]** *key*]]	Configures the area ID, source address and destination address of the sham link.
Ruijie(config-router)# **show running-config**	Displays existing configuration information.

☑ Supported by RSR20 series running 10.4(3) or later versions

☑ Supported by RSR30 series running 10.4(3) or later versions

☑ Supported by RSR50 series running 10.4(3) or later versions

☑ Supported by RSR50E series running 10.4(3) or later versions

Note

The sham link must be configured on two PEs that intend to establish the sham link. The sham link cannot be established if only one PE is configured.

The following conditions must be met in order to establish the sham link between two PEs:

1.The area-id of the sham link configured on two PEs must be identical.

2.The source address and destination address of the sham link configured on one PE must correspond to the destination address and source address of the sham link configured on another PE.

3.The source address and destination address used to establish the sham link on the PE must be a 32-bit loopback address bound to a VRF.

Because OSPF routes advertised by a sham link do not carry VPN labels, the routes cannot be used to forward packets. Packets are forwarded through BGP VPNv4 routes. Therefore, there must be VPNv4 routes corresponding to the OSPF routes learned from the sham link.

The source address for a sham link is advertised in BGP VPNv4 routes, but not calculated in OSPF instances.

Configure a sham link for a VRF OSPF instance, with the area ID being 0, the source address being 1.1.1.1, and the destination address being 2.2.2.2.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10 vrf vrf1
Ruijie(config-router)# area 0 sham-link 1.1.1.1 2.2.2.2
```

Configuring Capability vrf-lite (Optional)

The PE-CE OSPF feature of the VRF OSPF instance includes LSA conversion according to the domain ID, DN bit, and VPN route tag. In certain circumstances, if you do not expect the VRF OSPF instance to support the PE-CE OSPF feature, you can use the **capability vrf-lite** command to disable the feature.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router ospf** *ospf-id* **vrf** *vrf-name*	Creates an OSPF instance and enters OSPF configuration mode.
Ruijie(config-router)# **capability vrf-lite**	(Optional) Disables the PE-CE OSPF feature of the VRF OSPF instance.
Ruijie(config-router)# **show running-config**	Displays existing configuration information.

☑ Supported by RSR20 series running 10.4(3) or later versions

☑ Supported by RSR30 series running 10.4(3) or later versions

☑ Supported by RSR50 series running 10.4(3) or later versions

☑ Supported by RSR50E series running 10.4(3) or later versions

☑ Supported by 3760E series running 10.4(3) or later versions

☑ Supported by 5750 series running 10.4(3) or later versions

☑ Supported by 5760E series running 10.4(3) or later versions

Note

This command is only applicable to an OSPF instance associated with a VRF.

In certain scenarios, you may expect to disable the loop detection function of the VRF OSPF instance. For example: A VPN user uses an MCE device to exchange VPN routes with a PE. If the MCE and PE exchange VPN routes via OSPF, to allow the VPN site to learn the routes of other VPN sites, you must use the **capability vrf-lite** command on the MCE device to disable the loop detection function of the VRF OSPF instance.

Disable the loop detection function of the VRF OSPF instance.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10 vrf vrf1
Ruijie(config-router)# capability vrf-lite
```

Configuring extcommunity-type (Optional)

When an OSPF route is redistributed to BGP to form a VPN route, the extended community attributes of the OSPF route are also attached, including router-id and route-type. By default, the type of the extended community attribute of router-id is 0x0107, and that of route-type is 0x0306.

You can use the following commands to manually configure the extended community attributes of rouer-id and route-type.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router ospf** *ospf-id* **vrf** *vrf-name*	Creates an OSPF instance and enters OSPF configuration mode.
Ruijie(config-router)# **extcommunity-type {router-id {0107|8001} | route-type {0306|8000}}**	(Optional) Configures the extended community attributes of OSPF router-id and route-type.
Ruijie(config-router)# **show running-config**	Displays existing configuration information.

☑ Supported by RSR20 series running 10.4(3) or later versions

☑ Supported by RSR30 series running 10.4(3) or later versions

☑ Supported by RSR50 series running 10.4(3) or later versions

☑ Supported by RSR50E series running 10.4(3) or later versions

Note

This command is only applicable to an OSPF instance associated with a VRF.
The type configuration of router-id provides good compatibility with multiple manufacturers. For example, some manufacturers support only the router-id type of 0x0107. When interconnecting with devices from such manufacturers, you must use the **extcommunity-type** command to set the type of router-id to 0x0107.
The type configuration of route-type provides good compatibility with multiple manufacturers. For example, some manufacturers support only the route-type type of 0x8000. When interconnecting with devices from such manufacturers, you must use the **extcommunity-type** command to set the type of route-type to 0x8000.

Configure the type of router-id of the VRF OSPF protocol to 0x0107.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10 vrf vrf1
Ruijie(config-router)# extcommunity-type router-id 0107
```

Verifying the BGP/MPLS IP VPN Configurations

This section describes how to verify the L3VPN configurations and VPN routes.

Enter privileged EXEC mode and run the following commands.

Command	Function
Ruijie# **show ip vrf** [*vrf_name*]	Displays the VRF configuration information.
Ruijie# **show bgp vpnv4 unicast all** [*network* | **neighbor** [*peer-address*] | **summary | label]**	Displays the VPN route information.
Ruijie# **show ip route vrf** *vrf_name* [*ip-address* | **bgp | connected | isis | ospf | rip | static]**	Displays the information about the VRF forwarding table.

Display the VPN route information.

```
Ruijie# show bgp vpnv4 unicast all
Network        Nexthop     Metric  Localprf           Path
Route Distinguisher : 100: 2
*>i 192.168.0.1/32  192.168.0.2  0      100    10 ?
*>i 192.168.1.0/32  192.168.0.2    0      100     ?
Route Distinguisher : 100:30
*>i 192.168.0.1/32  192.168.0.2  0      100    10 ?
*> 192.168.4.0  192.168.4.1         0            20 ?
* 192.168.4.0   0.0.0.0           0      32768     ?
```

Field	Description
*****	Indicates a valid route.
s (lower-case)	Indicates that the route is suppressed by an aggregate route.
s (upper-case)	Indicates that the route is a stale entry.
>	Indicates that the route is an optimal one.
I	Indicates that the route is learned from the IBGP.
Nexthop	Indicates the next hop information of the route.
Metric	Indicates the route metric.
Localprf	Indicates the local preference of the route.
Path	Indicates the AS path included in the route.
I	Indicates that the origin of the route is IGP.
E	Indicates that the origin of the route is EGP.
?	Indicates that the origin of the route is another attribute except IGP or EGP (for example, a redistributed BGP route).

Display the information about the VRF routing table.

```
Ruijie# show ip route vrf vrf1
Codes: C - connected, S - static, R - RIP,B - BGP
O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2 , ia - IS-IS inter area
* - candidate default
```

```
B    192.168.0.1/32 , [200/0] via 192.168.0.2, 01:02:33
B    192.168.0.3/32 , [200/0] via 192.168.4.1 , 01:02:33
C    192.168.4.0/24 is directly connected ,eth1
```

Display the VRF configuration information.

```
Ruijie# show ip vrf vrf1
VRF vrf1; default RD : 100: 2
Interfaces:
Eth0
Export VPN route-target communities:
RT : 100: 30
No import VPN route-target community
No import route-map
```

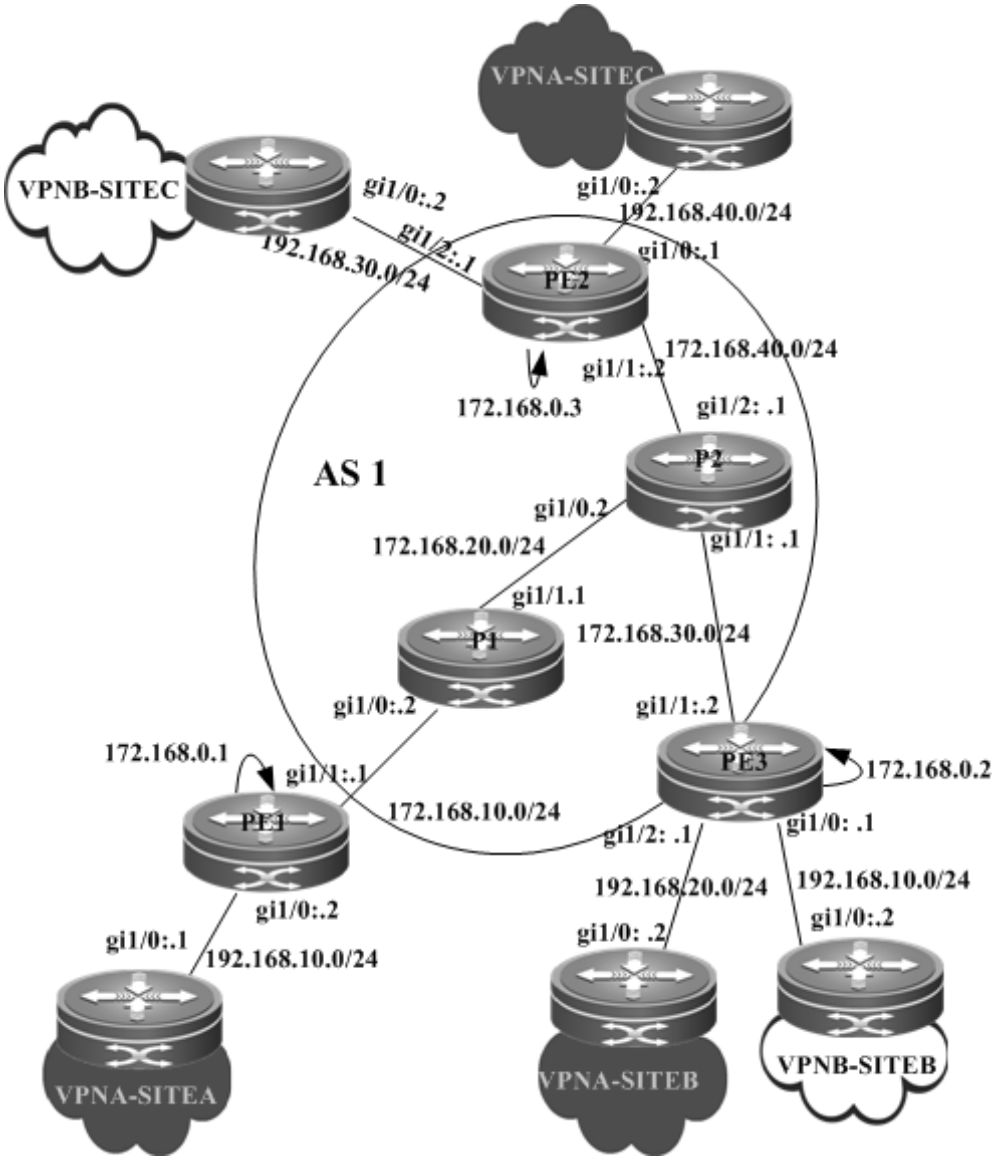
BGP/MPLS IP VPN Configuration Examples

Intranet Configuration Example

Networking Requirements

There are two VPN users: VPNA and VPNB. VPNA has sites at SITEA, SITEB, and SITEC and VPNB has sites at SITEB and SITEC. It is now required that: the users at different sites of VPNA access each other, the users at different sites of VPNB access each other, and the users at the two VPNs not access each other, as shown in the following figure.

Figure 29



Configuration Steps

PE1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 172.168.0.1 255.255.255.255
```

Configure the VRF.

Create one VRF instance: VPNA. Set the RD and RT values, and associate the VRF with the corresponding interface.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf VPNA
Ruijie(config-vrf)# rd 1:100
Ruijie(config-vrf)# route-target both 1:100
Ruijie(config-vrf)# end
```

Associate the VRF with an interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/0
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/0)# ip ref
Ruijie(config-if-GigabitEthernet 1/0)#ip vrf forwarding VPNA
Ruijie(config-if-GigabitEthernet 1/0)#ip address 192.168.10.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/0)# end
```

Enable BGP and set up MP-IBGP sessions with PE2 and PE3.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 172.168.0.2 remote-as 1
Ruijie(config-router)# neighbor 172.168.0.2 update-source loopback 0
Ruijie(config-router)# neighbor 172.168.0.3 remote-as 1
Ruijie(config-router)# neighbor 172.168.0.3 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 172.168.0.2 activate
Ruijie(config-router-af)# neighbor 172.168.0.3 activate
Ruijie(config-router-af)# end
```

Configure CE neighbors through EBGP.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config)# address-family ipv4 vrf VPNA
Ruijie(config-router-af)# neighbor 172.168.10.1 remote-as 65002
Ruijie(config-router-af)# end
```

Configure the MPLS signaling protocol on the backbone network and enable MPLS on the public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# ip address 172.168.10.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/1)# end
```

Configure a routing protocol on the backbone network.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 172.168.10.0 0.0.0.255 area 0
Ruijie(config-router)# network 172.168.0.1 0.0.0.0 area 0
Ruijie(config-router)# end
```

PE2:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 172.168.0.3 255.255.255.255
```

Configure the VRF.

Create two VRFs: VPNA and VPNB. Set the RD and RT values, and associate the VRFs with corresponding interfaces.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf VPNA
Ruijie(config-vrf)# rd 1:100
Ruijie(config-vrf)# route-target both 1:100
Ruijie(config-vrf)# exit
Ruijie(config)# ip vrf VPNB
Ruijie(config-vrf)# rd 1:200
Ruijie(config-vrf)# route-target both 1:200
Ruijie(config-vrf)# exit
```

Associate the VRF with an interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/0
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/0)# ip ref
Ruijie(config-if-GigabitEthernet 1/0)# ip vrf forwarding VPNB
Ruijie(config-if-GigabitEthernet 1/0)# ip address 192.168.10.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/0)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)#ip vrf forwarding VPNA
Ruijie(config-if-GigabitEthernet 1/1)#ip address 192.168.20.1
255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# exit
```

Enable BGP and set up MP-IBGP sessions with PE2 and PE3.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 172.168.0.1 remote-as 1
Ruijie(config-router)# neighbor 172.168.0.1 update-source loopback 0
Ruijie(config-router)# neighbor 172.168.0.3 remote-as 1
Ruijie(config-router)# neighbor 172.168.0.3 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 172.168.0.1 activate
Ruijie(config-router-af)# neighbor 172.168.0.3 activate
Ruijie(config-router-af)# end
```

Configure CE neighbors through EBGP.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config)# address-family ipv4 vrf VPNA
Ruijie(config-router-af)# neighbor 172.168.20.2 remote-as 65003
Ruijie(config-router-af)# exit
Ruijie(config)# address-family ipv4 vrf VPNB
Ruijie(config-router-af)# neighbor 172.168.10.2 remote-as 65004
Ruijie(config-router-af)# end
```

Configure the MPLS signaling protocol on the backbone network and enable MPLS on the public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# ip address 172.168.30.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/1)# end
```

Configure a routing protocol on the backbone network.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 172.168.30.0 255.255.255.0 area 0
Ruijie(config-router)# network 172.168.0.2 255.255.255.255 area 0
Ruijie(config-router)# end
```

PE3:

The configuration procedure is similar to that of PE2.

VPNA-SITEA:

Set up an EBGP session with PE1.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 65002
Ruijie(config-router)# neighbor 172.168.10.2 remote-as 1
Ruijie(config-router-af)# end
```

VPNA-SITEB:

The configuration procedure is similar to that of VPNA-SITEA.

VPNA-SITEC:

The configuration procedure is similar to that of VPNA-SITEA.

VPNB-SITEB:

The configuration procedure is similar to that of VPNA-SITEA.

VPNB-SITEC:

The configuration procedure is similar to that of VPNA-SITEA.

P1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 172.168.0.5 255.255.255.255
```

Configure the MPLS signaling protocol on the backbone network and enable MPLS on the public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
```

```
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/0
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/0)# ip ref
Ruijie(config-if-GigabitEthernet 1/0)# ip address 172.168.10.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/0)# label-switching
Ruijie(config-if-GigabitEthernet 1/0)# mpls ip
Ruijie(config-if-GigabitEthernet 1/0)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# ip address 172.168.20.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/0)# end
```

Configure a routing protocol on the backbone network.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 172.168.10.0 0.0.0.255 area 0
Ruijie(config-router)# network 172.168.20.0 0.0.0.255 area 0
Ruijie(config-router)# end
```

P2:

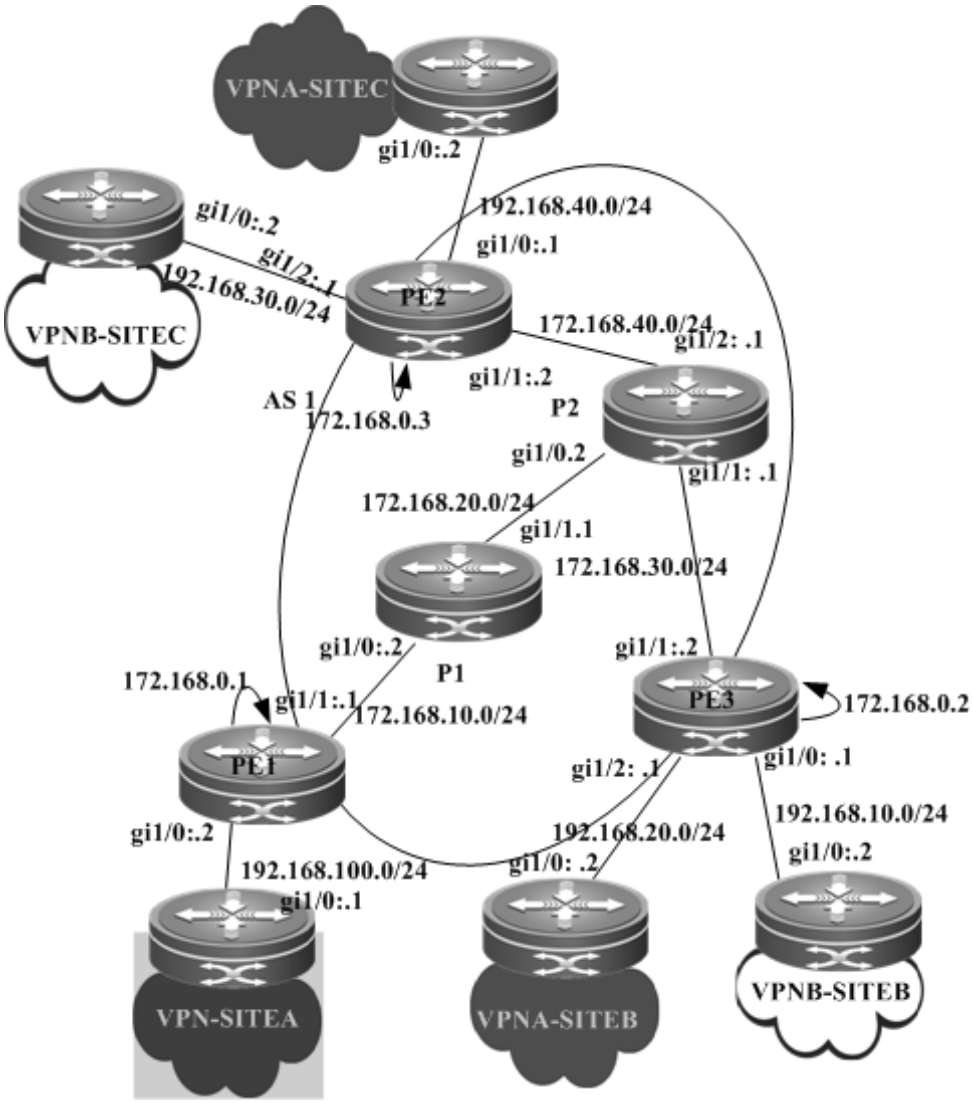
The configuration procedure is similar to that of P1.

Extranet Configuration Example

Networking Requirements

There are two VPN users: VPNA and VPNB. Mutual access is required in a VPN. The two VPNs cannot access each other but can access some shared resources. As shown in the following figure, VPNA and VPNB sites should access the resources of VPN-SITEA.

Figure 30



Configuration Steps

PE1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 172.168.0.1 255.255.255.255
```

Configure the VRF.

Create one VRF instance: VPN_EXTRA. Set the RD and RT values, and associate the VRF with the corresponding interface.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf VPN_EXTRA
Ruijie(config-vrf)# rd 1:100
Ruijie(config-vrf)# route-target both 1:100
Ruijie(config-vrf)# route-target both 1:200
```

```
Ruijie(config-vrf)# end
```

Associate the VRF with an interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/0
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/0)# ip ref
Ruijie(config-if-GigabitEthernet 1/0)# ip vrf forwarding VPN_EXTRA
Ruijie(config-if-GigabitEthernet 1/0)# ip address 192.168.100.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/0)# end
```

Enable BGP and set up MP-IBGP sessions with PE2 and PE3.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 172.168.0.2 remote-as 1
Ruijie(config-router)# neighbor 172.168.0.2 update-source loopback 0
Ruijie(config-router)# neighbor 172.168.0.3 remote-as 1
Ruijie(config-router)# neighbor 172.168.0.3 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 172.168.0.2 activate
Ruijie(config-router-af)# neighbor 172.168.0.3 activate
Ruijie(config-router-af)# end
```

Enable OSPF to exchange routes with a CE.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10 vrf VPN_EXTRA
Ruijie(config-router)# network 192.168.100.0 255.255.255.0 area 0
Ruijie(config-router)# redistribute bgp subnets
Ruijie(config-router)# exit
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf VPN_EXTRA
Ruijie(config-router-af)# redistribute ospf 10
Ruijie(config-router-af)# end
```

Configure the MPLS signaling protocol on the backbone network and enable MPLS on the public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# ip address 172.168.10.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/1)# end
```

Configure a routing protocol on the backbone network.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 172.168.10.0 0.0.0.255 area 0
Ruijie(config-router)# network 172.168.0.1 0.0.0.0 area 0
Ruijie(config-router)# end
```

PE2:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 172.168.0.3 255.255.255.255
```

Configure the VRF.

Create two VRF instances: VPNA and VPNB. Set the RD and RT values, and associate the VRFs with corresponding interfaces.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf VPNA
Ruijie(config-vrf)# rd 1:100
Ruijie(config-vrf)# route-target both 1:100
Ruijie(config-vrf)# exit
Ruijie(config)# ip vrf VPNB
Ruijie(config-vrf)# rd 1:200
Ruijie(config-vrf)# route-target both 1:200
Ruijie(config-vrf)# exit
```

Associate the VRF with an interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/0
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/0)# ip ref
Ruijie(config-if-GigabitEthernet 1/0)# ip vrf forwarding VPNB
Ruijie(config-if-GigabitEthernet 1/0)# ip address 192.168.10.1
255.255.255.0
Ruijie(config-if-GigabitEthernet 1/0)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# ip vrf forwarding VPNA
Ruijie(config-if-GigabitEthernet 1/1)# ip address 192.168.20.1
255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# exit
```

Enable BGP and set up MP-IBGP sessions with PE2 and PE3.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 172.168.0.1 remote-as 1
Ruijie(config-router)# neighbor 172.168.0.1 update-source loopback 0
Ruijie(config-router)# neighbor 172.168.0.3 remote-as 1
Ruijie(config-router)# neighbor 172.168.0.3 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 172.168.0.1 activate
Ruijie(config-router-af)# neighbor 172.168.0.3 activate
Ruijie(config-router-af)# end
```

Enable OSPF to exchange VPN routes with a CE.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10 vrf VPNA
Ruijie(config-router)# network 192.168.20.0 255.255.255.0 area 0
Ruijie(config-router)# redistribute bgp subnets
Ruijie(config-router)# exit
Ruijie(config)# router ospf 20 vrf VPNB
Ruijie(config-router)# network 192.168.10.0 255.255.255.0 area 0
Ruijie(config-router)# redistribute bgp subnets
Ruijie(config-router)# exit
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf VPNA
Ruijie(config-router-af)# redistribute ospf 10
Ruijie(config-router-af)# exit
```

```
Ruijie(config-router)# address-family ipv4 vrf VPNB
Ruijie(config-router-af)# redistribute ospf 20
Ruijie(config-router-af)# exit
```

Configure the MPLS signaling protocol on the backbone network and enable MPLS on the public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# ip address 172.168.30.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/1)# end
```

Configure a routing protocol on the backbone network.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 172.168.30.0 0.0.0.255 area 0
Ruijie(config-router)# network 172.168.0.2 0.0.0.0 area 0
Ruijie(config-router)# end
```

PE3:

The configuration procedure is similar to that of PE2.

VPNA-SITEA:

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 192.168.100.0 255.255.255.0 area 0
Ruijie(config-router)# end
```

VPNA-SITEB:

The configuration procedure is similar to that of VPNA-SITEA.

VPNA-SITEC:

The configuration procedure is similar to that of VPNA-SITEA.

VPNB-SITEB:

The configuration procedure is similar to that of VPNA-SITEA.

VPNB-SITEC:

The configuration procedure is similar to that of VPNA-SITEA.

P1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 172.168.0.5 255.255.255.255
```

Configure the MPLS signaling protocol on the backbone network and enable MPLS on the public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/0
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/0)# ip ref
Ruijie(config-if-GigabitEthernet 1/0)# ip address 172.168.10.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/0)# label-switching
Ruijie(config-if-GigabitEthernet 1/0)# mpls ip
Ruijie(config-if-GigabitEthernet 1/0)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# ip address 172.168.20.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/0)# end
```

Configure a routing protocol on the backbone network.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 1
```

```
Ruijie(config-router)# network 172.168.10.0 0.0.0.255 area 0
Ruijie(config-router)# network 172.168.20.0 0.0.0.255 area 0
Ruijie(config-router)# end
```

P2:

The configuration procedure is similar to that of P1.

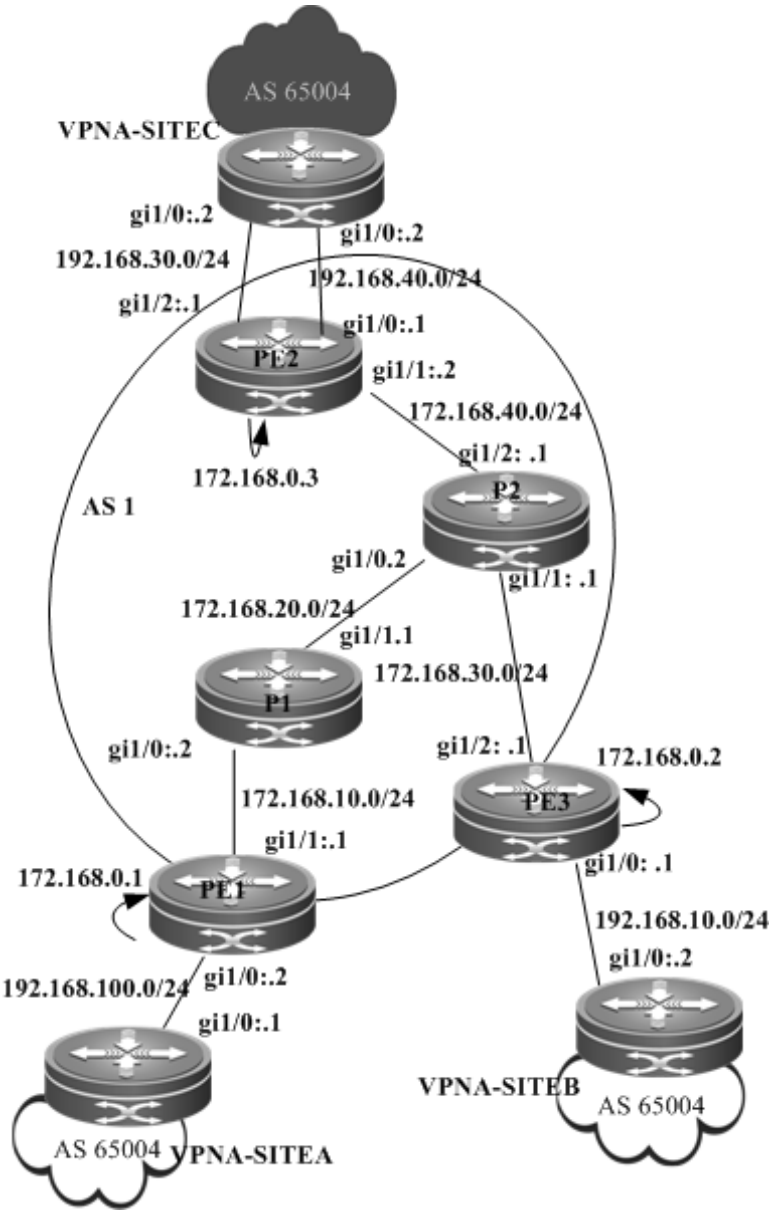
For the protocol between PEs and CEs, you can choose EBGP, OSPF, RIP, or other routing protocol as required.

Hub-and-Spoke Configuration Example

Networking Requirements

The VPN internal data should not be directly exchanged. Instead, the data must be exchanged through the unified control center. Only the control center is entitled to access all resources of a VPN. Any VPN users who want to obtain the VPN resources, must be notified through the control center. As shown in the following figure, to access VPNA-SITEB resources, VPNA-SITEA must pass the control center VPNA-SITEC. Direct access is not available.

Figure 31



Configuration Steps

PE1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 172.168.0.1 255.255.255.255
```

Configure the VRF.

Create one VRF instance: spoke1. Set the RD and RT values, and associate the VPNA with the corresponding interface.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf spoke1
Ruijie(config-vrf)# rd 1:100
Ruijie(config-vrf)# route-target export 1:200
```

```
Ruijie(config-vrf)# route-target import 1:100
Ruijie(config-vrf)# end
```

Associate the VRF with an interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/0
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/0)# ip ref
Ruijie(config-if-GigabitEthernet 1/0)# ip vrf forwarding spoke1
Ruijie(config-if-GigabitEthernet 1/0)# ip address 192.168.100.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/0)# end
```

Enable BGP and set up MP-IBGP sessions with PE3.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 172.168.0.3 remote-as 1
Ruijie(config-router)# neighbor 172.168.0.3 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 172.168.0.3 activate
Ruijie(config-router-af)# neighbor 172.168.0.3 allowas-in
Ruijie(config-router-af)# end
```

Configure CE neighbors through EBGP.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config)# address-family ipv4 vrf spoke1
Ruijie(config-router-af)# neighbor 192.168.100.1 remote-as 65004
Ruijie(config-router-af)# neighbor 192.168.100.1 as-override
Ruijie(config-router-af)# end
```

Configure the MPLS signaling protocol on the backbone network and enable MPLS on the public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
Ruijie(config-if-GigabitEthernet 1/1)# ip address 172.168.10.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/1)# end
```

Configure a routing protocol on the backbone network.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 172.168.10.0 0.0.0.255 area 0
Ruijie(config-router)# network 172.168.0.1 0.0.0.0 area 0
Ruijie(config-router)# end
```

PE2:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 172.168.0.3 255.255.255.255
```

Configure the VRF.

Create one VRF instance: spoke2. Set the RD and RT values, and associate the VRF with the corresponding interface.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf spoke2
Ruijie(config-vrf)# rd 1:100
Ruijie(config-vrf)# route-target export 1:300
Ruijie(config-vrf)# route-target import 1:100
Ruijie(config-vrf)# exit
```

Associate the VRF with an interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/0
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
Ruijie(config-if-GigabitEthernet 1/0)# ip vrf forwarding spoke2
Ruijie(config-if-GigabitEthernet 1/0)# ip address 192.168.10.1
255.255.255.0
Ruijie(config-if-GigabitEthernet 1/0)# exit
```

Enable BGP and set up MP-IBGP sessions with PE3.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 172.168.0.3 remote-as 1
Ruijie(config-router)# neighbor 172.168.0.3 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 172.168.0.3 activate
Ruijie(config-router-af)# neighbor 172.168.0.3 allowas-in
Ruijie(config-router-af)# end
```

Configure CE neighbors through EBGP.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf spoke2
Ruijie(config-router-af)# neighbor 192.168.10.2 remote-as 65004
Ruijie(config-router-af)# neighbor 192.168.10.2 as-override
Ruijie(config-router-af)# end
```

Configure the MPLS signaling protocol on the backbone network and enable MPLS on the public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
Ruijie(config-if-GigabitEthernet 1/1)# ip address 172.168.30.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/1)# end
```

Configure a routing protocol on the backbone network.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 172.168.30.0 0.0.0.255 area 0
Ruijie(config-router)# network 172.168.0.2 0.0.0.0 area 0
Ruijie(config-router)# end
```

PE3:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 172.168.0.2 255.255.255.255
```

Configure the VRF.

Create two VRF instances: from-spoke and from-hub. Set the RD and RT values, and associate the VRFs with corresponding interfaces.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf from-spoke
Ruijie(config-vrf)# rd 1:100
Ruijie(config-vrf)# route-target import 1:300
Ruijie(config-vrf)# route-target import 1:200
Ruijie(config-vrf)# exit
Ruijie(config)# ip vrf from-hub
Ruijie(config-vrf)# rd 1:200
Ruijie(config-vrf)# route-target export 1:100
Ruijie(config-vrf)# exit
```

Associate the VRF with an interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/0
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
Ruijie(config-if-GigabitEthernet 1/0)# ip vrf forwarding from-hub
Ruijie(config-if-GigabitEthernet 1/0)# ip address 192.168.40.1
255.255.255.0
Ruijie(config-if-GigabitEthernet 1/0)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
Ruijie(config-if-GigabitEthernet 1/1)# ip vrf forwarding from-spoke
Ruijie(config-if-GigabitEthernet 1/1)# ip address 192.168.30.1
255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# exit
```

Enable BGP and set up MP-IBGP sessions with PE1 and PE2.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 172.168.0.1 remote-as 1
Ruijie(config-router)# neighbor 172.168.0.1 update-source loopback 0
Ruijie(config-router)# neighbor 172.168.0.2 remote-as 1
Ruijie(config-router)# neighbor 172.168.0.2 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 172.168.0.3 activate
Ruijie(config-router-af)# neighbor 172.168.0.2 activate
Ruijie(config-router-af)# end
```

Configure CE neighbors through EBGP.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf from-spoke
Ruijie(config-router-af)# neighbor 192.168.30.2 remote-as 65004
Ruijie(config-router-af)# neighbor 192.168.30.2 as-override
Ruijie(config-router-af)# exit
Ruijie(config-router)# address-family ipv4 vrf from-hub
Ruijie(config-router-af)# neighbor 192.168.40.2 remote-as 65004
Ruijie(config-router-af)# neighbor 192.168.40.2 allows-in
Ruijie(config-router-af)# exit
```

Configure the MPLS signaling protocol on the backbone network and enable MPLS on the public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

Enable MPLS fast forwarding on a router. This command is unnecessary on a switch.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
Ruijie(config-if-GigabitEthernet 1/1)# ip address 172.168.30.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/1)# end
```

Configure a routing protocol on the backbone network.

```
Ruijie# configure terminal
```

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 172.168.30.0 0.0.0.255 area 0
Ruijie(config-router)# network 172.168.0.2 0.0.0.0 area 0
Ruijie(config-router)# end
```

VPNA-SITEA:

Configure a PE session through EBGP.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 65004
Ruijie(config-router)# neighbor 192.168.100.2 remote-as 1
Ruijie(config-router)# exit
```

The configuration of VPNA-SITEB is similar to that of VPNA-SITEA.

VPNA-SITEC:

Configure a PE session through EBGP.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 65004
Ruijie(config-router)# neighbor 192.168.30.1 remote-as 1
Ruijie(config-router)# neighbor 192.168.40.1 remote-as 1
Ruijie(config-router)# exit
```

Internet Unified Egress Interface Configuration Example

Networking Requirements

Several VPNs cannot access each other, but the VPNs need to access the Internet through a device. As shown in Figure 32 and Figure 33, VPN1 and VPN2 cannot access each other but can access the Internet through PE1.

To isolate VPN1 and VPN2, you can use centralized isolation or distributed isolation. The differences between the above schemes are as follows:

For the centralized isolation, add filtering rules on only a CE egress interface for subsequently added VPN sites to access the Internet through the unified egress interface. Other VPN sites do not need any change of configuration. This scheme features good scalability. The disadvantage of this scheme is that isolated packets can be discarded only when they reach the CE egress interface, which consumes network bandwidth.

For the distributed isolation, add filtering rules on the CE of each VPN site that needs to access the Internet through the unified egress interface. This scheme features poor scalability. The advantage of this scheme is that isolated packets are discarded on the CE of a VPN site, which saves network bandwidth.

Networking Requirements

Several VPNs cannot access each other, but the VPNs need to access the Internet through a device. As shown in Figure 32 and Figure 33, VPN1 and VPN2 cannot access each other but can access the Internet through PE1.

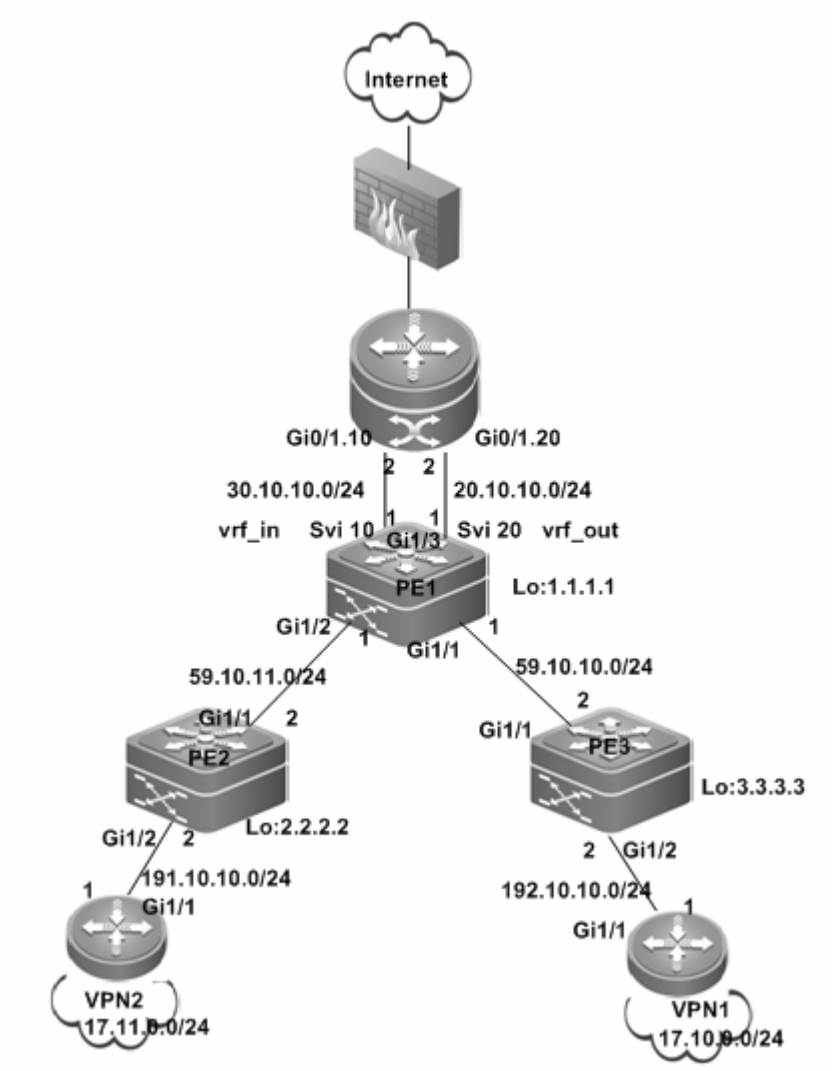
To isolate VPN1 and VPN2, you can use centralized isolation or distributed isolation. The differences between the above schemes are as follows:

For the centralized isolation, add filtering rules on only a CE egress interface for subsequently added VPN sites to access the Internet through the unified egress interface. Other VPN sites do not need any change of configuration. This scheme features good scalability. The disadvantage of this scheme is that isolated packets can be discarded only when they reach the CE egress interface, which consumes network bandwidth.

For the distributed isolation, add filtering rules on the CE of each VPN site that needs to access the Internet through the unified egress interface. This scheme features poor scalability. The advantage of this scheme is that isolated packets are discarded on the CE of a VPN site, which saves network bandwidth.

Centralized Isolation

Figure 32



Configuration Steps

- Configuring PE2

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 2.2.2.2 255.255.255.255
```

Configure the VRF.

Create a VRF, create VPN1, and set the RD and RT values.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf VPN1
Ruijie(config-vrf)# rd 1:100
Ruijie(config-vrf)# route-target both 1:100
Ruijie(config-vrf)# end
```

Associate the VRF with an interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/2
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/2)# no switchport
Ruijie(config-if-GigabitEthernet 1/2)# ip vrf forwarding VPN1
Ruijie(config-if-GigabitEthernet 1/2)# ip address 191.10.10.2
255.255.255.0
Ruijie(config-if-GigabitEthernet 1/2)# end
```

Configure OSPF route exchange with CE2.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10 vrf VPN2
Ruijie(config-router)# network 191.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# default-information originate
Ruijie(config-router)# redistribute bgp subnets
Ruijie(config-router)# exit
```

Establish an IBGP neighbor relation with PE1.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 1
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# end
```

Configure IP route distribution.

```
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf VPN1
Ruijie(config-router-af)# redistribute ospf 10
Ruijie(config-router-af)# end
```

Configure MPLS signaling for the backbone network and enable MPLS on the public network interface.

```
Ruijie# configure terminal
```

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
Ruijie(config-if-GigabitEthernet 1/1)# ip address 59.10.11.2
255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/1)# end
```

Configure a routing protocol on the backbone network.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 59.10.11.0 0.0.0.255 area 0
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# end
```

- Configuring CE2

Configure the IP address of an interface connected to PE2.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
Ruijie(config-if-GigabitEthernet 1/1)# ip address 191.10.10.1 255.255.255.0
```

Configure OSPF route exchange with PE2.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 191.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# network 172.11.0.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

- Configuring PE3

The configuration is similar to the PE2 configuration. Assume that the export and import RT of VPN2 is 1: 200.

- Configuring PE1

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
```

```
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
```

Create the trunk interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/3
Ruijie(config)# switch mode trunk
Ruijie(config)# switch trunk vlan allow remove vlan 1-9,11-19,21-4094
```

Configure the out_vrf as the outgoing interface for accessing the Internet.

Create a VRF, configure the vrf_out, set the RD and RT values, and associate the VRF with the corresponding interface.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf vrf_out
Ruijie(config-vrf)# rd 1:300
Ruijie(config-vrf)# route-target export 1:100
Ruijie(config-vrf)# route-target export 1:200
Ruijie(config-vrf)# end
```

Bind the interface to the VRF.

```
Ruijie# configure terminal
Ruijie(config)#interface vlan 20
Ruijie(config-if-Vlan 20)# ip vrf forwarding vrf_out
Ruijie(config-if-Vlan 20)# ip address 20.10.10.1 255.255.255.0
```

Configure the default route to the Internet.

```
Ruijie# configure terminal
Ruijie(config)# ip route vrf vrf_out 0.0.0.0 0.0.0.0 vlan 20 20.10.10.2
```

Configure in_vrf as the incoming interface of traffic returned from the Internet.

Create a VRF, configure the vrf_in, set the RD and RT values, and associate the VRF with the corresponding interface.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf vrf_in
Ruijie(config-vrf)# rd 1:400
Ruijie(config-vrf)# route-target import 1:100
Ruijie(config-vrf)# route-target import 1:200
Ruijie(config-vrf)# end
```

Bind the interface to the VRF.

```
Ruijie# configure terminal
Ruijie(config)#interface vlan 10
Ruijie(config-if-Vlan 20)# ip vrf forwarding vrf_in
Ruijie(config-if-Vlan 20)# ip address 30.10.10.1 255.255.255.0
```

Configure EBGP route exchange with CE1.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
```

```
Ruijie(config-router)# address-family ipv4 vrf vrf_in
Ruijie(config-router-af)# neighbor 30.10.10.2 remote-as 100
```

Establish IBGP neighbor relations with PE2 and PE3.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 2.2.2.2 remote-as 1
Ruijie(config-router)# neighbor 2.2.2.2 update-source loopback 0
Ruijie(config-router)# neighbor 3.3.3.3 remote-as 1
Ruijie(config-router)# neighbor 3.3.3.3 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 2.2.2.2 activate
Ruijie(config-router-af)# neighbor 3.3.3.3 activate
Ruijie(config-router-af)# end
```

Configure VRF vrf_out route exchange.

```
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf vrf_out
Ruijie(config-router-af)# default-information originate
Ruijie(config-router-af)# redistribute static
Ruijie(config-router-af)# end
```

Configure MPLS signaling for the backbone network and enable MPLS on the public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/2
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/2)# no switchport
Ruijie(config-if-GigabitEthernet 1/2)# ip address 59.10.11.1
255.255.255.0
Ruijie(config-if-GigabitEthernet 1/2)# label-switching
Ruijie(config-if-GigabitEthernet 1/2)# mpls ip
Ruijie(config-if-GigabitEthernet 1/2)# end
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
Ruijie(config-if-GigabitEthernet 1/1)# ip address 59.10.10.1
255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
```

```
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/1)# end
```

Configure a routing protocol on the backbone network.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 59.10.11.0 0.0.0.255 area 0
Ruijie(config-router)# network 59.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# end
```

- Configuring CE1

Create the sub-interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 0/1.10
Ruijie(config-if-Gigabitethernet 0/1.10)# encapsulation dot1q 10
Ruijie(config-if-Gigabitethernet 0/1.10)# ip address 30.10.10.2 255.255.255.0
Ruijie(config)# exit
Ruijie(config)# interface gigabitethernet 0/1.20
Ruijie(config-if-Gigabitethernet 0/1.20)# encapsulation dot1q 20
Ruijie(config-if-Gigabitethernet 0/1.20)# ip address 20.10.10.2 255.255.255.0
```

Establish an EBGP neighbor relation with PE1.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 100
Ruijie(config)# neighbor 30.10.10.1 remote-as 1
```

Create an ACL rule.

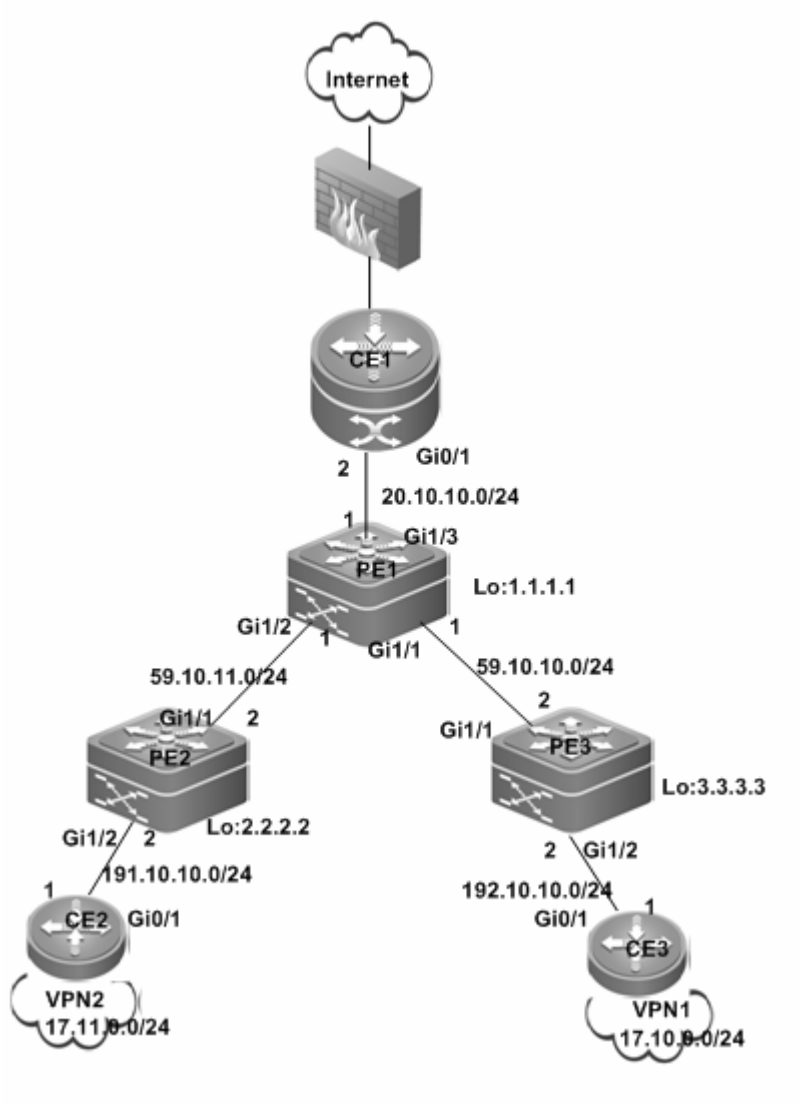
```
Ruijie(config)#access-list 1 deny 17.0.0.0 0.255.255.255
Ruijie(config)# access-list 1 permit any
```

Configure the ACL rule on the sub-interface Gi 0/1.10.

```
Ruijie(config)# interface gigabitethernet 0/1.10
Ruijie(config-if-Gigabitethernet 0/1.10)# ip access-group 1 out
```

Distributed Isolation

Figure 33



- Configuring PE1

Configure the loopback interface.

This configuration is the same as Centralized Isolation.

Configure the VRF.

Create a VRF, create vrf_net, and set the RD and RT values.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf vrf_net
Ruijie(config-vrf)# rd 1:300
Ruijie(config-vrf)# route-target import 1:100
Ruijie(config-vrf)# route-target import 1:200
Ruijie(config-vrf)# route-target export 1:100
Ruijie(config-vrf)# route-target export 1:200
```

Associate the VRF with an interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/3
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/3)# no switchport
Ruijie(config-if-GigabitEthernet 1/3)# ip vrf forwarding vrf_net
Ruijie(config-if-GigabitEthernet 1/3)# ip address 20.10.10.1 255.255.255.0
```

Configure the default route to the Internet.

```
Ruijie(config)#ip route vrf vrf_net 0.0.0.0 0.0.0.0 gigabitethernet 1/3 20.10.10.2
```

Configure EBGP route exchange with CE1.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf vrf_net
Ruijie(config-router-af)# neighbor 20.10.10.2 remote-as 100
```

Establish IBGP neighbor relations with PE2 and PE3.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 2.2.2.2 remote-as 1
Ruijie(config-router)# neighbor 2.2.2.2 update-source loopback 0
Ruijie(config-router)# neighbor 3.3.3.3 remote-as 1
Ruijie(config-router)# neighbor 3.3.3.3 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 2.2.2.2 activate
Ruijie(config-router-af)# neighbor 3.3.3.3 activate
Ruijie(config-router-af)# end
```

Configure VRF vrf_net route exchange.

```
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf vrf_net
Ruijie(config-router-af)# default-information originate
Ruijie(config-router-af)# redistribute static
Ruijie(config-router-af)# end
```

Configure MPLS and routes for the backbone network.

This configuration is the same as Centralized Isolation**错误！未指定书签。**.

- Configuring CE1

```
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)# ip address 20.10.10.2 255.255.255.0
```

Establish an EBGP neighbor relation with PE1.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 20.10.10.1 remote-as 1
```

- Configuring PE2

This configuration is the same as Centralized Isolation**错误！未指定书签。**.

- Configuring CE2

Configure an ACL rule.

```
Ruijie# configure terminal
Ruijie(config)# access-list 2000 deny ip any 17.10.0.0 0.0.255.255
Ruijie(config)# access-list 2000 permit ip any any
```

Apply the ACL rule to the interface.

```
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)# ip access-group 2000 out
```

Configure route exchange with PE2.

This configuration is the same as Centralized Isolation.

Configure the default static route.

This configuration is the same as Centralized Isolation.

Configuring PE3

This configuration is the same as Centralized Isolation.

Configuring CE3

Configure an ACL rule.

```
Ruijie# configure terminal
Ruijie(config)# access-list 2000 deny ip any 17.11.0.0 0.0.255.255
Ruijie(config)# access-list 2000 permit ip any any
```

Apply the ACL rule to the interface.

```
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)# ip access-group 2000 out
```

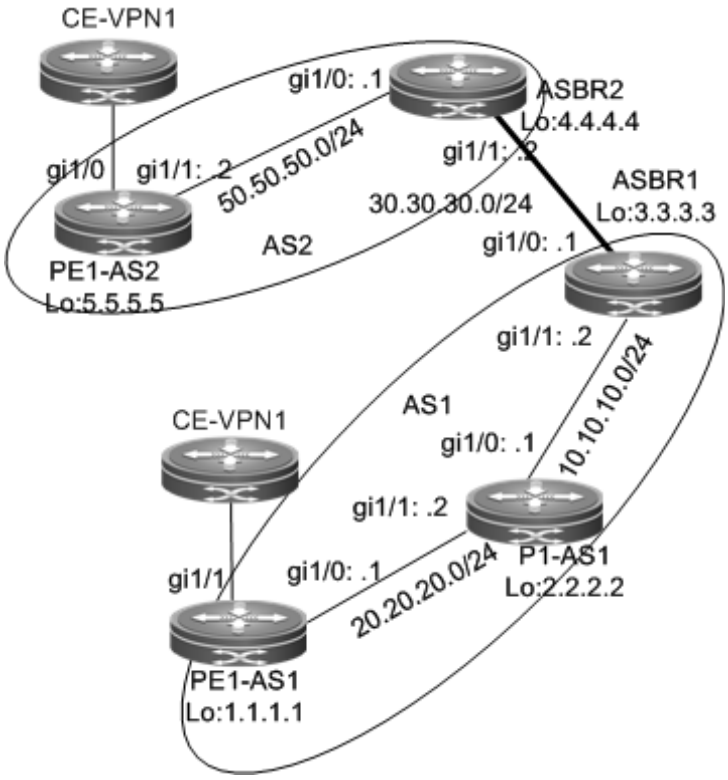
Other configurations are the same as Centralized Isolation.

Inter-AS VPN OptionB: Next Hop Unchanged

Networking Requirements

One VPN user has sites at both ASs. It is required that the VPN sites in different ASs access each other.

Figure 34 OptionB: Next Hop Unchanged



The configuration scheme is as follows:

PE1-AS1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
```

Configure the VRF.

Create one VRF instance: VPN1. Set the RD and RT values, and associate the VRF with the corresponding interface.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf VPN1
Ruijie(config-vrf)# rd 1:100
Ruijie(config-vrf)# route-target both 1:100
Ruijie(config-vrf)# end
```

Associate the VRF with an interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
Ruijie(config-if-GigabitEthernet 1/1)# ip vrf forwarding VPN1
```

```
Ruijie(config-if-GigabitEthernet 1/1)# ip address 192.168.16.2
255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# end
```

Enable BGP and set up MP-IBGP sessions with ASBR1.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 3.3.3.3 remote-as 1
Ruijie(config-router)# neighbor 3.3.3.3 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 3.3.3.3 activate
Ruijie(config-router-af)# end
```

Configure CE neighbors through EBGP.

See the configuration procedure in the "Running BGP Between PEs and CEs to Transmit Route Information" section and the related configurations in the "Intranet Configuration Examples" section.

Configure the MPLS signaling protocol on the backbone network and enable MPLS on the public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/0
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
Ruijie(config-if-GigabitEthernet 1/0)# ip address 20.20.20.1
255.255.255.0
Ruijie(config-if-GigabitEthernet 1/0)# label-switching
Ruijie(config-if-GigabitEthernet 1/0)# mpls ip
Ruijie(config-if-GigabitEthernet 1/0)# end
```

Configure a routing protocol on the backbone network.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# end
```

The configuration procedure of **PE1-AS2** is similar to the preceding one.

P1-AS1:

Configure the loopback interface.

```
Ruijie# configure terminal
```

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 2.2.2.2 255.255.255.255
```

Configure the MPLS signaling protocol on the backbone network and enable MPLS on the public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/0
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
Ruijie(config-if-GigabitEthernet 1/0)# ip address 10.10.10.1
255.255.255.0
Ruijie(config-if-GigabitEthernet 1/0)# label-switching
Ruijie(config-if-GigabitEthernet 1/0)# mpls ip
Ruijie(config-if-GigabitEthernet 1/0)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
Ruijie(config-if-GigabitEthernet 1/1)# ip address 20.20.20.2
255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
```

Configure a routing protocol on the backbone network.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# end
```

ASBR1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 3.3.3.3 255.255.255.255
```

Enable BGP, disable the BGP RT filtering function, and establish neighbor relations with PE1-AS1 and ASBR2.

```
Ruijie# configure terminal
```

```
Ruijie(config)# router bgp 1
Ruijie(config-router)# no bgp default route-target filter
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 1
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruijie(config-router)# neighbor 30.30.30.2 remote-as 2
Ruijie(config-router)# address-family vpnv4 unicast
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# neighbor 30.30.30.2 activate
Ruijie(config-router-af)# end
```

Configure MPLS signaling and enable MPLS on a public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
Ruijie(config-if-gigabitethernet 1/1)# ip address 10.10.10.2
255.255.255.0
Ruijie(config-if-gigabitethernet 1/1)# label-switching
Ruijie(config-if-gigabitethernet 1/1)# mpls ip
Ruijie(config-if-gigabitethernet 1/1)# end
```

Run OSPF on the backbone network to transmit routes and redistribute directly connected subnet routes.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# redisteibute connected subnets
Ruijie(config-router)# end
```

Assign an IP address to the interface connected to ASBR2.

```
Ruijie(config)# interface gigabitethernet 1/0
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
Ruijie(config-if-gigabitethernet 1/0)# ip address 30.30.30.1
255.255.255.0
```

Enable label switching on an interface.

```
Ruijie(config-if-gigabitethernet 1/0)# label-switching
```

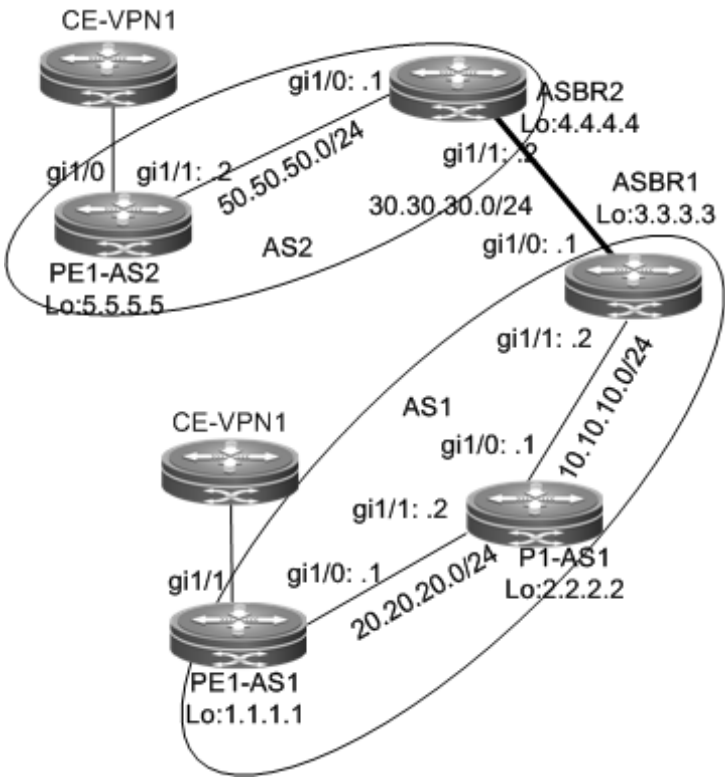
The configuration scheme of ASBR2 is similar to that of ASBR1.

Inter-AS VPN OptionB: Next Hop Changed

Networking Requirements

One VPN user has sites at both ASs. It is required that the VPN sites in different ASs access each other.

Figure 35 OptionB: Next Hop Changed



The configuration scheme is as follows:

PE1-AS1:

The configuration procedure is similar to that of PE1-AS1 in the "Inter-AS VPN OptionB: Next Hop Unchanged" section and is not described here.

P1-AS1:

The configuration procedure is similar to that of P1-AS1 in the "Inter-AS VPN OptionB: Next Hop Unchanged" section and is not described here.

ASBR1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 3.3.3.3 255.255.255.255
```

Enable BGP, disable the BGP RT filtering function, establish neighbor relations with the PE and ASBR, and change the next hop of routes to the neighbor PE into the local address.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# no bgp default route-target filter
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 1
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruijie(config-router)# neighbor 30.30.30.2 remote-as 2
Ruijie(config-router)# address-family vpnv4 unicast
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# neighbor 1.1.1.1 next-hop-self
Ruijie(config-router-af)# neighbor 30.30.30.2 activate
Ruijie(config-router-af)# end
```

Configure MPLS signaling and enable MPLS on a public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-gigabitethernet 1/1)# no switchport
Ruijie(config-if-gigabitethernet 1/1)# ip address 10.10.10.2
255.255.255.0
Ruijie(config-if-gigabitethernet 1/1)# label-switching
Ruijie(config-if-gigabitethernet 1/1)# mpls ip
Ruijie(config-if-gigabitethernet 1/1)# end
```

Run OSPF on the backbone network to transmit route information.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# end
```

Assign an IP address to the interface connected to ASBR2.

```
Ruijie(config)# interface gigabitethernet 1/0
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
Ruijie(config-if-gigabitethernet 1/0)# ip address 30.30.30.1
255.255.255.0
```

Enable label switching on an interface.

```
Ruijie(config-if-gigabitethernet 1/0)# label-switching
```

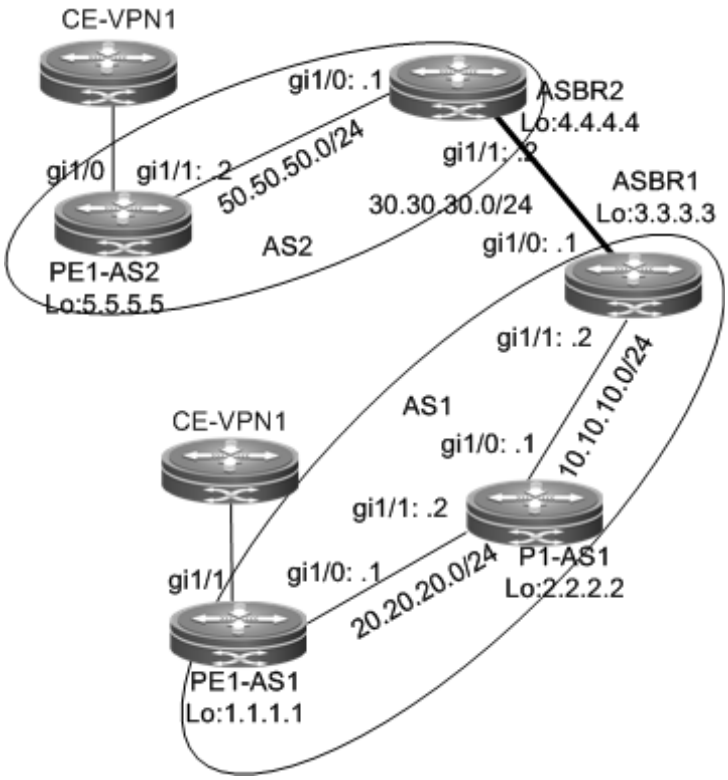
The configuration scheme of ASBR2 is similar to that of ASBR1.

Inter-AS VPN OptionC: Enabling IPv4 Label Switching Between EBGP Neighbors

Networking Requirements

One VPN user has sites at both ASs. It is required that the VPN sites in different ASs access each other.

Figure 36 OptionC: enabling IPv4 label switching between EBGP neighbors



The configuration scheme is as follows:

PE1-AS1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
```

Configure the VRF.

The configuration procedure is similar to that of PE1-AS1 in the "Inter-AS VPN OptionB: Next Hop Unchanged" section and is not described here.

Configure a multi-hop MP-EBGP session and disable IPv4 route exchange for the session.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 5.5.5.5 remote-as 2
```

```
Ruijie(config-router)# neighbor 5.5.5.5 update-source loopback 0
Ruijie(config-router)# neighbor 5.5.5.5 ebgp-multihop
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# no neighbor 5.5.5.5 activate
Ruijie(config-router-af)# exit
Ruijie(config-router)# address-family vpnv4 unicast
Ruijie(config-router-af)# neighbor 5.5.5.5 activate
Ruijie(config-router-af)# end
```

Configure CE neighbors through EBGP.

See the configuration procedure in the "Running BGP Between PEs and CEs to Transmit Route Information" section and the related configurations in the "Intranet Configuration Examples" section.

Configure MPLS signaling and enable MPLS on a public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-gigabitethernet 1/1)# no switchport
Ruijie(config-if-gigabitethernet 1/1)# ip address 20.20.20.1
255.255.255.0
Ruijie(config-if-gigabitethernet 1/1)# label-switching
Ruijie(config-if-gigabitethernet 1/1)# mpls ip
Ruijie(config-if-gigabitethernet 1/1)# end
```

Run OSPF on the backbone network to transmit route information.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# end
```

P1-AS1:

The configuration mainly includes the MPLS signaling protocol and IGP and is not described here. See the P1-AS1 configuration scheme in the "Inter-AS VPN OptionB: Next Hop Unchanged" section.

ASBR1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
```

```
Ruijie(config-if-Loopback 0)# ip address 3.3.3.3 255.255.255.255
```

Configure ACL rules and route map rules to distribute or set labels only for routes that match the rules.

```
Ruijie# configure terminal
Ruijie(config)# ip access-list extended 101
Ruijie(config-ext-nacl)# permit ip host 1.1.1.1 any
uijie(config-ext-nacl)# exit
Ruijie(config)# ip access-list extended 102
Ruijie(config-ext-nacl)# permit ip host 5.5.5.5 any
Ruijie(config-ext-nacl)# exit
Ruijie(config)# route-map set-mpls
Ruijie(config-route-map)# match ip address 101
Ruijie(config-route-map)# set mpls-label
Ruijie(config-route-map)# exit
Ruijie(config)# route-map external-pe-route
Ruijie(config-route-map)# match ip address 102
Ruijie(config-route-map)# end
```

Set up an EBGP session with ASBR2 and configure route map rules to distribute labels for PE routes that match the rules (the route map rules are optional and allow BGP to distribute labels for only certain routes), and configure static routes to PEs in the local AS.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 30.30.30.2 remote-as 2
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 30.30.30.2 send-label
Ruijie(config-router-af)# neighbor 30.30.30.2 route-map set-mpls out
Ruijie(config-router-af)# network 1.1.1.1 mask 255.255.255.255
Ruijie(config-router-af)# end
```

Configure MPLS to distribute label for certain BGP routes through ACL rules (the ACL rules are optional and allow you to reduce the number of unnecessary routes).

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# advertise-labels for bgp-routes acl 102
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-Gigabitethernet 1/1)# no switchport
Ruijie(config-if-Gigabitethernet 1/1)# ip address 10.10.10.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
```

```
Ruijie(config-if-Gigabitethernet 1/1)# end
```

Configure a routing protocol on the backbone network to redistribute only BGP routes that match the route map rules (the route map rules are optional and allow you to reduce the number of unnecessary routes).

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# redisteibute bgp subnets route-map external-pe-route
Ruijie(config-router)# end
```

Assign an IP address to the interface connected to ASBR2.

```
Ruijie(config)# interface gigabitethernet 1/0
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
Ruijie(config-if-gigabitethernet 1/0)# ip address 30.30.30.1
255.255.255.0
```

Enable label switching on an interface.

```
Ruijie(config-if-gigabitethernet 1/0)# label-switching
```

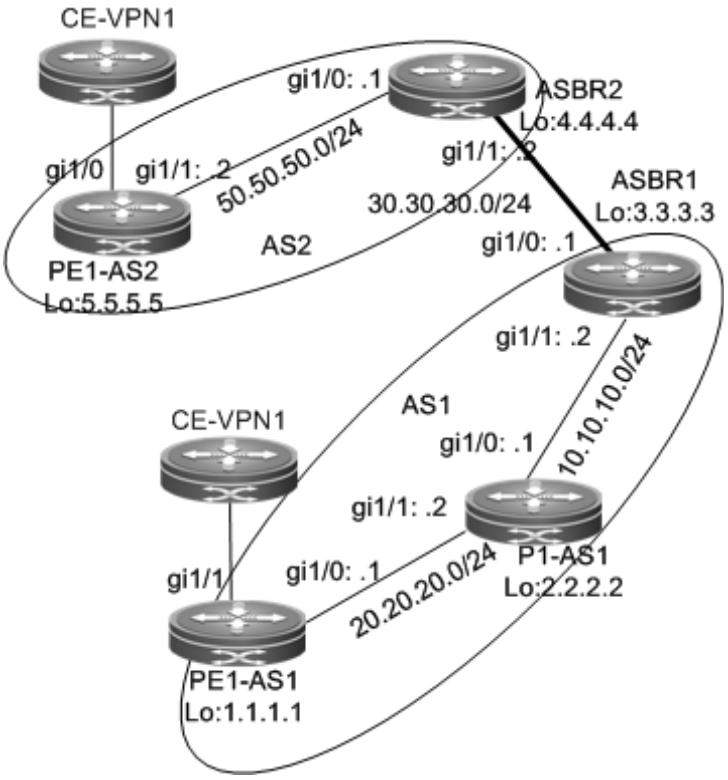
The configuration scheme of ASBR2 is similar to that of ASBR1.

Inter-AS VPN OptionC: Enabling IPv4 Label Switching Between Both EBGP and IBGP Neighbors

Networking Requirements

One VPN user has sites at both ASs. It is required that the VPN sites in different ASs access each other.

Figure 37 OptionC: enabling IPv4 label switching between both EBGP and IBGP neighbors



The configuration scheme is as follows:

PE1-AS1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
```

Configure the VRF.

The configuration procedure is similar to that of PE1-AS1 in the "Inter-AS VPN OptionB: Next Hop Unchanged" section and is not described here.

Configure a multi-hop MP-EBGP session and disable IPv4 route exchange for the session.

The configuration procedure is similar to that of "Inter-AS VPN OptionC: Enabling IPv4 Label Switching Between EBGP Neighbors" and is not described here.

Set up an IBGP session with the ASBR and enable IPv4 label switching.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 3.3.3.3 remote-as 1
Ruijie(config-router)# neighbor 3.3.3.3 update-source loopback 0
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 3.3.3.3 activate
Ruijie(config-router-af)# neighbor 3.3.3.3 send-label
```

```
Ruijie(config-router-af)# end
```

Configure CE neighbors through EBGP.

See the configuration procedure in the "Running BGP Between PEs and CEs to Transmit Route Information" section and the related configurations in the "Intranet Configuration Examples" section.

Configure MPLS signaling and enable MPLS on a public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/0
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-gigabitethernet 1/0)# no switchport
Ruijie(config-if-gigabitethernet 1/0)# ip address 20.20.20.1
255.255.255.0
Ruijie(config-if-gigabitethernet 1/0)# label-switching
Ruijie(config-if-gigabitethernet 1/0)# mpls ip
Ruijie(config-if-gigabitethernet 1/0)# end
```

Run OSPF on the backbone network to transmit route information.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# end
```

The configuration of PE1-AS2 is similar to that of PE1-AS1.

P1-AS1:

The configuration mainly includes the MPLS signaling protocol and IGP and is not described here. It is similar to "Example of Configuring Basic MPLS Functions".

ASBR1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 3.3.3.3 255.255.255.255
```

Configure ACL rules and route map rules to distribute or set labels only for routes that match the rules.

```
Ruijie# configure terminal
Ruijie(config)# ip access-list extended 101
Ruijie(config)# permit ip host 1.1.1.1 any
```

```
Ruijie(config)# exit
Ruijie(config)# ip access-list extended 102
Ruijie(config)# permit ip host 5.5.5.5 any
Ruijie(config)# route-map internal-mpls-route permit 10
Ruijie(config-route-map)# match ip address 101
Ruijie(config-route-map)# set mpls-label
Ruijie(config-route-map)# exit
Ruijie(config)# route-map external-mpls-route permit 10
Ruijie(config-route-map)#  match ip address 102
Ruijie(config-route-map)#  set mpls-label
Ruijie(config-route-map)#  end
```

Set up an EBGP session with the ASBR and configure route map rules to distribute labels for PE routes that match the rules (the route map rules are optional and allow BGP to distribute labels for only certain routes), and configure static routes to PEs in the local AS.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 30.30.30.2 remote-as 2
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 1
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 30.30.30.2 send-label
Ruijie(config-router-af)# neighbor 30.30.30.2 route-map internal-mpls-route out
Ruijie(config-router-af)# neighbor 1.1.1.1 send-label
Ruijie(config-router-af)# neighbor 1.1.1.1 route-map external-mpls-route out
Ruijie(config-router-af)#  network 1.1.1.1 mask 255.255.255.255
Ruijie(config-router-af)# end
```

Configure MPLS signaling and enable MPLS on an interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-Gigabitethernet 1/1)# no switchport
Ruijie(config-if-Gigabitethernet 1/1)# ip address 10.10.10.2
255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
Ruijie(config-if-Gigabitethernet 1/1)# end
```

Run OSPF on the backbone network to transmit route information.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 10.10.10.0 255.255.255.0 area 0
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# end
```

Assign an IP address to the interface connected to ASBR2.

```
Ruijie(config)# interface gigabitethernet 1/0
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
Ruijie(config-if-gigabitethernet 1/0)# ip address 30.30.30.1
255.255.255.0
```

Enable label switching on an interface.

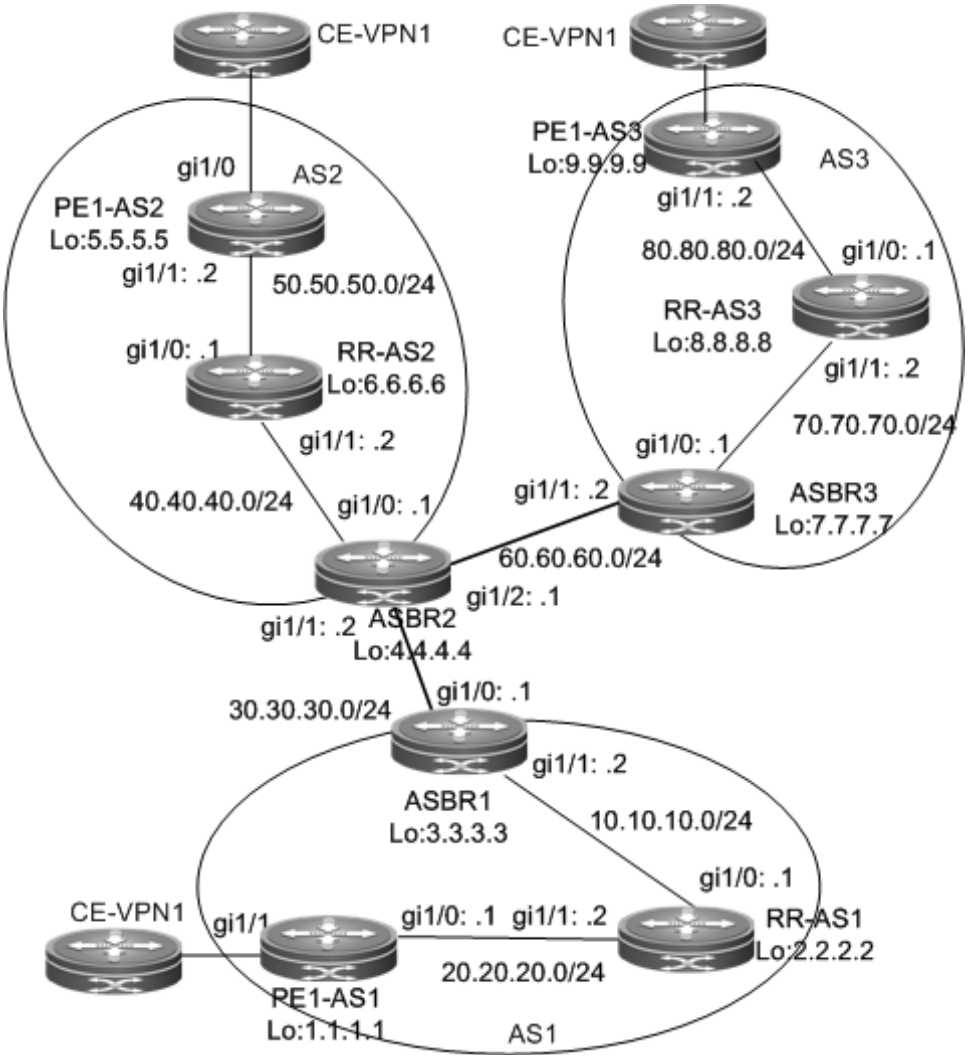
```
Ruijie(config-if-gigabitethernet 1/0)# label-switching
```

The configuration scheme of ASBR2 is similar to that of ASBR1.

Inter-AS VPN OptionC: RR Networking Scheme

In the two implementation modes of OptionC, another problem exists. If the sites of the same VPN user are located at different ASs, a common OptionC scheme requires full mesh BGP connections for the inter-AS PEs to ensure the reachability of the VPN sites. As shown in the following figure, the sites of the VPN user are located at three different ASs. If a new VPN site is added, the new site needs to set up BGP connections with the other VPN sites. This restricts the application of the common OptionC scheme. To solve the preceding expansion problem, you can add an RR to each AS in the OptionC scheme. The RRs set up multi-hop MP-EBGP connections to exchange inter-AS VPN routes. At the same time, you can set up MP-IBGP sessions between PEs and the RR in the AS.

Figure 38 Setting up multi-hop MP-EBGP sessions between RRs in the OptionC scheme



The configuration scheme is as follows:

PE1-AS1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
```

Configure the VRF.

The configuration procedure is similar to that of PE1-AS1 in the "Inter-AS VPN OptionB: Next Hop Unchanged" section and is not described here.

Set up an MP-IBGP session with the RR and enable label distribution for IPv4 routes.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 2.2.2.2 remote-as 1
Ruijie(config-router)# neighbor 2.2.2.2 update-source loopback 0
```

```
Ruijie(config-router)# address-family vpnv4 unicast
Ruijie(config-router-af)# neighbor 2.2.2.2 activate
Ruijie(config-router-af)# exit
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 2.2.2.2 activate
Ruijie(config-router-af)# neighbor 2.2.2.2 send-label
Ruijie(config-router-af)# end
```

Configure CE neighbors through EBGP.

See the configuration procedure in the "Running BGP Between PEs and CEs to Transmit Route Information" section and the related configurations in the "Intranet Configuration Examples" section.

The configurations of PE1-AS2 and PE1-AS3 are similar to that of PE1-AS1.

RR-AS1

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 2.2.2.2 255.255.255.255
```

Set up an MP-IBGP session with the PE, specify the PE as the RR client, and enable label distribution for IPv4 routes.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 1
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruijie(config-router)# address-family vpnv4 unicast
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# neighbor 1.1.1.1 route-reflector-client
Ruijie(config-router-af)# exit
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# neighbor 1.1.1.1 send-label
Ruijie(config-router-af)# neighbor 1.1.1.1 route-reflector-client
Ruijie(config-router-af)# end
```

Set up a multi-hop MP-EBGP session with the RR, do not change the next hop of VPN routes exchanged with the RR, and disable the IPv4 route exchange with the RR.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 6.6.6.6 remote-as 2
Ruijie(config-router)# neighbor 6.6.6.6 update-source loopback 0
Ruijie(config-router)# neighbor 6.6.6.6 ebgp-multihop
Ruijie(config-router)# neighbor 8.8.8.8 remote-as 3
Ruijie(config-router)# neighbor 8.8.8.8 update-source loopback 0
Ruijie(config-router)# neighbor 8.8.8.8 ebgp-multihop
Ruijie(config-router)# address-family ipv4
```

```
Ruijie(config-router-af)# no neighbor 6.6.6.6 activate
Ruijie(config-router-af)# no neighbor 8.8.8.8 activate
Ruijie(config-router-af)# exit-address-family
Ruijie(config-router)# address-family vpnv4 unicast
Ruijie(config-router-af)# neighbor 6.6.6.6 activate
Ruijie(config-router-af)# neighbor 6.6.6.6 next-hop-unchanged
Ruijie(config-router-af)# neighbor 8.8.8.8 activate
Ruijie(config-router-af)# neighbor 8.8.8.8 next-hop-unchanged
Ruijie(config-router-af)# end
```

Set up an IBGP session with the ASBR and enable IPv4 label switching.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 3.3.3.3 remote-as 1
Ruijie(config-router)# neighbor 3.3.3.3 update-source loopback 0
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 3.3.3.3 activate
Ruijie(config-router-af)# neighbor 3.3.3.3 send-label
Ruijie(config-router-af)# end
```

Configure MPLS.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-gigabitethernet 1/1)# no switchport
Ruijie(config-if-gigabitethernet 1/1)# ip address 20.20.20.2
255.255.255.0
Ruijie(config-if-gigabitethernet 1/1)# label-switching
Ruijie(config-if-gigabitethernet 1/1)# mpls ip
Ruijie(config-if-gigabitethernet 1/1)# exit
Ruijie(config)# interface gigabitethernet 1/0
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-gigabitethernet 1/0)# no switchport
Ruijie(config-if-gigabitethernet 1/0)# ip address 10.10.10.1
255.255.255.0
Ruijie(config-if-gigabitethernet 1/0)# label-switching
Ruijie(config-if-gigabitethernet 1/0)# mpls ip
Ruijie(config-if-gigabitethernet 1/0)# end
```

Run OSPF on the backbone network to transmit route information.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# end
```

The procedures of RR-AS2 and RR-AS3 are similar to the preceding procedure.

ASBR1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 3.3.3.3 255.255.255.255
```

Configure ACL rules and route map rules.

```
Ruijie# configure terminal
Ruijie(config)# ip access-list extended 101
Ruijie(config-ext-nacl)# permit ip host 1.1.1.1 any
Ruijie(config-ext-nacl)# exit
Ruijie(config)# ip access-list extended 102
Ruijie(config-ext-nacl)# permit ip host 5.5.5.5 any
Ruijie(config-ext-nacl)# permit ip host 9.9.9.9 any
Ruijie(config-ext-nacl)# exit
Ruijie(config)# route-map internal-mpls-route permit 10
Ruijie(config-route-map)# match ip address 101
Ruijie(config-route-map)# set mpls-label
Ruijie(config-route-map)# exit
Ruijie(config)# route-map external-mpls-route permit 10
Ruijie(config-route-map)# match ip address 102
Ruijie(config-route-map)# set mpls-label
Ruijie(config-route-map)# end
```

Set up an EBGP session with the ASBR, enable label distribution for IPv4 routes, and configure route map rules to distribute labels for PE routes that match the rules (the route map rules are optional and allow the BGP to distribute labels for only certain routes). Set up an IBGP session with the RR, enable label distribution for IPv4 routes, and configure route map rules to distribute labels for inter-AS PE routes that match the rules. Configure static routes to the PEs in the local AS.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 30.30.30.2 remote-as 2
Ruijie(config-router)# neighbor 2.2.2.2 remote-as 1
Ruijie(config-router)# neighbor 2.2.2.2 update-source loopback 0
Ruijie(config-router)# address-family ipv4
```

```
Ruijie(config-router-af)# neighbor 30.30.30.2 send-label
Ruijie(config-router-af)# neighbor 30.30.30.2 route-map internal-mpls-route out
Ruijie(config-router-af)# neighbor 2.2.2.2 send-label
Ruijie(config-router-af)# neighbor 2.2.2.2 route-map external-mpls-route out
Ruijie(config-router-af)# network 1.1.1.1 mask 255.255.255.255
Ruijie(config-router-af)# end
```

Configure MPLS signaling and enable MPLS on an interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-Gigabitethernet 1/1)# no switchport
Ruijie(config-if-Gigabitethernet 1/1)#ip address 10.10.10.2
255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
Ruijie(config-if-Gigabitethernet 1/1)# end
```

Run OSPF on the backbone network to transmit route information.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# end
```

Assign an IP address to the interface connected to ASBR2.

```
Ruijie(config)# interface gigabitethernet 1/0
```

Use the **no switchport** command to switch the port mode on the switch series to the Routed Port mode. This command is not applicable to routers.

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
Ruijie(config-if-gigabitethernet 1/0)# ip address 30.30.30.1
255.255.255.0
```

Enable label switching on an interface.

```
Ruijie(config-if-gigabitethernet 1/0)# label-switching
```

The configuration schemes of ASBR2 and ASBR3 are similar to that of ASBR1.

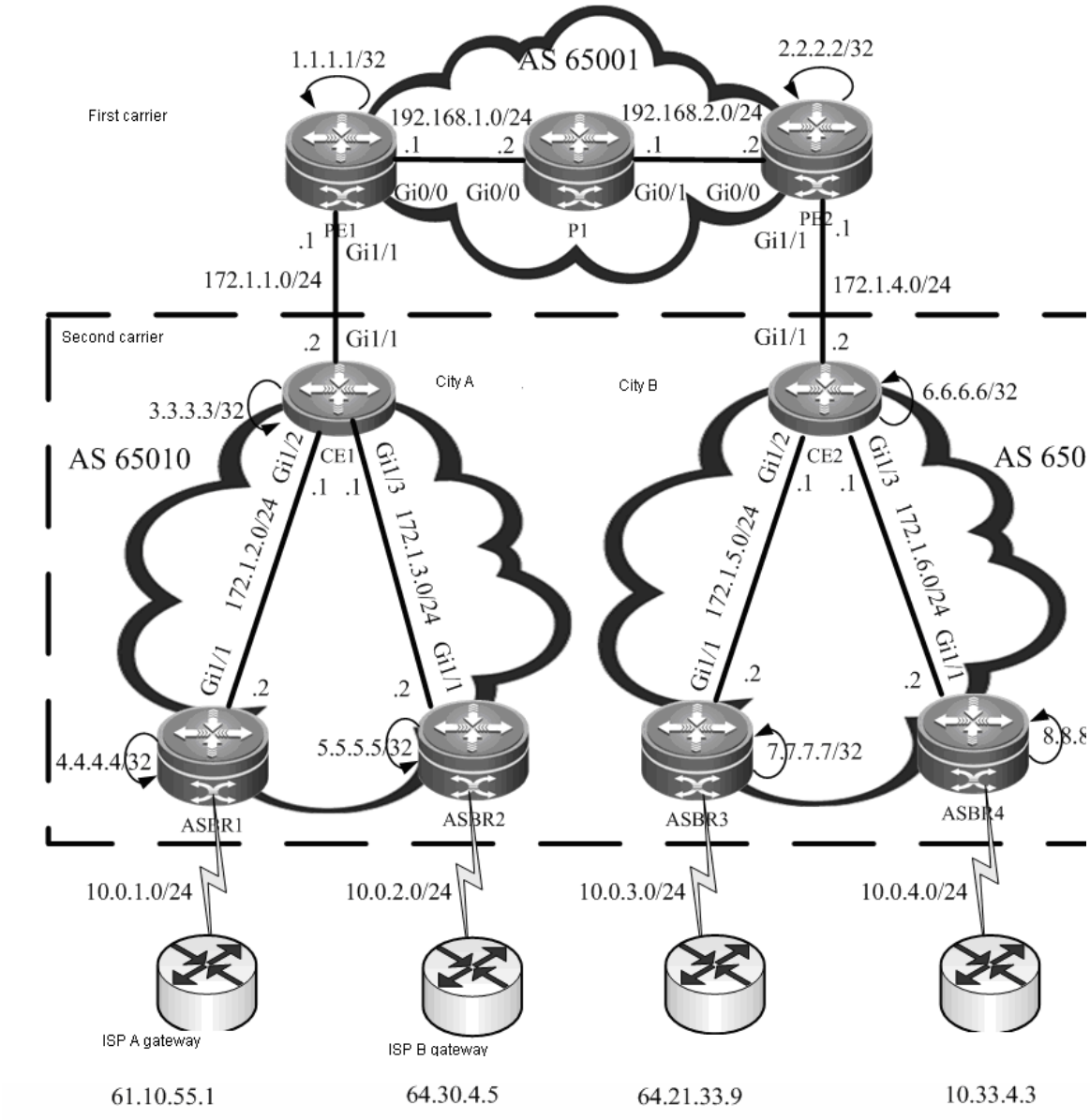
CSC: The Second Carrier Provides Internet Services Based on IP Core

Networking Requirements

A carrier owns an intranet in City A, and this network has the BGP gateways to ISP A and ISP B. This carrier utilizes its intranet to provide Internet services for users in City A. Currently, this carrier expects to expand services to City B, and therefore leases MPLS VPN services from a VPN carrier in the hope of connecting the sites of two cities via VPN, so that users in City B can access the Internet through the existing Internet gateways. The internal routes are exchanged via IGP (OSPF), and the external routes are exchanged via BGP.

Networking Topology

Figure 39 Network topology of scenario I



Configuration Tips

- Configuring basic BGP/MPLS IP VPN functions for the first carrier
- Enabling the CSC function
- Configuring the second carrier

- Configuring user access

Configuration Steps

- Configuring basic BGP/MPLS IP VPN functions for the first carrier

Configure an MPLS network: PE1 is used as an example. The configurations of P1 and PE2 are similar.

Configure a loopback interface.

```
Ruijie(config)# interface Loopback 0
Ruijie(config-if)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if)# exit
```

Globally enable MPLS and LDP.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp rouer-id interface Loopback 0
Ruijie(config-mpls-router)# exit
```

Enable MPLS and LDP on the interface.

```
Ruijie(config)# interface gigabitEthernet 0/0
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 192.168.1.1 255.255.255.0
Ruijie(config-if)# label-switching
Ruijie(config-if)# mpls ip
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
```

Configure IGP (OSPF).

```
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 192.168.1.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure an MP-IBGP neighbor: PE1 is used as an example. The configurations of PE2 are similar.

```
Ruijie(config)# router bgp 65001
Ruijie(config-router)# neighbor 2.2.2.2 remote-as 65001
Ruijie(config-router)# neighbor 2.2.2.2 update-source Loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 2.2.2.2 activate
Ruijie(config-router-af)# neighbor 2.2.2.2 send-community both
```

Configure a VRF: PE1 is used as an example. The configurations of PE2 are similar.

```
Ruijie(config)# ip vrf vpn1
Ruijie(config-vrf)# rd 65001:20
Ruijie(config-vrf)# route-target both 65001:20
Ruijie(config-vrf)# alloc-label per-route
Ruijie(config-vrf)# exit
Ruijie(config)# interface loopback 1
Ruijie(config-if)# ip vrf forwarding vpn1
Ruijie(config-if)# ip address 10.1.1.1 255.255.255.255
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitEthernet 1/1
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip vrf forwarding vpn1
Ruijie(config-if)# ip address 172.1.1.1 255.255.255.0
Ruijie(config-if)# no shutdown
```

Configure a CE to connect to a PE: CE1 is used as an example. The configurations of CE2 are similar.

```
Ruijie(config)# interface gigabitEthernet 1/1
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 172.1.1.2 255.255.255.0
Ruijie(config-if)# no shutdown
```

Configure route exchange between PEs and CEs: Route exchange between PE1 and CE1 is used as an example. The configurations of route exchange between PE2 and CE2 are similar.

First, configure PE1.

```
Ruijie(config)# router ospf 100 vrf vpn1
Ruijie(config-router)# network 172.1.1.0 0.0.0.255 area 0
Ruijie(config-router)# redistribute bgp 65001 subnets
Ruijie(config-router)# exit
Ruijie(config)# router bgp 65001
Ruijie(config-router)# address-family ipv4 vrf vpn1
Ruijie(config-router-af)# redistribute ospf 100 vrf vpn1
Ruijie(config-router-af)# exit
Ruijie(config-router)# exit
```

Then, configure CE1.

```
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 172.1.1.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

- Enabling the CSC function

Enable CSC on the PE: PE1 is used as an example. The configurations of PE2 are similar.

```
Ruijie(config)# mpls router ldp vpn1
Ruijie(config-mpls-router)# ldp rouer-id interface Loopback 1
Ruijie(config-mpls-router)# advertise-labels for bgp-routes
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitEthernet 1/1
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# label-switching
Ruijie(config-if)# mpls ip
```

Enable MPLS and LDP on the CE: CE1 is used as an example. The configurations of CE2 are similar.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp rouer-id interface Loopback 0
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitEthernet 1/1
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# label-switching
Ruijie(config-if)# mpls ip
```

- Configuring the second carrier

Configure the interface and IGP: CE1 is used as an example. The configurations of CE2, ASBR1, ASBR2, ASBR3 and ASBR4 are similar.

```
Ruijie(config)# interface gigabitEthernet 1/2
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 172.1.2.1 255.255.255.0
```

```
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitEthernet 1/3
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 172.1.3.1 255.255.255.0
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
Ruijie(config)# interface Loopback 0
Ruijie(config-if)# ip address 3.3.3.3 255.255.255.255
Ruijie(config-if)# exit
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# network 172.1.2.0 0.0.0.255 area 0
Ruijie(config-router)# network 172.1.3.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

On the ASBR, configure the CE as a BGP neighbor: ASBR1 is used as an example. The configurations of ASBR2, ASBR3 and ASBR4 are similar.

```
Ruijie(config)# router bgp 65010
Ruijie(config-router)# neighbor 3.3.3.3 remote-as 65010
Ruijie(config-router)# neighbor 3.3.3.3 update-source Loopback 0
Ruijie(config-router)# neighbor 3.3.3.3 next-hop-self
```

On the CE, configure the ASBR and a peer CE as the RR client and enable resolution of the next hop of a BGP route to an LSP tunnel: CE1 is used as an example. The configurations of CE2 are similar.

```
Ruijie(config)# router bgp 65010
Ruijie(config-router)# neighbor 4.4.4.4 remote-as 65010
Ruijie(config-router)# neighbor 4.4.4.4 update-source Loopback 0
Ruijie(config-router)# neighbor 4.4.4.4 route-reflector-client
Ruijie(config-router)# neighbor 5.5.5.5 remote-as 65010
Ruijie(config-router)# neighbor 5.5.5.5 update-source Loopback 0
Ruijie(config-router)# neighbor 5.5.5.5 route-reflector-client
Ruijie(config-router)# neighbor 6.6.6.6 remote-as 65010
Ruijie(config-router)# neighbor 6.6.6.6 update-source Loopback 0
Ruijie(config-router)# neighbor 6.6.6.6 route-reflector-client
Ruijie(config-router)# exit
Ruijie(config)# recursive-route lookup lsp
```

- Configuring user access

It is assumed that user network 1 is connected to ASBR3. The configurations of other external networks (user network and Internet gateway) are similar.

On ASBR3, use the following command.

```
Ruijie(config)# interface gigabitEthernet 1/2
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 10.0.3.1 255.255.255.0
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
Ruijie(config)# router bgp 65010
Ruijie(config-router)# neighbor 10.0.3.2 remote-as 100
Ruijie(config-router)# exit
```

On the edge router of user network 1, use the following command.

```
Ruijie(config)# interface gigabitEthernet 0/0
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 10.0.3.2 255.255.255.0
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitEthernet 0/1
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 64.21.33.9 255.255.255.0
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 10.0.3.1 remote-as 65010
Ruijie(config-router)# network 64.21.33.0 mask 255.255.255.0
```

Verification

Display VRF routes and labels on the PE: PE1 is used as an example. The verification of PE2 is similar.

// In the VRF routing table of the PE, there are only internal routes of the second carrier. There is no external route (for example, 64.30.4.0/24).

```
Ruijie# show ip route vrf vpn1
Routing Table: vpn1

Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
O    3.3.3.3/32 [110/11] via 172.1.1.2, 00:00:07, gigabitEthernet 1/1
C    172.1.1.0/24 is directly connected, gigabitEthernet 1/1
C    172.1.1.1/32 is local host.
O    172.1.2.0/24 [110/12] via 172.1.1.2, 00:00:07, gigabitEthernet 1/1
B    172.1.4.0/24 [200/0] via 2.2.2.2, 00:00:30
......
Ruijie# show mpls ldp bindings vrf vpn1
VRF vpn1(id 1)
    lib entry: 3.3.3.3/32
        local binding:  to lsr:   172.1.1.2:0, label: 1025
        remote binding: from lsr: 172.1.1.2:0, label: imp-null
    lib entry: 172.1.1.0/24
        local binding:  to lsr:   172.1.1.2:0, label: imp-null
        remote binding: from lsr: 172.1.1.2:0, label: imp-null
    lib entry 172.1.2.0/24
        local binding:  to lsr:   172.1.1.2:0, label: 1026
        remote binding: from lsr: 172.1.1.2:0, label: 1024
    ......
```

On the ASBR and user network, display the routing table.

// On the ASBR, there are both external routes and internal routes (using ASBR3 as the example).

```
Ruijie# show ip route
Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
......
O    3.3.3.3/24 [110/12] via 172.1.5.1, 00:00:30, gigabitEthernet 1/1
B    61.10.55.0/24 [200/0] via 3.3.3.3, 00:00:40
B    64.21.33.0/24 [200/0] via 10.0.3.2, 00:00:31
```

```
......
```

// In the user network, there are external routes (using the edge device of user network 1 as the example).

```
Ruijie# show ip route
Ruijie# show ip route
Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
......
B    61.10.55.0/24 [200/0] via 10.0.3.1, 00:00:40
C    64.21.33.0/24 is directly connected, gigabitEthernet 0/1
C    64.21.33.9/32 is local host.
......
```

Verify that the external networks are interconnected.

// On the edge device of user network 1, use the following command.

```
Ruijie# ping 61.10.55.1 source 64.21.33.9
Sending 5, 100-byte ICMP Echoes to 61.10.55.1, timeout is 2 seconds:
Packet sent with a source address of 64.21.33.9
  < press Ctrl+C to break >
!!!!!
```

CSC: The Second Carrier Provides Internet Services Based on MPLS Core

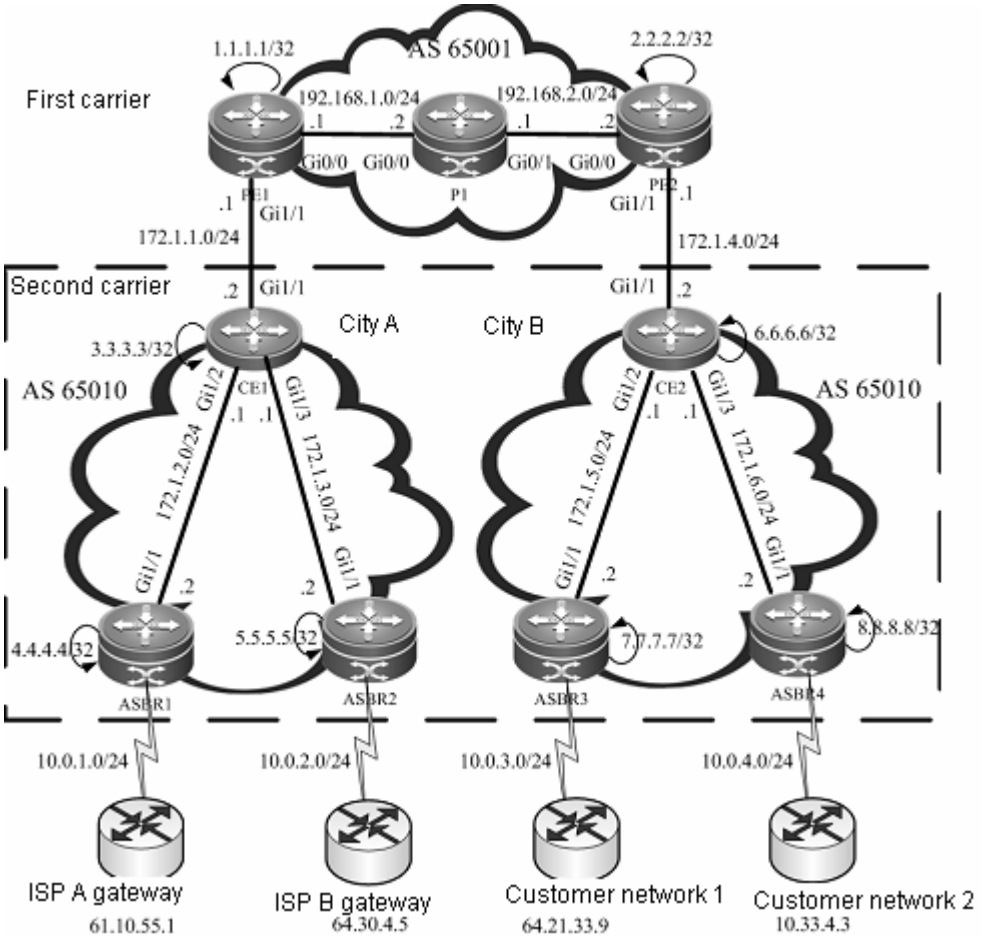
Networking Requirements

A carrier provides Internet services for users in City A. Considering that it may need to provide MPLS services for users in the future, this carrier has deployed MPLS on its backbone network. Now this carrier intends to expand its service to City B, and has built an MPLS network in City B. To interconnect the core networks in the two cities, this carrier leases the VPN service from another MPLS VPN service provider. Therefore, this carrier has become a second carrier, while the MPLS VPN service provider is the first carrier.

The first carrier PE and second carrier CE will exchange (internal) routes via BGP. The second carrier will directly establish BGP neighbors between ASBRs to exchange external routes. The traffic will flow from the external network into the second carrier network and be forwarded on the tunnel until the traffic leaves the second carrier network.

Networking Topology

Figure 40 Network topology of scenario II



Configuration Tips

- Configuring basic BGP/MPLS IP VPN functions for the first carrier
- Enabling the CSC function
- Configuring the second carrier
- Configuring user access

Configuration Steps

- Configuring basic BGP/MPLS IP VPN functions for the first carrier

The configuration steps are similar to those in Scenario I. The difference is that routes are exchanged between PEs and CEs. Only configurations of route exchange between PEs and CEs will be shown below. For other configurations, see "Configuring basic BGP/MPLS IP VPN functions" in the example of "The Second Carrier Provides Internet Services Based on IP Core".

Configure route exchange between PEs and CEs.

First, configure the PE (using PE1 as an example).

```
Ruijie(config)# router bgp 65001
Ruijie(config-router)# address-family ipv4 vrf vpn1
Ruijie(config-router-af)# neighbor 172.1.1.2 remote-as 65010
Ruijie(config-router-af)# neighbor 172.1.1.2 as-override
```

```
Ruijie(config-router-af)# exit
Ruijie(config-router)# exit
```

Then, configure the CE (using CE1 as an example).

```
Ruijie(config)# router bgp 65010
Ruijie(config-router)# neighbor 172.1.1.2 remote-as 65001
Ruijie(config-router)# redistribute ospf 1
Ruijie(config-router)# exit
Ruijie(config)# router ospf 1
Ruijie(config-router)# redistribute bgp 65010 subnets
Ruijie(config-router)# exit
```

- Enabling the CSC function

Enable CSC on the PE: PE1 is used as an example. The configurations of PE2 are similar.

```
Ruijie(config)# interface gigabitEthernet 1/1
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip vrf forwarding vpn1
Ruijie(config-if)# ip address 172.1.1.1 255.255.255.0
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
Ruijie(config)# router bgp 65001
Ruijie(config-router)# address-family ipv4 vrf vpn1
Ruijie(config-router-af)# neighbor 172.1.1.2 send-label
Ruijie(config-router-af)# exit
Ruijie(config-router)# exit
```

Enable MPLS and BGP label distribution on the CE.

```
Ruijie(config)# interface gigabitEthernet 1/1
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# label-switching
Ruijie(config-if)# ip address 172.1.1.2 255.255.255.0
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
Ruijie(config)# router bgp 65010
Ruijie(config-router)# neighbor 172.1.1.1 send-label
Ruijie(config-router)# exit
```

- Configuring the second carrier

Configure an MPLS network: See "Configuring an MPLS network" in the example of "The Second Carrier Provides Internet Services Based on IP Core". Configuration objects are CE1, CE2 and ASBRs (1 to 4).

Note

You need to enable LDP on the CSC-CE in order to set up sessions with other intra-site devices to build an MPLS network. If the CSC-CE and CSC-PE use BGP to exchange routes, you must use the **advertise-labels for bgp-routes** command on the CSC-CE to allow LDP to distribute labels for BGP routes.

Configure a BGP neighbor: Establish a BGP neighbor relation between two ASBRs.

Configure ASBR2 as the BGP neighbor on ASBR1. The configurations of other ASBRs are similar.

```
Ruijie(config)# router bgp 65010
Ruijie(config-router)# neighbor 5.5.5.5 remote-as 65010
Ruijie(config-router)# neighbor 5.5.5.5 update-source Loopback 0
Ruijie(config-router)# neighbor 5.5.5.5 next-hop-self
Ruijie(config-router)# exit
Ruijie(config)# recursive-route lookup lsp
```

- Configuring user access

See "Configuring user access" in the example of "The Second Carrier Provides Internet Services Based on IP Core".

Verification

Display VRF routes and labels on the first carrier PE: PE1 is used as an example. The verification of PE2 is similar.

// In the VRF routing table of PE1, there are only internal routes of the second carrier. There is no external routes (for example, 64.30.4.0/24).

```
Ruijie# show ip route vrf vpn1
Routing Table: vpn1

Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
B    3.3.3.3/32 [200/0] via 172.1.1.2, 00:00:07
C    172.1.1.0/24 is directly connected, gigabitEthernet 1/1
C    172.1.1.1/32 is local host.
B    172.1.2.0/24 [200/0] via 172.1.1.2, 00:00:07
B    172.1.4.0/24 [200/0] via 2.2.2.2, 00:00:30
......
Ruijie# show bgp vpnv4 unicast vrf vpn1 labels
```

```
BGP table version is 1, local router ID is 1.1.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
            S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network         Next Hop       In Label/Out Label
Route Distinguisher: 65001:20 (Default for VRF vpn1)
*> 3.3.3.3/32      172.1.1.2        2048/1024
*> 172.1.2.0/24    172.1.1.2       2049/1025
*>i6.6.6.6/32      2.2.2.2          2050/2112
......
```

On the ASBR and user network, display the routing table.

// On the ASBR (using ASBR3 as an example), use the following command.

```
Ruijie# show ip route
Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
......
B    61.10.55.0/24 [200/0] via 4.4.4.4, 00:00:40
B    64.21.33.0/24 [200/0] via 10.0.3.2, 00:00:31
......
```

// In the user network, use the edge device of user network 1 as an example.

```
Ruijie# show ip route
Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
......
B    61.10.55.0/24 [200/0] via 10.0.3.1, 00:00:40
C    64.21.33.0/24 is directly connected, gigabitEthernet 0/1
C    64.21.33.9/32 is local host.
......
```

Verify that the external networks are interconnected.

// On the edge device of user network 1, use the following command.

```
Ruijie# ping 61.10.55.1 source 64.21.33.9
Sending 5, 100-byte ICMP Echoes to 61.10.55.1, timeout is 2 seconds:
  < press Ctrl+C to break >
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 10/20/40 ms
```

CSC: The Second Carrier Provides VPN Services Based on MPLS Core

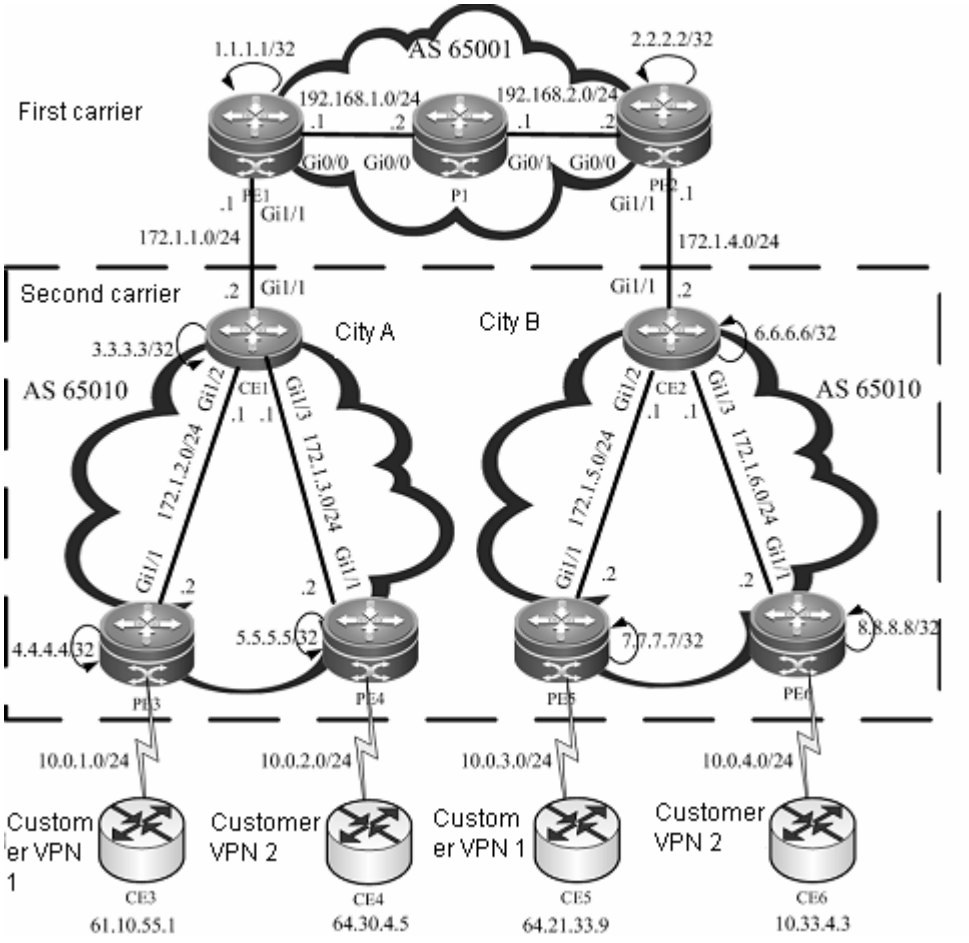
Networking Requirements

A carrier owns an MPLS core network in City A and provides MPLS VPN services for users in this city. Now this carrier intends to expand the service to City B, and has built an MPLS core network in City B. In order to interconnect the core networks in these two cities, this carrier leases the VPN service from another MPLS VPN service provider, thus forming the CSC networking model.

The first carrier PE and second carrier CE will exchange (internal) routes via BGP. An MP-IBGP neighbor relation is established between second carrier PEs to exchange user VPN routes. OSPF is deployed between the second carrier PE and the user VPN CE to exchange routes.

Networking Topology

Figure 41 MPLS core second VPN provider



Configuration Tips

- Configuring basic BGP/MPLS IP VPN functions for the first carrier
- Enabling the CSC function
- Configuring the second carrier
- Configuring user access

Configuration Steps

- Configuring basic BGP/MPLS IP VPN functions for the first carrier

See "Configuring basic BGP/MPLS IP VPN functions" in the example of "The Second Carrier Provides Internet Services Based on MPLS Core".

- Enabling the CSC function

See "Enabling the CSC function" in the example of "The Second Carrier Provides Internet Services Based on MPLS Core".

- Configuring the second carrier

Configure an MPLS network: See "Configuring an MPLS network" in the example of "The Second Carrier Provides Internet Services Based on MPLS Core". Configuration objects are CE1, CE2 and PEs (3 to 6).

Note

You need to enable LDP on the CSC-CE in order to set up sessions with other intra-site devices to build an MPLS network. If the CSC-CE and CSC-PE use BGP to exchange routes, you must run **advertise-labels for bgp-routes** on the CSC-CE to allow LDP to distribute labels for BGP routes.

Configure an MP-IBGP neighbor: See "Configuring an MP-IBGP neighbor" in the example of "The Second Carrier Provides Internet Services Based on IP Core". Configure the MP-IBGP neighbor relations between PE3, PE4, PE5 and PE6.

- Configuring user access

The configurations include configuring a VRF, configuring route exchange between PEs and CEs, and so on. These configurations are the same as those of the BGP/MPLS IP VPN. It is assumed that CE3 is connected to PE3.

On PE3, use the following commands.

```
Ruijie(config)# ip vrf customer_vpn1
Ruijie(config-vrf)# rd 65010:1
Ruijie(config-vrf)# route-target both 65010:1
Ruijie(config-vrf)# exit
Ruijie(config)# interface gigabitEthernet 1/2
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable MPLS fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip vrf forwarding customer_vpn1
Ruijie(config-if)# ip address 10.0.1.1 255.255.255.0
```

```
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
Ruijie(config)# router ospf 10 vrf customer_vpn1
Ruijie(config-router)# network 10.0.1.0 0.0.0.255 area 0
Ruijie(config-router)# redistribute bgp 65010 subnets
Ruijie(config-router)# exit
Ruijie(config)# router bgp 65010
Ruijie(config-router)# address-family ipv4 vrf customer_vpn1
Ruijie(config-router-af)# redistribute ospf 10 vrf customer_vpn1
Ruijie(config-router-af)# exit
Ruijie(config-router)# exit
```

On CE3, use the following command.

```
Ruijie(config)# interface gigabitEthernet 0/0
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 10.0.1.2 255.255.255.0
Ruijie(config-if)# no shutdown
Ruijie(config)# interface gigabitEthernet 0/1
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 61.10.55.1 255.255.255.0
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 10.0.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 61.10.55.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Verification

Display VRF routes and labels on the first carrier PE: PE1 is used as an example. The verification of PE2 is similar.

// In the VRF routing table of PE1, there are only internal routes of the second carrier. There is no VPN route (for example, 64.30.4.0/24).

```
Ruijie# show ip route vrf vpn1
Routing Table: vpn1

Codes:  C - connected, S - static, R - RIP, B - BGP
```

```
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
B    3.3.3.3/32 [200/0] via 172.1.1.2, 00:00:07
C    172.1.1.0/24 is directly connected, gigabitEthernet 1/1
C    172.1.1.1/32 is local host.
B    172.1.2.0/24 [200/0] via 172.1.1.2, 00:00:07
B    172.1.4.0/24 [200/0] via 2.2.2.2, 00:00:30
......
Ruijie# show bgp vpnv4 unicast vrf vpn1 labels
BGP table version is 1, local router ID is 1.1.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
           S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

  Network         Next Hop       In Label/Out Label
Route Distinguisher: 65001:20 (Default for VRF vpn1)
*> 3.3.3.3/32      172.1.1.2        2048/1024
*> 172.1.2.0/24    172.1.1.2       2049/1025
*>i6.6.6.6/32      2.2.2.2          2050/2112
......
```

In the VRF of the second carrier PE and user VPN CE, display the routing table.

// On the PE (using PE3 as an example), use the following command.

```
Ruijie# show ip route vrf customer_vpn1
Routing Table: customer_vpn1

Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
......
O    61.10.55.0/24 [200/0] via 10.0.1.2, 00:00:40, gigabitEthernet 1/2
B    64.21.33.0/24 [200/0] via 7.7.7.7, 00:00:31
......
```

// On the user VPN CE (using CE3 as an example), use the following command.

```
Ruijie# show ip route
Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
......
C    61.10.55.0/24 is directly connected, gigabitEthernet
C    61.10.55.1/32 is local host.
O    64.21.33.0/24 [200/0] via 10.0.1.1, 00:00:42, gigabitEthernet 0/0
......
```

Verify that the user VPN networks are interconnected.

//On CE3, use the following command.

```
Ruijie# ping 64.21.33.9
Sending 5, 100-byte ICMP Echoes to 64.21.33.9, timeout is 2 seconds:
  < press Ctrl+C to break >
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 10/20/40 ms
```

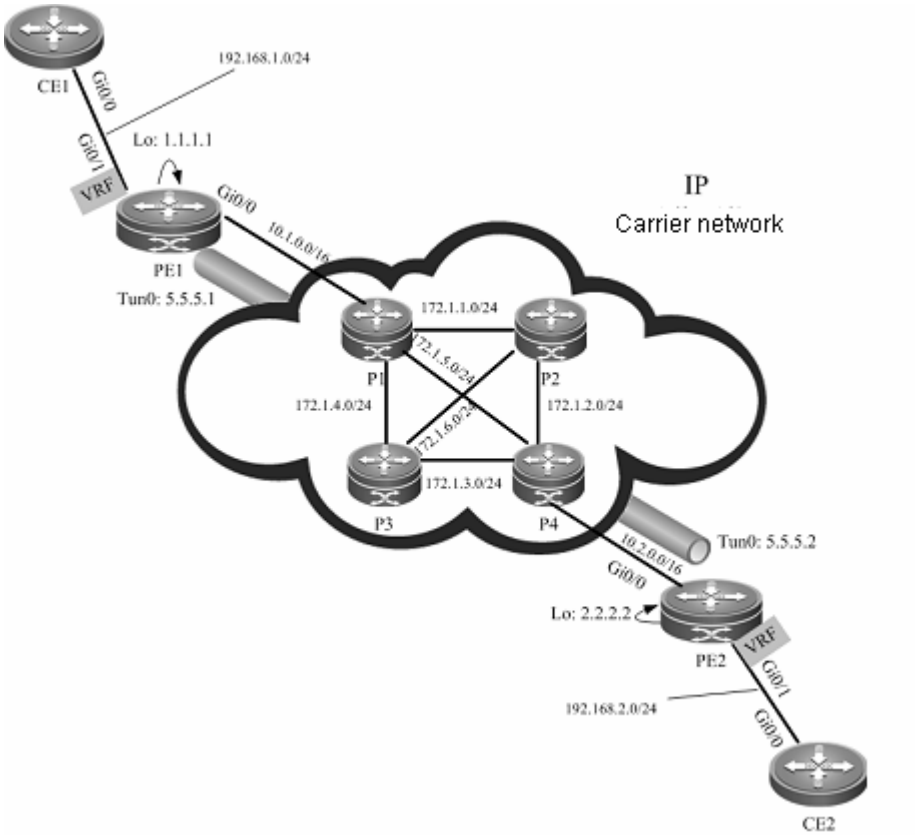
MPLS VPN over GRE

Networking Requirements

In an IP core network, the edge router PE supports the MPLS VPN. Now it is required to use the MPLS VPN over GRE technology to use the IP core network to provide MPLS VPN services for users. The IP core network adopts dual OSPF instances to introduce VPN traffic into the GRE tunnel, while the PE and CE exchange routes via OSPF.

Networking Topology

Figure 42 Network topology



Configuration Tips

- Creating a GRE tunnel
- Configuring an IGP route
- Configuring an MPLS network
- Configuring an MPLS VPN

Configuration Steps

- Configure the P device. P1 is used as an example. The configurations of other devices are similar.

Configure an interface and IP address.

```
Ruijie(config)# interface gigabitEthernet 0/0
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 10.1.0.2 255.255.0.0
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitEthernet 0/1
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 172.1.1.1 255.255.255.0
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitEthernet 1/1
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 172.1.5.1 255.255.255.0
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitEthernet 0/3
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 172.1.4.1 255.255.255.0
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
```

Configure an IGP routing instance.

```
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 172.1.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 172.1.5.0 0.0.0.255 area 0
Ruijie(config-router)# network 172.1.4.0 0.0.0.255 area 0
Ruijie(config-router)# network 10.1.0.0 0.0.255.255 area 0
Ruijie(config-router)# exit
```

- Configure the PE device. PE1 is used as an example. The configurations of other devices are similar.

Configure a public network interface and IP address.

```
Ruijie(config)# interface Loopback 0
Ruijie(config-if)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitEthernet 0/0
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 10.1.0.1 255.255.0.0
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
```

Create a GRE tunnel.

```
Ruijie(config)# interface tunnel 0
Ruijie(config-if)# ip address 5.5.5.1 255.255.255.0
Ruijie(config-if)# tunnel mode gre ip
Ruijie(config-if)# tunnel source 10.1.0.1
Ruijie(config-if)# tunnel destination 10.2.0.1
Ruijie(config-if)# exit
```

Configure an IGP route.

```
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 10.1.0.0 0.0.255.255 area 0
Ruijie(config-router)# exit
Ruijie(config)# router ospf 2
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 5.5.5.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure an MPLS network.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface tunnel 0
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# mpls ip
Ruijie(config-if)# label-switching
Ruijie(config-if)# exit
```

Configure an MPLS VPN.

Configure a VRF.

```
Ruijie(config)# ip vrf vpn1
Ruijie(config-vrf)# rd 100:1
Ruijie(config-vrf)# route-target both 100:1
Ruijie(config-vrf)# exit
Ruijie(config)# interface gigabitEthernet 0/1
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip vrf forwarding vpn1
Ruijie(config-if)# ip address 192.168.1.1 255.255.255.0
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
```

Configure MP-IBGP.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 2.2.2.2 remote-as 100
Ruijie(config-router)# neighbor 2.2.2.2 update-source Loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 2.2.2.2 active
Ruijie(config-router-af)# neighbor 2.2.2.2 send-community both
Ruijie(config-router-af)# exit
Ruijie(config-router)# address-family ipv4 vrf vpn1
Ruijie(config-router-af)# redistribute ospf 10 vrf vpn1
Ruijie(config-router-af)# exit
Ruijie(config-router)# exit
```

Configure route exchange between PEs and CEs.

```
Ruijie(config)# router ospf 10 vrf vpn1
Ruijie(config-router)# network 192.168.1.0 0.0.0.255 area 0
Ruijie(config-router)# redistribute bgp 100 subnets
Ruijie(config-router)# exit
```

- Configure the CE. CE1 is used as an example. The configurations of CE2 are similar.

```
Ruijie(config)# interface gigabitEthernet 0/0
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 192.168.1.2 255.255.255.0
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 192.168.1.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Verification

On the PE, check routing entries. PE1 is used as an example. The next-hop interface of route 2.2.2.2/32 is Tunnel 0.

```
Ruijie# show ip route
Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
```

```
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
C    10.1.0.0/16 is directly connected, gigabitEthernet 0/0
C    10.1.0.1/32 is local host.
C    1.0.0.0/8 is subnetted
C      1.1.1.1/32 is local host.
O    2.0.0.0/8 is subnetted
O      2.2.2.2/32 [110/11] via 5.5.5.2, 00:00:40, Tunnel 0
......
```

Verify the VPN route on PE. PE1 is used as an example.

```
Ruijie# show ip route vrf vpn1
Routing Table: vpn1

Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
C    192.168.1.0/24 is directly connected, gigabitEthernet 0/1
C    192.168.1.1/32 is local host.
B    192.168.2.0/24 [200/0] via 2.2.2.2, 00:00:41
......
```

Check MPLS forwarding entries on the PE. PE1 is used as an example.

```
Ruijie# show mpls forwarding-table
Label Operation Code:
PH--PUSH label
PP--POP label
SW--SWAP label
SP—-SWAP topmost label and push new label
DP—-DROP packet
PC—-POP label and continue lookup( IP or Label )
PI--POP label and do ip lookup forward
PN--POP label and forward to nexthop
PM--POP label and do MAC lookup forward
PV--POP label and output to VC attach interface
IP--IP lookup forward
Local  Outgoing  OP  FEC        Outgoing      Next Hop
label  label                   interface
```

```
--    3         PH 2.2.2.2/32  Tunnel 0      5.5.5.2
--    21        PH 192.168.2.0/24(V) Tunnel 0  Point2point
......
```

Verify the routing table on the CE.

```
Ruijie# show ip route
Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
C    192.168.1.0/24 is directly connected, gigabitEthernet 0/1
C    192.168.1.2/32 is local host.
O    192.168.2.0/24 [112/11] via 192.168.1.1, 00:00:41
......
```

Verify the intercommunication between CEs. On CE1, use the following command.

```
Ruijie# ping 192.168.2.2
Sending 5, 100-byte ICMP Echoes to 192.168.2.2, timeout is 2 seconds:
  < press Ctrl+C to break >
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 10/20/40 ms
```

OSPF VPN Configuration Examples

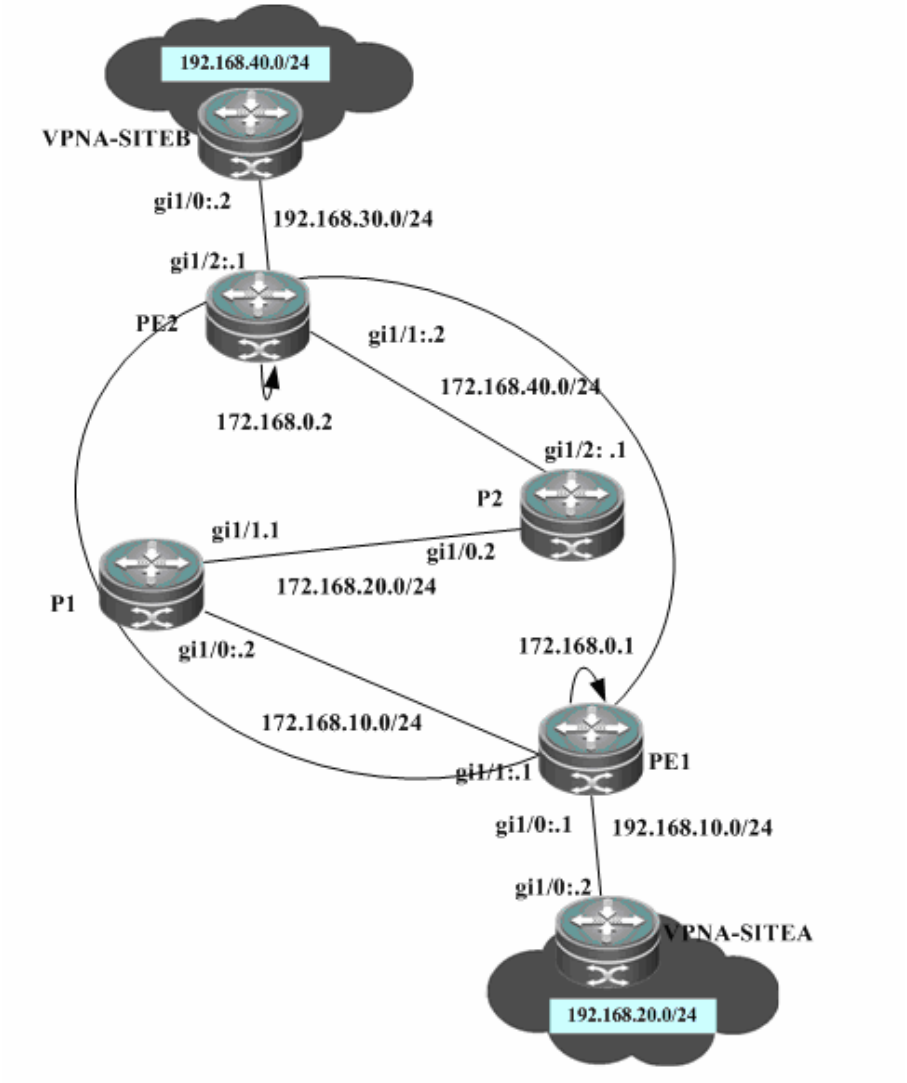
Domain-id Configuration Example

Networking Requirements

Two different sites of a customer exchange VPN routes via an MPLS backbone network. The customer's sites are connected to a PE via OSPF. It is required that the customer's OSPF routes can be restored to the OSPF routes of original sites after being exchanged over the MPLS backbone network.

Networking Topology

Figure 43



To meet the requirements, configure two VRF OSPF instances with the same domain ID on two PEs, as shown below:

Configuration Steps

SITEA:

Configure the OSPF protocol between the PE and the CE.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 192.168.10.0 255.255.255.0 area 0
```

PE1:

Configure a loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 172.168.0.1 255.255.255.255
```

Configure a VRF.

Create a VRF named VPNA, set the RD and RT values, and associate the VRF with the corresponding interface.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf VPNA
Ruijie(config-vrf)# rd 1:100
Ruijie(config-vrf)# route-target both 1:100
Ruijie(config-vrf)# end
```

Associate the CE-connecting interface with the VRF.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/0
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if-GigabitEthernet 1/0)# ip ref
Ruijie(config-if-GigabitEthernet 1/0)# ip vrf forwarding VPNA
Ruijie(config-if-GigabitEthernet 1/0)# ip address 192.168.10.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/0)# end
```

Configure the BGP protocol to set up an MP-IBGP session with PE2.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 172.168.0.2 remote-as 1
Ruijie(config-router)# neighbor 172.168.0.2 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 172.168.0.2 activate
Ruijie(config-router-af)# end
```

Exchange routes with the CE via OSPF; set the domain ID of the OSPF instance to 10.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10 VPNA
Ruijie(config-router)# network 192.168.10.0 255.255.255.0 area 0
Ruijie(config-router)# redistribute bgp subnets
Ruijie(config-router)# domain-id 10
Ruijie(config-router)# exit
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf VPNA
Ruijie(config-router-af)# redistribute ospf 10
Ruijie(config-router-af)# end
```

Configure MPLS signaling on the backbone network. Enable MPLS on the public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
```

```
Ruijie(config)# interface gigabitethernet 1/1
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# ip address 172.168.10.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/1)# end
```

Configure a routing protocol on the backbone network.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 172.168.10.0 0.0.0.255 area 0
Ruijie(config-router)# network 172.168.0.1 0.0.0.0 area 0
Ruijie(config-router)# end
```

P1 and P2:The configuration steps are similar to the configuration steps of P in the MPLS backbone network.

SITEB:

Run OSPF with PE2.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 192.168.30.0 255.255.255.0 area 0
```

PE2:

Configure a loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 172.168.0.2 255.255.255.255
```

Configure a VRF.

Create a VRF named VPNA, set the RD and RT values, and associate the VRF with the corresponding interface.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf VPNA
Ruijie(config-vrf)# rd 1:100
Ruijie(config-vrf)# route-target both 1:100
Ruijie(config-vrf)# exit
```

Associate the CE-connecting interface with the VRF.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/2
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if-GigabitEthernet 1/2)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if-GigabitEthernet 1/2)# ip ref
Ruijie(config-if-GigabitEthernet 1/2)# ip vrf forwarding VPNA
Ruijie(config-if-GigabitEthernet 1/2)# ip address 192.168.30.1
255.255.255.0
Ruijie(config-if-GigabitEthernet 1/0)# exit
```

Configure the BGP protocol to set up an MP-IBGP session with PE2.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 172.168.0.1 remote-as 1
Ruijie(config-router)# neighbor 172.168.0.1 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 172.168.0.1 activate
Ruijie(config-router-af)# end
```

Exchange VPN routes with the CE via OSPF; set the domain ID to 10.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10 VPNA
Ruijie(config-router)# network 192.168.30.0 255.255.255.0 area 0
Ruijie(config-router)# redistribute bgp subnets
Ruijie(config-router)# domain-id 10
Ruijie(config-router)# exit
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf VPNA
Ruijie(config-router-af)# redistribute ospf 10
Ruijie(config-router-af)# exit
```

Configure MPLS signaling on the backbone network. Enable MPLS on the public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# ip address 172.168.40.2 255.255.255.0
```

```
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/1)# end
```

Configure a routing protocol on the backbone network.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 172.168.40.0 0.0.0.255 area 0
Ruijie(config-router)# network 172.168.0.2 0.0.0.0 area 0
Ruijie(config-router)# end
```

Verification

- VPNA-SITEB:

```
Ruijie# show ip route
Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
O IA    192.168.10.0/24 [110/2] via 192.168.30.1, 00:00:36, GigabitEthernet 1/0
O IA    192.168.20.0/24 [110/2] via 192.168.30.1, 00:00:36, GigabitEthernet 1/0
C       192.168.30.0/24 is directly connected, GigabitEthernet 1/0
O       192.168.40.0/24 [110/101] via 192.168.24.2, 00:56:23, GigabitEthernet 1/1
```

- PE2:

```
Ruijie# show ip route vrf VPNA
Routing Table: VPNA

Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
B       192.168.10.0/24 [110/2] via 172.168.0.1, 00:00:36
B       192.168.20.0/24 [110/2] via 172.168.0.1, 00:00:36
C       192.168.30.0/24 is directly connected, GigabitEthernet 1/2
O       192.168.40.0/24 [110/101] via 192.168.30.2, 00:56:23, GigabitEthernet 1/2
```

- PE1:

```
Ruijie# show ip route vrf VPNA
```

```
Routing Table: VPNA

Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
C      192.168.10.0/24 is directly connected, GigabitEthernet 1/0
O      192.168.20.0/24 [110/101] via 192.168.10.2, 00:56:23, GigabitEthernet 1/0
B      192.168.30.0/24 [110/2] via 172.168.0.2, 00:00:36
B      192.168.40.0/24 [110/2] via 172.168.0.2, 00:00:36
```

- VPNA-SITEA:

```
Ruijie# show ip route
Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
C      192.168.10.0/24 is directly connected, GigabitEthernet 1/0
O      192.168.20.0/24 [110/101] via 192.168.23.2, 00:56:23, GigabitEthernet 1/1
O IA    192.168.30.0/24 [110/2] via 192.168.10.1, 00:00:36, GigabitEthernet 1/0
O IA    192.168.40.0/24 [110/2] via 192.168.10.1, 00:00:36, GigabitEthernet 1/0
```

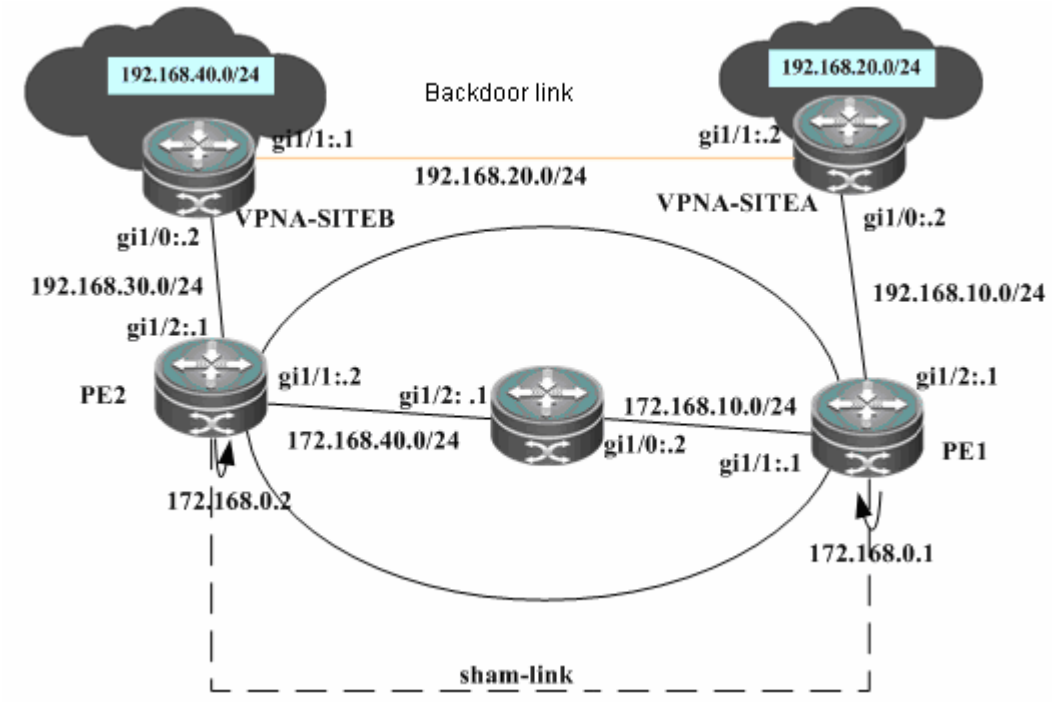
Sham Link Configuration Example

Networking Requirements

Two different sites of a customer exchange VPN routes via an MPLS backbone network. At the same time, a "backdoor link" is also established between these two sites to ensure that information can still be exchanged between both sites through this backup link when the MPLS backbone network fails.

Networking Topology

Figure 44



Configuration Steps

SITEA:

Run the OSPF protocol with PE1 and SITEB. The OSPF protocol runs over the backdoor link with SITEB.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 192.168.10.0 255.255.255.0 area 0
Ruijie(config-router)# network 192.168.20.0 255.255.255.0 area 0
```

Configure the OSPF cost on an interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/0
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if-GigabitEthernet 1/0)# ip ref
Ruijie(config-if-GigabitEthernet 1/0)# ip address 192.168.10.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/0)# ip ospf cost 1
Ruijie(config)# interface gigabitethernet 1/1
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# ip address 192.168.20.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# ip ospf cost 200
```

PE1:

Configure a loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 172.168.0.1 255.255.255.255
```

Configure a VRF.

Create a VRF named VPNA, set the RD and RT values, and associate the VRF with the corresponding interface.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf VPNA
Ruijie(config-vrf)# rd 1:100
Ruijie(config-vrf)# route-target both 1:100
Ruijie(config-vrf)# end
```

Associate the CE-connecting interface with the VRF.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/2
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if-GigabitEthernet 1/2)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if-GigabitEthernet 1/2)# ip ref
Ruijie(config-if-GigabitEthernet 1/2)# ip vrf forwarding VPNA
Ruijie(config-if-GigabitEthernet 1/2)# ip address 192.168.10.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/2)# end
```

Configure the VRF loopback interface to establish a sham link.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 10
Ruijie(config-if-Loopback 10)# ip vrf forwarding VPNA
Ruijie(config-if-Loopback 10)# ip address 192.168.0.1 255.255.255.255
```

Configure the BGP protocol to set up an MP-IBGP session with PE2.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 172.168.0.2 remote-as 1
Ruijie(config-router)# neighbor 172.168.0.2 update-source loopback 0
```

```
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 172.168.0.2 activate
Ruijie(config-router-af)# end
```

Exchange routes with the CE via OSPF, and establish a sham link with the OSPF instance on PE2.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10 VPNA
Ruijie(config-router)# network 192.168.10.0 255.255.255.0 area 0
Ruijie(config-router)# redistribute bgp subnets
Ruijie(config-router)# area 0 sham-link 192.168.0.1 192.168.0.2
Ruijie(config-router)# exit
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf VPNA
Ruijie(config-router-af)# redistribute ospf 10
Ruijie(config-router-af)# redistribute connected
Ruijie(config-router-af)# end
```

Configure MPLS signaling on the backbone network. Enable MPLS on the public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# ip address 172.168.10.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/1)# end
```

Configure a routing protocol on the backbone network.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 172.168.10.0 0.0.0.255 area 0
Ruijie(config-router)# network 172.168.0.1 0.0.0.0 area 0
Ruijie(config-router)# end
```

P1:

The configuration steps are similar to the configuration steps of P in the MPLS backbone network.

SITEB:

Run the OSPF protocol with PE2 and SITEA. The OSPF protocol runs over the backup link with SITEA.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 192.168.30.0 255.255.255.0 area 0
Ruijie(config-router)# network 192.168.20.0 255.255.255.0 area 0
```

Configure the OSPF cost on an interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/0
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if-GigabitEthernet 1/0)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if-GigabitEthernet 1/0)# ip ref
Ruijie(config-if-GigabitEthernet 1/0)# ip address 192.168.30.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/0)# ip ospf cost 1
Ruijie(config)# interface gigabitethernet 1/1
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# ip address 192.168.20.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# ip ospf cost 200
```

PE2:

Configure a loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 172.168.0.2 255.255.255.255
```

Configure a VRF.

Create a VRF named VPNA, set the RD and RT values, and associate the VRF with the corresponding interface.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf VPNA
Ruijie(config-vrf)# rd 1:100
Ruijie(config-vrf)# route-target both 1:100
Ruijie(config-vrf)# exit
```

Associate the CE-connecting interface with the VRF.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/2
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if-GigabitEthernet 1/2)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if-GigabitEthernet 1/2)# ip ref
Ruijie(config-if-GigabitEthernet 1/2)# ip vrf forwarding VPNA
Ruijie(config-if-GigabitEthernet 1/2)# ip address 192.168.30.1
255.255.255.0
Ruijie(config-if-GigabitEthernet 1/2)# exit
```

Configure the VRF loopback interface to establish a sham link.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 10
Ruijie(config-if-Loopback 10)# ip vrf forwarding VPNA
Ruijie(config-if-Loopback 10)# ip address 192.168.0.2 255.255.255.255
```

Configure the BGP protocol to set up an MP-IBGP session with PE2 and PE3.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 172.168.0.1 remote-as 1
Ruijie(config-router)# neighbor 172.168.0.1 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 172.168.0.1 activate
Ruijie(config-router-af)# end
```

Exchange VPN routes with the CE via OSPF, and establish a sham link with PE1.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10 VPNA
Ruijie(config-router)# network 192.168.30.0 255.255.255.0 area 0
Ruijie(config-router)# redistribute bgp subnets
Ruijie(config-router)# area 0 sham-link  192.168.0.2 192.168.0.1
Ruijie(config-router)# exit
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf VPNA
Ruijie(config-router-af)# redistribute ospf 10
uijie(config-router-af)# redistribute connected
Ruijie(config-router-af)# exit
```

Configure MPLS signaling on the backbone network. Enable MPLS on the public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# ip address 172.168.40.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/1)# end
```

Configure a routing protocol on the backbone network.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 172.168.40.0 0.0.0.255 area 0
Ruijie(config-router)# network 172.168.0.2 0.0.0.0 area 0
Ruijie(config-router)# end
```

Verification

- PE1

```
Ruijie# show ip ospf 10 sham-links
Sham Link OSPF_SL0 to address 192.168.0.2 is up
Area 0 source address 192.168.0.1
  Run as demand circuit
  DoNotAge LSA allowed. Cost of using 1 State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40,
    Hello due in 00:00:06
    Adjacency State FULL (Hello suppressed)
    Index 2/2, retransmission queue length 0, number of retransmission 0
    First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
    Last retransmission scan length is 0, maximum is 0
Last retransmission scan time is 0 msec, maximum is 0 msec
Ruijie# show ip ospf 10 neighbor
Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.0.2       0   FULL/  -          -        192.168.0.2     OSPF_SL0
Ruijie# show ip route vrf VPNA
Codes:  C - connected, S - static, R - RIP, B - BGP
        O - OSPF, IA - OSPF inter area
        N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
        E1 - OSPF external type 1, E2 - OSPF external type 2
        i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
        ia - IS-IS inter area, * - candidate default
C       192.168.10.0/24 is directly connected, Gi1/2
O       192.168.20.0/24 [110/101] via 192.168.1.2, 00:56:23, Gi1/2
O       192.168.40.0/24 [110/2] via 172.168.0.2, 00:00:36
```

- PE2

```
Ruijie# show ip ospf 10 sham-links
Sham Link SLINK0 to address 192.168.0.1 is up
  Area 0.0.0.0 source address 192.168.0.2, Cost: 1
  Output interface is GigabitEthernet 1/1
  Nexthop address 172.16.10.1
  Transmit Delay is 1 sec, State Point-To-Point,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:01
    Adjacency state Full

Ruijie# show ip ospf 10 neighbor

OSPF process 10, 1 Neighbors, 1 is Full:
Neighbor ID     Pri   State              BFD State  Dead Time   Address        Interface
192.168.0.1       1   Full/ -             -         00:00:34    192.168.0.1        SLINK0

Ruijie# show ip route vrf VPNA
Routing Table: VPNA

Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
O      192.168.10.0/24 [110/2] via 172.168.0.1, 00:00:36
O      192.168.20.0/24 [110/2] via 172.168.0.1, 00:00:36
C      192.168.30.0/24 is directly connected, GigabitEthernet 1/2
O      192.168.40.0/24 [110/101] via 192.168.30.2, 00:56:23, GigabitEthernet 1/2
```

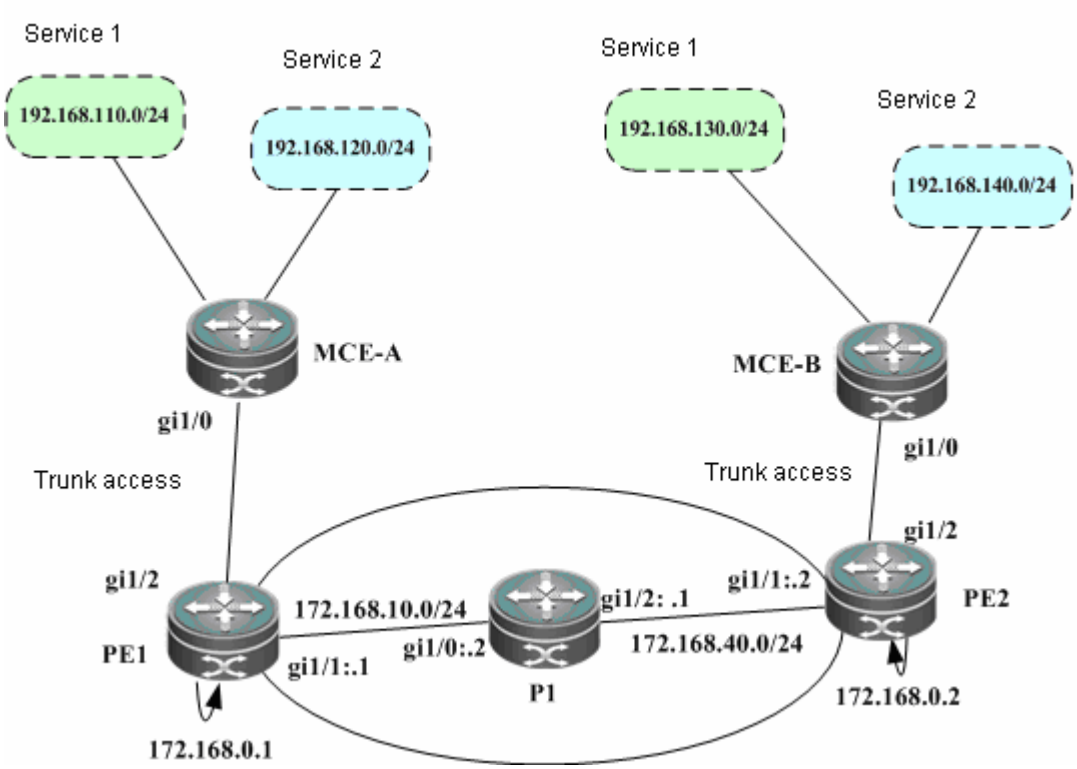
Configuring Multiple OSPF Instances on an MCE

Networking Requirements

A customer site involves multiple services. The same services communicate with each other over an MPLS backbone network and different services are isolated from each other.

Networking Topology

Figure 45



Configuration Steps

MCE-A:

Configure a trunk link between a PE and a CE.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/0
```

VLAN is a configuration command used on switch products, and is not applicable to routers (except for the switching card interface). Routers can use the routing interface to connect to the PE.

```
Ruijie(config-if-GigabitEthernet 1/0)# switchport mode trunk
Ruijie(config-if-GigabitEthernet 1/0)# end
```

Configure two VRFs to represent different services and bind respective interfaces.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf VPN1
Ruijie(config-vrf)# exit
Ruijie(config)# VLAN 10
Ruijie(config)# interface vlan 10
```

VLAN is a configuration command used on switch products, and is not applicable to routers (except for the switching card interface). Routers can use the sub-interface to bind the VRF.

```
Ruijie(config-if-vlan 10)# ip vrf forwarding VPN1
Ruijie(config-if-vlan 10)# ip address 192.168.10.2 255.255.255.0
Ruijie(config)# ip vrf VPN2
Ruijie(config-vrf)# exit
Ruijie(config)# VLAN 20
```

```
Ruijie(config)# interface vlan 20
```

VLAN is a configuration command used on switch products, and is not applicable to routers (except for the switching card interface). Routers can use the sub-interface to bind the VRF.

```
Ruijie(config-if-vlan 20)# ip vrf forwarding VPN2
Ruijie(config-if-vlan 20)# ip address 192.168.20.2 255.255.255.0
```

Run the OSPF protocol with the PE for two VRFs.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10 VPN1
Ruijie(config-router)# network 192.168.10.0 255.255.255.0 area 0
Ruijie(config-router)# capability vrf-lite
```

```
Ruijie(config)# router ospf 10 VPN2
Ruijie(config-router)# network 192.168.20.0 255.255.255.0 area 0
Ruijie(config-router)# capability vrf-lite
```

PE1:

Configure a loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 172.168.0.1 255.255.255.255
```

Configure the trunk link between the PE and the CE.

```
Ruijie(config)# interface gigabitethernet 1/2
Ruijie(config-if-GigabitEthernet 1/2)# switchport mode trunk
Ruijie(config-if-GigabitEthernet 1/2)# end
```

Configure VRFs.

Create two VRFs named VPN1 and VPN2 to represent different services, and associate the VRFs with the corresponding interfaces.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf VPN1
Ruijie(config-vrf)# rd 1:100
Ruijie(config-vrf)# route-target both 1:100
Ruijie(config-vrf)# end
Ruijie# configure terminal
Ruijie(config)# ip vrf VPN2
Ruijie(config-vrf)# rd 1:200
Ruijie(config-vrf)# route-target both 1:200
Ruijie(config-vrf)# end
```

Associate the CE-connecting interface with the VRF.

```
Ruijie(config)# VLAN 10
```

```
Ruijie(config)# interface vlan 10
```

VLAN is a configuration command used on switch products, and is not applicable to routers (except for the switching card interface). Routers can use the sub-interface to bind the VRF.

```
Ruijie(config-if-vlan 10)# ip vrf forwarding VPN1
Ruijie(config-if-vlan 10)# ip address 192.168.10.1 255.255.255.0

Ruijie(config)# VLAN 20
Ruijie(config)# interface vlan 20
```

VLAN is a configuration command used on switch products, and is not applicable to routers (except for the switching card interface). Routers can use the sub-interface to bind the VRF.

```
Ruijie(config-if-vlan 20)# ip vrf forwarding VPN1
Ruijie(config-if-vlan 20)# ip address 192.168.20.1 255.255.255.0
```

Configure the BGP protocol to set up an MP-IBGP session with PE2.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 172.168.0.2 remote-as 1
Ruijie(config-router)# neighbor 172.168.0.2 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 172.168.0.2 activate
Ruijie(config-router-af)# end
```

Exchange routes with the CE via OSPF.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10 VPN1
Ruijie(config-router)# network 192.168.10.0 255.255.255.0 area 0
Ruijie(config-router)# exit
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf VPNA
Ruijie(config-router-af)# redistribute ospf 10
Ruijie(config-router-af)# redistribute connected
Ruijie(config-router-af)# end

Ruijie# configure terminal
Ruijie(config)# router ospf 20 VPN2
Ruijie(config-router)# network 192.168.20.0 255.255.255.0 area 0
Ruijie(config-router)# redistribute bgp subnets
Ruijie(config-router)# exit
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf VPN2
Ruijie(config-router-af)# redistribute ospf 20
Ruijie(config-router-af)# redistribute connected
Ruijie(config-router-af)# end
```

Configure MPLS signaling on the backbone network. Enable MPLS on the public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# ip address 172.168.10.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/1)# end
```

Configure a routing protocol on the backbone network.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 172.168.10.0 0.0.0.255 area 0
Ruijie(config-router)# network 172.168.0.1 0.0.0.0 area 0
Ruijie(config-router)# end
```

P1:

The configuration steps are similar to the configuration steps of P in the MPLS backbone network.

SITEB:

Configure the trunk link between the PE and the CE.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/0
```

VLAN is a configuration command used on switch products, and is not applicable to routers (except for the switching card interface). Routers can use the routing interface to connect to the PE.

```
Ruijie(config-if-GigabitEthernet 1/0)# switchport mode trunk
Ruijie(config-if-GigabitEthernet 1/0)# end
```

Configure two VRFs to represent different services and bind respective interfaces.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf VPN1
Ruijie(config-vrf)# exit
Ruijie(config)# VLAN 10
Ruijie(config)# interface vlan 30
```

VLAN is a configuration command used on switch products, and is not applicable to routers (except for the switching card interface). Routers can use the sub-interface to bind the VRF.

```
Ruijie(config-if-vlan 10)# ip vrf forwarding VPN1
Ruijie(config-if-vlan 10)# ip address 192.168.30.2 255.255.255.0

Ruijie(config)# ip vrf VPN2
Ruijie(config-vrf)# exit
Ruijie(config)# VLAN 40
Ruijie(config)# interface vlan 40
```

VLAN is a configuration command used on switch products, and is not applicable to routers (except for the switching card interface). Routers can use the sub-interface to bind the VRF.

```
Ruijie(config-if-vlan 20)# ip vrf forwarding VPN2
Ruijie(config-if-vlan 20)# ip address 192.168.40.2 255.255.255.0
```

Run the OSPF protocol with the PE for two VRFs.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10 VPN1
Ruijie(config-router)# network 192.168.30.0 255.255.255.0 area 0
Ruijie(config-router)# capability vrf-lite

Ruijie(config)# router ospf 10 VPN2
Ruijie(config-router)# network 192.168.40.0 255.255.255.0 area 0
Ruijie(config-router)# capability vrf-lite
```

PE2:

Configure a loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 172.168.0.2 255.255.255.255
```

Configure the trunk link between the PE and the CE.

```
Ruijie(config)# interface gigabitethernet 1/2
Ruijie(config-if-GigabitEthernet 1/2)# switchport mode trunk
Ruijie(config-if-GigabitEthernet 1/2)# end
```

Configure VRFs.

Create two VRFs named VPN1 and VPN2 to represent different services, and associate the VRFs with the corresponding interfaces.

```
Ruijie# configure terminal
Ruijie(config)# ip vrf VPN1
Ruijie(config-vrf)# rd 1:100
Ruijie(config-vrf)# route-target both 1:100
Ruijie(config-vrf)# end
```

```
Ruijie# configure terminal
Ruijie(config)# ip vrf VPN2
Ruijie(config-vrf)# rd 1:200
Ruijie(config-vrf)# route-target both 1:200
Ruijie(config-vrf)# end
```

Associate the CE-connecting interface with the VRF.

```
Ruijie(config)# VLAN 30
Ruijie(config)# interface vlan 30
```

VLAN is a configuration command used on switch products, and is not applicable to routers (except for the switching card interface). Routers can use the sub-interface to bind the VRF.

```
Ruijie(config-if-vlan 10)# ip vrf forwarding VPN1
Ruijie(config-if-vlan 10)# ip address 192.168.30.1 255.255.255.0

Ruijie(config)# VLAN 40
Ruijie(config)# interface vlan 40
```

VLAN is a configuration command used on switch products, and is not applicable to routers. Routers can use the sub-interface to bind the VRF.

```
Ruijie(config-if-vlan 20)# ip vrf forwarding VPN2
Ruijie(config-if-vlan 20)# ip address 192.168.40.1 255.255.255.0
```

Configure the BGP protocol to set up an MP-IBGP session with PE2.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 172.168.0.1 remote-as 1
Ruijie(config-router)# neighbor 172.168.0.1 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router-af)# neighbor 172.168.0.1 activate
Ruijie(config-router-af)# end
```

Exchange routes with the CE via OSPF.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10 VPN1
Ruijie(config-router)# network 192.168.30.0 255.255.255.0 area 0
Ruijie(config-router)# redistribute bgp subnets
Ruijie(config-router)# exit
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf VPN1
Ruijie(config-router-af)# redistribute ospf 10
Ruijie(config-router-af)# redistribute connected
Ruijie(config-router-af)# end

Ruijie# configure terminal
Ruijie(config)# router ospf 20 VPN2
```

```
Ruijie(config-router)# network 192.168.40.0 255.255.255.0 area 0
Ruijie(config-router)# redistribute bgp subnets
Ruijie(config-router)# exit
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf VPN2
Ruijie(config-router-af)# redistribute ospf 20
Ruijie(config-router-af)# redistribute connected
Ruijie(config-router-af)# end
```

Configure MPLS signaling on the backbone network. Enable MPLS on the public network interface.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

In case of a switch, configure the interface to a RoutedPort interface (not applicable to a router).

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
```

In case of a router, enable fast forwarding on the interface (not applicable to a switch).

```
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# ip address 172.168.40.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/1)# end
```

Configure a routing protocol on the backbone network.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 172.168.40.0 0.0.0.255 area 0
Ruijie(config-router)# network 172.168.0.2 0.0.0.0 area 0
Ruijie(config-router)# end
```

Verification

- MCEA

```
Ruijie# show ip route vrf VPN1
Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default
C      192.168.10.0/24 is directly connected, VLAN 10
O      192.168.110.0/24 [110/101] via 192.168.21.2, 00:56:23, Gi1/1
O E2    192.168.130.0/24 [110/2] via 192.168.10.1, 00:00:36, VLAN 10
```

```
Ruijie# show ip route vrf VPN2
Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default
C      192.168.20.0/24 is directly connected, VLAN 20
O      192.168.120.0/24 [110/101] via 192.168.22.2, 00:56:23, Gi1/2
O E2    192.168.140.0/24 [110/2] via 192.168.20.1, 00:00:36, VLAN 20
```

■ MCEB

```
Ruijie# show ip route vrf VPN1
Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default
C      192.168.30.0/24 is directly connected, VLAN 30
O      192.168.130.0/24 [110/101] via 192.168.23.2, 00:56:23, Gi1/1
O E2    192.168.110.0/24 [110/2] via 192.168.30.1, 00:00:36, VLAN 30

Ruijie# show ip route vrf VPN2
Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default
C      192.168.40.0/24 is directly connected, VLAN 40
O      192.168.140.0/24 [110/101] via 192.168.24.2, 00:56:23, Gi1/2
O E2    192.168.140.0/24 [110/2] via 192.168.40.1, 00:00:36, VLAN 40
```

L2VPN Configuration

☑ Only the switch equipped with the MPLS multi-service card or EC line card can support the L2VPN service.

☑ For the router with the L2VPN service enabled, the L2VPN service can be properly forwarded if the fast forwarding function is enabled both on the interfaces connected to the user and the public network.

Understanding L2VPN

Similar to an MPLS/BGP L3VPN, an L2VPN also uses the existing public network to extend the private network of a user. For an MPLS L2VPN, Layer 2 user data (such as ATM cells, FR frames, and Ethernet frames) is transparently transmitted on an MPLS network. As far as the user is concerned, the MPLS network is a Layer 2 switching network where different sites set up Layer 2 connections on the MPLS network.

Compared with L3VPN, L2VPN has the following advantages:

- Supports various link layer protocols. On an MPLS network, you can provide Layer 2 VPN services based on various protocols including ATM, FR, VLAN, Ethernet, PPP, and HDLC. L2VPN also supports multiple network layer protocols, including IP, IPv6, IPX, and SNA.
- A provider edge (PE) does not store the information about user VPNs, reducing the overhead on the PE. This largely lessens the burden of PEs and the entire service provider (SP) network and allows the carriers to support more VPNs and access more users.
- Allows a user to control the advertising of VPN routes and frees the PE from managing VPN routes. This guarantees reliability and confidentiality of user routes and lessens the management burden of carriers.

At present, an MPLS L2VPN has the following two service models:

- Virtual Private Wire Service (VPWS)

You can set up a Pseudo Wire (PW), also called Virtual Circuit (VC), on an IP/MPLS network to simulate Layer 2 point-to-point services, including Ethernet, PPP, HDLC, AAL5 frames, ATM cells, FR, and SONET/SDH. For a user, the VPWS resembles a physical line provided for the user on the carrier's network.

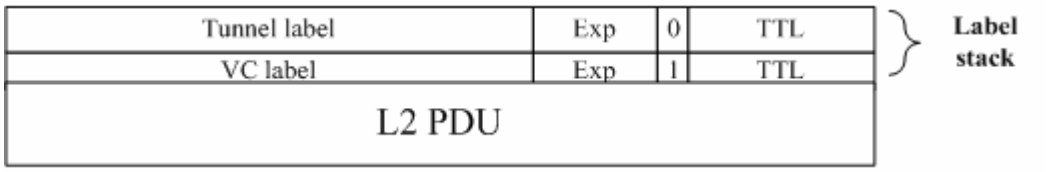
- Virtual Private LAN Service (VPLS)

Simulate LAN services on an IP/MPLS network to implement Ethernet connections on the WAN. For a user, its Layer 2 devices are connected to each other across the IP/MPLS core network and the core network is like a virtual switch.

Frame Format of an MPLS L2VPN Packet

As shown in the following figure, an MPLS L2VPN packet is generally encapsulated in two layers of labels. The outer layer is a public label that is responsible for forwarding the packet on the public network. The inner layer is the VC label that is used to identify a VC instance on a PE.

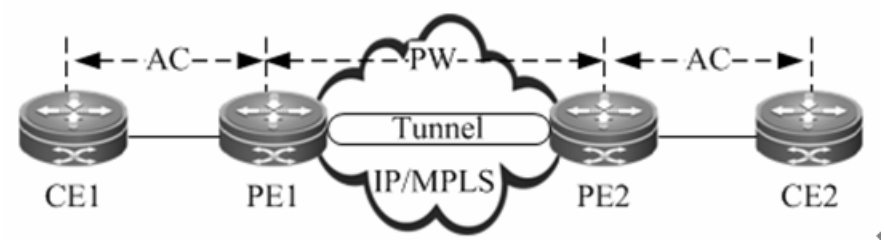
Figure 46



Basic Concepts

The following figure shows the components of an L2VPN.

Figure 47



CE

A custom edge (CE) is a user device directly connected to the SP.

PE

A PE, an edge device on the SP network, is connected to CEs and is responsible for the access of VPN services. It forwards packets from a private network to a public tunnel and from the public tunnel to the private network.
On a hierarchical VPLS network, PEs are classified into User Facing Provider Edge devices (U-PEs) and Network Facing Provider Edge devices (N-PEs).

- U-PE

A U-PE is a PE next to the user side as the hierarchical VPLS network. It is an aggregation device for users to access a VPN.

- N-PE

An N-PE is a core PE device on the hierarchical VPLS network. It is located at the edge of core VPLS domains to provide transparent transmission of VPLS services between core networks.

AC

On an L2VPN of any type (VPWS/VPLS), CEs must be connected to PEs through physical lines or virtual lines. These physical or virtual lines are referred to as the ACs. For example, an AC can be an Ethernet cable, a VLAN, or an MPLS LSP. All user packets on the AC are generally forwarded to the peer CE without any changes.

PW

A PW is responsible for setting up and maintaining the signaling protocol between PEs. The AC transmits frames from a CE to a PE and the PW sends user frames from one PE to another PE.

On a hierarchical VPLS network, PWs are classified into Hub PWs and Spoke PWs.

- Hub PW

A Hub PW indicates a PW set up between N-PEs.

- Spoke PW

A Spoke PW indicates a PW set up between a U-PE and an N-PE, or a PW with which a user accesses the PE on a basic VPLS network.

Forwarder

On an L2VPN, every frame received by a PE from the AC must be forwarded to the corresponding PW. Similarly, the frames received by the PE from the PW are sent to the corresponding AC. This process of making forwarding decisions is called the forwarder.

In VPWS, the forwarder performs the one-to-one mapping between ACs and PWs.

In VPLS, the forwarder is also called the Virtual Switch Instance (VSI) or Virtual Forwarding Instance (VFI), which is the VPLS forwarding table. Through the VFI, you can map the ACs of actual VPLS users to PWs.

Tunnel

The traffic of PWs between PEs is transmitted over the tunnel. One tunnel can carry multiple PWs. The tunnels mentioned in this chapter refer to MPLS LSPs.

Encapsulation

The L2VPN payload is transmitted over PWs. The PWE3 defines the encapsulation formats and transmission technologies of various packets transmitted over PWs. The PW supports two encapsulation modes: raw and tag. In raw mode, the service distinguishers are removed from the PDUs transmitted on PWs. In tag mode, the service distinguishers are included in the PDUs transmitted on PWs. For Ethernet emulated services, the service distinguisher is generally a VLAN tag. Encapsulation and transmission methods of PPP and HDLC packets are defined in the RFC4618.

PW Signaling

PW signaling protocols include LDP and BGP. They are responsible for creating and maintaining PWs.

- When using LDP sessions to set up PWs

When using LDP sessions to set up PWs, you should set up two types of LDP sessions: LDP sessions set up through the basic discovery mechanism and LDP sessions set up through the extended discovery mechanism. The former is used to set up public LSPs and the latter to transmit the label mapping messages of PWs. The setup and disconnection of a PW are as follows:

- PEs exchange Hello packets through the target LDP session (through the extended LDP discovery mechanism) and set up the LDP session.
- When the status of the AC at one PE end is Up, the PE assigns a label to the corresponding PW.
- The PE encodes the label value and the PW ID into the FEC TLV and sends a label mapping message to the peer PE through the target LDP session.

- Upon receipt of the label mapping message, the peer PE decodes the PW ID and label value and checks whether the interface parameters (such as MTU) and PW types are consistent.
- The PW is set up after both ends exchange their label values and verify the validity of PW IDs and interface parameters.
- To disconnect a PW, a PE sends a label withdrawal message to the peer PE. Then the PW is disconnected.

Caution

The following conditions must be met when you set up a PW through LDP; otherwise, the PW cannot be set up:

1) The MTUs and PW types on the devices at both ends of the PW must be consistent.

2) The PW IDs on the devices at both ends of the PW must be consistent.

- Using BGP signaling to set up PWs

Unlike using LDP signaling, this method does not require static configuration of the connection between CEs. Instead, the entire carrier network is divided into different VPNs and CEs are numbered globally in VPN sites. Similar to BGP/MPLS L3VPN, BGP signaling uses VPN Target to identify CE sites that belong to the same VPN. The process of discovering VPN sites by using VPN Target is called the automatic discovery. If BGP is used as the signaling protocol, there will be two stages. The first stage is automatic discovery and the second stage is to set up bidirectional PWs between PEs based on the result of the automatic discovery.

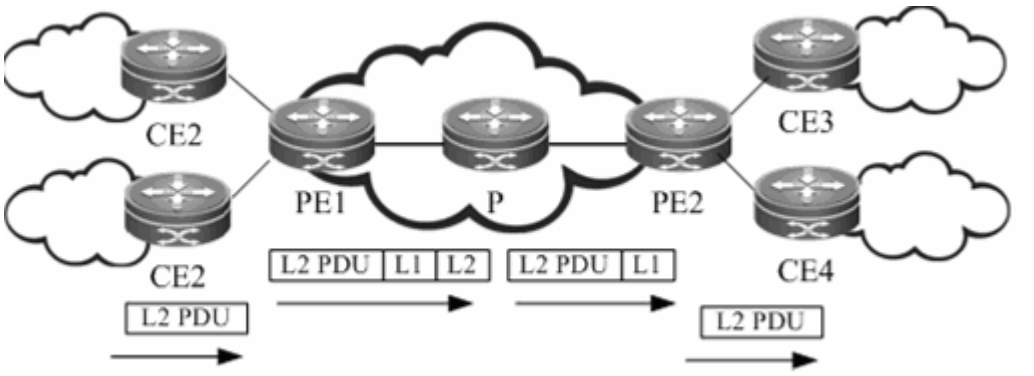
The method of establishing PWs by using BGP has brought in a concept of the label blocks. It uses the label block to allocate labels for multiple links at a time. Users can specify the site range for a local CE, indicating the number of remote CEs that can be connected with the CE. The system allocates one label block to the CE at a time. The label block's size is equal to the site range. In this way, users can allocate extra labels for VPN. This may cause waste of the label resource in a short term but can reduce the configuration workload for VPN expansion.

Given the BGP's characteristics, such as the route reflector's characteristics, this method of setting up PWs can reduce the full inter-connection of BGP sessions, facilitating the expansion of capacity.

Basic Forwarding Process

An L2VPN adopts the two-layer label stack to transmit services on the backbone network. The outer label is used to forward packets on the backbone network and the inner VC label is used to identify VC instances on PEs. Based on the inner VC label, a PE determines the CE to which the packets needs to be sent. The following figure shows the forwarding process.

Figure 48



After receiving a Layer 2 packet from CE2, PE1 searches for the PW forwarding entry based on the PW associated with the AC and learns that the next hop is PE2 and the PW label is L1. PE1 then searches for the public LSP based on the next hop (PE2) and obtains the outer label L2. As a result, PE1 encapsulates an MPLS header and pushes the inner label L1 and outer label L2 to the Layer packet and sends the packet to P. P forwards the MPLS packet based on the label and the penultimate hop popping (PHP) P pops out the outer label and sends the packet to PE2. Upon receipt of the packet, PE2 searches for the PW ID entry based on the inner label L1, learns the output interface (that is, the egress AC), pops out the inner label, and directly sends the Layer 2 packet to the destination CE4.

VPWS

Understanding VPWS

As an end-to-end bearer technology of Layer 2 services, VPWS is a P2P L2VPN. VPWS provides MPLS network-based L2VPN services so that carriers can provide L2VPN services based on various protocols including ATM, FR, VLAN, Ethernet and PPP over a unified MPLS network. Moreover, the MPLS network can provide traditional IP, MPLS L3VPN and other services. Simply speaking, MPLS L2VPN is to transmit users' layer-2 data transparently on the MPLS network.

- Signaling protocol of VPWS

VPWSs can be divided into Martini and Kompella VPWSs by signaling protocol. Martnini VPWSs use LDP as the signaling protocol while Kompella VPWSs use BGP as the signaling protocol.

- Intercommunication of heterogeneous media of VPWSs

If CEs on two ends of the same L2VPN feature different link types, L2VPN's feature of heterogeneous media intercommunication are needed. According to the suggestion of draft-kompella-ppvpn-l2vpn, the encapsulation type of the L2VPN interface of PEs needs to be ip-interworking during the establishment of the L2VPN connection. Users' layer-3 data (IP packets) is transmitted on the MPLS network transparently.

Configuring Martini VPWS

Configuring a Public Tunnel

You must set up an LSP on the public network to carry VC services. To run MPLS on the backbone network, you must enable LDP on Ps and PEs to establish a public network tunnel. This means that you have to configure LDP on the routers and enable MPLS forwarding on each interface. The configuration procedure is as follows:

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **mpls ip**	Enables MPLS globally. Caution This command is not applicable to switch chip forwarding.
Ruijie(config)# **mpls router ldp**	Enables LDP and enters MPLS routing configuration mode.
Ruijie(config-**mpls-router)# ldp router-id interface loopback** *id* [**force**]	Configures the LDP router ID. The IP address of the loopback interface is generally used as the router ID.
Ruijie(config-mpls-router)# **exit**	Exits MPLS routing configuration mode.

Ruijie(config)# **interface** *type ID*	Enters public network interface configuration mode.
Ruijie(config-**if**-*type ID*)# **ip address** *ip-address mask*	Assigns an IP address to the interface.
Ruijie(config-if-*type ID*)# **label-switching**	Enables MPLS forwarding on the interface at the public network side.
Ruijie(config-if-*type ID*)# **mpls ip**	Enables LDP on the interface.
Ruijie(config-if-*type ID*)# **ip ref**	☑ For routers, the fast forwarding function of the interface must be enabled. You do not need to use this command on switches.
Ruijie(config-if-*type ID*)# **show running-config**	Displays all configuration information.

Configure an MPLS network.

```
Ruijie# configure terminal
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# )# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
```

The **no switchport** command is used on switches to switch the port mode to routed port mode. It does not apply to routers and does not need to be used on routers.

```
Ruijie(config-if-gigabitethernet 1/1)# no switchport
```

Enable the fast forwarding function of the interface on routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 1/1)# no switchport
Ruijie(config-if-gigabitethernet 1/1)# ip address 192.168.10.1 255.255.255.0
Ruijie(config-if-gigabitethernet 1/1)# label-switching
Ruijie(config-if-gigabitethernet 1/1)# mpls ip
```

Configuring Remote LDP Peers

A PW is set up and maintained by the extended LDP. If other LSRs exist between two PEs, use the extended LDP discovery mechanism to set up a remote LDP session between the PEs and assign PW labels in the session. The procedures for configuring a remote LDP peer and setting up a remote LDP session are as follows:

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **mpls router ldp**	Enables LDP and enters LDP configuration mode.
Ruijie(config-mpls-router)# **neighbor** *ip-address*	Configures a remote LDP session.
Ruijie(config-mpls-router)# **show running-config**	Displays all configuration information.

Configure a remote LDP peer at 3.3.3.3.

```
Ruijie# configure terminal
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# neighbor 3.3.3.3
Ruijie(config)# exit
```

Caution The PW label messages of the LDP are not affected by the LDP label distribution mode or label retention mode. The LDP is forced to work in DU and liberal label retention mode.

Configuring User Access VPWS

VPWS Access Modes for Switches

Only Ethernet VPWS services are provided on switches. According to whether the packet carries a VLAN tag, user access can be divided into the following modes:

59) Access interface access
60) Trunk interface access
61) Dot1q Tunnel interface access

Caution VPWS services are supported by only VLAN interfaces (that is, SVI interfaces on switches). In addition, the VLAN can have only one member interface. You have trouble in enabling both IP and VPWS services on VLAN interfaces at the same time.
One VLAN interface can be bound to only one VC instance. The same VC instance cannot be bound to different VLAN interfaces.
When the **xconnect** command is used to specify the neighbor address of the VC peer end, you must use the router ID of this peer end as the peer address. The router ID of this peer end must be the 32-bit address of the loopback interface.
After the port protection mode is enabled on the member ports of the AC end of L2VPN, the port protection mode does not take effect for non-Tunk member ports.

These access modes are described in details as follows:

- VLAN access interface access

This mode applies when user packets transmitted on ACs are not encapsulated through 802.1Q (that is, packets without VLAN tags). Use the following commands to configure VLAN access interface access in privileged mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters interface configuration mode.
Ruijie(config-if-*type ID*)# **switchport mode access**	Enables the interface to work in access mode.
Ruijie(config-if-*type ID*)# **switchport access vlan** *vlan-id*	Sets the interface as a member interface of a VLAN.
Ruijie(config-if-*type ID*)# **exit**	Exits interface configuration mode.
Ruijie(config)# **interface vlan** *vlan-id*	Creates and enters VLAN interface configuration mode.
Ruijie(config-if-*type ID*)# **xconnect** *vc_id vc_peer* **encapsulation mpls** {**ethernet**|**ethernetvlan**} **raw**	Creates a VC and configures the raw encapsulation mode.
Ruijie(config-if-*type ID*)# **show running-config**	Displays all configuration information.

Configure **Gigabitethernet** *1/1* as an access interface and configure VPWS services for the corresponding VLAN interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/1
Ruijie(config-if-gigabitethernet 1/1)# switchport mode access
Ruijie(config-if-gigabitethernet 1/1)# switchport access vlan 2
Ruijie(config-if-gigabitethernet 1/1)# exit
Ruijie(config)# interface vlan 2
Ruijie(config-if-vlan 2)# xconnect 2  2.2.2.2 encapsulation mpls ethernet raw
```

Caution In access interface access mode, we recommend setting the PW type to Ethernet, and the PW encapsulation mode must be raw.

- VLAN trunk interface access

This mode applies to the transmission of VPWS services from multiple users on the same AC. The PE determines the VPWS services for user packets based on their VLAN tags to provide the multiplexing of access interfaces.

Use the following commands to configure VLAN trunk interface access in privileged mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters interface configuration mode.
Ruijie(config-if-*type ID*)# **switchport mode trunk**	Enables the interface to work in trunk mode.
Ruijie(config-if-*type ID*)# **switchport trunk allow vlan add** *vlan-list*	Enables the trunk link to allow VLAN traffic.
Ruijie(config-if-*type ID*)# **exit**	Exits the interface configuration mode.
Ruijie(config)# **interface vlan** *vlan-id*	Creates and enters VLAN interface configuration mode.
Ruijie(config-if-*type ID*)# **xconnect** *vc_peer vc_id* **encapsulation mpls ethernetvlan tagged**	Creates a VC and configures the tagged encapsulation mode.
Ruijie(config-if-*type ID*)# **show running-config**	Displays all configuration information.

Configure **Gigabitethernet** *1/1* as a trunk port and configure VPWS services for the corresponding VLAN interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/1
Ruijie(config-if-gigabitethernet 1/1)# switchport mode trunk
Ruijie(config-if-gigabitethernet 1/1)# switchport trunk  allowed vlan add  2 3
Ruijie(config-if-gigabitethernet 1/1)# exit
Ruijie(config)# interface vlan 2
Ruijie(config-if-vlan 2)# xconenct 2  2.2.2.2 encapsulation mpls ethernetvlan tagged
Ruijie(config-if-vlan 2)# exit
Ruijie(config)# interface vlan 3
```

```
Ruijie(config-if-vlan 2)# xconenct 3  2.2.2.2 encapsulation mpls ethernetvlan tagged
```

Caution In trunk interface access mode, we recommend setting the PW type to **ethernetvlan**, and the PW encapsulation mode must be tagged.
The L2VPN service cannot be bound to the Native VLAN of the Trunk interface.

- VLAN tunnel interface access

This mode applies when user service packets transmitted on ACs carry private VLAN tags if users access VPWS services. In this mode, the PE forwards all packets received from the VLAN tunnel interface without any changes. This mode requires the VLAN member interfaces that connect PEs with CEs to work in tunnel mode.

Use the following commands to configure VLAN tunnel interface access in privileged mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters interface configuration mode.
Ruijie(config-if-*type ID*)# **switchport access** *vlan-id*	Sets the interface as a VLAN member interface.
Ruijie(config-if-*type ID*)# **switchport mode dot1q-tunnel**	Sets the interface to work in tunnel mode.
Ruijie(config-if-*type ID*)# **exit**	Exits interface configuration mode.
Ruijie(config)# **interface** vlan *vlan-id*	Creates and enters VLAN interface configuration mode.
Ruijie(config-if-*type ID*)# **xconnect** *vc_id vc_peer* **encapsulation mpls ethernet raw**	Creates a VC and configures the raw encapsulation mode.
Ruijie(config-if-*type ID*)# **show running-config**	Displays all configuration information.

Configure **Gigabitethernet** *1/1* as a VLAN tunnel interface and configure VPWS services for the corresponding VLAN interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/1
Ruijie(config-if-gigabitethernet 1/1)# switchport mode dot1q-tunnel
Ruijie(config-if-gigabitethernet 1/1)# switchport access 2
Ruijie(config-if-gigabitethernet 1/1)# exit
Ruijie(config)# interface vlan 2
Ruijie(config-if-vlan 2)# xconenct 2  2.2.2.2 encapsulation mpls ethernet raw
Ruijie(config-if-vlan 2)# exit
```

Caution For the access mode of the VLAN tunnel port, we recommend setting the PW type to **ethernet** and the encapsulation mode must be raw.
For the access mode of the VLAN tunnel interface, only the basic QinQ is supported.

VPWS Access Modes for Routers

There are several ways for users to access VPWS services provided by routers. Users can choose access modes according to actual application needs. Services provided by the VPWS depend on the link protocol adopted by the interface that connects the PE with the CE. Currently, the following four point-to-point L2VPN services are supported:

1) Simulative Ethernet line service
2) Simulative 802.1Q line service
3) Simulative PPP line service
4) Simulative HDLC line service

For the PE, the four L2VPN line services correspond to four access modes.

Caution You have trouble in enabling both IP and VPWS services on VLAN interfaces at the same time.
One VLAN interface can be bound to only one VC instance. The same VC instance cannot be bound to different VLAN interfaces.

☑ For the router product, VPWS services can be properly forwarded only when the fast forwarding function is enabled on the interfaces connected to the access user VPWS and to the public network.

Caution When the **xconnect** command is used to specify the neighbor address of the VC peer end, you must use the router ID of this peer end as the peer address. The router ID of this peer end must be the 32-bit address of the loopback interface.

■ Ethernet access

In this mode, the interface between a PE and a CE encapsulates the Ethernet link protocol and provides VPWS services. The CE connects to the PE through the Ethernet link and requests Ethernet frames transmitted transparently by the PE. The Ethernet interface access mode applies when user service packets transmitted on ACs carry private VLAN tags or do not carry VLAN tags in the case of VPWS service access. In this mode, all packets received by PEs from the interface are forwarded without any changes.

Use the following commands to configure Ethernet access in privileged mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters interface configuration mode.
Ruijie(config-if-*type ID*)# **xconnect** *vc_peer vc_id* **encapsulation mpls ethernet raw**	Creates a VC, and configure the Ethernet PW type and the raw encapsulation mode.
Ruijie(config-if-*type ID*)# **ip ref**	☑ For routers, the fast forwarding function of the interface must be enabled. You do not need to use this command on switches.
Ruijie(config-if-*type ID*)# **show running-config**	Displays all configuration information.

Configure VPWS services for the Ethernet access interface **Gigabitethernet** *1/1*.

```
Ruijie# configure terminal
```

```
Ruijie(config)# interface gigabitethernet 0/1
```

Enable the fast forwarding function of the interface on routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 1/1)# ip ref
Ruijie(config-if-gigabitethernet 0/1)# xconnect 2.2.2.2 2 encapsulation mpls ethernet raw
Ruijie(config-if-gigabitethernet 0/1)# exit
```

- Ethernet sub-interface access

In this mode, the interface between a PE and a CE encapsulates the 802.1Q link protocol and provides VPWS services. The CE connects to the PE through the Ethernet sub-interface and requests Ethernet frames transmitted transparently by the PE. The Ethernet sub-interface access mode applies when several VPWS services for multiple users are transmitted on an access physical link. The PE matches packets with VPWS services according to dot1q tags carried by the user packets to provide the multiplexing of access interfaces. In this access mode, packets sent by CEs to PEs must carry VLAN tags.

Use the following commands to configure Ethernet sub-interface access in privileged mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters interface configuration mode.
Ruijie(config-if-*type ID*)# **xconnect** *vc_peer vc_id* **encapsulation mpls ethernetvlan tagged**	Creates a VC, and configures the Ethernet VLAN PW type and the tagged encapsulation mode.
Ruijie(config-if-*type ID*)# **ip ref**	☑ For routers, the fast forwarding function of the interface must be enabled. You do not need to use this command on switches. Use the command to configure the sub-interface's fast forwarding function on its master interface.
Ruijie(config-**if**-*type ID*)# **show running-config**	Displays all configuration information.

Configure **Gigabitethernet** *1/1* as an access interface and configure VPWS services for the corresponding VLAN interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 0/1.1
Ruijie(config-if-gigabitethernet 0/1.1)#encapsulation dot1Q 1
```

Enable the fast forwarding function of the interface on routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 1/1)# ip ref
Ruijie(config-if-gigabitethernet 0/1.1)# xconnect 2.2.2.2 2 encapsulation mpls ethernetvlan
tagged
Ruijie(config-if-gigabitethernet 0/1.1)# exit
```

Caution

If the VPWS service is enabled on both the master interface and sub-interface, or is enabled on one of them, packets without VLAN tags received by the Ethernet interface belong to the service provided by the master

interface. If they carry VLAN tags and match with the sub-interface's VLAN ID, they belong to the service provided by the sub-interface.

To enable the sub-interface to support the fast forwarding function, use the **ip ref** command to enable the fast forwarding function on its master interface.

Users can use **mpls mtu** command to modify the **mpls mtu** value. By default, the value is equal to the **mtu** value of the interface.

- PPP access

In this mode, the interface that connects a PE with a CE encapsulates the PPP link protocol and provides VPWS services. The CE connects to the PE in PPP mode and requests the PPP frames transmitted transparently by the PE. The interface that encapsulates the PPP protocol is bound with the L2VPN service and its PE-end PPP protocol will be disabled. Therefore, the LCP and NCP of one CE will not interact with each other. The PE will transparently transmit the PPP negotiation controlling packet sent by CE. The PPP negotiation will be conducted between CEs.

Use the following commands to configure PPP access in privileged mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters interface configuration mode.
Ruijie(config-if-*type ID*)# **encapsulation ppp**	Enables the interface to encapsulate PPP.
Ruijie(config-if-*type ID*)# **xconnect** *vc_peer vc_id* **encapsulation mpls ppp**	Creates the VC and configures the PW type as PPP.
Ruijie(config-if-*type ID*)# **ip ref**	☑ For routers, the fast forwarding function of the interface must be enabled. You do not need to use this command on switches.
Ruijie(config-if-*type ID*)# **show running-config**	Displays the existing configuration information.

Configure **serial** *1/0* to provide the VPWS service of transparently transmitting PPP frames.

```
Ruijie# configure terminal
Ruijie(config)# interface serial 1/0
Ruijie(config-if-serial 1/0)# encapsulation ppp
Ruijie(config-if-serial 1/0)# xconnect 2.2.2.2 2 encapsulation mpls ppp
Ruijie(config-if-serial 1/0)# exit
```

- HDLC access

In this mode, the interface that connects a PE with a CE encapsulates the HDLC link protocol and provides VPWS services. The CE connects to the PE in HDLC mode and requests the HDLC frames transmitted transparently by the PE.

Use the following commands to configure HDLC access in privileged mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters interface configuration mode.
Ruijie(config-if-*type ID*)# **encapsulation hdlc**	Enables the interface to encapsulate HDLC.
Ruijie(config-if-*type ID*)# **xconnect** *vc_peer vc_id* **encapsulation mpls hdlc**	Creates the VC and configures the PW type as HDLC.
Ruijie(config-if-*type ID*)# **show running-config**	Disables the existing configuration information.

Configure **serial** *1/0* to provide the VPWS service of transparently transmitting HDLC.

```
Ruijie# configure terminal
Ruijie(config)# interface serial 1/0
```

Enable the fast forwarding function of the interface on routers. You do not need to use this command on switches.

```
Ruijie(config-if-serial 1/0)# ip ref
Ruijie(config-if-serial 1/0)# encapsulation hdlc
Ruijie(config-if-serial 1/0)# xconnect 2.2.2.2 2 encapsulation mpls ppp
Ruijie(config-if-serial 1/0)# exit
```

Configuring Heterogeneous Media Communication VPWS

If CEs on two ends of the same L2VPN feature different link types, the L2VPN's feature of heterogeneous media intercommunication is needed. According to the suggestion of draft-kompella-ppvpn-l2vpn, the encapsulation type of the L2VPN interface of PEs needs to be ip-interworking during the establishment of the L2VPN connection. Users' IP packets are transmitted on the MPLS network transparently. When the L2VPN's heterogeneous media communication function is used, VPWS service interfaces of PEs on both ends must encapsulate ip-interworking. After PW connection is set up, packets are processed as follows:

62) After a PE receives packets from a CE and decapsulates the link layer, the PE transmits IP packets to the MPLS network.
63) IP packets are transmitted transparently through the MPLS network to the peer PE.
64) The peer PE re-encapsulates the IP packets according to its link layer protocol type and sends them to the CE connected to it.
65) The link layer control packet (such as PPP's IPCP) sent by the CE are processed by the PE without being transmitted on the MPLS network.
66) Non-IP packets (such as MPLS packets) are discarded and do not enter the MPLS network.

- Among the Ethernet interfaces on the PE, the following L2VPN interfaces can be encapsulated in ip-interworking mode:

67) Ethernet interface or sub-interface
68) GigabitEthernet interface or sub-interface

Note the following points:

69) After being encapsulated as ip-interworking, the PE's Ethernet interface processes only ARP and IP packets received by the local CE and discards the others including IPv6 packets.
70) When the PE receives IP packets from the CE, the dynamic MAC is not updated.
71) If the VPWS inbound interface that encapsulates ip-interworking on the PE receives the CE's ARP request packets, the VPWS inbound interface uses the PE's MAC address to reply regardless of the destination IP address.
72) Each Ethernet interface or sub-interface of the PE can be connected to only one CE and cannot be connected to multiple CEs or other devices through a hub or a layer-2 switch. Otherwise, MAC addresses learned by the PE will be covered, obstructing the forwarding.

- If a CE uses the PPP link protocol to access a PE, pay attention to the following points:

73) Unlike the negotiation that provides the homogeneous media L2VPN PPP simulative line service, the negotiation of PPP is conducted between the CE and the PE, rather than CEs; the address of the negotiation between PE and CE will not generate the corresponding route.
74) It supports PAP and CHAP authentication. The authentication method is the same as the common situation.

75) It does not support IPHC compression.

76) It supports transparent transmission of IP packets from the local CE to the peer CE and does not support transparent transmission though protocols such as MPLS and IPv6.

77) The **ppp ipcp address proxy** command must be used on the PE to specify the remote CE's IP address, which is the same as the IPCP proxy address of the PE as the remote CE. The address will not generate a route on the PE.

Use the following commands to configure the heterogeneous media communication VPWS access service in privileged mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters interface configuration mode.
Ruijie(config-if-*type ID*)# **ppp ipcp address proxy** *remote-ce-ip-addr*	(Optional) When the interface that connects the PE to the CE encapsulates the PPP link protocol, configure the remote CE's IP address on the PE as the proxy address for the remote CE to conduct IPCP negotiation with the local CE.
Ruijie(config-if-*type ID*)# **xconnect** *vc_peer vc_id* **encapsulation mpls ip-interworking** [**local-ce mac** *mac*]	Creates VC and configures the PW type as the heterogeneous media communication. (Optional) **local-ce mac** *mac*: When the interface that connects PE to CE encapsulates the Ethernet protocol, the local CE's MAC address must be configured.
Ruijie(config-if-*type ID*)# **ip ref**	☑ For routers, the fast forwarding function of the interface must be enabled. You do not need to use this command on switches.
Ruijie(config-if-*type ID*)# **show running-config**	Displays the existing configuration information.

Configure **serial** *1/0* to provide the heterogeneous media VPWS service of the PPP access mode.

```
Ruijie# configure terminal
Ruijie(config)# interface serial 1/0
Ruijie(config-if-serial 1/0)# encapsulation ppp
```

Enable the fast forwarding function of the interface on routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 1/1)# ip ref
Ruijie(config-if-serial 1/0)# ppp ipcp address proxy 192.168.1.1
Ruijie(config-if-serial 1/0)# xconnect 2.2.2.2 2 encapsulation mpls ip-interworking
Ruijie(config-if-serial 1/0)# exit
```

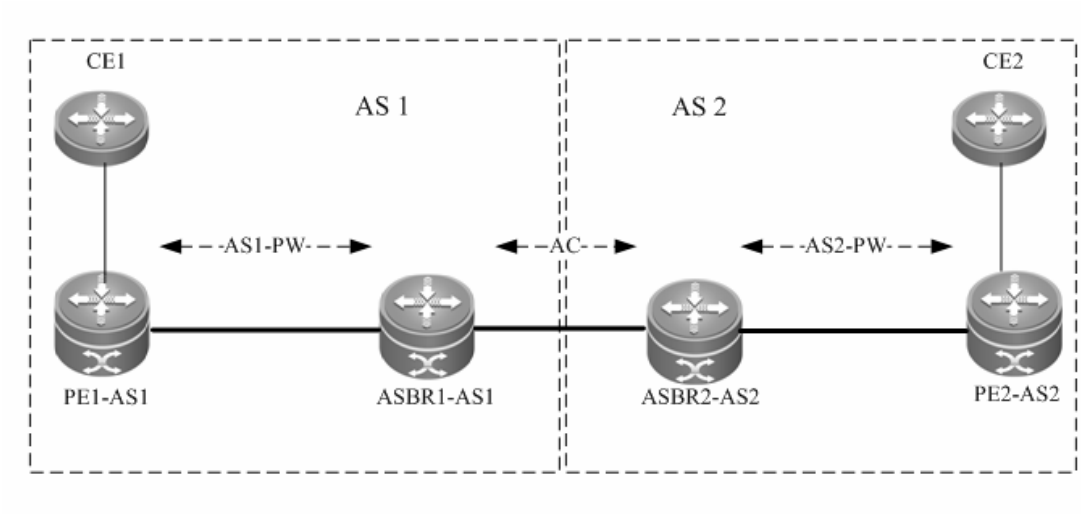
Configuring Inter-AS VPWS

There are two solutions for configuring Inter-AS Martini VPWS:

- Inter-AS Option A: This solution is simple and can be adopted when the number of inter-AS L2VPNs on ASBR is small.
- Inter-AS Option C: You do not need to create or maintain any VCs on ASBR. When each AS has numerous inter-AS L2VPNs, this solution can be applied to solve the bottleneck of the ASBR's scalability.

Inter-AS Option A

Figure 49 Option A Inter-AS VPWS



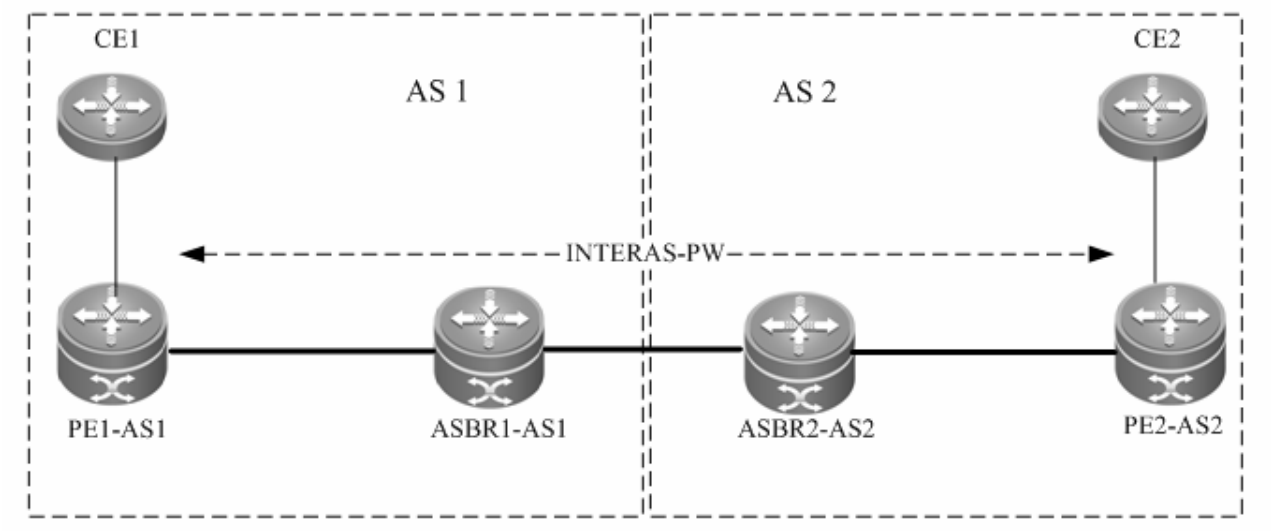
In the solution, ASBRs of two ASs are connected with each other and are PEs of their respective autonomous systems. Each ASBR considers the peer ASBR as its CE device. As shown in the preceding figure, for ASBR1-AS1 of AS1, ASBR2-AS2 of AS2 is only an accessed CE device; for ASBR2-AS2 of AS2, ASBR1-AS1 is also only an accessed CE device.

The Option A solution is easy to implement. You do not need to especially configure two PEs that serve as ASBRs or configure an IP address for the interface between ASBRs. For each inter-AS L2VPN or each Inter-AS PW, a logical or physical link must be allocated between ASBRs of two ASs. When there are numerous inter-AS PWs, great pressure is caused to ASBRs, hindering the expansion.

The solution's configuration is similar to the aaforementioned basic VPWS configuration.

Inter-AS Option C

Figure 50 Option C Inter-AS VPWS



As shown in the preceding figure, Option C solution is to set up an inter-AS PW on two ASs directly and exchange PW tags. The principle is described as follows:

By sending tag IPv4 routes to the PE in respective ASs and sending tag IPv4 routes received by PEs in respective ASs to the ASBR peers of peer ASs, ASBRs connect the tunnel between two ASs and set up an LSP tunnel between the ingress PE and egress PE. Then, the inter-AS LDP remote session are set up between PEs in different ASs and PW information are exchanged.

In the solution, ASBRs do not need to maintain inter-AS L2VPN information or prepare a physical or logical interface for the inter-AS L2VPN. However, it needs to provide an MPLS tunnel. The L2VPN information is directly exchanged between PEs, decreasing the pressure on ASBRs and facilitating the scalability.

The configuration procedure is as follows:

78) Configure MPLS signaling.
79) Configure PEs.
80) Configure ASBRs.
81) Configure the remote LDP session.
82) Configure the user access VPWS.

- Configure MPLS signaling.

In each AS, enable the MPLS and LDP functions on PE and P devices and the interface that connects to the P or PE device in AS of the ABSR to set up a basic MPLS network. For the configuration procedures, see the chapter about basic MPLS configuration.

- Configuring PEs

Configure the PEs in ASs, set up an IBGP session between the PE and the AS, and exchange IPv4 routes that carry tags.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *asn-number*	Configures BGP and enters BGP configuration mode.
Ruijie(config-router)# **neighbor** *asbr-address* **remote-as** *asbr-asn-number*	Sets up IBGP sessions between the PE and ASBR.
Ruijie(config-router)# **neighbor** *asbr-adddress* **update-source** *interface-name*	Uses the loopack address as the source address of the BGP session set up between peers.
Ruijie(config-router)# **address-family ipv4**	Enters the IPv4 address family.
Ruijie(config-router-af)# **neighbor** *asbr-address* **send-label**	Enables IPv4 route tag switching.
Ruijie(config-router-af)# **show running-config**	Displays configuration information.

Set up the IBGP session with the ASBR device 10.10.10.2 and enable the IPv4 route tag switching function.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 10.10.10.2 remote-as 1
Ruijie(config-router)# neighbor 10.10.10.2  update-source loopback 0
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 10.10.10.2 activate
Ruijie(config-router-af)# neighbor 10.10.10.2 send-label
Ruijie(config-router-af)# exit
```

- Configuring ASBRs

Configure ASBRs to set up the IBGP session with the PE in the same AS and with the ASBR in the other AS. Enable the IPv4 route tag switching function on both sessions. Configure the PE address to be transmitted to another ASBR on the ASBR.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **mpls ip**	Enables the device to support MPLS forwarding. This command is not applicable to switch chip forwarding.
Ruijie(config)# **mpls router ldp**	Enables LDP globally.
Ruijie(config-mpls-router)# **ldp router-id interface Loopback** *id* **force**	Configures the IP address of the loopback interface as the router ID.
Ruijie(config-mpls-router)# **advertise-labels for bgp-routes**	Allocates tags for BGP's route.
Ruijie(config-mpls-router)# **exit**	Returns to config mode.
Ruijie(config)# r**outer bgp** *asn-number*	Configures BGP and enters BGP configuration mode.
Ruijie(config-router)# **neighbor** *asbr-address* **remote-as** *asbr-asn-number*	Sets up EBGP session with ASBRs.
Ruijie(config-router)# **neighbor** *pe-address* **remote-as** *asn-number*	Sets up EBGP session with PEs.
Ruijie(config-router)# **neighbor** *pe-adddress* **update-source loopback** *id*	Uses the loopback address as the source address of the BGP session set up between PE peer.
Ruijie(config-router)# **address-family ipv4**	Enters the IPv4 address family.
Ruijie(config-router-af)# **network** *pe-address* **mask** *mask-value*	(Optional) Uses the **network** command to import the PE route received to BGP. The IGP protocol can be re-distributed to import the route.
Ruijie(config-router-af)# **neighbor** *asbr-address* **send-label**	Enables the IPv4 route tag switching function on BGP that is set up with the ASBR in another AS.
Ruijie(config-router-af)# **neighbor** *pe-address* **send-label**	Enables the IPv4 route tag switching function on BGP that is set up with the PE in the same AS.
Ruijie(config-router-af)# **neighbor** *asbr-ip-address* **route-map** *name* **out**	(Optional) Configures the route allocation policy. You can define route map rules (routemap) to control allocation of routes to neighbors and control whether these routes carry tags when they are sent.
Ruijie(config-router-af)# **neighbor** *asbr-ip-address* **route-map** *name* **in**	(Optional) Configures the route allocation policy. You can define route map rules (routemap) to control only routes that carry tags.
Ruijie(config-router-af)# **show running-config**	Displays configuration information.

In the following example, the configured ASBR sets up an EBGP session with the ASBR in another AS (30.30.30.2) and the tag switching function is enabled for IPv4 routes. The IBG neighbor is created between the ASBR and the PE in the same AS (10.10.10.1) and the tag switching function is enabled for IPv4 routes.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 30.30.30.2 remote-as 2
```

```
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 30.30.30.2 activate
Ruijie(config-router-af)# neighbor 30.30.30.2 send-label
Ruijie(config-router-af)# exit
Ruijie(config-router)# neighbor 10.10.10.1 remote-as 1
Ruijie(config-router)# neighbor 10.10.10.1 update-source loopback 0
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 10.10.10.1 send-label
Ruijie(config-router-af)# exit
```

Caution

For the IBGP session set up between ASBR and the PE in the same AS, the **neighbor** *peer-address* **update-source** *loopback id* command must be used on the ASBR and PE to configure the address of the device's loopback interface as the source address of the session. Otherwise, the inter-AS LSP tunnel cannot be established.

The direct EBGP session established between ASBRs usually uses the direct connection interface's address as the source address of the BGP session to ensure that both ASBRs have routes that lead to each other. Therefore, you are not advised to use the **neighbor** *peer-address* **update-source** *loopback id* command on the EBGP session established based on direct connection to configure the address of the device's loopback interface as the source address of the session. If necessary, use the **neighbor ebgp-multihop** command to enable the multi-hop EBGP function, configure the static route on ASBR to ensure that the route can lead to the peer, and configure the static FTN to ensure that the inter-AS LSP's tunnel is available.

The **label-switching** command must be used on the interface between ASBRs to enable the interface's MPLS packet forwarding capability.

- Configuring the LDP remote session

Set up an inter-AS LDP remote session between PEs in two ASs. See the Configuring LDP Remote Peer chapter.

- Configuring the user access VPWS

For detailed configuration, see the Configuring User Access VPWS chapter.

- Checking the configuration result

Command	Function
show bgp ipv4 unicast labels	Displays label information allocated by BGP for IPv4 routes.
show mpls ldp neighbor	Displays neighbor information of LDP.
show mpls l2transport vc [**detail**]	Displays VC status information.

View route and label information on an ASBR or a PE.

```
Ruijie # show bgp ipv4 unicast labels
Network        Next Hop       In Label/Out Label
1.1.1.1/32      192.167.1.1     17/18
1.1.1.2/32      192.167.1.1     nolabel/19
```

Field	Definition
Network	Route prefix

Nexthop	Route's next hop
In Label	Label (if any) allocated by the router
Out Label	Label (if any) learned from the next-hop router of the route

View LDP session information on a PE.

```
Ruijie # show mpls ldp neighbor
Default VRF:
   Peer LDP Ident: 10.20.10.10:0; Local LDP Ident: 8.8.8.8:0
      TCP connection: 10.20.10.10.62488 - 8.8.8.8.646
      State: OPERATIONAL; Msgs sent/recv: 42/45; UNSOLICITED
      Up time: 00:33:49
      LDP discovery sources:
        Link Peer on GigabitEthernet 2/1, Src IP addr: 192.168.201.220
        Targeted Hello 8.8.8.8 -> 10.20.10.10
      Addresses bound to peer LDP Ident:
        10.20.10.10   192.168.201.220 192.168.198.1   10.5.0.1
```

Field	Definition
Peer LDP Ident	LDP identifier of the peer neighbor of the LDP session
Local LDP Identifier	Router's LDP identifier
TCP connection	TCP connection that supports the LDP session
State	Status of the LDP session
Msgs sent/recv	Quantity of LDP messages sent to/received by the session peer
UNSOLICITED and ONDEMAND	Label allocation mode

View VC status information.

```
Ruijie # show mpls l2transport vc detail
Local interface : VLAN 2, AC state: up
Peer address: 192.168.0.1 ,VC ID: 2, VC status: up
VC type: vlan     VC mode:tagged
Group id: 0    MTU: 1500
Control Word not support
Output interface: VLAN 300 , imposed label stack {22 ,501 }
MPLS VC label:  local 22, remote 22
```

Field	Definition
Local interface	Local interface bound to VC
AC state	AC status, up or down
Peer address	Peer IP address
VC ID	VC's unique identifier
VC status	VC status, up or down
VC type	VC type
VC mode	VC mode, tagged or raw (only applies to the Ethernet access mode)
Group id	VC's local group ID
MTU	MTU of the locally configured VC

Field	Definition
Control Word	Whether the control word is supported
Output interface	Output interface on the public network used to transmit the VC process
imposed label stack	Added label stack
MPLS VC label	**Local** indicates the label locally allocated for the VC while **Remote** indicates the label allocated by the peer for the VC.

Configuring Kompella VPWS

Configuring the Public Network Tunnel

The LSP tunnel must be set up on the public network to carry the VC service. To run MPLS on the backbone network, LDP must be run on Ps and PEs to establish the public network tunnel. This includes configuring the label allocation protocol for MPLS devices and enabling the MPLS forwarding on each interface. The configuration procedure is as follows:

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie# **mpls ip**	Enables MPLS forwarding globally. Caution This command is not applicable to switch chip forwarding.
Ruijie(config)# **mpls router ldp**	Enables LDP and enters LDP configuration mode.
Ruijie(config-mpls-router)# **ldp router-id interface loopback** *id* [**force**]	Configures LDP's router ID, which is usually the IP address of the loopback interface.
Ruijie(config-mpls-router)# **exit**	Exits LDP configuration mode.
Ruijie(config)# **interface** *type ID*	Enters public network interface configuration mode.
Ruijie(config-if-*type ID*)# **label-switching**	Enables the interface's MPLS forwarding function.
Ruijie(config-if-*type ID*)# **mpls ip**	Enables the interface's LDP function and MPLS forwarding function.
Ruijie(config-if-*type ID*)# **ip ref**	Enables the fast forwarding function for routers. You do not need to be enable the function for switches.
Ruijie(config-if-type ID)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves configuration.

Configure the public network tunnel between PEs.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
```

```
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# end
Ruijie# copy running-config startup-config
```

Caution The LDP is a topology-driven protocol. To ensure the normal working of the LDP, enable IPv4 routing protocols and ensure their normal operations.

Configuring the L2VPN Address Family

Kompella VPWS uses MP-BGP4 as the signaling protocol to transmit layer-2 information and VC labels, realizing point-to-point VPN. In addition, the MP-BGP4 protocol can be used as the auto-discovery protocol and connect remote CEs. The procedure for enabling the L2VPN address family is as follows:

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router bg**p *asn-num*	Creates BGP and enters BGP configuration mode.
Ruijie(config)# **neighbor** *peer-address* remote-as *asn-number*	Sets up the IBGP session.
Ruijie(config)# **neighbor** *peer-adddress* **update-source** *interface-name*	Enables the IBGP session to use the address of the loopback interface as the session's source address.
Ruiije(config-router)# **address-family l2vpn vpws**	Enters the L2VPN VPWS address family.
Ruijie(config-router-af)# **neighbor** *ip-address* **activate**	Activates switching of L2VPN information on the BGP session.
Ruijie(config-router-af)# **neighbor** { *ip-address* | *peer-group-name* } **send-community** [**both | standard | extended**]	Specifies the extended community attribute to be sent to BGP neighbors.
Ruijie(config-router-af)# **end**	Returns from address family configuration mode to privileged mode.
Ruijie# **show bgp l2vpn vpws** { **all** [*id:offset* | **neighbor** *ip-address* **| summary**] }	Displays L2VPN address family information.

Configure the L2VPN address family and enable VPWS information switching.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 10.10.10.1 remote-as 1
Ruijie(config-router)# neighbor 10.10.10.1 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpws
Ruijie(config-router-af)# neighbor 10.10.10.1 activate
Ruijie(config-router-af)# neighbor 10.10.10.1 send-community extended
Ruijie(config-router-af)# end
Ruijie# show bgp l2vpn vpws all
```

Configuring the Kompella VPWS Instance

The **l2 vfi** command can be used to create Kompella VPWS instances or enter Kompella VPWS configuration mode. The **no l2 vfi** command can be used to delete VFI instances. The unique local VFI instance name and the unique local device VPN ID must be specified when the instance is being created. The auto-discovery function must be enabled for the specified VFI instance. One VFI name must correspond to one VPN ID.

The **label-saving** command can be used to enable the label saving mode and allocate a label for the specified remote site. In label saving mode, **site range** does not take effect.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **l2 vfi** *vpls-name* **vpnid** *vpn-id* **point-to-point**	Creates the Kompella VPWS instance and enters VPWS configuration mode.
Ruijie(config-vfi)# **rd** *rd_value*	Configures the RD value. Configure the RD first.
Ruijie(config-vfi)# **encapsulation mpls** [**ethernet** | **ethernetvlan | ppp | hdlc | ip-interworking**]	Specifies the encapsulation type of Kompella L2VPN PWs, which is Ethernet by default.
Ruijie(config-vfi)# r**oute-target** { **import | export | both** } *rt_value*	Configures RTs. Multiple RTs can be configured.
Ruijie(config-vfi)# **site-id** *id* [**site-range** *size*]	Configures the CE ID of a site and the site range. If the site range is not configured, the default value 16 will be adopted. Multiple site IDs can be configured for Kompella VPWS.
Ruijie(config-vfi-site)# **xconnect interface** *interface-type interface-number* **remote-ce-id** *id*	Binds the local interface and specifies the ID of the remote CE to be connected.
Ruijie(config-vfi-site)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves configuration.

Configure a Kompella VPWS instance.

```
Ruijie#configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 point-to-point
Ruijie(config-vfi)# rd 100:1
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 4500:2
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface gi 2/2 remote-ce-id 2
Ruijie(config-vfi-site)#end
Ruijie# copy running-config startup-config
```

Caution

The **point-to-point** keyword must be specified after the **l2 vfi** command to create a Kompella VPWS instance.

VFI instances of one VPN must be configured with the same ID to facilitate management.

Each site's ID is globally unique in VFI instances.

VFI instances of all PEs on one VPN must be configured with the same VPWS PW type. Otherwise, BGP

signaling cannot be used to establish PWs.

We recommend specifying the PW type as Ethernet VLAN for VPWS connected through the sub-interface and as Ethernet for VPWS connected through the Ethernet. If the interface type is different from the specified PW type, although PWs can be established, two PW types adopt different ways to process tags of user packets, causing problems to communication between CEs. VLAN tags carried by user packets are processed as p-tags in Ethernet VLAN PWs while are transmitted transparently as c-tags in Ethernet PWs.

Configuring User Access VPWS

A created VFI instance takes effect only after the user configured with the VFI instance is connected with the link. Multiple point-to-point VCs can be configured in one VFI.

Switch VPWS access mode

Switches can provide only Ethernet VPWS services. The user access mode can be divided into the following modes according to whether packets carry VLAN tags:

83) Access interface access
84) Trunk interface access
85) VLAN tunnel interface access

Caution

Only the VLAN interface (SVI interface of switches) can provide the VPWS service. IP and VPWS services cannot be enabled concurrently on the VLAN interface at the same time.

One VLAN interface can bind only one VC instance and one VC instance cannot be bound on different VLAN interfaces.

When the port protection mode is enabled on the AC-end member port of L2VPN, the port protection mode does not take effect on the member port if the corresponding member port is not a Trunk interface.

These access modes are described in details as follows:

- VLAN access interface access

This mode applies when user packets transmitted on ACs are not encapsulated by 802.1Q (that is, the packets do not carry VLAN tags). Use the following commands to configure VLAN access interface access in privileged mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters interface configuration mode.
Ruijie(config-if-*type ID*)# **switchport mode access**	Sets the interface in access mode.
Ruijie(config-if-*type ID*)# **switchport access vlan** *vlan-id*	Sets the interface as a member port of a VLAN port.
Ruijie(config-if-*type ID*)# **exit**	Exits interface configuration mode.
Ruijie(config)# **l2 vfi** *vfi_name* **vpnid** *vpn_id* **point-to-point**	Enters VFI configuration mode.
Ruijie(config-vfi)**# rd** *rd_value*	Defines the RD value of the Kompella VPWS instance.
Ruijie(config-vfi)# **route-target** { **import | export | both** } *rt_value*	Configures RT.
Ruijie(config-vfi)# **encapsulation mpls ethernet**	Configures the encapsulation method of VFI as Ethernet.
Ruijie(config-vfi)# **site-id** *id* [**site-range** *size*]	Configures site information of the VFI.

Command	Function
Ruijie(config-vfi-site)#**xconnect interface vlan** *vlan-id* **remote-ce-id** *id*	Connects the interface that binds VFI locally with the VFI's remote CEs.

Caution In VLAN access interface access mode, we recommend setting the PW encapsulation mode to **ethernet**, and the encapsulation modes on two ends of a PW must be the same.

Configure **gigabitethernet** *1/1* to be connected through the access interface and configure VPWS services under the corresponding VLAN interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/1
Ruijie(config-if-gigabitethernet 1/1)# switchport mode access
Ruijie(config-if-gigabitethernet 1/1)# switchport access vlan 2
Ruijie(config-if-gigabitethernet 1/1)# exit
Ruijie(config)# l2 vfi vfiA vpnid 1 point-to-point
Ruijie(config-vfi)# rd 2:2
Ruijie(config-vfi)# route-target both 2:2
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface vlan 2  remote-ce-id 2
```

- VLAN trunk interface access

This mode applies when several VPWS services for multiple users are transmitted on an AC. PE devices can match packets with VPWS services according to VLAN tags carried by the user packets to provide the multiplexing of access interfaces.

Use the following commands to configure VLAN trunk interface access in privileged mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters interface configuration mode.
Ruijie(config-if-*type ID*)# **switchport mode trunk**	Sets the interface in trunk working mode.
Ruijie(config-if-*type ID*)# **switchport trunk allow vlan add** *vlan-list*	Sets the VLAN flows allowed to be transmitted on the trunk link.
Ruijie(config-if-*type ID*)# **exit**	Exits interface configuration mode.
Ruijie(config)# **l2 vfi** *vfi_name* **vpnid** *vpn_id* **point-to-point**	Enters VFI configuration mode.
Ruijie(config-vfi)# **rd** *rd_value*	Defines the RD value of the Kompella VPWS instance.
Ruijie(config-vfi)# **route-target** { **import | export| both** } *rt_value*	Configures RT.
Ruijie(config-vfi)# **encapsulation mpls ethernetvlan**	Configures the encapsulation method of VFI as Ethernet VLAN.
Ruijie(config-vfi)# **site-id** *id* [**site-range** *size*]	Configures site information of the VFI.

Command	Function
Ruijie(config-vfi-site)#**xconnect interface vlan** *vlan-id* **remote-ce-id** *id*	Connects the interface that binds VFI locally with the VFI's remote CEs.

Caution In trunk access interface access mode, we recommend setting the PW encapsulation mode to **ethernetvlan**, and the encapsulation modes on two ends of a PW must be the same.
The L2 VPN service cannot be bound to the Native VLAN of the Trunk interface.

Configure **gigabitethernet** *1/1* to be connected through the trunk interface and configure VPWS under the corresponding VLAN interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/1
Ruijie(config-if-gigabitethernet 1/1)# switchport mode trunk
Ruijie(config-if-gigabitethernet 1/1)# switchport trunk allowed vlan add 2 3
Ruijie(config-if-gigabitethernet 1/1)# exit
Ruijie(config)# l2 vfi vfiA vpnid 1 point-to-point
Ruijie(config-vfi)# rd 2:2
Ruijie(config-vfi)# route-target both 2:2
Ruijie(config-vfi)# encapsulation mpls ethernetvlan
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface vlan 2  remote-ce-id 2
```

- VLAN tunnel interface access

This mode applies when user service packets transmitted on an AC carry private VLAN tags if users access the VPWS service. In this mode, all packets received by PEs from the interface are forwarded without any changes. This mode requires the VLAN member ports between PEs with CEs to work in tunnel mode.

Use the following commands to configure VLAN tunnel interface access in privileged mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters interface configuration mode.
Ruijie(config-if-*type ID*)# **switchport access** *vlan-id*	Sets the VLAN member port of the interface.
Ruijie(config-if-*type ID*)# **switchport mode dot1q-tunnel**	Sets the interface to work in tunnel mode.
Ruijie(config-if-*type ID*)**# exit**	Exits interface configuration mode.
Ruijie(config)# **l2 vfi** *vfi_name* **vpnid** *vpn_id* **point-to-point**	Enters VFI configuration mode.
Ruijie(config-vfi)# **rd** *rd_value*	Defines the RD value of the Kompella VPWS instance.
Ruijie(config-vfi)# **route-target** { **import | export | both** } *rt_value*	Configures RT.
Ruijie(config-vfi)# **encapsulation mpls ethernetvlan**	Configures the encapsulation method of VFI as Ethernet VLAN.
Ruijie(config-vfi)# **site-id** *id* [**site-range** *size*]	Configures site information of the VFI.

Command	Function
Ruijie(config-vfi-site)#**xconnect interface vlan** *vlan-id* **remote-ce-id** *id*	Connects the interface that binds VFI locally with the VFI's remote CEs.

Caution In VLAN tunnel interface access mode, we recommend setting the PW encapsulation mode to **ethernet**, and the encapsulation modes on two ends of a PW must be the same.
For the VLAN tunnel interface access mode, only the basic QinQ is supported.

Configure **gigabitethernet** *1/1* to be connected through the VLAN tunnel interface and configure VPWS under the corresponding VLAN interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/1
Ruijie(config-if-gigabitethernet 1/1)# switchport mode dot1q-tunnel
Ruijie(config-if-gigabitethernet 1/1)# switchport access 2
Ruijie(config-if-gigabitethernet 1/1)# exit
Ruijie(config)# l2 vfi vfiA vpnid 1 point-to-point
Ruijie(config-vfi)# rd 2:2
Ruijie(config-vfi)# route-target both 2:2
Ruijie(config-vfi)# encapsulation mpls ethernetvlan
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface vlan 2  remote-ce-id 2
```

Router VPWS access mode

There are several ways for users to connect to VPWS services provided by routers. Users can choose access modes according to actual application needs. Services provided by the VPWS depend on the link protocol adopted by the interface that connects the PE with the CE. Currently, the following four point-to-point L2VPN services are supported:

86) Simulative Ethernet line service
87) Simulative 802.1Q line service
88) Simulative PPP line service
89) Simulative PPP line service

- Ethernet interface access

This mode applies when user service packets transmitted on ACs carry private VLAN tags or do not carry VLAN tags in the case of VFI service access. In this mode, all packets received by PEs from the interface are forwarded without any changes and the private tags are considered part of the data.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters interface configuration mode.
Ruijie(config-if-*type ID*)# **ip ref**	Enables fast forwarding of the Ethernet interface.
Ruijie(config-if-*type ID*)# **exit**	Exits interface configuration mode.
Ruijie(config)# **l2 vfi** *vfi_name* **vpnid** *vpn_id* **point-to-point**	Enters VFI configuration mode.

Ruijie(config-vfi)# **rd** *rd_value*	Defines the RD value of the Kompella VPWS instance.
Ruijie(config-vfi)# **route-target** { **import | export | both** } *rt_value*	Configures RT.
Ruijie(config-vfi)# **encapsulation mpls ethernet**	Configures the encapsulation mode of VFI as Ethernet.
Ruijie(config-vfi)# **site-id** *id* [**site-range** *size*]	Configures site information of the VFI.
Ruijie(config-vfi-site)# **xconnect interface** *type ID* **remote-ce-id** *id*	Connects the interface that binds VFI locally with the VFI's remote CEs.

Configure **gigabitethernet** *1/0* to provide the VPWS service of transparently transmitting Ethernet frames.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/0
Ruijie(config-if-gigabitethernet 1/0)# ip ref
Ruijie(config-if-gigabitethernet 1/0)# exit
Ruijie(config)# l2 vfi vfiA vpnid 1 point-to-point
Ruijie(config-vfi)# rd 2:2
Ruijie(config-vfi)# route-target both 2:2
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface gigabitethernet 1/0 remote-ce-id 2
```

Caution In Ethernet interface access mode, we recommend setting the PW encapsulation mode to **ethernet**, and the encapsulation modes on two ends of a PW must be the same.
The remote CE ID must be specified to establish the Kompella VPWS.

- Ethernet sub-interface access

In this mode, the interface between a PE and a CE is encapsulated by the 802.1Q link protocol and provides VPWS services. The CE connects to the PE through the Ethernet sub-interface and requests Ethernet frame transmitted transparently by the PE. The Ethernet sub-interface access mode applies when several VPWS services for multiple users are transmitted on a physical access link. PE devices can match packets with VPWS services according to dot1q tags carried by the user packets to provide the multiplexing of access interfaces. In this mode, packets sent by the CE to the PE must carry VLAN tags.

Use the following commands to configure Ethernet sub-interface access in privileged mode.

Command	**Function**
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters sub-interface configuration mode.
Ruijie(config-if-*type ID*)# **encapsulation dot1Q** *vlan-id*	Configures the VLAN ID to be encapsulated.
Ruijie(config-if-*type ID*)# **exit**	Exits interface configuration mode.
Ruijie(config)# **l2 vfi** *vfi_name* **vpnid** *vpn_id* **point-to-point**	Enters VFI configuration mode.
Ruijie(config-vfi)# **rd** *rd_value*	Defines the RD value of the Kompella VPWS instance.
Ruijie(config-vfi)# **route-target** { **import | export | both** } *rt_value*	Configures RT.

Ruijie(config-vfi)# **encapsulation mpls ethernetvlan**	Configures the encapsulation mode of VFI as Ethernet VLAN.
Ruijie(config-vfi)# **site-id** *id* [**site-range** *size*]	Configures site information of the VFI.
Ruijie(config-vfi-site)# **xconnect interface** *type ID* **remote-ce-id** *id*	Connects the interface that binds VFI locally with the VFI's remote CEs.

Configure **gigabitethernet** *1/0.100* to provide the VPWS service of transparently transmitting Ethernet frames.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/0
Ruijie(config-if-gigabitethernet 1/0)# ip ref
Ruijie(config-if-gigabitethernet 1/0)# exit
Ruijie(config)# interface gigabitethernet 1/0.100
Ruijie(config-if-serial 1/0.100)# encapsulation dot1q 100
Ruijie(config-if-serial 1/0.100)# exit
Ruijie(config)# l2 vfi vfiA vpnid 1 point-to-point
Ruijie(config-vfi)# rd 2:2
Ruijie(config-vfi)# route-target both 2:2
Ruijie(config-vfi)# encapsulation mpls ethernetvlan
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface gigabitethernet 1/0.100  remote-ce-id 2
```

Caution In sub-interface access mode, we recommend setting the PW encapsulation mode to **ethernetvaln**, and the encapsulation modes on two ends of a PW must be the same.
The **ip ref** command must be used to enable the fast forwarding function on the master interface of the sub-interface.

- PPP access

In this mode, the interface between a PE and a CE encapsulates the PPP link protocol and provides VPWS services. The CE connects to the PE in PPP mode and requests the PPP frames transmitted transparently by the PE. The interface that encapsulates the PPP protocol is bound with the L2VPN service and its PE-end PPP protocol will be disabled. Therefore, the LCP and NCP of one CE will not interact with each other. The PE will transparently transmit the PPP negotiation control packet sent by the CE. The PPP negotiation will be conducted between CEs.

Use the following commands to configure PPP access in privileged mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters interface configuration mode.
Ruijie(config-if-*type ID*)# **ip ref**	Enables fast forwarding of the sub-interface.
Ruijie(config-if-*type ID*)# **encapsulation ppp**	Configures the PPP encapsulation protocol.
Ruijie(config-if-*type ID*)# **exit**	Exits interface configuration mode.
Ruijie(config)# **l2 vfi** *vfi_name* **vpnid** *vpn_id* **point-to-point**	Enters VFI configuration mode.
Ruijie(config-vfi)# **rd** *rd_value*	Defines the RD value of the Kompella VPWS instance.

Ruijie(config-vfi)# **route-target** { **import | export | both** } *rt_value*	Configures RT.
Ruijie(config-vfi)# **encapsulation mpls ppp**	Configures the encapsulation mode of VFI as PPP.
Ruijie(config-vfi)# **site-id** *id* [**site-range** *size*]	Configures site information of the VFI.
Ruijie(config-vfi-site)# **xconnect interface** *type ID* **remote-ce-id** *id*	Connects the interface that binds VFI locally with the VFI's remote CEs.

Configure **serial** *1/0* to provide the VPWS service of transparently transmitting PPP frames.

```
Ruijie# configure terminal
Ruijie(config)# interface serial 1/0
Ruijie(config-if-serial 1/0)# encapsulation ppp
Ruijie(config-if-serial 1/0)# ip ref
Ruijie(config-if-serial 1/0)# exit
Ruijie(config)# l2 vfi vfiA vpnid 1 point-to-point
Ruijie(config-vfi)# rd 2:2
Ruijie(config-vfi)# route-target both 2:2
Ruijie(config-vfi)# encapsulation mpls ppp
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface serial 1/0 remote-ce-id 2
```

- HDLC access

In this mode, the interface between a PE and a CE encapsulates the HDLC link protocol and provides VPWS services. The CE connects to the PE in HDLC mode and requests the HDLC frames transmitted transparently by the PE.

Use the following commands to configure HDLC access in privileged mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters interface configuration mode.
Ruijie(config-if-*type ID*)# **ip ref**	Enables fast forwarding of the sub-interface.
Ruijie(config-if-*type ID*)# **encapsulation hdlc**	Configures the HDLC encapsulation protocol.
Ruijie(config-if-*type ID*)# **exit**	Exits interface configuration mode.
Ruijie(config)# **l2 vfi** *vfi_name* **vpnid** *vpn_id* **point-to-point**	Enters VFI configuration mode.
Ruijie(config-vfi)# **rd** *rd_value*	Defines the RD value of the Kompella VPWS instance.
Ruijie(config-vfi)# **route-target** { **import | export | both** } *rt_value*	Configures RT.
Ruijie(config-vfi)# **encapsulation mpls hdlc**	Configures the encapsulation mode of VFI as PPP.
Ruijie(config-vfi)# **site-id** *id* [**site-range** *size*]	Configures site information of the VFI.
Ruijie(config-vfi-site)# **xconnect interface** *type ID* **remote-ce-id** *id*	Connects the interface that binds VFI locally with the VFI's remote CEs.

Configure **serial** *1/0* to provide the VPWS service of transparently transmitting HDLC frames.

```
Ruijie# configure terminal
Ruijie(config)# interface serial 1/0
Ruijie(config-if-serial 1/0)# encapsulation hdlc
Ruijie(config-if-serial 1/0)# ip ref
```

```
Ruijie(config-if-serial 1/0)# exit
Ruijie(config)# l2 vfi vfiA vpnid 1 point-to-point
Ruijie(config-vfi)# rd 2:2
Ruijie(config-vfi)# route-target both 2:2
Ruijie(config-vfi)# encapsulation mpls hdlc
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface serial 1/0  remote-ce-id 2
```

Configuring Heterogeneous Media Communication VPWS

If CEs on two ends of the same L2VPN feature different link types, the L2VPN's feature of heterogeneous media intercommunication is needed. According to the suggestion of draft-kompella-ppvpn-l2vpn, the encapsulation type of the L2VPN interface of PEs needs to be ip-interworking during the establishment of L2VPN connection. Users' IP packets are transmitted on the MPLS network transparently. When the L2VPN's heterogeneous media communication function is used, VPWS service interfaces of PEs on both ends must encapsulate ip-interworking. After PW connection is set up, packets are processed as follows:

90) After a PE receives packets from a CE and decapsulates the link layer, the PE transmits IP packets to the MPLS network.
91) IP packets are transmitted transparently through the MPLS network to the peer PE.
92) The peer PE re-encapsulates the IP packets according to its link layer protocol type and sends them to the CE connected to it.
93) The link layer control packet (such PPP's IPCP) sent by the CE are processed by the PE without being transmitted on the MPLS network.
94) Non-IP packets (such as MPLS packets) are discarded and do not enter the MPLS network.

- Among the Ethernet interfaces on the PE, the following L2VPN interfaces can be encapsulated in ip-interworking mode:

95) Ethernet interface or sub-interface
96) GigabitEthernet interface or sub-interface

Note the following points:

97) After being encapsulated as ip-interworking, the PE's Ethernet interface processes only ARP and IP packets received by the local CE and discards the others including IPv6 packets.
98) When the PE receives IP packets from the CE, the dynamic MAC is not updated;
99) If the VPWS inbound interface that encapsulates ip-interworking on the PE receives the CE's ARP request packets, the VPWS inbound interface uses the PE's MAC address to reply regardless of the destination IP address.
100) Each Ethernet interface or sub-interface of the PE can be connected to only one CE and cannot be connected to multiple CEs or other devices through a hub or a layer-2 switch. Otherwise, MAC addresses learned by the PE will be covered, obstructing the forwarding.

- If a CE uses the PPP link protocol to access a PE, pay attention to the following points:

101) Unlike the negotiation that provides the homogeneous media L2VPN PPP simulative line service, the negotiation of PPP is conducted between the CE and the PE, rather than CEs; the address of the negotiation between PE and CE will not generate the corresponding route.
102) It supports PAP and CHAP authentication. The authentication method is the same as the common situation.
103) It does not support IPHC compression.
104) It supports transparent transmission of IP packets from the local CE to the peer CE and does not support transparent transmission though protocols such as MPLS and IPv6.

105) The **ppp ipcp address proxy** command must be used on the PE to specify the remote CE's IP address, which is the same as the IPCP proxy address of the PE as the remote CE. The address will not generate a route on the PE.

Caution

If both ends of the CE is configured with the address of the same network segment, they can be connected no matter which IP address is configured for the PE-end PPP proxy as the CE has a network segment route that leads to the peer CE and the next-hop output interface can be obtained.

If two ends of the CE are configured with addresses of different network segments, the PE-end PPP proxy must be specified as the peer CE address and a route that leads to the peer CE's network segment must be configured statically in the CE.

Use the following commands to configure the heterogeneous media communication VPWS access service in privileged mode.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **l2 vfi** *vpws-name* **vpnid** *vpn-id* point-to-point	Creates the Kompella VPWS instance and enters VPWS configuration mode.
Ruijie(config-vfi)# **rd** *rd_value*	Configures the RD value. Configure the RD first.
Ruijie(config-vfi)# **encapsulation mpls ip-interworking**	Specifies ip-interworking as the encapsulation type of Kompella L2VPN PW.
Ruijie(config-vfi)# **route-target** { **import | export | both** } *rt_value*	Configures RTs. Multiple RTs can be configured.
Ruijie(config-vfi-site)# **xconnect interface** *interface-type interface-number* **remote-ce-id** *id*	Configures the local interface to be bound and specifies the ID of the CE to be connected remotely.
Ruijie(config-vfi-site)# **local-ce mac** *mac*	Specifies the CE's static MAC address.
Ruijie(config-vfi-site)# **exit-site-mode**	Returns to VFI configuration mode.
Ruijie(config-vfi)# **exit**	Returns to global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters interface configuration mode.
Ruijie(config-if-*type ID*)# **ppp ipcp address proxy** *remote-ce-ip-addr*	(Optional) When the interface that connects the PE to the CE encapsulates the PPP link protocol, configure the remote CE's IP address on the PE as the proxy address for the remote CE to conduct IPCP negotiation with the local CE.
Ruijie(config-if-*type ID*)# **ip ref**	☑ For routers, the fast forwarding function of the interface must be enabled. You do not need to use this command on switches.
Ruijie(config-if-*type ID*)# **show running-config**	Displays the existing configuration information.

Configure **serial** *1/0* to provide the heterogeneous media VPWS service of the PPP access mode.

```
Ruijie(config)# interface serial 1/0
Ruijie(config-if-serial 1/0)# encapsulation ppp
```

Enable the fast forwarding function of the interface on routers. You do not need to use this command on switches.

```
Ruijie(config-if-serial 1/0)# ip ref
Ruijie(config-if-serial 1/0)# ppp ipcp address proxy 192.168.1.1
Ruijie(config-if-serial 1/0)# exit

Ruijie# configure terminal
Ruijie# l2 vfi vpws1 vpnid 1 point-to-point
Ruijie(config-vfi)# rd 100:1
Ruijie(config-vfi)# encapsulation mpls ip-interworking
Ruijie(config-vfi)# route-target both 100:1
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface serial 1/0 remote-ce-id 2
```

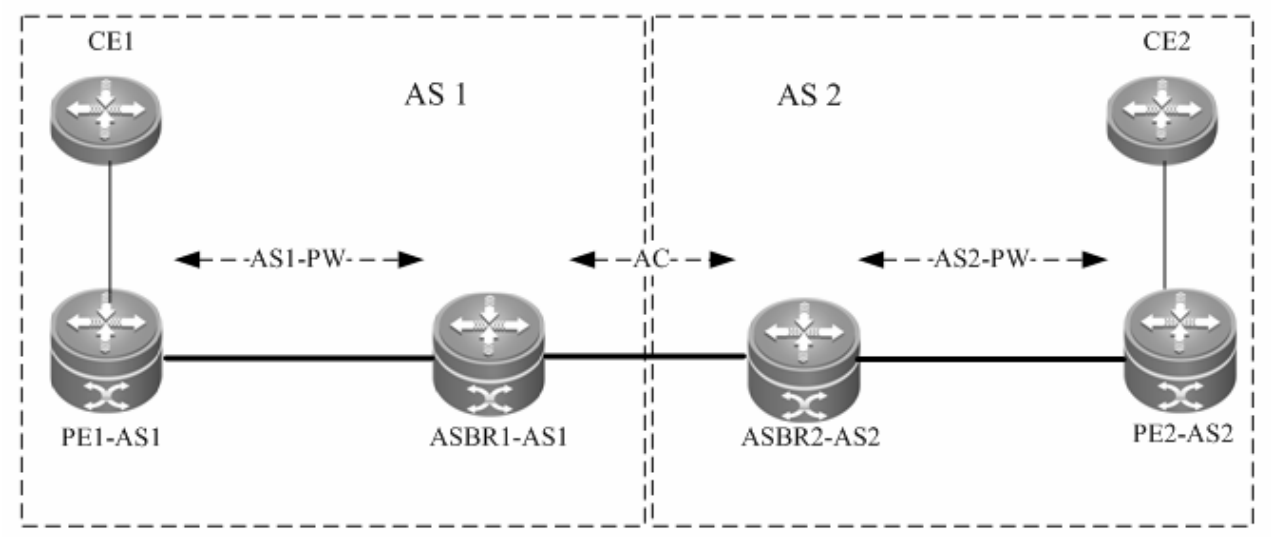
Configuring Inter-AS VPWS

In real application, multiple sites of a user's VPN may be connected to multiple SPs using different ASs or multiple ASs of an SP. The application mode in which the VPN crosses multiple ASs is called the inter-AS VPN. There are two solutions for configuring inter-AS VPWS:

- Inter-AS Option A: This solution is simple and can be adopted when the number of inter-AS L2VPNs on ASBR is small.
- Inter-AS Option C: You do not need to create or maintain any VCs on ASBR. When each AS has numerous inter-AS L2VPNs, this solution can be applied to solve the bottleneck of the ASBR's scalability.

Option A

Figure 51 Option A Inter-AS VPWS



In the solution, ASBRs of two ASs are connected with each other and are PEs of their respective autonomous systems. Each ASBR considers the peer ASBR as its CE device. As shown in the preceding figure, for ASBR1-AS1 of AS1, ASBR2-AS2 of AS2 is only an accessed CE device; for ASBR2-AS2 of AS2, ASBR1-AS1 is also only an accessed CE device.

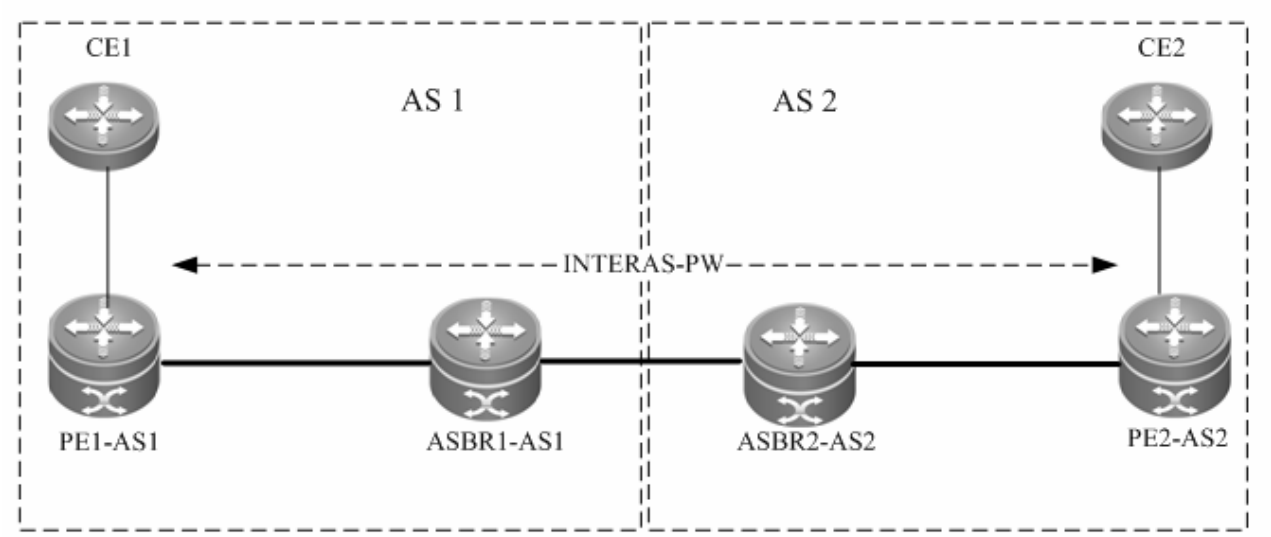
Option A is easy to implement. You do not need to especially configure two PEs that serve as ASBRs or configure an IP address for the interface between ASBRs. For each inter-AS L2VPN or each Inter-AS PW, a logical or physical link must

be allocated between ASBRs of two ASs. When there are numerous inter-AS PWs, great pressure is caused to ASBRs, hindering the expansion.

The solution's configuration is similar to the aforementioned basic VPWS configuration.

Option C

Figure 52 Option C Inter-AS VPWS



As shown in the preceding figure, Option C is to set up an inter-AS PW on two ASs directly and switch PW labels. The principle is described as follows:

By sending tag IPv4 routes to the PE in respective ASs and sending tag IPv4 routes received by PEs in respective ASs to the ASBR peers of peer ASs, ASBRs connect the tunnel between two ASs and set up an LSP tunnel between the ingress PE and egress PE. Then, the Inter-AS LDP remote session are set up between PEs in different ASs and PW information are switched.

In the solution, ASBRs do not need to maintain inter-AS L2VPN information or prepare a physical or logical interface for the inter-AS L2VPN. However, it needs to provide an MPLS tunnel. The L2VPN information is directly switched between PEs, decreasing the pressure on ASBRs and facilitating the scalability.

The configuration procedure is as follows:

106) Configure MPLS signaling.
107) Configure PEs.
108) Configure ASBR.
109) Configure the L2VPN address family.
110) Configure a Kompella VPWS instance.
111) Configure the user access VPWS.
112) Check the configuration result.

- Configure MPLS signaling.

In each AS, enable the MPLS and LDP functions on PE and P devices and the interface that connects to the P or PE device in AS of the ABSR to set up a basic MPLS network. For the configuration procedures, see the chapter about basic MPLS configuration.

- Configuring PEs

Configure the PEs in ASs, set up an IBGP session between the PE and the AS, and exchange IPv4 routes that carry tags.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *asn-number*	Configures BGP and enters BGP configuration mode.
Ruijie(config-router)# **neighbor** *asbr-address* **remote-as** *asbr-asn-number*	Sets up IBGP sessions between the PE and ASBR.
Ruijie(config-router)# **neighbor** *asbr-adddress* **update-source** *interface-name*	Uses the loopack address as the source address of the BGP session set up between peers.
Ruijie(config-router)# **address-family ipv4**	Enters the IPv4 address family.
Ruijie(config-router-af)# **neighbor** *asbr-address* **send-label**	Enables IPv4 route tag switching.
Ruijie(config-router-af)# **show running-config**	Displays configuration information.

Set up the IBGP session with the ASBR device 10.10.10.2 and enable the IPv4 route tag switching function.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 10.10.10.2 remote-as 1
Ruijie(config-router)# neighbor 10.10.10.2  update-source loopback 0
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 10.10.10.2 activate
Ruijie(config-router-af)# neighbor 10.10.10.2 send-label
Ruijie(config-router-af)# exit
```

- Configuring ASBRs

Configure ASBRs to set up the IBGP session with the PE in the same AS and with the ASBR in the other AS. Enable the IPv4 route tag switching function on both sessions and enable MPLS globally. Configure the PE address to be transmitted to another ASBR on the ASBR.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **mpls ip**	Enables the device to support MPLS forwarding. Caution This command is not applicable to switch chip forwarding.
Ruijie(config)# **mpls router ldp**	Enables LDP protocol globally.
Ruijie(config-mpls-router)# **ldp router-id interface loopbac**k *id* **force**	Configures the IP address of the loopback interface as the router ID.
Ruijie(config-mpls-router)# **advertise-labels for bgp-routes**	Allocates labels for BGP's route.
Ruijie(config-mpls-router)# **exit**	Returns to config mode.
Ruijie(config)# **router bgp** *asn-number*	Configures BGP and enters BGP configuration mode.
Ruijie(config-router)# **neighbo**r *asbr-address* **remote-as** *asbr-asn-number*	Sets up EBGP session with ASBRs.
Ruijie(config-router)# **neighbo**r *pe-address* **remote-as** *asn-number*	Sets up EBGP session with PEs.

Ruijie(config-router)# **neighbor** *pe-adddress* **update-source loopback** *id*	Uses the loopack address as the source address of the BGP session set up between PE peer.
Ruijie(config-router)# **address-family ipv4**	Enters the IPv4 address family.
Ruijie(config-router-af)# **network** *pe-address* **mask** *mask-value*	(Optional) Uses the **network** command to import the PE route received to BGP. The IGP protocol can be re-distributed to import the route
Ruijie(config-router-af)# **neighbor** *asbr-address* **send-label**	Enables the IPv4 route label switching function on BGP that is set up with the ASBR in another AS.
Ruijie(config-router-af)# **neighbor** *pe-address* **send-label**	Enables the IPv4 route label switching function on BGP that is set up with the PE in the same AS.
Ruijie(config-router-af)# **neighbor** *asbr-ip-address* **route-map** *name* **out**	(Optional) Configures the route allocation policy. You can define route map rules (routemap) to control allocation of routes to neighbors and control whether these routes carry labels when they are sent.
Ruijie(config-router-af)# **neighbor** *asbr-ip-address* **route-ma**p *name* **in**	(Optional) Configures the route allocation policy. You can define route map rules (routemap) to control only routes that carry labels.
Ruijie(config-router-af)# **show running-config**	Displays configuration information.

In the following example, the configured ASBR sets up an EBGP session with the ASBR in another AS (30.30.30.2) and the label switching function is enabled for IPv4 routes. The IBG neighbor is created between the ASBR and the PE in the same AS (10.10.10.1) and the label switching function is enabled for IPv4 routes.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# advertise-labels for bgp-routes
Ruijie(config-mpls-router)# exit
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 30.30.30.2 remote-as 2
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 30.30.30.2 activate
Ruijie(config-router-af)# neighbor 30.30.30.2 send-label
Ruijie(config-router-af)# exit
Ruijie(config-router)# neighbor 10.10.10.1 remote-as 1
Ruijie(config-router)# neighbor 10.10.10.1 update-source loopback 0
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 10.10.10.1 send-label
Ruijie(config-router-af)# exit
```

Caution For the IBGP session set up between ASBR and the PE in the same AS, the **neighbor** *peer-address* **update-source** *loopback id* command must be used on the ASBR and PE to configure the address of the device's loopback interface as the source address of the session. Otherwise, the inter-AS LSP tunnel cannot

be established.

The direct EBGP session established between ASBRs usually uses the direct connection interface's address as the source address of the BGP session to ensure that both ASBRs have routes that lead to each other. Therefore, you are not advised to use the **neighbor** *peer-address* **update-source** *loopback id* command on the EBGP session established based on direct connection to configure the address of the device's loopback interface as the source address of the session. If necessary, use the **neighbor ebgp-multihop** command to enable the multi-hop EBGP function, configure the static route on ASBR to ensure that the route can lead to the peer, and configure the static FTN to ensure that the inter-AS LSP's tunnel is available.

The **label-switching** command must be used on the interface between ASBRs to enable the interface's MPLS packet forwarding capability.

- Configuring the L2VPN address family

Configure L2VPN address families between PEs of ASs. For detailed configuration, see the Configuring L2VPN Address Family chapter.

- Configuring a Kompella VPWS instance

Configure L2VPN address families between PEs of ASs. For detailed configuration, see the Configuring Kompella VPWS Instance chapter.

- Configuring the user access VPWS

For detailed configuration, see the Configuring User Access VPWS chapter.

- Checking the configuration result

Command	Function
show bgp ipv4 unicast labels	Displays label information allocated by BGP for IPv4 routes.
show bgp l2vpn vpws all connections	Displays Kompella VPWS connection information.
show mpls l2transport vc [**detail**]	Displays VC status information.

View route and label information on an ASBR or a PE.

```
Ruijie # show bgp ipv4 unicast labels
Network         Next Hop        In Label/Out Label
1.1.1.1/32      192.167.1.1     17/18
1.1.1.2/32      192.167.1.1     nolabel/19
```

Field	Definition
Network	Route prefix
Nexthop	Route's next-hop
In Label	Label (if any) allocated by the router
Out Label	Label (if any) learned from the next-hop router of the route

View VC status information.

```
Ruijie # show mpls l2transport vc detail
Local interface : VLAN 2, AC state: up
Peer address: 192.168.0.1 ,VC ID: 2, VC status: up
VC type: vlan     VC mode:tagged
```

```
Group id: 0    MTU: 1500
Control Word not support
Output interface: VLAN 300 , imposed label stack {22 ,501 }
MPLS VC label:  local 22, remote 22
```

Field	Definition
Local interface	Local interface bound by VC
AC state	AC status, up or down
Peer address	VC's peer IP address
VC ID	VC's unique identifier
VC status	VC status, up or down
VC type	VC type
VC mode	VC mode, tagged or raw (only applies to the Ethernet access mode)
Group id	VC's local group ID
MTU	MTU of the locally configured VC
Control Word	Whether the control word is supported
Output interface	Output interface on the public network used to transmit the VC process
imposed label stack	Added label stack
MPLS VC label	Local and peer private labels bound for the VC

Other Parameters for Configuring Kompella VPWS

Configuring VPWS Instance Descriptors (Optional)

You can configure the descriptive information of each VPWS instance.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **l2 vfi** *vfi-name*	Enters VFI configuration mode.
Ruijie(config-vfi)# **description** *vfi-description*	(Optional) Configures VFI's descriptive information.
Ruijie(config-vfi)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves configuration.

Configuring VPWS's Compatibility (Optional)

By default, the PW's mtu value provided by L2VPN is 1500 bytes. If the same PW's mtu values on two PEs are different, PW connection cannot be set up between the two PEs. Some manufacturers' devices do not support configuring mtu in L2VPN instances. When such devices perform Kompella communication with devices of other manufacturers, the **ingore match l2-extcommunity** command can be used to ignore received mtu and matching detection of **EncapsType** and **Control Flag**, ensuring that the VC link is UP.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **l2 vfi** *vpls-name* **vpnid** *vpn-id* **autodiscovery**	Creates the Kompella VPWS instance and enters VPWS configuration mode.

Ruijie(config-vfi)# **ingore match l2-extcommunity**	Configures ignoring detection of L2VPN expanded community attribute members.
Ruijie# **copy running-config startup-config**	Saves configuration.

Caution This command only takes effect on Kompella L2VPN.

Configuring mtu of a VPWS Instance (Optional)

You can configure each VFI instance's mtu value, which is **1500** by default. The mtu value of VFI indicates the length of the packet that can be transmitted by the PW, or the length of the user's layer-2 packet plus the length of the PW-encapsulated packet. By default, if the PW does not enable the control word, assuming that two labels are encapsulated, the length of an Ethernet packet that can be transmitted is 1492 bytes, of which 8 bytes are encapsulated by the PW (2 labels).

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **l2 vfi** *name*	Enters VFI configuration mode.
Ruijie(config-vfi)# **mtu** *mtu*	(Optional) Configures the mtu value of the VFI.
Ruijie(config-vfi)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves configuration.

Caution The mtu values of one VFI instance on different PEs must be the same. Otherwise, the signaling protocol cannot establish PWs.

If the PW signaling protocol negotiation's mtu is modified, the mtu of the user access service interface must be adjusted (generally adjusted to the PW mtu length minus the encapsulated length); the PW's public-network-end output interface's mtu, MPLS mtu and PW mtu must be the same to ensure proper forwarding. The **mtu** command can be used on an interface to modify the interface's mtu. Use the **mpls mtu** command to modify the interface's MPLS mtu.

Configuring Static VC FTN and ILM Entries (Optional)

There are two methods to add VC FTN and ILM entries: by switching VC labels through the extended LDP and static configurations. These two methods cannot be applied to a VC instance at the same time. That is, if you add a VC FTN or ILM entry through the extended LDP, you cannot use the CLI command to add entries for the VC. Similarly, if you use the CLI command to add a VC FTN or ILM entry, you cannot add VC FTN or ILM entry by using the VPWS signaling protocol.

The procedure for configuring a VC FTN entry is as follows:

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **mpls static l2vc-ftn** *vc-id vc-peer-ip* **out-label** *out-label*	Configures an FTN entry for a static VC instance.
Ruijie(config)# **show running-config**	Displays all configuration information.

The procedure for configure a VC ILM entry is as follows:

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **mpls static ilm in-label** *in_label* **forward-action pop-l2vc-destport** *vc-id vc_peer_addr*	Configures an ILM entry for a static VC instance.
Ruijie(config)# **show running-config**	Displays all configuration information.

Caution

We do not recommend configuring static VC FTN and ILM when using the VPW dynamic signaling protocol to establish PW. For configured static VC forwarding table entries, the static public network LSP must be configured. VC is only effective when the corresponding public network LSP tunnel exists.
Static VC FTN and ILMF are not needed for heterogeneous media communication.
Static VC FTN and ILM do not take effect on a Kompella VPWS VC instance but only on a Martini VC instance. That is, they are generated by static forwarding table entries, not by LDP signaling.

Verifying VPWS Configuration

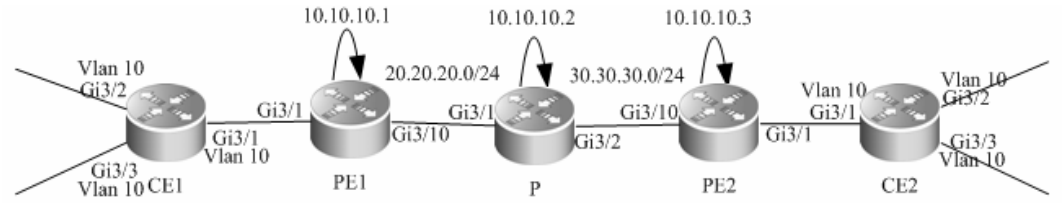
Command	Function
show bgp l2vpn vpws all	Displays NLRI information about all Kompella VPWS instances.
show bgp l2vpn vpws all connections	Displays Komplla VPWS signaling information.
show mpls l2transport vc [*vc_id* [*ip-address*]] | [**interface** *interface_name*] [**detail**]	Displays VC information established by VPWS.
show mpls vfi [*name*]	Displays VFI instance information of Kompella VPWS.
show mpls ldp vc	Displays VC signaling information of Martini VPWS.

MartiniVPWS Switch Configuration Instance

Applying Access Access Mode Between CEs and PEs and Configuring the PW to Work in Ethernet Mode

As shown in the following network topology, the interface between PEs and CEs works in access mode, which means that CEs are connected to PEs through ACs. PEs set up the PW service for the VLAN where the access interface is located. Working in Raw mode, frames transmitted by the PW set up between PE1 and PE2 do not carry VLAN tag 10.

Figure 53



The configuration procedure is as follows:

- Configuring CE1:

Configure the access interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 3/2
Ruijie(config-if-Gigabitethernet 3/2)# switchport mode access
Ruijie(config-if-Gigabitethernet 3/2)# switchport access vlan 10
Ruijie(config-if-Gigabitethernet 3/2)# exit
Ruijie(config)# interface gigabitethernet 3/3
Ruijie(config-if-Gigabitethernet 3/3)# switchport mode access
Ruijie(config-if-Gigabitethernet 3/3)# switchport access vlan 10
Ruijie(config-if-Gigabitethernet 3/3)# end
```

Configure the access access mode on CEs and between PEs.

```
Ruijie(config)# interface gigabitethernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# switchport mode access
Ruijie(config-if-Gigabitethernet 3/1)# switchport access vlan 10
Ruijie(config-if-Gigabitethernet 3/1)# end
```

- Configuring PE1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 10.10.10.1 255.255.255.255
```

Configure the public network LSP tunnel and remote LDP neighbor.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# neighbor 10.10.10.3
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 3/10
```

The **no switchport** command is used on switches to switch the port mode to the Routed Port mode. It does not apply to routers and does not need to be used on routers.

```
Ruijie(config-if-Gigabitethernet 3/10)# no switchport
Ruijie(config-if-Gigabitethernet 3/10)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 3/10)# mpls ip
Ruijie(config-if-Gigabitethernet 3/10)# label-switching
Ruijie(config-if-Gigabitethernet 3/10)# exit
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# network 10.10.10.1 0.0.0.0 area 0
Ruijie(config-router)# end
```

Configure the access mode between PEs and CEs.

```
Ruijie# configure terminal
```

```
Ruijie(config)# interface gigabitethernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# switchport mode access
Ruijie(config-if-Gigabitethernet 3/1)# switchport access vlan 10
Ruijie(config-if-Gigabitethernet 3/1)# exit
```

Configure the PW service for VLAN 10 on PEs.

```
Ruijie# configure terminal
Ruijie(config)# interface vlan 10
Ruijie(config-if-vlan 10)# xconnect 10.10.10.3 2 encapsulation mpls ethernet raw
Ruijie(config-if-vlan 10)# exit
```

- Configuring P:

Configure the public network route protocol and LSP tunnel.

The configuration procedure is similar to the aforementioned MPLS basic function configuration instance.

- Configuring PE2:

The configuration is similar to that of PE1..

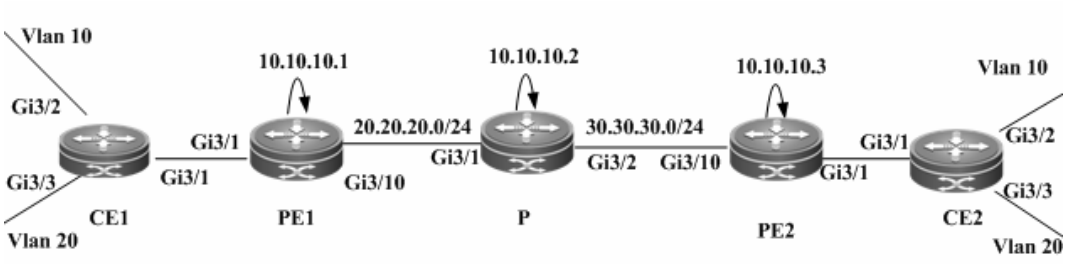
- Configuring CE2:

The configuration is similar to that ofsimilar to CE1.

Applying Trunk Access Mode Between CEs and PEs and Configuring the PW to Work in Ethernet VLAN Mode

As shown in the following network topology, CE1 and CE2 have two VLANs respectively. CEs are connected to PEs through Trunk. PEs have to set up a PW for each user's VLAN. In the application model, multiple VLAN interfaces share one physical port. PE1 and PE2 established two PWs for VLAN 10 and VLAN 20 respectively to transmit frames carrying VLAN tag 10 and VLAN tag 20.

Figure 54



The configuration procedure is as follows:

- Configuring CE1:

Configure the access interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 3/2
Ruijie(config-if-Gigabitethernet 3/2)# switchport mode access
Ruijie(config-if-Gigabitethernet 3/2)# switchport access vlan 10
```

```
Ruijie(config-if-Gigabitethernet 3/2)# exit
Ruijie(config)# interface gigabitethernet 3/3
Ruijie(config-if-Gigabitethernet 3/3)# switchport mode access
Ruijie(config-if-Gigabitethernet 3/3)# switchport access vlan 20
Ruijie(config-if-Gigabitethernet 3/3)# end
```

Configure the trunk interface on CEs for connection with PEs.

```
Ruijie(config)# interface gigabitethernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# switchport mode trunk
Ruijie(config-if-Gigabitethernet 3/1)# switchport trunk allow vlan add 10,20
Ruijie(config-if-Gigabitethernet 3/1)# end
```

- Configuring PE1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 10.10.10.1 255.255.255.255
```

Configure the public network LSP tunnel and remote LDP neighbor.

The configuration is similar to that for applying the access access mode between CEs and PEs.

Configure the trunk interface on PEs for connection with CEs.

```
Ruijie(config)# interface gigabitethernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# switchport mode trunk
Ruijie(config-if-Gigabitethernet 3/1)# end
```

Establish the PW service for VLAN 10 and VLAN 20 on PEs.

```
Ruijie# configure terminal
Ruijie(config)# interface vlan 10
Ruijie(config-if-vlan 10)# xconnect 10.10.10.3 1 encapsulation mpls ethernetvlan tagged
Ruijie(config-if-vlan 10)# exit
Ruijie(config)# interface vlan 20
Ruijie(config-if-vlan 20)# xconnect 10.10.10.3 2 encapsulation mpls ethernetvlan tagged
Ruijie(config-if-vlan 20)# exit
```

- Configuring P:

Configure the public network's LSP tunnel.

The configuration is similar to that for applying the access access mode between CEs and PEs.

- Configuring PE2:

The configuration is similar to that of PE1.

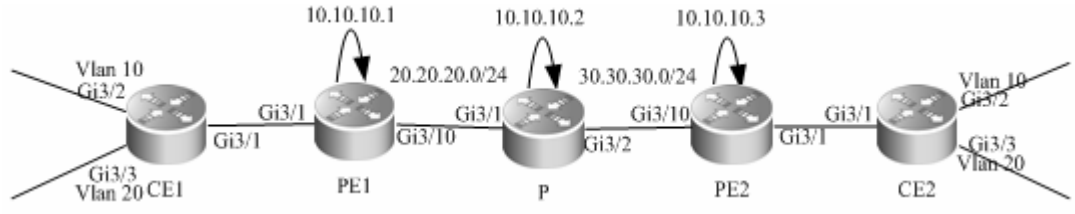
- Configuring CE2:

The configuration is similar to that of CE1.

Applying dot1q Tunnel Access Mode Between CEs and PEs and Configuring the PW to Work in Ethernet Mode

As shown in the following network topology, the PW service is provided for a physical interface on PEs so that CEs can connect to PEs through the dot1q tunnel and the PW service can be enabled on the VLAN interface where the tunnel is located. Therefore, the VLAN tag carried by the user's frames will be transmitted transparently. Working in Raw mode, the PW set up between PE1 and PE2 transmits frames with layer-1 VLAN tags, which are VLAN tags carried by frames received on CEs.

Figure 55



The configuration procedure is as follows:

- Configuring CE1:

Configure the access interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 3/2
Ruijie(config-if-Gigabitethernet 3/2)# switchport mode access
Ruijie(config-if-Gigabitethernet 3/2)# switchport access vlan 10
Ruijie(config-if-Gigabitethernet 3/2)# exit
Ruijie(config)# interface gigabitethernet 3/3
Ruijie(config-if-Gigabitethernet 3/3)# switchport mode access
Ruijie(config-if-Gigabitethernet 3/3)# switchport access vlan 20
Ruijie(config-if-Gigabitethernet 3/3)# end
```

Configure the trunk interface on CEs for connection with PEs.

```
Ruijie(config)# interface gigabitethernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# switchport mode trunk
Ruijie(config-if-Gigabitethernet 3/1)# switchport trunk allow vlan add 10,20
Ruijie(config-if-Gigabitethernet 3/1)# end
```

- Configuring PE1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 10.10.10.1 255.255.255.255
```

Configure the public network LSP tunnel and remote LDP neighbor.

The configuration is similar to that for applying the access access mode between CEs and PEs.

Configure PEs to connect with CEs through dot1q.

```
Ruijie(config)# interface gigabitethernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# switchport access vlan 2
Ruijie(config-if-Gigabitethernet 3/1)# switchport mode dot1q-tunnel
```

Configure the PW service for VLAN 2 on PEs.

```
Ruijie(config)# interface vlan 2
Ruijie(config-if-Vlan 2)# xconnect 10.10.10.3 2 encapsulation mpls ethernet raw
Ruijie(config-if-Vlan 2)# end
```

- Configuring P:

The configuration is similar to that for applying the access access mode between CEs and PEs.

- Configuring PE2:

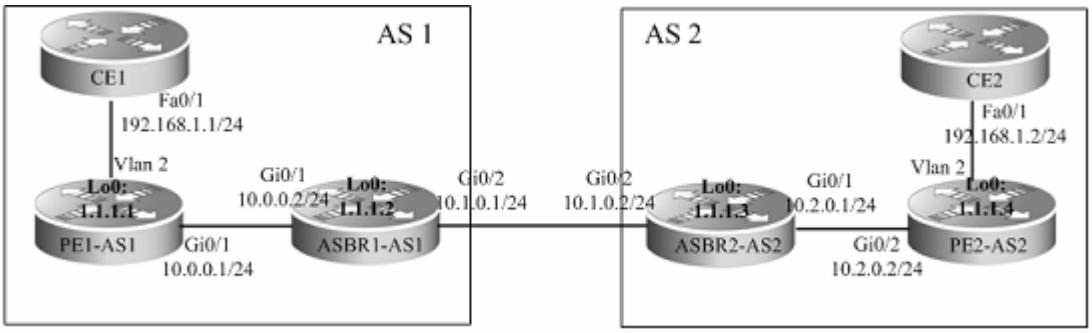
The configuration is similar to that of PE1.

- Configuring CE2:

The configuration is similar to that of CE1.

Option C Inter-AS VPWS

Figure 56 Option C: Inter-AS VPWS



The proceding figure shows how to realize inter-AS VPWS by using the Option C solution. To set up a PW between PEs of different ASs, PW information is not maintained on ASBR and OSPF is used in each AS as IGP to realize inter-AS communication. Assuming that CE1 is connected to a PE through the access interface, it is required to establish L2VPN communication between CE1 and CE2. Configuration of devices is described as follows (only configuration related to the function is included):

Note

If CE1 and CE2 are connected to PEs in other modes such as Trunk mode, you only need to adjust the configuration of L2VPN in the VLAN interface mode (see configuration instances of various access modes for L2VPN). The configuration of inter-AS BGP and public network's IGP and MPLS does not need to be modified.

- Configuring CE1:

```
Ruijie# configure terminal
Ruijie(config)# interface FastEthernet 0/1
```

The **no switchport** command is used on switches to switch the port mode to the Routed Port mode. It does not apply to routers and does not need to be used on routers.

```
Ruijie(config-if-FastEthernet 0/1)# no switchport
Ruijie(config-if-FastEthernet 0/1)# ip address 192.168.1.1 255.255.255.0
Ruijie(config-if-FastEthernet 0/1)# end
```

The configuration of CE2 is similar to that of CE1.

- Configuring PE1-AS1:

Configure the public network route protocol, MPLS signaling, and remote neighbors.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# neighbor 1.1.1.4
Ruijie(config-mpls-router)# exit
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 10.0.0.0 0.0.0.255 area 0
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# exit
Ruijie(config)# interface GigabitEthernet 0/1
```

The **no switchport** command is used on switches to switch the port mode to the Routed Port mode. It does not apply to routers and does not need to be used on routers.

```
Ruijie(config-if-GigabitEthernet 0/1)# no switchport
Ruijie(config-if-GigabitEthernet 0/1)# ip address 10.0.0.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/1)# mpls ip
Ruijie(config-if-GigabitEthernet 0/1)# label-switching
Ruijie(config-if-GigabitEthernet 0/1)# end
```

Configure BGP.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 1.1.1.2 remote-as 1
Ruijie(config-router)# neighbor 1.1.1.2 update-source loopback 0
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 1.1.1.2  activate
Ruijie(config-router-af)# neighbor 1.1.1.2  send-label
Ruijie(config-router-af)# end
```

Configure the user access VPWS.

```
Ruijie# configure terminal
```

```
Ruijie(config)# interface GigabitEthernet 0/2
Ruijie(config-if-GigabitEthernet 0/2)# switchport access vlan 2
Ruijie(config-if-GigabitEthernet 0/2)# exit
Ruijie(config)# interface vlan 2
Ruijie(config-if-vlan 2)# xconnect 1.1.1.1 1 encapsulation mpls ethernet
Ruijie(config-if-vlan 2)# end
```

The configuration of PE2-AS2 is similar to that of PE1-AS1.

- Configuring ASBR1-AS1:

Configure the loopback interface.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.2 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure the public network route protocol and MPLS signaling.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface GigabitEthernet 0/1
```

The **no switchport** command is used on switches to switch the port mode to the Routed Port mode. It does not apply to routers and does not need to be used on routers.

```
Ruijie(config-if-GigabitEthernet 0/1)# no switchport
Ruijie(config-if-GigabitEthernet 0/1)# ip address 10.0.0.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/1)# mpls ip
Ruijie(config-if-GigabitEthernet 0/1)# label-switching
Ruijie(config-if-GigabitEthernet 0/1)# exit
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 10.0.0.0 0.0.0.255 area 0
Ruijie(config-router)# network 1.1.1.2 0.0.0.0 area 0
Ruijie(config-router)# exit
```

Configure the IP address of the interface connected to ASBR2.

```
Ruijie(config)# interface GigabitEthernet 0/2
```

The **no switchport** command is used on switches to switch the port mode to the Routed Port mode. It does not apply to routers and does not need to be used on routers.

```
Ruijie(config-if-GigabitEthernet 0/2)# no switchport
Ruijie(config-if-GigabitEthernet 0/2)# ip address 10.1.0.1 255.255.255.0
```

Enable the interface's label packet forwarding capability.

```
Ruijie(config-if-GigabitEthernet 0/2)# label-switching
Ruijie(config-if-GigabitEthernet 0/2)# exit
```

Configure BGP.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 1
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruijie(config-router)# neighbor 10.1.0.2 remote-as 2
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# neighbor 1.1.1.1 send-label
Ruijie(config-router-af)# neighbor 10.1.0.2 activate
Ruijie(config-router-af)# neighbor 10.1.0.2 send-label
Ruijie(config-router-af)# network 1.1.1.1 mask 255.255.255.255
Ruijie(config-router-af)# end
```

The configuration of ASBR2-AS2 is similar to that of ASBR1-AS1.

The configuration of PE2-AS2 is similar to that of PE1-AS1.

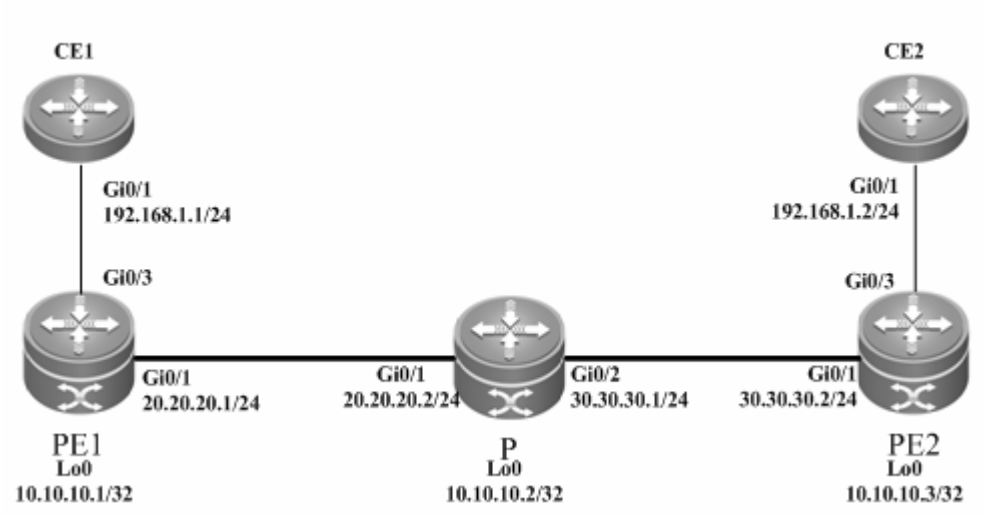
The configuration of CE2 is similar to that of CE1.

MartiniVPWS Router Configuration Instance

Connecting CEs to PEs Through Ethernet

As shown in the following network topology, the interface between PEs and CEs is an Ethernet interface. That is, CEs are connected to PEs through the Ethernet interface, through which L2VPN service is provided between CE1 and CE2.

Figure 57



The configuration procedure is as follows:

- Configuring CE1:

Configure the interface that connects CE1 and PE1.

```
Ruijie(config)# interface gigabitethernet 0/1
```

```
Ruijie(config-if-Gigabitethernet 0/1)# ip address 192.168.1.1 255.255.255.0
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/1)# ip ref
Ruijie(config-if-Gigabitethernet 0/1)# end
```

- Configuring PE1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 10.10.10.1 255.255.255.255
```

Configure the public network LSP tunnel and remote LDP neighbor.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# neighbor 10.10.10.3
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 0/1)# mpls ip
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/1)# ip ref
Ruijie(config-if-Gigabitethernet 0/1)# exit
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# network 10.10.10.1 0.0.0.0 area 0
Ruijie(config-router)# end
```

Configure the interface that connects PEs and CEs to enable the VPWS service.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 0/3
Ruijie(config-if-Gigabitethernet 0/3)# xconnect 10.10.10.3 2 encapsulation mpls ethernet raw
Ruijie(config-if-Gigabitethernet 0/3)# exit
```

- Configuring P:

Configure the public network route protocol and LSP tunnel.

The configuration procedure is similar to the aforementioned MPLS basic function configuration instance.

- Configuring PE2:

The configuration is similar to that of PE1.

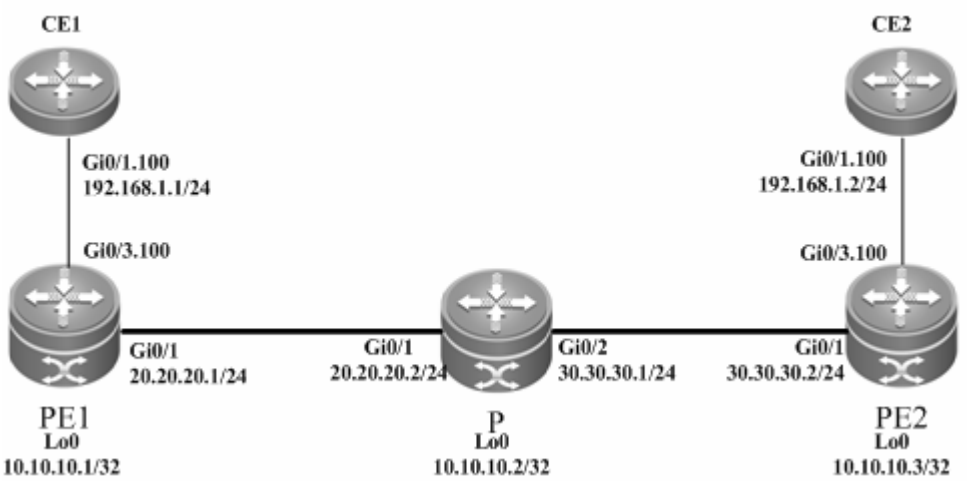
- Configuring CE2:

The configuration is similar to that of CE1.

Connecting CEs to PEs Through VLAN

As shown in the following network topology, the interface between PEs and CEs is an Ethernet sub-interface. That is, CEs are connected to PEs through the Ethernet sub-interface, through which L2VPN service is provided between CE1 and CE2.

Figure 58



The configuration procedure is as follows:

- Configuring CE1:

Configure the interface that connects CE1 and PE2.

```
Ruijie(config)# interface gigabitethernet 0/1
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/1)# ip ref
Ruijie(config-if-gigabitethernet 0/1)# exit
Ruijie(config)# interface gigabitethernet 0/1.100
Ruijie(config-if-Gigabitethernet 0/1.100)# encapsulation dot1Q 100
Ruijie(config-if-Gigabitethernet 0/1.100)# ip address 192.168.1.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 0/1.100)# end
```

- Configuring PE1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 10.10.10.1 255.255.255.255
```

Configure the public network LSP tunnel and remote LDP neighbor.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
```

```
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# neighbor 10.10.10.3
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 0/1)# mpls ip
Ruijie(config-if-Gigabitethernet 0/1)# label-switching
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/1)# ip ref
Ruijie(config-if-Gigabitethernet 0/1)# exit
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# network 10.10.10.1 0.0.0.0 area 0
Ruijie(config-router)# end
```

Configure the interface that connects PEs and CEs to enable the VPWS service.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 0/3
Ruijie(config-if-Gigabitethernet 0/3)# ip ref
Ruijie(config-if-Gigabitethernet 0/3)# exit
Ruijie(config)# interface gigabitethernet 0/3.100
Ruijie(config-if-Gigabitethernet 0/3.100)# encapsulation dot1Q 100
Ruijie(config-if-Gigabitethernet 0/3.100)# xconnect 10.10.10.3 2 encapsulation mpls
ethernetvlan tagged
Ruijie(config-if-Gigabitethernet 0/3.100)# exit
```

- Configuring P:

Configure the public network route protocol and LSP tunnel.

The configuration procedure is similar to the aforementioned MPLS basic function configuration instance.

- Configuring PE2:

The configuration is similar to that of PE1.

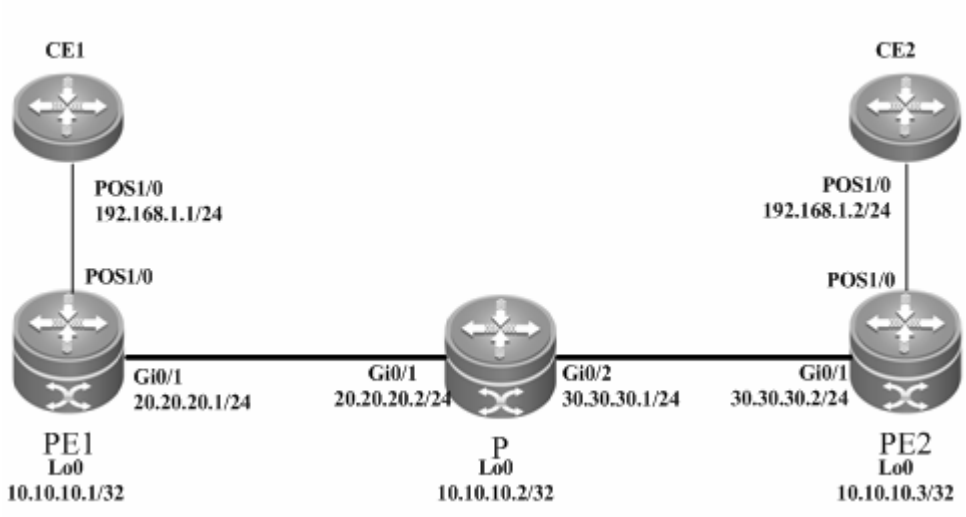
- Configuring CE2:

The configuration is similar to that of CE1.

Connecting CEs to PEs Through PPP

As shown in the following network topology, the interface between PEs and CEs is a POS interface. That is, the PPP link protocol is encapsulated and CEs are connected to PEs through PPP, through which L2VPN service is provided between CE1 and CE2.

Figure 59



The configuration procedure is as follows:

- Configuring CE1:

Configure the interface that connects CE1 and PE2.

```
Ruijie(config)# interface pos 1/0
Ruijie(config-if-pos 1/0)# encapsulation ppp
Ruijie(config-if-pos 1/0)# ip address 192.168.1.1 255.255.255.0
Ruijie(config-if-pos 1/0)# clock internal
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-pos 1/0)# ip ref
Ruijie(config-if-pos 1/0)# end
```

- Configuring PE1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 10.10.10.1 255.255.255.255
```

Configure the public network LSP tunnel and remote LDP neighbor.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# neighbor 10.10.10.3
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 0/1)# mpls ip
Ruijie(config-if-Gigabitethernet 0/1)# label-switching
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/1)# ip ref
Ruijie(config-if-Gigabitethernet 0/1)# exit
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# network 10.10.10.1 0.0.0.0 area 0
Ruijie(config-router)# end
```

Configure the interface that connects PEs and CEs to enable the VPWS service.

```
Ruijie(config)# interface pos 1/0
Ruijie(config-if-pos 1/0)# encapsulation ppp
Ruijie(config-if-pos 1/0)# clock internal
Ruijie(config-if-pos 1/0)# xconnect 10.10.10.3 2 encapsulation mpls ppp
Ruijie(config-if-pos 1/0)# end
```

- Configuring P:

Configure the public network route protocol and LSP tunnel.

The configuration procedure is similar to the aforementioned MPLS basic function configuration instance.

- Configuring PE2:

The configuration is similar to that of PE1.

- Configuring CE2:

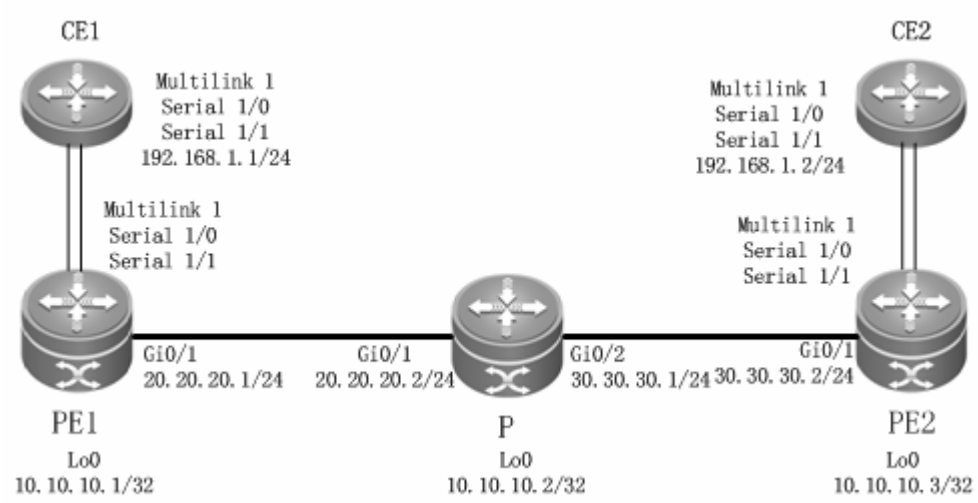
The configuration is similar to that of CE1.

Connecting CEs to PEs Through MultiPPP

As shown in the following network topology, PEs and CEs are connected through the Serial interface and the PPP protocol is encapsulated. PEs and CEs bind two Serial interfaces, which work in MultiPPP mode. Therefore, CEs are connected to PEs through MultiPPP to establish the L2VPN service between CE1 and CE2.

CEs are connected to PEs through MultiPPP by enabling the heterogeneous media access mode on the PE-end multilink interface. The mode does not support the homogeneous media access mode.

Figure 60



The configuration procedure is as follows:

- Configuring CE1:

Configure the multilink interface that connects CE1 and PE2.

```
Ruijie(config)# interface mutilink 1
Ruijie(config-multilink 1)# ip address 192.168.1.1 255.255.255.0
```

Enable the fast forwarding function of routers on the interface for routers. You do not use this command on switches.

```
Ruijie(config-multilink 1)# ip ref
Ruijie(config-multilink 1)# end
```

Configure the serial interface bound with the multilink interface.

```
Ruijie(config)# interface serial 1/0
Ruijie(config-serial 1/0)# encapsulation ppp
Ruijie(config-serial 1/0)# ppp multilink
Ruijie(config-serial 1/0)# ppp multilink group 1
Ruijie(config-serial 1/0)# end
Ruijie(config)# interface serial 1/1
Ruijie(config-serial 1/1)# encapsulation ppp
Ruijie(config-serial 1/1)# ppp multilink
Ruijie(config-serial 1/1)# ppp multilink group 1
Ruijie(config-serial 1/1)# end
```

- Configuring PE1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 10.10.10.1 255.255.255.255
```

Configure the public network LSP tunnel and remote LDP neighbor.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# neighbor 10.10.10.3
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 0/1)# mpls ip
Ruijie(config-if-Gigabitethernet 0/1)# label-switching
```

Enable the fast forwarding function of routers on the interface for routers. You do not use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/1)# ip ref
Ruijie(config-if-Gigabitethernet 0/1)# exit
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# network 10.10.10.1 0.0.0.0 area 0
Ruijie(config-router)# end
```

Configure the interface that connects PEs and CEs to enable the VPWS service.

Configure the multilink interface.

```
Ruijie(config)# interface mutilink 1
Ruijie(config-multilink 1)# ip ref
Ruijie(config-multilink 1)# xconnect 10.10.10.3 2 encapsulation mpls ip-interworking
Ruijie(config-multilink 1)# ppp ipcp address proxy 192.168.1.2
```

Configure the serial interface bound with the multilink interface.

```
Ruijie(config)# interface serial 1/0
Ruijie(config-serial 1/0)# encapsulation ppp
Ruijie(config-serial 1/0)# ppp multilink
Ruijie(config-serial 1/0)# ppp multilink group 1
Ruijie(config-serial 1/0)# end
Ruijie(config)# interface serial 1/1
Ruijie(config-serial 1/1)# encapsulation ppp
Ruijie(config-serial 1/1)# ppp multilink
Ruijie(config-serial 1/1)# ppp multilink group 1
Ruijie(config-serial 1/1)# end
```

- Configuring P:

Configure the public network route protocol and LSP tunnel.

The configuration proceduce is similar to the aforementioned MPLS basic function configuration instance.

- Configuring PE2:

The configuration proceduce is similar to that of PE1.

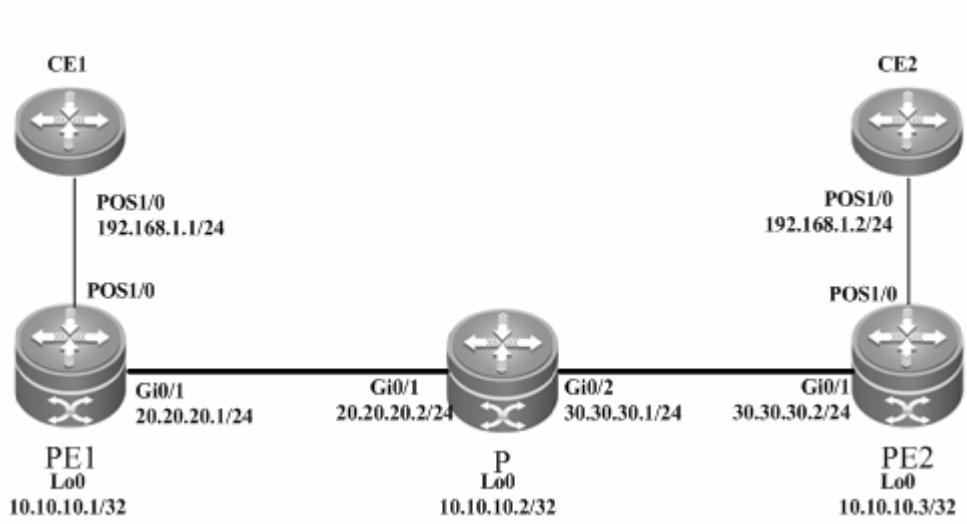
- Configuring CE2:

The configuration proceduce is similar to that of CE1.

Connecting CEs to PEs Through HDLC

As shown in the following network topology, the interface that connects PEs and CEs is a POS interface and the HDLC link protocol is encapsulated. That is, CEs are connected to PEs through a HDLC interface, through which L2VPN service is provided between CE1 and CE2.

Figure 61



The configuration procedure is as follows:

- Configuring CE1:

Configure the interface that connects CE1 and PE2.

```
Ruijie(config)# interface pos 1/0
Ruijie(config-if-pos 1/0)# encapsulation hdlc
Ruijie(config-if-pos 1/0)# ip address 192.168.1.1 255.255.255.0
Ruijie(config-if-pos 1/0)# clock internal
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-pos 1/0)# ip ref
Ruijie(config-if-pos 1/0)# end
```

- Configuring PE1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 10.10.10.1 255.255.255.255
```

Configure the public network LSP tunnel and remote LDP neighbor.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# neighbor 10.10.10.3
Ruijie(config-mpls-router)# exit
```

```
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 0/1)# mpls ip
Ruijie(config-if-Gigabitethernet 0/1)# label-switching
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/1)# ip ref
Ruijie(config-if-Gigabitethernet 0/1)# exit
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# network 10.10.10.1 0.0.0.0 area 0
Ruijie(config-router)# end
```

Configure the interface that connects PEs and CEs to enable the VPWS service.

```
Ruijie(config)# interface pos 1/0
Ruijie(config-if-pos 1/0)# encapsulation hdlc
Ruijie(config-if-pos 1/0)# clock internal
Ruijie(config-if-pos 1/0)# xconnect 10.10.10.3 2 encapsulation mpls hdlc
Ruijie(config-if-pos 1/0)# end
```

- Configuring P:

Configure the public network route protocol and LSP tunnel.

The configuration procedure is similar to the aforementioned MPLS basic function configuration instance.

- Configuring PE2:

The configuration is similar to that of PE1.

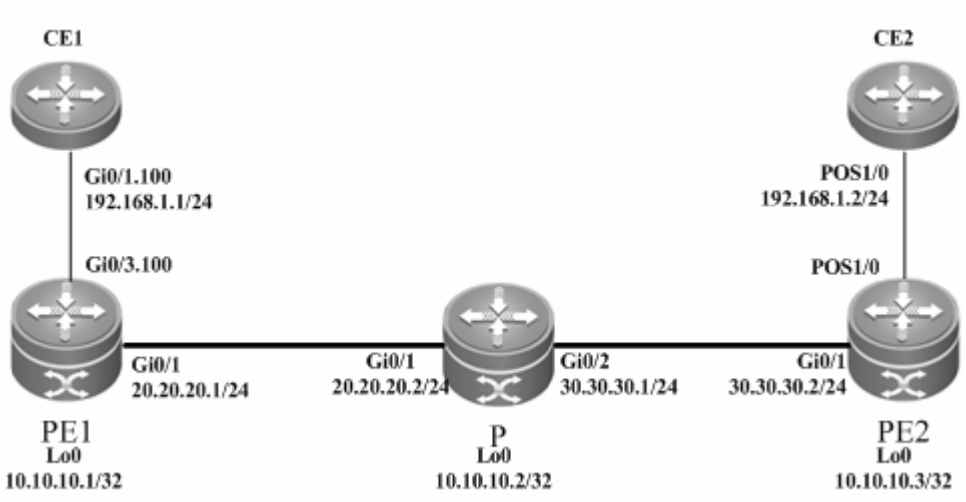
- Configuring CE2:

The configuration is similar to that of CE1.

VLAN and PPP Heterogeneous Media Communication

As shown in the following network topology, the interface that connects PE1 and CE1 is an Ethernet sub-interface and the encapsulated link protocol is 802.1Q. PE2 and CE2 are connected through the POS interface and the encapsulated link protocol is PPP, through which the L2VPN service is established between CE1 and CE2. VPWS provides the heterogeneous media communication L2VPN service.

Figure 62



The configuration procedure is as follows:

Configure the interface that connects CE1 and PE1.

```
Ruijie(config)# interface gigabitethernet 0/1
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/1)# ip ref
Ruijie(config-if-gigabitethernet 0/1)# exit
Ruijie(config)# interface gigabitethernet 0/1.100
Ruijie(config-if-Gigabitethernet 0/1.100)# encapsulation dot1Q 100
Ruijie(config-if-Gigabitethernet 0/1.100)# ip address 192.168.1.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 0/1.100)# end
```

- Configuring PE1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 10.10.10.1 255.255.255.255
```

Configure the public network LSP tunnel and remote LDP neighbor.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# neighbor 10.10.10.3
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 0/1)# mpls ip
Ruijie(config-if-Gigabitethernet 0/1)# label-switching
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/1)# ip ref
Ruijie(config-if-Gigabitethernet 0/1)# exit
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# network 10.10.10.1 0.0.0.0 area 0
Ruijie(config-router)# end
```

Configure the interface that connects PEs and CEs to enable the VPWS service.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 0/3
Ruijie(config-if-Gigabitethernet 0/3)# ip ref
Ruijie(config-if-Gigabitethernet 0/3)# exit
Ruijie(config)# interface gigabitethernet 0/3.100
Ruijie(config-if-Gigabitethernet 0/3.100)# encapsulation dot1Q 100
Ruijie(config-if-Gigabitethernet 0/3.100)# xconnect 10.10.10.3 2 encapsulation mpls
ip-interworking local-ce mac 00d0.f811.2111
Ruijie(config-if-Gigabitethernet 0/3.100)# exit
```

- Configuring P:

Configure the public network route protocol and LSP tunnel.

The configuration procedures is similar to the aforementioned MPLS basic function configuration instance.

- Configuring PE2:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 10.10.10.3 255.255.255.255
```

Configure the public network LSP tunnel and remote LDP neighbor.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# neighbor 10.10.10.1
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)# ip address 30.30.30.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 0/1)# mpls ip
Ruijie(config-if-Gigabitethernet 0/1)# label-switching
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/1)# ip ref
Ruijie(config-if-Gigabitethernet 0/1)# exit
```

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 30.30.30.0 0.0.0.255 area 0
Ruijie(config-router)# network 10.10.10.3 0.0.0.0 area 0
Ruijie(config-router)# end
```

Configure the interface that connects PEs and CEs to enable the VPWS service.

```
Ruijie# configure terminal
Ruijie(config)# interface pos 1/0
Ruijie(config-if-pos1/0)# ip ref
Ruijie(config-if-pos1/0)# encapsulation ppp
Ruijie(config-if-pos1/0)# ppp ipcp address proxy 192.168.1.1
Ruijie(config-if- pos1/0)# xconnect 10.10.10.3 2 encapsulation mpls ip-interworking
Ruijie(config-if-pos1/0)# exit
```

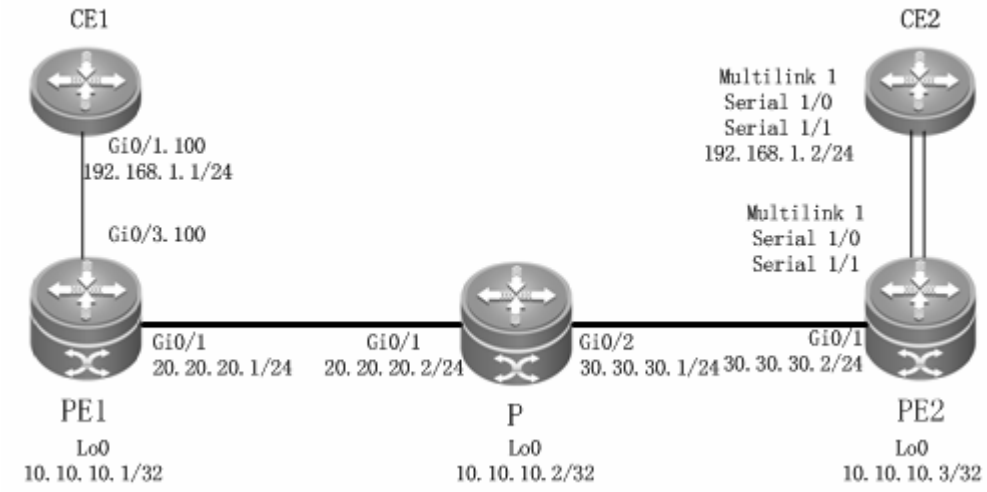
- Configuring CE2:

```
Ruijie(config)# interface pos 1/0
Ruijie(config-if-pos 1/0)# ip ref
Ruijie(config-if-pos 1/0)# encapsulation ppp
Ruijie(config-if-pos 1/0)# ip address 192.168.1.2 255.255.255.0
Ruijie(config-if-pos 1/0)# clock internal
Ruijie(config-if-pos 1/0)# end
```

VLAN and MultiPPP Heterogeneous Media Communication

As shown in the following network topology, the interface that connects PE1 and CE1 is an Ethernet sub-interface and the encapsulated link protocol is 802.1Q. PE2 and CE2 are connected through the Serial interface and the encapsulated link protocol is PPP. PPP is bound by two physical lines in the MultiPPP working mode, through which the L2VPN service is established between CE1 and CE2. VPWS provides the heterogeneous media communication L2VPN service.

Figure 63



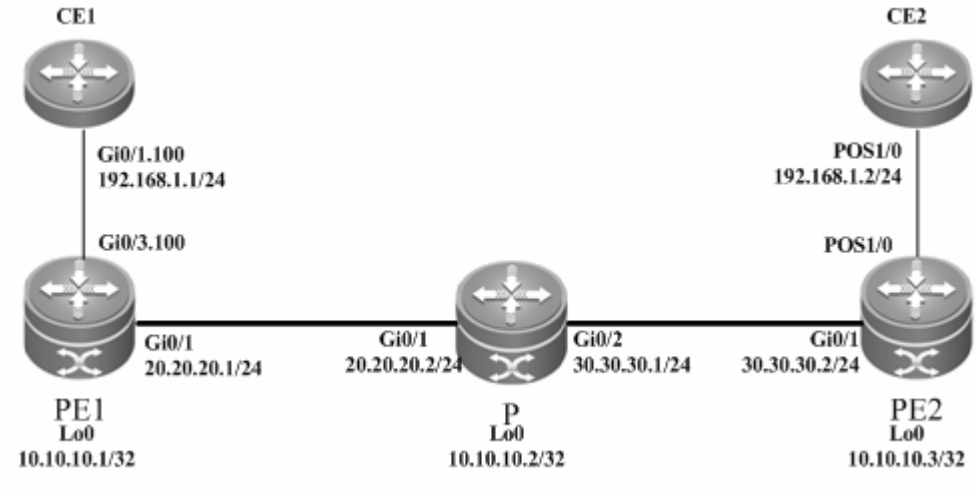
The configuration of CE1 and PE1 is generally the same as the configuration of VLAN and PPP heterogeneous media communication.

The configuration of CE2 and PE2 is generally the same as the configuration of a CE when it is connected to a PE through MutilPPP.

VLAN and HDLC Heterogeneous Media Communication

As shown in the following network topology, the interface between PE1 and CE1 is an Ethernet sub-interface and the encapsulated link protocol is 802.1Q. PE2 and CE2 are connected through the POS interface and the encapsulated link protocol is HDLC, through which the L2VPN service is established between CE1 and CE2. VPWS provides the heterogeneous media communication L2VPN service.

Figure 64



The configuration procedure is as follows:

Configure the interface that connects CE1 and PE1.

```
Ruijie(config)# interface gigabitethernet 0/1
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/1)# ip ref
Ruijie(config-if-gigabitethernet 0/1)# exit
Ruijie(config)# interface gigabitethernet 0/1.100
Ruijie(config-if-Gigabitethernet 0/1.100)# encapsulation dot1Q 100
Ruijie(config-if-Gigabitethernet 0/1.100)# ip address 192.168.1.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 0/1.100)# end
```

- Configuring PE1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 10.10.10.1 255.255.255.255
```

Configure the public network LSP tunnel and remote LDP neighbor.

```
Ruijie(config)# mpls ip
```

```
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# neighbor 10.10.10.3
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 0/1)# mpls ip
Ruijie(config-if-Gigabitethernet 0/1)# label-switching
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/1)# ip ref
Ruijie(config-if-Gigabitethernet 0/1)# exit
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# network 10.10.10.1 0.0.0.0 area 0
Ruijie(config-router)# end
```

Configure the interface that connects PEs and CEs to enable the VPWS service.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 0/3
Ruijie(config-if-Gigabitethernet 0/3)# ip ref
Ruijie(config-if-Gigabitethernet 0/3)# exit
Ruijie(config)# interface gigabitethernet 0/3.100
Ruijie(config-if-Gigabitethernet 0/3.100)# encapsulation dot1Q 100
Ruijie(config-if-Gigabitethernet 0/3.100)# xconnect 10.10.10.3 2 encapsulation mpls
ip-interworking local-ce mac 00d0.f811.2111
Ruijie(config-if-Gigabitethernet 0/3.100)# exit
```

- Configuring P:

Configure the public network route protocol and LSP tunnel.

The configuration procedure is similar to the aforementioned MPLS basic function configuration instance.

- Configuring PE2:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 10.10.10.3 255.255.255.255
```

Configure the public network LSP tunnel and remote LDP neighbor.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# neighbor 10.10.10.1
Ruijie(config-mpls-router)# exit
```

```
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)# ip address 30.30.30.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 0/1)# mpls ip
Ruijie(config-if-Gigabitethernet 0/1)# label-switching
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/1)# ip ref
Ruijie(config-if-Gigabitethernet 0/1)# exit
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 30.30.30.0 0.0.0.255 area 0
Ruijie(config-router)# network 10.10.10.3 0.0.0.0 area 0
Ruijie(config-router)# end
```

Configure the interface that connects PEs and CEs to enable the VPWS service.

```
Ruijie# configure terminal
Ruijie(config)# interface pos 1/0
Ruijie(config-if-pos 1/0)# ip ref
Ruijie(config-if-pos1/0)# encapsulation hdlc
Ruijie(config-if- pos1/0)# xconnect 10.10.10.3 2 encapsulation mpls ip-interworking
Ruijie(config-if-pos1/0)# exit
```

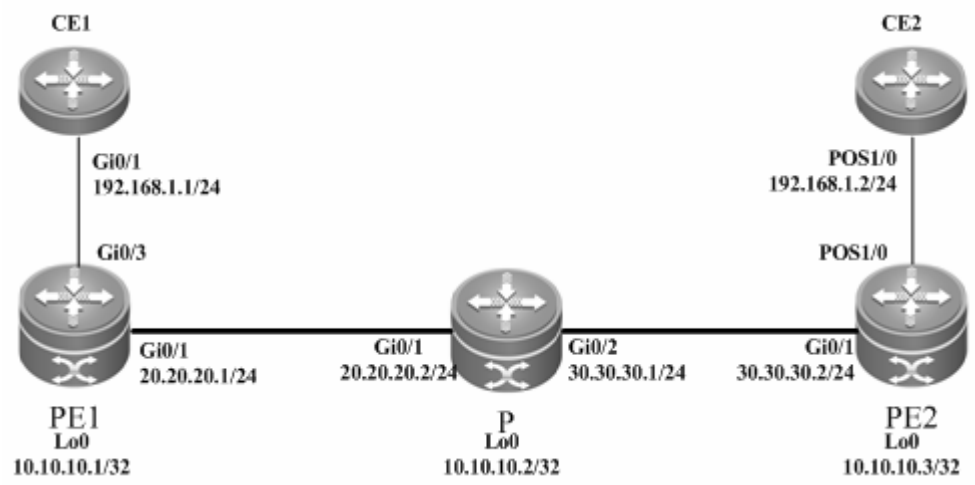
- Configuring CE2:

```
Ruijie(config)# interface pos 1/0
Ruijie(config-if-pos 1/0)# ip ref
Ruijie(config-if-pos 1/0)# encapsulation hdlc
Ruijie(config-if-pos 1/0)# ip address 192.168.1.2 255.255.255.0
Ruijie(config-if-pos 1/0)# clock internal
Ruijie(config-if-pos 1/0)# end
```

Ethernet and PPP Heterogeneous Media Communication

As shown in the following network topology, the interface between PE1 and CE1 is an Ethernet interface and the encapsulated link protocol is EthernetII. PE2 and CE2 are connected through the POS interface and the encapsulated link protocol is PPP, through which the L2VPN service is established between CE1 and CE2. VPWS provides the heterogeneous media communication L2VPN service.

Figure 65

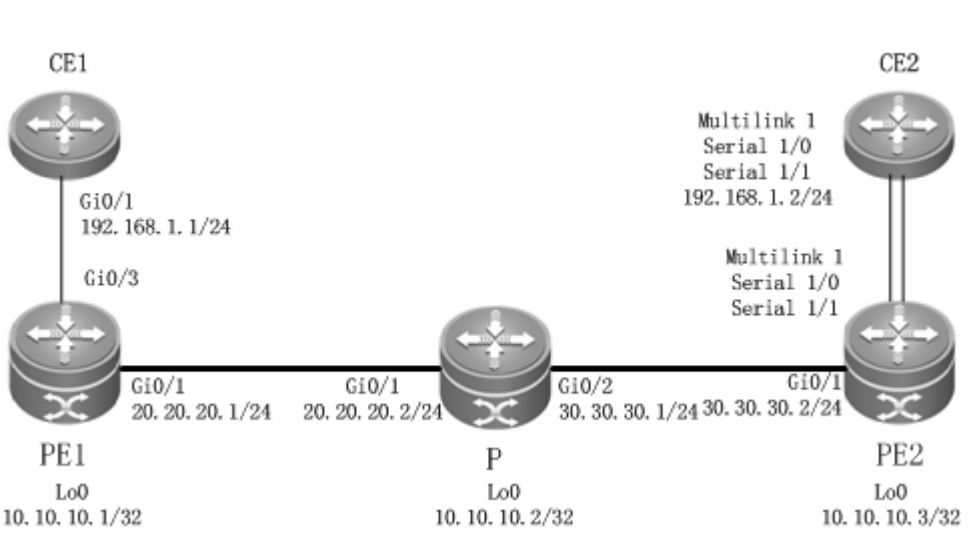


The configuration is generally the same as that for VLAN and PPP heterogeneous media communication, except the access modes of PE1 and CE1.

Ethernet and MultiPPP Heterogeneous Media Communication

As shown in the following network topology, the interface between PE1 and CE1 is an Ethernet interface and the encapsulated link protocol is EthernetII. PE2 and CE2 are connected through the Serial interface and the encapsulated link protocol is PPP. PPP is bound by two physical lines in the MultiPPP working mode, through which the L2VPN service is established between CE1 and CE2. VPWS provides the heterogeneous media communication L2VPN service.

Figure 66



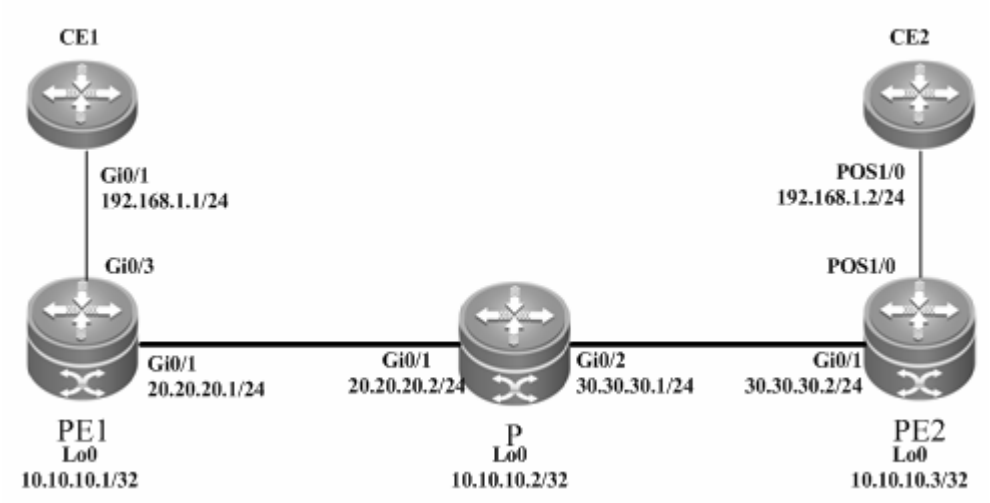
The configuration of CE1 and PE1 is generally the same as that for VLAN and PPP heterogeneous media communication, except the access mode of PE1 and CE1.

The configuration of CE2 and PE2 is generally the same as the configuration of a CE when it is connected to a PE through MutilPPP.

Ethernet and HDLC Heterogeneous Media Communication

As shown in the following network topology, the interface between PE1 and CE1 is an Ethernet interface and the encapsulated link protocol is EthernetII. PE2 and CE2 are connected through the POS interface and the encapsulated link protocol is HDLC, through which the L2VPN service is established between CE1 and CE2. VPWS provides the heterogeneous media communication L2VPN service.

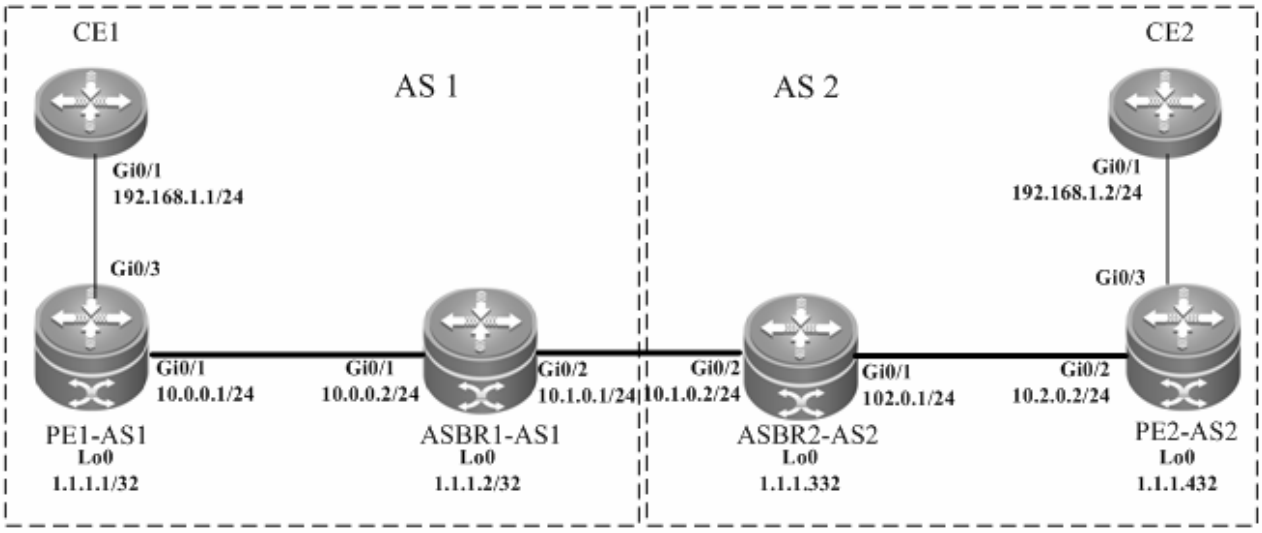
Figure 67



The configuration is generally the same as the configuration of VLAN and HDLC heterogeneous media communication, except the access modes of PE1 and CE1.

Option C Inter-AS VPWS

Figure 68 Option C: Inter-AS VPWS



The proceding figure shows how to realize inter-AS VPWS by using the Option C solution. To set up a PW between PEs of different ASs, PW information is not maintained on ASBR and OSPF is used in each AS as IGP to realize inter-AS communication. Assuming that CE1 is connected to a PE through the master port, it is required to establish L2VPN

communication between CE1 and CE2. Configuration of devices is described as follows (only configuration related to the function is included):

- Configuring CE1:

```
Ruijie# configure terminal
Ruijie(config)# interface GigabitEthernet 0/1
```

The **no switchport** command is used on switches to switch the port mode to the Routed Port mode. It does not apply to routers and does not need to be used on routers.

```
Ruijie(config-if-GigabitEthernet 0/1)# no switchport
Ruijie(config-if-GigabitEthernet 0/1)# ip address 192.168.1.1 255.255.255.0
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/1)# ip ref
Ruijie(config-if-GigabitEthernet 0/1)# end
```

The configuration of CE2 is similar to that of CE1.

- Configuring PE1-AS1:

Configure the public network route protocol, MPLS signaling, and remote neighbors.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# neighbor 1.1.1.4
Ruijie(config-mpls-router)# exit
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 10.0.0.0 0.0.0.255 area 0
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# exit
Ruijie(config)# interface GigabitEthernet 0/1
```

The **no switchport** command is used on switches to switch the port mode to the Routed Port mode. It does not apply to routers and does not need to be used on routers.

```
Ruijie(config-if-GigabitEthernet 0/1)# no switchport
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/1)# ip ref
Ruijie(config-if-GigabitEthernet 0/1)# ip address 10.0.0.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/1)# mpls ip
Ruijie(config-if-GigabitEthernet 0/1)# label-switching
```

```
Ruijie(config-if-GigabitEthernet 0/1)# end
```

Configure BGP.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 1.1.1.2 remote-as 1
Ruijie(config-router)# neighbor 1.1.1.2 update-source loopback 0
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 1.1.1.2  activate
Ruijie(config-router-af)# neighbor 1.1.1.2  send-label
Ruijie(config-router-af)# end
```

Configure the user access VPWS.

```
Ruijie# configure terminal
Ruijie(config)# interface GigabitEthernet 0/3
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/3)# ip ref
Ruijie(config-if-GigabitEthernet 0/3)# xconnect 1.1.1.1 1 encapsulation mpls ethernet
Ruijie(config-if-GigabitEthernet 0/3)# end
```

The configuration of PE2-AS2 is similar to that of PE1-AS1.

- Configuring ASBR1-AS1:

Configure the loopback interface.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.2 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure the public network route protocol and MPLS signaling.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface GigabitEthernet 0/1
```

The **no switchport** command is used on switches to switch the port mode to the Routed Port mode. It does not apply to routers and does not need to be used on routers.

```
Ruijie(config-if-GigabitEthernet 0/1)# no switchport
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/3)# ip ref
Ruijie(config-if-GigabitEthernet 0/1)# ip address 10.0.0.2 255.255.255.0
```

```
Ruijie(config-if-GigabitEthernet 0/1)# mpls ip
Ruijie(config-if-GigabitEthernet 0/1)# label-switching
Ruijie(config-if-GigabitEthernet 0/1)# exit
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 10.0.0.0 0.0.0.255 area 0
Ruijie(config-router)# network 1.1.1.2 0.0.0.0 area 0
Ruijie(config-router)# exit
```

Configure the IP address of the interface connected to ASBR2.

```
Ruijie(config)# interface GigabitEthernet 0/2
```

The **no switchport** command is used on switches to switch the port mode to the Routed Port mode. It does not apply to routers and does not need to be used on routers.

```
Ruijie(config-if-GigabitEthernet 0/2)# no switchport
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/2)# ip ref
Ruijie(config-if-GigabitEthernet 0/2)# ip address 10.1.0.1 255.255.255.0
```

Enable the interface's label packet forwarding capability.

```
Ruijie(config-if-GigabitEthernet 0/2)# label-switching
Ruijie(config-if-GigabitEthernet 0/2)# exit
```

Configure BGP.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 1
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruijie(config-router)# neighbor 10.1.0.2 remote-as 2
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# neighbor 1.1.1.1 send-label
Ruijie(config-router-af)# neighbor 10.1.0.2 activate
Ruijie(config-router-af)# neighbor 10.1.0.2 send-label
Ruijie(config-router-af)# network 1.1.1.1 mask 255.255.255.255
Ruijie(config-router-af)# end
```

The configuration of ASBR2-AS2 is similar to that of ASBR1-AS1.

The configuration of PE2-AS2 is similar to that of PE1-AS1.

The configuration of CE2 is similar to that of CE1.

Kompella VPWS Switch Configuration Instance

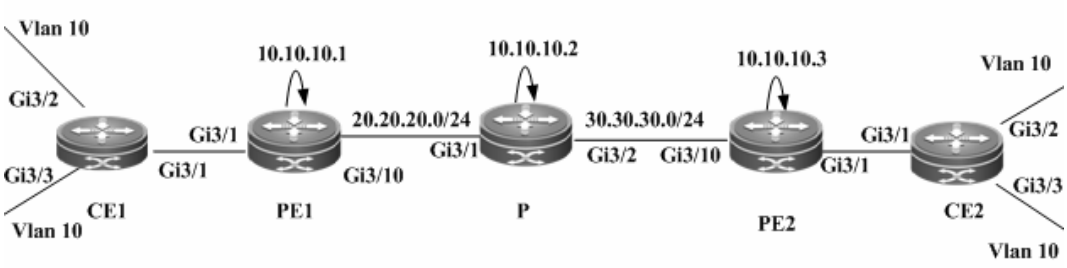
Applying Access Access Mode Between CEs and PEs and Configuring the PW to Work in Ethernet Mode

Networking Requirements

- The interface between PEs and CEs works in access mode, which means that CEs are connected to PEs through ACs.
- PEs set up the PW service for the VLAN where the access interface is located. PEs works in Raw mode, frames transmitted by the PW set up between PE1 and PE2 do not carry VLAN tag 10.

Networking Topology

Figure 69



Configuration Tips

Before configuring Kompella VPWS, complete the following tasks:

- Run IGP in the carrier's network to realize connection between PE1 and PE2 devices.
- Connect CEs to PEs in access mode.
- Obtain Kompella VPWS configuration information including VPWS instance descriptive information, RT value, CE ID, maximum planned site number, CE ID deviation, and interface information from the network administrator.

Configuration Steps

- Configuring CE1:

Configure the access interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 3/2
Ruijie(config-if-Gigabitethernet 3/2)# switchport mode access
Ruijie(config-if-Gigabitethernet 3/2)# switchport access vlan 10
Ruijie(config-if-Gigabitethernet 3/2)# exit
Ruijie(config)# interface gigabitethernet 3/3
Ruijie(config-if-Gigabitethernet 3/3)# switchport mode access
Ruijie(config-if-Gigabitethernet 3/3)# switchport access vlan 10
Ruijie(config-if-Gigabitethernet 3/3)# end
```

Configure the access access mode on CEs and between PEs.

```
Ruijie(config)# interface gigabitethernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# switchport mode access
```

```
Ruijie(config-if-Gigabitethernet 3/1)# switchport access vlan 10
Ruijie(config-if-Gigabitethernet 3/1)# end
```

- Configuring PE1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 10.10.10.1 255.255.255.255
```

Configure the public network LSP tunnel and remote LDP neighbor.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# neighbor 10.10.10.3
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 3/10
```

The **no switchport** command is used on switches to switch the port mode to the Routed Port mode. It does not apply to routers and does not need to be used on routers.

```
Ruijie(config-if-Gigabitethernet 3/10)# no switchport
Ruijie(config-if-Gigabitethernet 3/10)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 3/10)# mpls ip
Ruijie(config-if-Gigabitethernet 3/10)# label-switching
Ruijie(config-if-Gigabitethernet 3/10)# exit
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# network 10.10.10.1 0.0.0.0 area 0
Ruijie(config-router)# end
```

Configure the access mode on PEs and between CEs.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# switchport mode access
Ruijie(config-if-Gigabitethernet 3/1)# switchport access vlan 10
Ruijie(config-if-Gigabitethernet 3/1)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 10.10.10.3 remote-as 100
Ruijie(config-router)# neighbor 10.10.10.3 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpws
Ruijie(config-router-af)# neighbor 10.10.10.3 activate
Ruijie(config-router-af)# neighbor 10.10.10.3 send-community extended
Ruijie(config-router-af)# exit
```

Configure a VFI instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpws-1 vpnid 1 point-to-point
Ruijie(config-vfi)# rd 1:1
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface vlan 10 remote-ce-id 2
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

- Configuring P:

Configure the public network route protocol and LSP tunnel.

The configuration procedure is similar to the aforementioned MPLS basic function configuration instance.

- Configuring PE2:

The configuration is similar to that of PE1.

- Configuring CE2:

The configuration is similar to that of CE1.

Verification

After the configuration, CE1 can ping with CE2.

After completing the configuration of Kompella VPWS, use the following commands to check the operation of VPWS:

Command	Function
Ruijie# **show bgp l2vpn vpws all**	Displays all the VPWS information.
Ruijie# **show mpls l2transport vc** [*vc_id* [*ip-address*]] | [**interface** *interface_name*] [**detail**]	Displays information about the PW (including VPWS PW and VPLS PW).
Ruijie# **show bgp l2vpn** { **vpls | vpws** } **all connections** [**neighbor** *address*] | [**interface** *interface_name*] | [**site-id** *id*] [**detail**]	Displays PW information.
Ruijie# **show mpls vfi** [*name*]	Displays all the configured or specified VFI information.

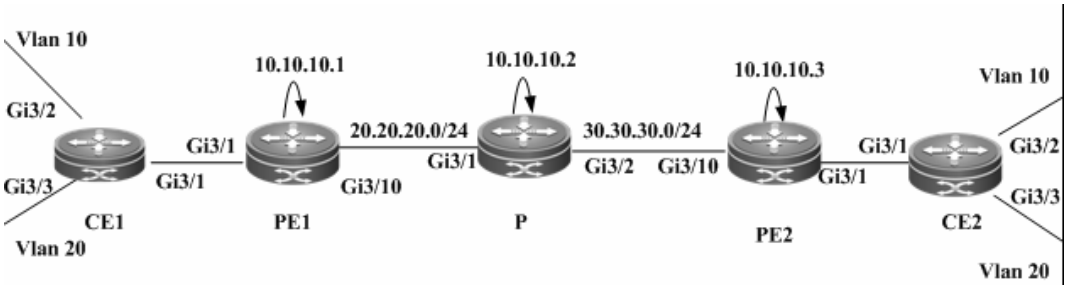
Applying Trunk Access Mode Between CEs and PEs and Configuring the PW to Work in Ethernet VLAN Mode

Networking Requirements

- CE1 and CE2 have two VLANs respectively. CEs are connected to PEs in trunk mode.
- PEs have to establish a PW for each user's VLAN; multiple VLAN interfaces share one physical port. PE1 and PE2 establish two PWs for VLAN 10 and VLAN 20 respectively to transmit frames carrying VLAN tag 10 and VLAN tag 20.

Networking Topology

Figure 70



Configuration Tips

Before configuring Kompella VPWS, complete the following tasks:

- Run IGP in the carrier's network to realize connection between PE1 and PE2 devices.
- Connect CEs to PEs in trunk mode.
- Obtain Kompella VPWS configuration information including VPWS instance descriptive information, RT value, CE ID, maximum planned site number, CE ID deviation, and interface information from the network administrator.

Configuration Steps

- Configuring CE1:

Configure the access interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 3/2
Ruijie(config-if-Gigabitethernet 3/2)# switchport mode access
Ruijie(config-if-Gigabitethernet 3/2)# switchport access vlan 10
Ruijie(config-if-Gigabitethernet 3/2)# exit
Ruijie(config)# interface gigabitethernet 3/3
Ruijie(config-if-Gigabitethernet 3/3)# switchport mode access
Ruijie(config-if-Gigabitethernet 3/3)# switchport access vlan 20
Ruijie(config-if-Gigabitethernet 3/3)# end
```

Configure the trunk interface on CEs for connection with PEs.

```
Ruijie(config)# interface gigabitethernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# switchport mode trunk
Ruijie(config-if-Gigabitethernet 3/1)# switchport trunk allow vlan add 10,20
Ruijie(config-if-Gigabitethernet 3/1)# end
```

- Configuring PE1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 10.10.10.1 255.255.255.255
```

Configure the public network LSP tunnel and remote LDP neighbor.

The configuration is similar to that of applying the access access mode between CEs and PEs.

Configure the trunk interface on PEs for connection with CEs.

```
Ruijie(config)# vlan 10
Ruijie(config-vlan)# exit
Ruijie(config)# interface vlan 10
Ruijie (config-VLAN 10) # exit
Ruijie(config)# vlan 20
Ruijie(config-vlan)# exit
Ruijie(config)# interface vlan 20
Ruijie (config-VLAN 20) # exit
Ruijie(config)# interface gigabitethernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# switchport mode trunk
Ruijie(config-if-Gigabitethernet 3/1)# end
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 10.10.10.3 remote-as 100
Ruijie(config-router)# neighbor 10.10.10.3 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpws
Ruijie(config-router-af)# neighbor 10.10.10.3 activate
Ruijie(config-router-af)# neighbor 10.10.10.3 send-community extended
Ruijie(config-router-af)# exit
```

Configure a VFI instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpws-1 vpnid 1 point-to-point
Ruijie(config-vfi)# rd 1:1
Ruijie(config-vfi)# encapsulation mpls ethernetvlan
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface vlan 10 remote-ce-id 2
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)# site-id 3
Ruijie(config-vfi-site)# xconnect interface vlan 20 remote-ce-id 4
Ruijie(config-vfi-site)#exit-site-mode
```

- Configuring P:

Configure the public network's LSP tunnel.

The configuration is similar to that for applying the access access mode between CEs and PEs.

- Configuring PE2:

The configuration is similar to that of PE1.

- Configuring CE2:

The configuration is similar to that of CE1.

Verification

After the configuration, CE1 can ping with CE2.

After completing the configuration of Kompella VPWS, use the following commands to check the operation of VPWS:

Command	Function
Ruijie# **show bgp l2vpn vpws all**	Displays all the VPWS information.
Ruijie# **show mpls l2transport vc** [*vc_id* [*ip-address*]] | [**interface** *interface_name*] [**detail**]	Displays information about the PW (including VPWS PW and VPLS PW).
Ruijie# s**how bgp l2vpn** { **vpls | vpws** } **all connections** [**neighbor** *address*] | [**interface** *interface_name*] | [**site-id** *id*] [**detail**]	Displays PW information.
Ruijie# **show mpls vfi** [*name*]	Displays all the configured or specified VFI information.

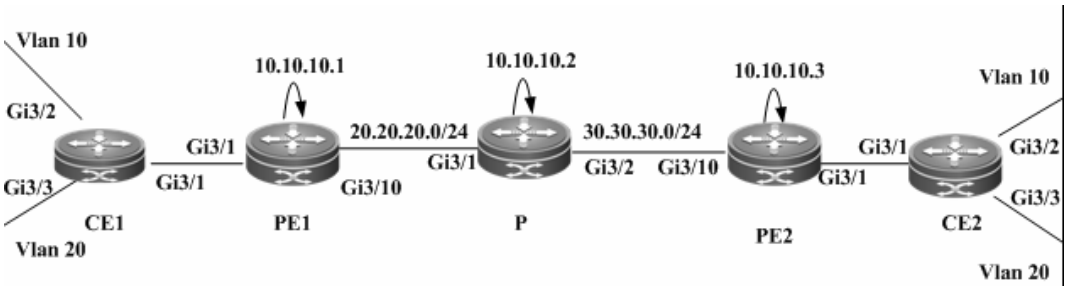
Applying dot1q Tunnel Access Mode Between CEs and PEs and Configuring the PW to Work in Ethernet Mode

Networking Requirements

- The PW service is provided for a physical interface on PEs so that CEs can connect to PEs through the dot1q tunnel and the PW service can be enabled on the VLAN interface where the tunnel is located. Therefore, the VLAN tag carried by user's frames will be transmitted transparently.
- Working in Raw mode, the PW set up between PE1 and PE2 transmits frames with layer-1 VLAN tags, which are VLAN tags carried by frames received on CEs.

Networking Topology

Figure 71 Kompella VPWS's dot1q tunnel access mode



Configuration Tips

Before configuring Kompella VPWS, complete the following tasks:

- Run IGP in the carrier's network to realize connection between PE1 and PE2 devices.
- Connect CEs to PEs in dot1q tunnel mode.
- Obtain Kompella VPWS configuration information including VPWS instance descriptive information, RT value, CE ID, maximum planned site number, CE ID deviation, and interface information from the network administrator.

Configuration Steps

- Configuring CE1:

Configure the access interface.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 3/2
Ruijie(config-if-Gigabitethernet 3/2)# switchport mode access
```

```
Ruijie(config-if-Gigabitethernet 3/2)# switchport access vlan 10
Ruijie(config-if-Gigabitethernet 3/2)# exit
Ruijie(config)# interface gigabitethernet 3/3
Ruijie(config-if-Gigabitethernet 3/3)# switchport mode access
Ruijie(config-if-Gigabitethernet 3/3)# switchport access vlan 20
Ruijie(config-if-Gigabitethernet 3/3)# end
```

Configure the trunk interface on CEs for connection with PEs.

```
Ruijie(config)# interface gigabitethernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# switchport mode trunk
Ruijie(config-if-Gigabitethernet 3/1)# switchport trunk allow vlan add 10,20
Ruijie(config-if-Gigabitethernet 3/1)# end
```

- Configuring PE1:

Configure the loopback interface.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 10.10.10.1 255.255.255.255
```

Configure the public network LSP tunnel and remote LDP neighbor.

The configuration is similar to that for applying the access access mode between CEs and PEs.

Configure the dot1q mode for PEs to connect CEs.

```
Ruijie(config)# vlan 2
Ruijie(config-vlan)# exit
Ruijie(config)# interface vlan 2
Ruijie (config-VLAN 2) # exit
Ruijie(config)# interface gigabitethernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# switchport access vlan 2
Ruijie(config-if-Gigabitethernet 3/1)# switchport mode dot1q-tunnel
Ruijie(config-if-Gigabitethernet 3/1)# exit
Ruijie(config)# interface vlan 2
Ruijie(config-if-Vlan 2)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 10.10.10.3 remote-as 100
Ruijie(config-router)# neighbor 10.10.10.3 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpws
Ruijie(config-router-af)# neighbor 10.10.10.3 activate
Ruijie(config-router-af)# neighbor 10.10.10.3 send-community extended
Ruijie(config-router-af)# exit
```

Configure a VFI instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpws-1 vpnid 1 point-to-point
```

```
Ruijie(config-vfi)# rd 1:1
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface vlan 10 remote-ce-id 2
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

- Configuring P:

The configuration is similar to that for applying the access access mode between CEs and PEs.

- Configuring PE2:

The configuration is similar to that of PE1.

- Configuring CE2:

The configuration is similar to that of CE1.

Verification

After the configuration, CE1 can ping with CE2.

After completing the configuration of Kompella VPWS, use the following commands to check the operation of VPWS.

Command	Function
Ruijie# **show bgp l2vpn vpws all**	Displays all the VPWS information.
Ruijie# **show mpls l2transport vc** [*vc_id* [*ip-address*]] | [**interface** *interface_name*] [**detail**]	Displays information about the PW (including VPWS PW and VPLS PW).
Ruijie# **show bgp l2vpn** { **vpls | vpws** } **all connection**s [**neighbor** *address*] | [**interface** *interface_name*] | [**site-id** *id*] [**detail**]	Displays PW information.
Ruijie# **show mpls vfi** [*name*]	Displays all the configured or specified VFI information.

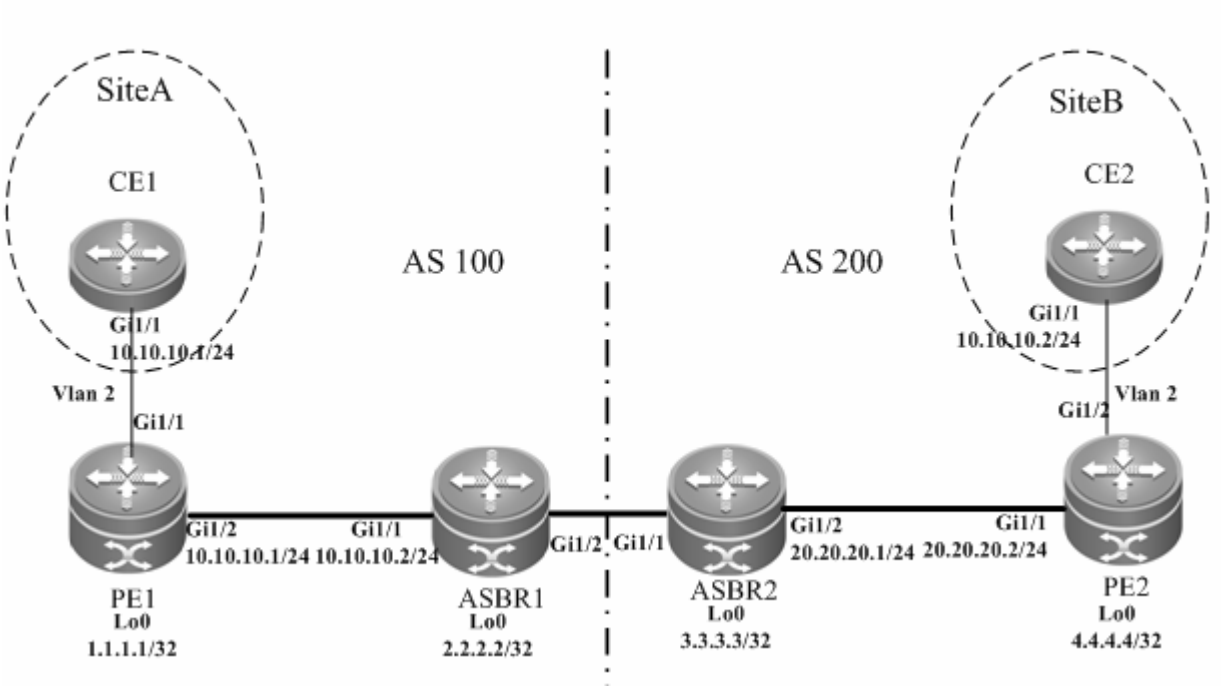
Option A Inter-AS VPWS

Networking Requirements

- CEs of customer S in site A and site B are connected with each other through the carrier's PE1 in AS 100 and PE2 in AS 200, realizing layer-2 point-to-point connection.
- PE1 and PE2 are in different autonomous ASs. ASBR1 and ASBR2 are considered CEs by each other, which means that the interface between ASBRs connects the AC to the VFI instance.

Networking Topology

Figure 72 Kompella VPWS inter-AS networking topology



The preceding figure shows the structure of the Kompella VPWS inter-AS networking topology in Option A. The intermediate interface is considered by ASBRs as AC access.

Configuration Tips

Before configuring Kompella VPWS, complete the following tasks:

- Run IGP in the carrier's network to realize connection between PE and ASBR devices.
- Establish the MP-IBGP peer relationship between PEs and intra-AS ASBRs.
- Obtain Kompella VPWS configuration information including VPWS instance descriptive information, RT value, CE ID, maximum planned site number, CE ID deviation, and interface information from the network administrator.

Configuration Steps

- Configuring CE1:

See "Configuring CE1" in basic configuration examples.

- Configuring PE1:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes so that PEs can ping with ASBRs in the same AS.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
```

```
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-Gigabitethernet 1/2)# no switchport
Ruijie(config-if-Gigabitethernet 1/2)# ip address 10.10.10.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/2)# mpls ip
Ruijie(config-if-Gigabitethernet 1/2)# label-switching
Ruijie(config-if-Gigabitethernet 1/2)# exit
```

Configure the user access VPWS.

```
Ruijie# configure terminal
Ruijie(config)# vlan 2
Ruijie(config-vlan)# exit
Ruijie(config)# interface vlan 2
Ruijie (config-VLAN 2) # exit
Ruijie(config)# interface GigabitEthernet 1/1
Ruijie(config-if-GigabitEthernet 1/1)# switchport access vlan 2
Ruijie(config-if-GigabitEthernet 1/1)# exit
Ruijie(config)# interface vlan 2
Ruijie(config-if-vlan 2)# end
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 2.2.2.2 remote-as 100
Ruijie(config-router)# neighbor 2.2.2.2 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpws
Ruijie(config-router-af)# neighbor 2.2.2.2 activate
Ruijie(config-router-af)# neighbor 2.2.2.2 send-community extended
Ruijie(config-router-af)# exit
```

Configure a VFI instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpws-1 vpnid 1 point-to-point
Ruijie(config-vfi)# rd 100:1
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface vlan 2 remote-ce-id 2
Ruijie(config-vfi-site)#exit-site-mode
```

```
Ruijie(config-vfi)#exit
```

- Configuring ASBR1:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 2.2.2.2 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes so that PEs can ping with ASBRs in the same AS.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# no switchport
Ruijie(config-if-Gigabitethernet 1/1)# ip address 10.10.10.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 100
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpws
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# exit
```

Configure the interface between ASBR1 and ASBR2.

```
Ruijie# configure terminal
Ruijie(config)# vlan 2
Ruijie(config-vlan)# exit
Ruijie(config)# interface vlan 2
Ruijie (config-VLAN 2) # exit
Ruijie(config)# interface GigabitEthernet 1/2
Ruijie(config-if-GigabitEthernet 1/2)# switchport access vlan 2
Ruijie(config-if-GigabitEthernet 1/2)# exit
Ruijie(config)# interface vlan 2
```

```
Ruijie(config-if-vlan 2)# end
```

Configure a VPWS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpws-1 vpnid 2 point-to-point
Ruijie(config-vfi)# rd 100:1
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 2
Ruijie(config-vfi-site)# xconnect interface vlan 2 remote-ce-id 1
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

- Configuring ASBR2:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 3.3.3.3 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes so that PEs can ping with ASBRs in the same AS.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-Gigabitethernet 1/2)# ip address 20.20.20.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/2)# mpls ip
Ruijie(config-if-Gigabitethernet 1/2)# label-switching
Ruijie(config-if-Gigabitethernet 1/2)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 200
Ruijie(config-router)# neighbor 4.4.4.4 remote-as 200
Ruijie(config-router)# neighbor 4.4.4.4 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpws
Ruijie(config-router-af)# neighbor 4.4.4.4 activate
Ruijie(config-router-af)# neighbor 4.4.4.4 send-community extended
Ruijie(config-router-af)# exit
```

Configure the interface that connects ASBR2 and ASBR1.

```
Ruijie# configure terminal
Ruijie(config)# vlan 2
Ruijie(config-vlan)# exit
Ruijie(config)# interface vlan 2
Ruijie (config-VLAN 2) # exit
Ruijie(config)# interface GigabitEthernet 1/1
Ruijie(config-if-GigabitEthernet 1/1)# switchport access vlan 2
Ruijie(config-if-GigabitEthernet 1/1)# exit
Ruijie(config)# interface vlan 2
Ruijie(config-if-vlan 2)# end
```

Configure a VPWS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpws-1 vpnid 1 point-to-point
Ruijie(config-vfi)# rd 200:1
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 3
Ruijie(config-vfi-site)# xconnect interface vlan 2 remote-ce-id 4
Ruijie(config-vfi-site)#exit-site-mode
Ruijie Networks(config-vfi)#exit
```

- Configuring PE2:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 4.4.4.4 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes so that PEs can ping with ASBRs in the same AS.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 4.4.4.4 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
```

```
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 200
Ruijie(config-router)# neighbor 3.3.3.3 remote-as 200
Ruijie(config-router)# neighbor 3.3.3.3 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpws
Ruijie(config-router-af)# neighbor 3.3.3.3 activate
Ruijie(config-router-af)# neighbor 3.3.3.3 send-community extended
Ruijie(config-router-af)# exit
```

Configure the interface that connects PE2 and a CE.

```
Ruijie# configure terminal
Ruijie(config)# vlan 2
Ruijie(config-vlan)# exit
Ruijie(config)# interface vlan 2
Ruijie (config-VLAN 2) # exit
Ruijie(config)# interface GigabitEthernet 1/2
Ruijie(config-if-GigabitEthernet 1/2)# switchport access vlan 2
Ruijie(config-if-GigabitEthernet 1/2)# exit
Ruijie(config)# interface vlan 2
Ruijie(config-if-vlan 2)# end
```

Configure a VPWS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpws-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 200:1
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 4
Ruijie(config-vfi-site)# xconnect interface vlan 2 remote-ce-id 3
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

- Configuring CE2:

See "Configuring CE2" in basic configuration examples.

Verification

After the configuration, CE1 can ping with CE2.

After completing the configuration of Kompella VPWS, use the following commands to check the operation of VPWS:

Command	Function
Ruijie# **show bgp l2vpn vpws all**	Displays all the VPWS information.

Ruijie# **show mpls l2transport vc** [*vc_id* [*ip-address*]]	[**interface** *interface_name*] [**detail**]	Displays information about the PW (including VPWS PW and VPLS PW).
Ruijie# **show bgp l2vpn** { **vpls | vpws** } **all connections** [**neighbor** *address*] | [**interface** *interface_name*] | [**site-id** *id*] [**detail**]	Displays PW information.
Ruijie# **show mpls vfi** [*name*]	Displays all the configured or specified VFI information.

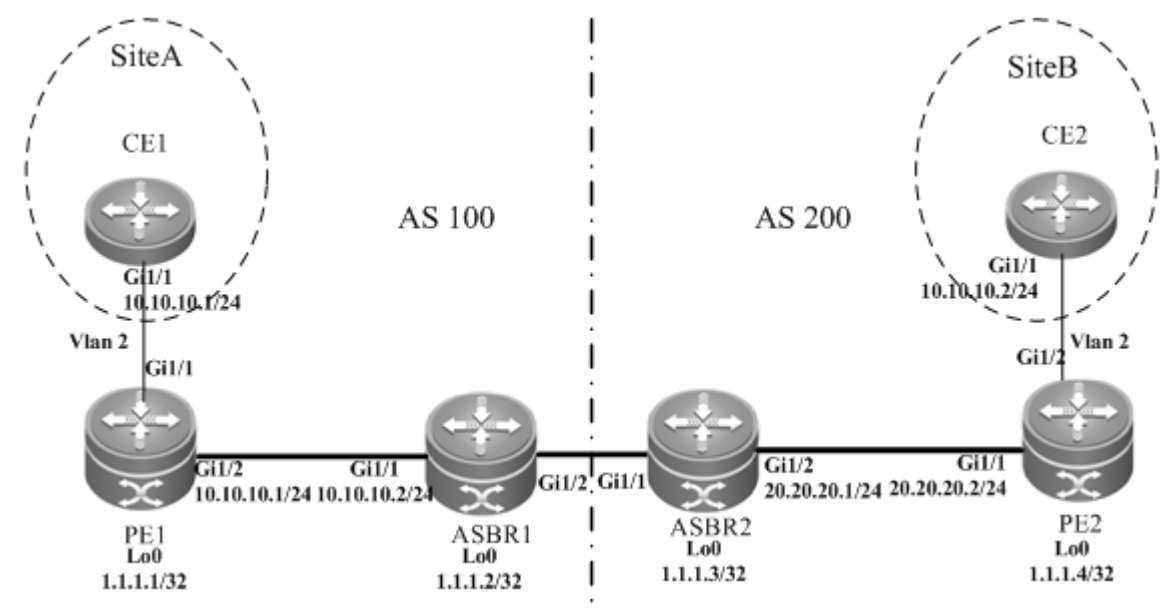
Option C Inter-AS VPWS

Networking Requirements

- Adopt Option C to realize Inter-AS VPWS.
- To set up a PW between PEs of different ASs, PW information is not maintained on ASBR and OSPF is used in each AS as IGP to realize inter-AS communication.
- Assuming that CE1 is connected to PE through the access interface, it is required to establish L2VPN communication between CE1 and CE2.

Networking Topology

Figure 73 Option C: Inter-AS VPWS



Note

If CE1 and CE2 are connected to PEs in other modes such as trunk mode, you only need to adjust the configuration of L2VPN in the VLAN interface mode (see configuration instances of various access modes for L2VPN). The configuration of BGP and public network's IGP and MPLS does not need to be modified.

Configuration Tips

Before configuring Kompella VPWS, complete the following tasks:

- Run IGP in the carrier's network to realize connection between PE and ASBR devices;
- Establish the MP-IBGP peer relationship between PEs and intra-AS ASBRs.

- Obtain Kompella VPWS configuration information including VPWS instance descriptive information, RT value, CE ID, maximum planned site number, CE ID deviation, and interface information from the network administrator.

Configuration Steps

Configuring CE1

```
Ruijie# configure terminal
Ruijie(config)# interface GigabitEthernet 1/1
```

The **no switchport** command is used on switches to switch the port mode to the Routed Port mode. It does not apply to routers and does not need to be used on routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
Ruijie(config-if-GigabitEthernet 1/1)# ip address 192.168.1.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# end
```

The configuration of CE2 is similar to that of CE1.

Configuring PE1-AS1

Configure the public network route protocol, MPLS signaling, and remote neighbors.

```
Ruijie# configure terminal
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# neighbor 1.1.1.4
Ruijie(config-mpls-router)# exit
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 10.0.0.0 0.0.0.255 area 0
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# exit
Ruijie(config)# interface GigabitEthernet 0/1
```

The **no switchport** command is used on switches to switch the port mode to the Routed Port mode. It does not apply to routers and does not need to be used on routers.

```
Ruijie(config-if-GigabitEthernet 1/2)# no switchport
Ruijie(config-if-GigabitEthernet 1/2)# ip address 10.0.0.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/2)# mpls ip
Ruijie(config-if-GigabitEthernet 1/2)# label-switching
Ruijie(config-if-GigabitEthernet 1/2)# end
```

Configure BGP.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 1.1.1.2 remote-as 100
```

```
Ruijie(config-router)# neighbor 1.1.1.2 update-source loopback 0
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 1.1.1.2  activate
Ruijie(config-router-af)# neighbor 1.1.1.2  send-label
Ruijie(config-router-af)# end
```

Configure the user access VPWS.

```
Ruijie# configure terminal
Ruijie(config)# vlan 2
Ruijie(config-vlan)# exit
Ruijie(config)# interface vlan 2
Ruijie (config-VLAN 2) # exit
Ruijie(config)# interface GigabitEthernet 1/1
Ruijie(config-if-GigabitEthernet 1/1)# switchport access vlan 2
Ruijie(config-if-GigabitEthernet 1/1)# exit
Ruijie(config)# interface vlan 2
Ruijie(config-if-vlan 2)# end
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 1.1.1.4 remote-as 100
Ruijie(config-router)# neighbor 1.1.1.4 update-source loopback 0
Ruijie(config-router)# neighbor 1.1.1.4  ebgp-multihop
Ruiije(config-router)# address-family l2vpn vpws
Ruijie(config-router-af)# neighbor 1.1.1.4 activate
Ruijie(config-router-af)# neighbor 1.1.1.4 send-community extended
Ruijie(config-router-af)# exit
```

Configure a VFI instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpws-1 vpnid 1 point-to-point
Ruijie(config-vfi)# rd 1:1
Ruijie(config-vfi)# encapsulation mpls ethernetvlan
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface vlan 2 remote-ce-id 2
Ruijie(config-vfi-site)#exit-site-mode
```

The configuration of PE2-AS2 is similar to that of PE1-AS1.

Configuring ASBR1-AS1

Configure the loopback interface.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.2 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure the public network route protocol and MPLS signaling.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface GigabitEthernet 1/1
```

The **no switchport** command is used on switches to switch the port mode to the Routed Port mode. It does not apply to routers and does not need to be used on routers.

```
Ruijie(config-if-GigabitEthernet 1/1)# no switchport
Ruijie(config-if-GigabitEthernet 1/1)# ip address 10.0.0.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
Ruijie(config-if-GigabitEthernet 1/1)# exit
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 10.0.0.0 0.0.0.255 area 0
Ruijie(config-router)# network 1.1.1.2 0.0.0.0 area 0
Ruijie(config-router)# exit
```

Configure the IP address of the interface connected to ASBR2.

```
Ruijie(config)# interface GigabitEthernet 1/2
```

The **no switchport** command is used on switches to switch the port mode to the Routed Port mode. It does not apply to routers and does not need to be used on routers.

```
Ruijie(config-if-GigabitEthernet 1/2)# no switchport
Ruijie(config-if-GigabitEthernet 1/2)# ip address 10.1.0.1 255.255.255.0
```

Enable the interface's label packet forwarding capability.

```
Ruijie(config-if-GigabitEthernet 1/2)# label-switching
Ruijie(config-if-GigabitEthernet 1/2)# exit
```

Configure BGP.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 100
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruijie(config-router)# neighbor 10.1.0.2 remote-as 200
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# neighbor 1.1.1.1 send-label
Ruijie(config-router-af)# neighbor 10.1.0.2 activate
Ruijie(config-router-af)# neighbor 10.1.0.2 send-label
Ruijie(config-router-af)# network 1.1.1.1 mask 255.255.255.255
Ruijie(config-router-af)# end
```

The configuration of ASBR2-AS2 is similar to that of ASBR1-AS1.

The configuration of PE2-AS2 is similar to that of PE1-AS1.

The configuration of CE2 is similar to that of CE1.

Verification

After the configuration, CE1 can ping with CE2.

After completing the configuration of Kompella VPWS, use the following commands to check the operation of VPWS:

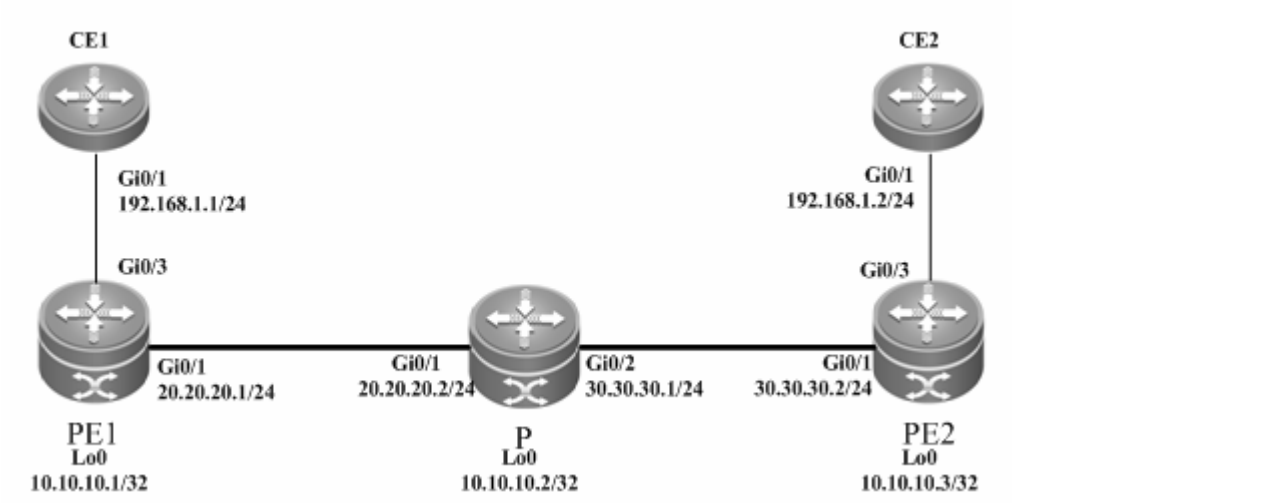
Command	Function
Ruijie# **show bgp l2vpn vpws all**	Displays all the VPWS information.
Ruijie# **show mpls l2transport vc** [*vc_id* [*ip-address*]] | [**interface** *interface_name*] [**detail**]	Displays information about the PW (including VPWS PW and VPLS PW).
Ruijie# **show bgp l2vpn** { **vpls | vpws** } **all connections** [**neighbor** *address*] | [**interface** *interface_name*] | [**site-id** *id*] [**detail**]	Displays PW information.
Ruijie# **show mpls vfi** [*name*]	Displays all the configured or specified VFI information.

Kompella VPWS Router Configuration Instance

Connecting CEs to PEs Through Ethernet

As shown in the following network topology, the interface between PEs and CEs is an Ethernet interface. That is, CEs are connected to PEs through the Ethernet interface, through which the L2VPN service is provided between CE1 and CE2.

Figure 74



The configuration procedure is as follows:

Configuring CE1:

Configure the interface between CE1 and PE1.

```
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)# ip address 192.168.1.1 255.255.255.0
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/1)# ip ref
Ruijie(config-if-Gigabitethernet 0/1)# end
```

Configuring PE1:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 10.10.10.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 10.10.10.1 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)# ip ref
Ruijie(config-if-Gigabitethernet 0/1)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 0/1)# mpls ip
Ruijie(config-if-Gigabitethernet 0/1)# label-switching
Ruijie(config-if-Gigabitethernet 0/1)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 10.10.10.3 remote-as 100
Ruijie(config-router)# neighbor 10.10.10.3 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpws
Ruijie(config-router-af)# neighbor 10.10.10.3 activate
Ruijie(config-router-af)# neighbor 10.10.10.3 send-community extended
Ruijie(config-router-af)# exit
```

Configure a VFI instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpws-1 vpnid 1 point-to-point
Ruijie(config-vfi)# rd 1:1
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
```

```
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface gigabitEthernet 0/3 remote-ce-id 2
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

Enable the interface to connect to remote CEs.

```
Ruijie(config)# interface gigabitEthernet 0/3
Ruijie(config-if-GigabitEthernet 0/3)# ip ref
Ruijie(config-if-GigabitEthernet 0/3)# exit
```

Configuring P:

Configure the public network route protocol and LSP tunnel.

The configuration is similar to the aforementioned MPLS basic function configuration instance.

Configuring PE2:

The configuration is similar to that of PE1.

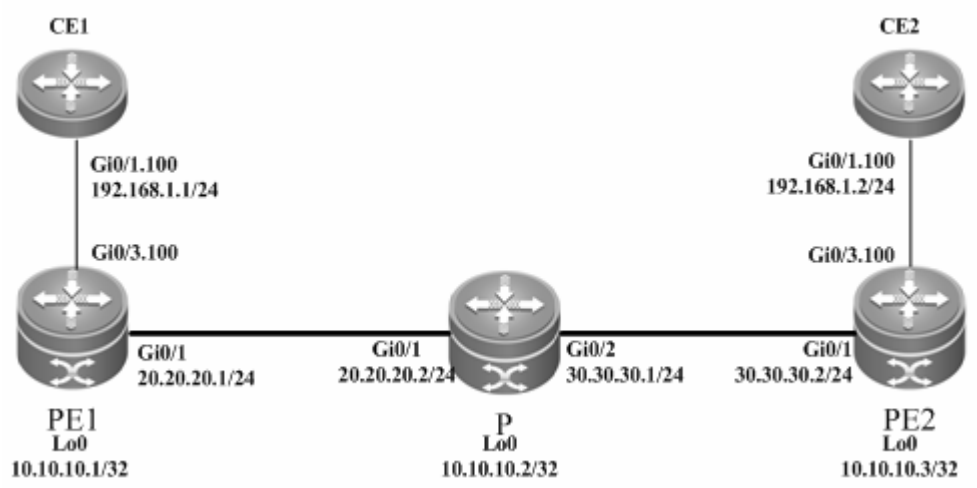
Configuring CE2:

The configuration is similar to that of CE1.

Connecting CEs to PEs Through VLAN

As shown in the following network topology, the interface that connects PEs and CEs is an Ethernet sub-interface. That is, CEs are connected to PEs through the Ethernet sub-interface, through which L2VPN service is provided between CE1 and CE2.

Figure 75



The configuration procedure is as follows:

Configuring CE1:

Configure the interface between CE1 and PE1.

```
Ruijie(config)# interface gigabitethernet 0/1
```

Enable the fast forwarding function of routers on the interface for routers. You do not need to use this command on switches.

```
Ruijie(config-if-gigabitethernet 0/1)# ip ref
Ruijie(config-if-gigabitethernet 0/1)# exit
Ruijie(config)# interface gigabitethernet 0/1.100
Ruijie(config-if-Gigabitethernet 0/1.100)# encapsulation dot1Q 100
Ruijie(config-if-Gigabitethernet 0/1.100)# ip address 192.168.1.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 0/1.100)# end
```

Configuring PE1:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 10.10.10.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 10.10.10.1 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
```

#Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)# ip ref
Ruijie(config-if-Gigabitethernet 0/1)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 0/1)# mpls ip
Ruijie(config-if-Gigabitethernet 0/1)# label-switching
Ruijie(config-if-Gigabitethernet 0/1)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 10.10.10.3 remote-as 100
Ruijie(config-router)# neighbor 10.10.10.3 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpws
Ruijie(config-router-af)# neighbor 10.10.10.3 activate
Ruijie(config-router-af)# neighbor 10.10.10.3 send-community extended
Ruijie(config-router-af)# exit
```

Configure the interface to connect with remote CEs.

```
Ruijie(config-if-Gigabitethernet 0/3.100)# encapsulation dot1Q 100
Ruijie(config-if-GigabitEthernet 0/3)# exit
```

Configure a VFI instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpws-1 vpnid 1 point-to-point
Ruijie(config-vfi)# rd 1:1
Ruijie(config-vfi)# encapsulation mpls ethernetvlan
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface gigabitEthernet 0/3.100 remote-ce-id 2
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

Configuring P:

Configure the public network route protocol and LSP tunnel.

The configuration is similar to the aforementioned MPLS basic function configuration instance.

Configuring PE2:

The configuration procedure is similar to that of PE1.

Configuring CE2:

The configuration procedure is similar to that of CE1.

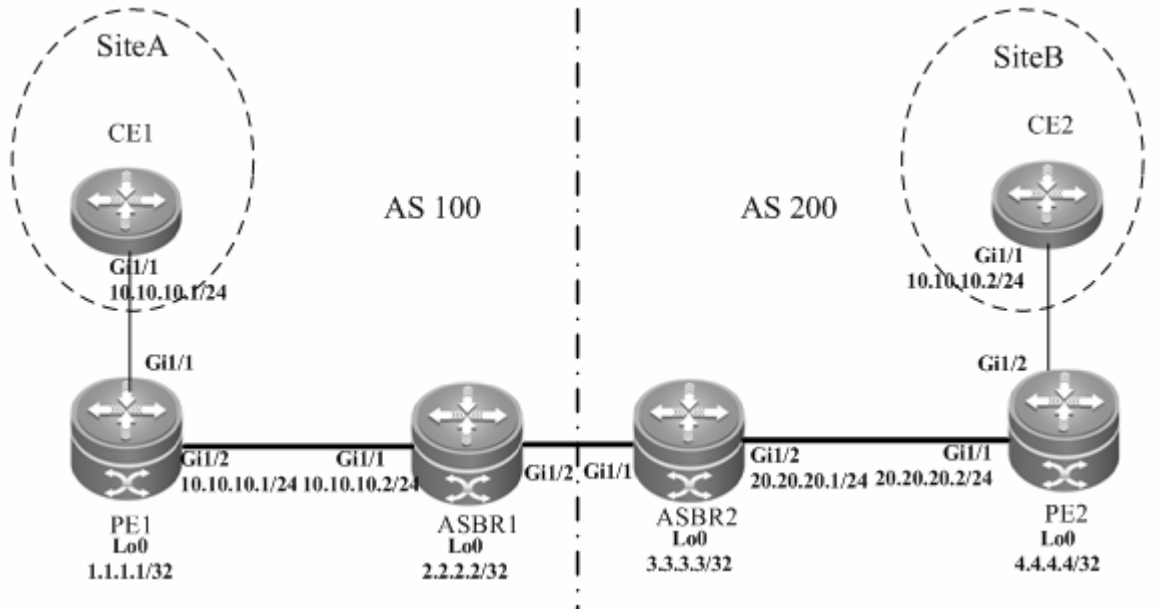
Option A Inter-AS VPWS

Networking Requirements

- CEs of customer S in site A and site B are connected with each other through the carrier's PE1 in AS 100 and PE2 in AS 200, realizing layer-2 point-to-point connection.
- PE1 and PE2 are in different autonomous ASs. ASBR1 and ASBR2 are considered CEs by each other, which means that the interface between ASBRs connects the AC to the VFI instance.

Networking Topology

Figure 76 Kompella VPWS inter-AS networking topology



The preceding figure shows the structure of the Kompella VPLS inter-AS networking topology in Option A. The intermediate interface is considered by ASBRs as AC access.

Configuration Tips

Before configuring Kompella VPWS, complete the following tasks:

- Run IGP in the carrier's network to realize connection between PE and ASBR devices.
- Establish the MP-IBGP peer relationship between PEs and intra-AS ASBRs.
- Obtain Kompella VPWS configuration information including VPWS instance descriptive information, RT value, CE ID, maximum planned site number, ID deviation, and interface information from the network administrator.

Configuration Steps

- Configuring CE1

See "Configuring CE1" in basic configuration examples.

- Configuring PE1

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes so that PEs can ping with ASBRs in the same AS.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
```

```
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-Gigabitethernet 1/2)# ip ref
Ruijie(config-if-Gigabitethernet 1/2)# ip address 10.10.10.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/2)# mpls ip
Ruijie(config-if-Gigabitethernet 1/2)# label-switching
Ruijie(config-if-Gigabitethernet 1/2)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 2.2.2.2 remote-as 100
Ruijie(config-router)# neighbor 2.2.2.2 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpws
Ruijie(config-router-af)# neighbor 2.2.2.2 activate
Ruijie(config-router-af)# neighbor 2.2.2.2 send-community extended
Ruijie(config-router-af)# exit
```

Configure a VFI instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpws-1 vpnid 1 point-to-point
Ruijie(config-vfi)# rd 100:1
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface gigabitEthernet 1/1 remote-ce-id 2
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

Configure the interface between CEs and PEs and specify the remote CE ID.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# exit
```

- Configuring ASBR1:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 2.2.2.2 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF protocol, establish public network routes so that PEs can ping with ASBRs in the same domain.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip ref
Ruijie(config-if-Gigabitethernet 1/1)# ip address 10.10.10.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 100
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpws
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# exit
```

Configure a VPWS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpws-1 vpnid 2 point-to-point
Ruijie(config-vfi)# rd 100:1
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 2
Ruijie(config-vfi-site)# xconnect interface gigabitEthernet 1/2 remote-ce-id 1
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

Configure the interface between ASBR1 and ASBR2.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-GigabitEthernet 1/2)# ip ref
Ruijie(config-if-GigabitEthernet 1/2)# exit
```

- Configure ASBR2:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 3.3.3.3 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF protocol, establish public network routes so that PEs can ping with ASBRs in the same domain.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
```

#Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-Gigabitethernet 1/2)# ip ref
Ruijie(config-if-Gigabitethernet 1/2)# ip address 20.20.20.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/2)# mpls ip
Ruijie(config-if-Gigabitethernet 1/2)# label-switching
Ruijie(config-if-Gigabitethernet 1/2)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 200
Ruijie(config-router)# neighbor 4.4.4.4 remote-as 200
Ruijie(config-router)# neighbor 4.4.4.4 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpws
Ruijie(config-router-af)# neighbor 4.4.4.4 activate
Ruijie(config-router-af)# neighbor 4.4.4.4 send-community extended
Ruijie(config-router-af)# exit
```

Configure a VPWS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpws-1 vpnid 1 point-to-point
Ruijie(config-vfi)# rd 200:1
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 3
Ruijie(config-vfi-site)# xconnect interface gigabitEthernet 1/1 remote-ce-id 4
Ruijie(config-vfi-site)#exit-site-mode
Ruijie Networks(config-vfi)#exit
```

Configure the interface between ASBR1 and ASBR2.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# exit
```

- Configuring PE2:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 4.4.4.4 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes so that PEs can ping with ASBRs in the same AS.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 4.4.4.4 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip ref
Ruijie(config-if-Gigabitethernet 1/1)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 200
Ruijie(config-router)# neighbor 3.3.3.3 remote-as 200
Ruijie(config-router)# neighbor 3.3.3.3 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpws
Ruijie(config-router-af)# neighbor 3.3.3.3 activate
Ruijie(config-router-af)# neighbor 3.3.3.3 send-community extended
Ruijie(config-router-af)# exit
```

Configure a VPWS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpws-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 200:1
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 4
Ruijie(config-vfi-site)# xconnect interface gigabitEthernet 1/2 remote-ce-id 3
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

Configure the interface between PE2 and a CE.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-GigabitEthernet 1/2)# ip ref
Ruijie(config-if-GigabitEthernet 1/2)# exit
```

- Configuring CE2:

See "Configuring CE2" in basic configuration examples.

Verification

After the configuration, CE1 can ping with CE2.

After completing the configuration of Kompella VPWS, use the following commands to check the operation of VPWS.

Command	Function
Ruijie# **show bgp l2vpn vpws all**	Displays all the VPWS information.
Ruijie# **show mpls l2transport vc** [*vc_id* [*ip-address*]] | [**interface** *interface_name*] [**detail**]	Displays information about the PW (including VPWS PW and VPLS PW).
Ruijie# **show bgp l2vpn** { **vpls | vpws** } **all connections** [**neighbor** *address*] | [**interface** *interface_name*] | [**site-i**d *id*] [**detail**]	Displays PW information.
Ruijie# **show mpls vfi** [*name*]	Displays all the configured or specified VFI information.

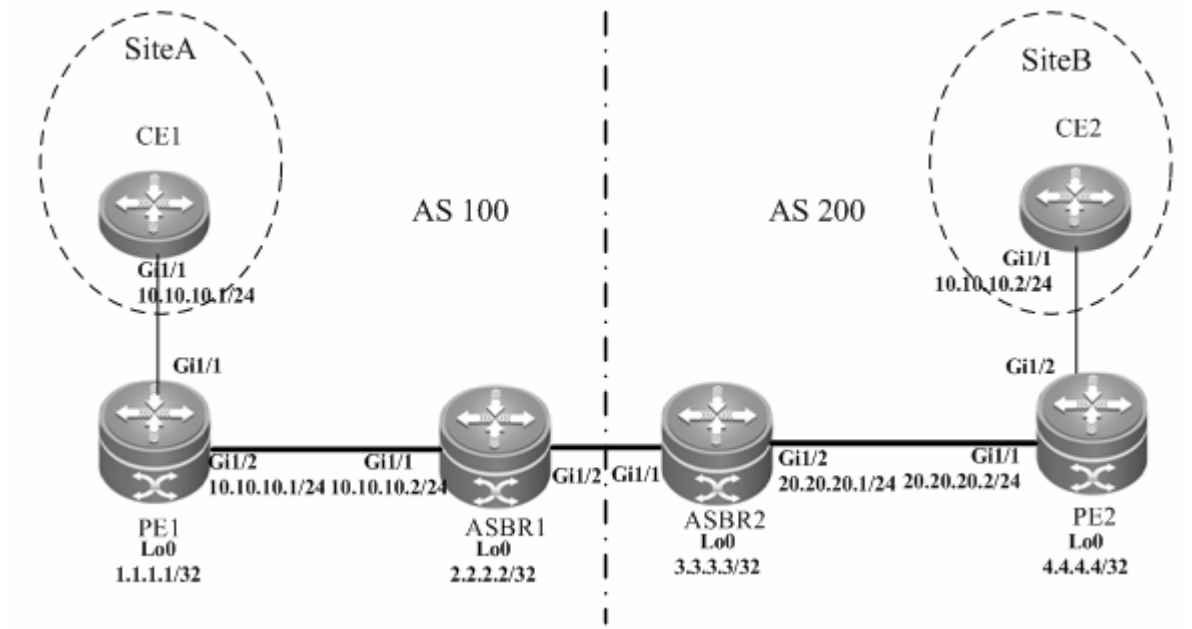
Option C Inter-AS VPWS

Networking Requirements

- CEs of customer S in site A and site B are connected with each other through the carrier's PE1 in AS 100 and PE2 in AS 200, realizing layer-2 point-to-point connection.
- PE1 and PE2 are in different ASs and can automatically detect PE devices involved in the VFI instance.
- ASBR is not responsible for maintaining VPWS label block messages.
- VPWS label block messages are directly switched between PEs.

Networking Topology

Figure 77 Kompella VPWS Option C inter-AS networking topology



The above figure shows the structure of Kompella VPWS Option C Inter-AS networking topology. Customer S's CE devices in Site A and Site B are connected to each other through PE1 in AS100 and PE2 in AS200, thus realizing layer-2 point-to-point connection.

Configuration Tips

Before configuring Kompella VPWS, complete the following tasks:

- Run IGP in the carrier's network to realize connection between PE and ASBR devices in the same AS.
- Establish a public network tunnel between PE and ASBR devices in the same AS and enable MPLS on the ASBR interface.
- Establish IBGP between PE and ASBR in the same AS.
- Establish EBGP between ASBR devices and enable send-label.
- Obtain Kompella VPWS configuration information including VPWS instance descriptive information, RT value, CE, planned site number, ID deviation, and interface information from the network administrator.

Configuration Steps

- Configuring CE1

See "Configuring CE1" in basic configuration examples.

- Configuring PE1

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
```

```
Ruijie(config-router)# exit
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-Gigabitethernet 1/2)# ip ref
Ruijie(config-if-Gigabitethernet 1/2)# ip address 10.10.10.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/2)# mpls ip
Ruijie(config-if-Gigabitethernet 1/2)# label-switching
Ruijie(config-if-Gigabitethernet 1/2)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 4.4.4.4 remote-as 200
Ruijie(config-router)# neighbor 4.4.4.4 update-source loopback 0
Ruijie(config-router)# neighbor 4.4.4.4  ebgp-multihop
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# no neighbor 4.4.4.4  activate
Ruijie(config-router-af)# exit
Ruiije(config-router)# address-family l2vpn vpws
Ruijie(config-router-af)# neighbor 4.4.4.4 activate
Ruijie(config-router-af)# neighbor 4.4.4.4 send-community extended
Ruijie(config-router-af)# exit
```

Configure a VPWS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpws-1 vpnid 1 point-to-point
Ruijie(config-vfi)# rd 100:1
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface gigabitEthernet 1/1 remote-ce-id 2
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

Configure the interface that connects CEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# exit
```

- Configuring ASBR1

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 2.2.2.2 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# redistribute bgp subnets
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# advertise-labels for bgp-routes
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip ref
Ruijie(config-if-Gigabitethernet 1/1)# ip address 10.10.10.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Configure the interface that connects ASBR.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-Gigabitethernet 1/2)# ip ref
Ruijie(config-if-Gigabitethernet 1/2)# ip address 192.168.1.1 255.255.255.252
Ruijie(config-if-Gigabitethernet 1/2)# label-switching
Ruijie(config-if-Gigabitethernet 1/2)# exit
```

Configure ASBR to allocate labels for PEs' routes.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 192.168.1.2 remote-as 200
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 192.168.1.2 send-label
Ruijie(config-router-af)# network 1.1.1.1 mask 255.255.255.255
Ruijie(config-router-af)# end
```

- Configuring ASBR2

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 3.3.3.3 255.255.255.255
```

```
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 20
Ruijie(config-router)# redistribute bgp subnets
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# advertise-labels for bgp-routes
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-Gigabitethernet 1/2)# ip ref
Ruijie(config-if-Gigabitethernet 1/2)# ip address 20.20.20.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/2)# mpls ip
Ruijie(config-if-Gigabitethernet 1/2)# label-switching
Ruijie(config-if-Gigabitethernet 1/2)# exit
```

Configure the interface that connects ASBR.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip ref
Ruijie(config-if-Gigabitethernet 1/1)# ip address 192.168.1.1 255.255.255.252
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Configure ASBR to allocate labels for PEs' routes.

```
Ruijie(config)# router bgp 200
Ruijie(config-router)# neighbor 192.168.1.1 remote-as 100
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 192.168.1.1  send-label
Ruijie(config-router-af)# network 4.4.4.4 mask 255.255.255.255
Ruijie(config-router-af)# end
```

- Configuring PE2

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 4.4.4.4 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 20
Ruijie(config-router)# network 4.4.4.4 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

#Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip ref
Ruijie(config-if-Gigabitethernet 1/1)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 100
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruijie(config-router)# neighbor  1.1.1.1  ebgp-multihop
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# no neighbor  1.1.1.1 activate
Ruijie(config-router-af)# exit
Ruiije(config-router)# address-family l2vpn vpws
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# neighbor 1.1.1.1 send-community extended
Ruijie(config-router-af)# exit
```

Configure a Kompella VPWS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpws-1 vpnid 1 point-to-point
Ruijie(config-vfi)# rd 200:1
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# mtu 1500
Ruijie(config-vfi)# site-id 2
Ruijie(config-vfi-site)# xconnect interface gigabitEthernet 1/2 remote-ce-id 1
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

Configure the interface between PEs and CEs.

```
Ruijie(config)# interface gigabitEthernet 1/2
```

```
Ruijie(config-if-GigabitEthernet 1/2)# ip ref
Ruijie(config-if-GigabitEthernet 1/2)# exit
```

- Configuring CE2

See "Configuring CE2" in basic configuration examples.

Verification

After the configuration, CE1 can ping with CE2.

After completing the configuration of Kompella VPLS, use the following commands to check the operation of VPWS:

Command	Function
Ruijie# **show bgp l2vpn vpws all**	Displays all the VPWS information.
Ruijie# **show mpls l2transport vc** [*vc_id* [*ip-address*]] | [**interface** *interface_name*] [**detail**]	Displays information about the PW (including VPWS PW and VPLS PW).
Ruijie# **show bgp l2vpn** { **vpls | vpws** } **all connections** [**neighbor** *address*] | [**interface** *interface_name*] | [**site-id** *id*] [**detail**]	Displays PW information.
Ruijie# **show mpls vfi** [*name*]	Displays all the configured or specified VFI information.

VPLS

Introduction to VPLS

The Virtual Private LAN Service (VPLS) is a technology that provides virtual and dedicated Ethernet services on an IP/MPLS network. By using VPLS, you can set up PWs in full mesh mode between PEs to forward encapsulated Layer 2 Ethernet frames between the PEs on the MPLS network. In this manner, you can create a P2MP Ethernet VPN. With a VPLS VPN, the user Layer 2 devices are connected to each other across the IP/MPLS core network and the core network is like a virtual switch for the user.

Compared with VPWS, VPLS can provide P2MP solutions. Compared with L3VPN, VPLS has the advantages of L2VPN to provide better network scalability and maintenance.

The terms used in this document are as follows:

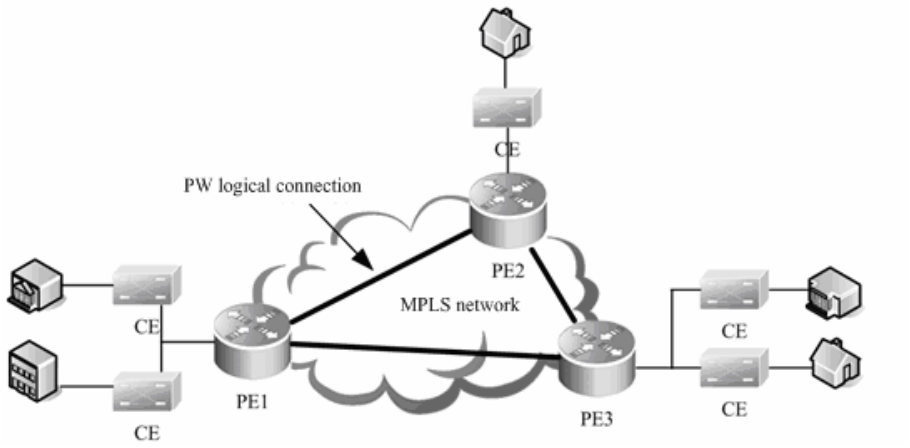
- PW: Pseudo Wire
- VPLS: Virtual Private LAN Service
- H-VPLS: Hierarchical VPLS
- MTU: Multi-Tenant Unit indicates corporate users at office buildings and business districts.
- As small edge devices at gathering places, the MTU is responsible for accessing corporate customers and aggregating users who require VPLS services to a PE through VCs.
- Spoke Connection: indicates the connection of a U-PE to an N-PE in H-VPLS. You can use a PW or QinQ.
- Spoke PW: indicates the Spoke connection between an N-PE and a U-PE when a PW is adopted, or the PW between a CE and PE when a user accesses the CE through PWs.

VPLS Network Structure

Basic VPLS

The following figure shows a typical VPLS model.

Figure 78



As shown in the VPLS networking in the preceding figure, PW logical connections are set up between PEs and the CEs are connected to the PEs enabled with VPLS. These VPLS PEs form P2MP services for the CEs. In this manner, the PEs are like a Layer 2 switch for the CEs to connect to.

The VPLS model in the dual-IGP instance has the following defects:

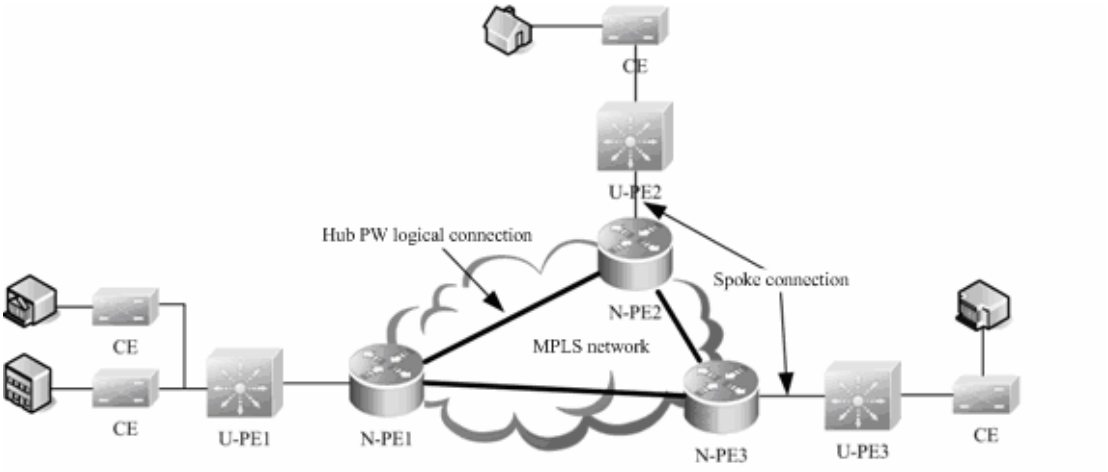
- Packets forwarded on the PWs between PEs are horizontally partitioned to avoid loops. That is, the packets received from a Hub PW are not forwarded to the Hub PW. Therefore, PWs must be set up between every two PEs. This incurs large system overheads and is not applicable to networks of large scales.
- The broadcast and multicast packets must be replicated at every PW, leading to low efficiency.

To address these problems, the hierarchical VPLS is introduced.

Hierarchical VPLS

The following figure shows a typical hierarchical VPLS (H-VPLS) model.

Figure 79



H-VPLS classifies the VPLS network into layers and sets up Hub PWs only between N-PEs on the core network. This addresses the problems on a common VPLS network. The Spoke connections between U-PEs and N-PEs are formed through PWs or QinQ tunnels. The U-PE can support VPWS or QinQ and is not required to support VPLS.

Using H-VPLS can reduce the burden on the VPLS core devices, decrease the overheads of the signaling protocol, reduce the number of packets that are replicated, and greatly strengthen the scalability of the VPLS network.

VPLS Signaling Protocol

VPLSs can be divided into Martini and Kompella VPLSs according to different VPLS signaling protocols. These two types of signaling are defined respectively in RFC4762 and RFC4761 of IETF. The Martini VPLS is based on the LDP signaling protocol and Kompella VPLS is based on the BGP signaling protocol. Given the BGP protocol's characteristics, such as the route reflector's characteristics, the Kompella VPLS can reduce the full inter-connection of BGP sessions, therefore facilitating the expansion of capacity. The Martini VPLS applies to small-sized and simple environment deployment.

VPLS Inter-AS

Both Martini and Kompella VPLSs can be inter-AS through Option A solution. In the inter-AS VPLS networking environment, the type of link between ASBRs must be the same as the type of VC. A sub-interface must be prepared for each inter-AS VC on ASBR. This solution can be adopted when the number of inter-AS VCs is small.

Option C is another solution to realize inter-AS VPLS. The SP network device only needs external tunnels on PEs in different ASs. ASBR does not maintain inter-AS VPLS information and does not need to prepare an interface for the inter-AS VPLS. VSI information of the VPLS can only be exchanged between PEs, reducing resource consumption without adding configuration tasks. The solution applies when the number of inter-AS VPLSs is large.

Configuring Martini VPLS

Configuring a Public Tunnel Between PEs

You must set up an LSP on the public network to carry VPLS services. To run MPLS on the backbone network, you must enable LDP on Ps and PEs at the same time to set up a public tunnel. This means that you have to configure LDP on MPLS devices and enable MPLS forwarding on each interface. The configuration procedure is as follows:

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **mpls ip**	Enables MPLS globally. Caution This command is not applicable to switch chip forwarding.
Ruijie(config)# **mpls router ldp**	Enables LDP and enters LDP configuration mode.
Ruijie(config-mpls-router)# **ldp router-id interface loopback** *id* [**force**]	Configures the LDP router ID. The IP address of the loopback interface is generally used as the router ID.
Ruijie(config-mpls-router)# **exit**	Exits LDP configuration mode.
Ruijie(config)# **interface** *type ID*	Enters public network interface configuration mode.
Ruijie(config-if-*type ID*)# **label-switching**	Enables MPLS on the interface at the public network side.
Ruijie(config-if-*type ID*)# **mpls ip**	Enables LDP and MPLS forwarding for the interface.

Ruijie(config-if-type ID)# **ip ref**	The interface's fast forwarding function must be enabled for routers.
Ruijie(config-if-type ID)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves the configuration.

Caution LDP is a topology-driven protocol. To ensure normal working of the LDP, enable IPv4 routing protocols and ensure their normal operations.

Configuring Remote LDP Peers

A PW is set up and maintained by the extended LDP. If other LSRs exist between two PEs, use the extended LDP discovery mechanism to set up a remote LDP session between the PEs and assign PW labels in the session. The procedures for configuring a remote LDP peer and setting up a remote LDP session are as follows:

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **mpls router ldp**	Enables LDP and enters LDP configuration mode.
Ruijie(config-mpls-router)# **neighbor** *ip_address*	Configures remote LDP peers.
Ruijie(config-mpls-router)# **exit**	Exits LDP configuration mode.
Ruijie(config)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves the configuration.

Caution The PW label messages of the LDP are not affected by the LDP label distribution mode or label retention mode. The LDP is forced to work in DU and liberal label retention mode.

Martini VPLS Configuration Example

The **l2 vfi** command is used to create a VPLS instance and enter VPLS mode. The **no l2 vfi** command is used to delete a VPLS instance. When creating a VPLS instance, you must specify a name that is unique on the local device and specify a unique VPN ID. Each VPLS name corresponds to a VPN ID.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **l2 vfi** *vpls-name* **vpnid** *vpn-id*	Creates a VPLS instance and enters VPLS configuration mode.
Ruijie(config-vfi)# **neighbor** *ip-address* **encapsulation mpls** [**vc-id** *vc-id*] [**hub-vc** | **spoke-vc**] [**ethernet** | **ethernetvlan**]	Configures a VPLS peer. The default PW type is Ethernet. We recommend using the PW type for access interface access and VLAN tunnel interface access on switches and Ethernet interface access on routers. ☑ We recommend setting the PW type as Ethernet VLAN if switchers use Trunk interface access or routers use sub-interface access VPLS service.

Ruijie(config-vpls)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves the configuration.


Caution

The VPLS peer must be unique in the VPLS instance scope. To facilitate management, you must configure VPLS instances of one VPN with the same ID.

A PW's key is the PW ID and the VPLS peer's LSR ID. It must be unique globally, including VPWS PW.

Each configuration of the same peer by using the **neighbor** command will cover the previous one.

The **mtu** parameter and PW type of interfaces on two ends of a PW must be the same. The default PW type of the VPLS is Ethernet. PW IDs on two ends of PEs(that is, the VC IDs) must be the same.

When using the **neighbor** command to specify the address of the VC's peer neighbor, you must use the peer router ID as the peer address and the 32-bit address of the loopback interface as the peer router ID.

☑ For switches, DHCP packets cannot be transmitted transparently after **ip dhcp snooping** is enabled globally.

Configuring User Access VPLS

☑ For switches, each VPLS can bind only one interface. For routers, multiple interfaces can be bound.

Configuring VPLS access mode for switches

A VPLS instance takes effect only after the user of the VPLS instance accesses the VPLS. At present, there are three modes of user access VPLS services:

☑ For switches, a VPLS can bind only one SVI interface because VPLS is supported only by the SVI interface.


Caution

When the port protection mode is enabled on the AC-end member port of a L2VPN, the port protection mode does not take effect on the member port if the corresponding member port is not a trunk interface.

- VLAN access interface access

The VLAN access interface is applicable to the transmission of user packets that are not encapsulated through 802.1Q (that is, packets without VLAN tags) on VPLS ACs.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters interface mode of the specified physical interface.
Ruijie(config-if-*type ID*)# **switchport mode access**	Enables the interface to work in access mode.
Ruijie(config-if-*type ID*)# **switchport access** *vlan-id*	Sets the interface as a VLAN member interface.
Ruijie(config-if-*type ID*)# **exit**	Exits interface configuration mode.
Ruijie(config)# **interface vlan** *vlan-id*	Enters VLAN interface mode.
Ruijie(config-if-*type ID*)# **xconnect vfi** *vpls-name*	Binds the VLAN to a VPLS instance.
Ruijie(config-if-*type ID*)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves the configuration.

Caution For the access interface access mode, we recommend setting the PW type to **ethernet**, and the two ends of PW must be set in the same type.

- VLAN trunk interface access

The VLAN trunk interface access is applicable to the transmission of multiple VPLS services on the same physical AC. Each VLAN corresponds to a VPLS instance. The PE determines the VPLS instance for user packets based on their VLAN tags to provide the multiplexing of access interfaces.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters interface mode of the specified physical interface.
Ruijie(config-if-*type ID*)# **switchport mode trunk**	Enables the interface to work in trunk mode.
Ruijie(config-if-*type ID)*# **switchport trunk allow vlan** *vlan-list*	Enables the trunk link to allow VLAN traffic.
Ruijie(config-if-*type ID*)# **exit**	Exits interface configuration mode.
Ruijie(config)# **interface vlan** *vlan-id*	Enters VLAN interface mode.
Ruijie(config-if-*type ID*)# **xconnect vfi** *vpls-name*	Binds the VLAN to a VPLS instance.
Ruijie(config-if-*type ID*)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves the configuration.

Caution For the Trunk interface access mode, we recommend setting the PW type as **ethernetvlan**, and the two ends of PW must be set in the same type.
The L2 VPN service cannot be bound to the Native VLAN of the Trunk interface.

- VLAN tunnel interface access

The VLAN tunnel interface access is applicable to the transmission of user service packets that carry private VLAN tags on the ACs when a user accesses VPLS services. In this mode, the PE forwards all packets received from the VLAN tunnel interface without any changes. This mode requires the VLAN member interfaces between PEs and CEs to work in tunnel mode.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters interface mode of the specified physical interface.
Ruijie(config-if-*type ID*)# **switchport access** *vlan-id*	Sets the interface as a VLAN member interface.
Ruijie(config-if-*type ID*)# **switchport mode dot1q-tunnel**	Enables the interface to work in tunnel mode.
Ruijie(config-if-*type ID*)# **exit**	Exits interface configuration mode.
Ruijie(config)# **interface vlan** *vlan-id*	Enters VLAN interface mode.
Ruijie(config-if-*type ID*)# **xconnect vfi** *vpls-name*	Binds the VLAN to a VPLS instance.
Ruijie(config-if-*type ID*)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves the configuration.

Caution For the VLAN tunnel interface access mode, we recommend setting the PW type as **Ethernet,** and the two ends of PW must be set in the same type.
For the VLAN tunnel interface access mode, only the basic QinQ is supported.

- PW access

The PW access is applicable to user access networks that are enabled with MPLS. In addition, the user is not directly connected to any VPLS PE link. In the H-VPLS model, the PW access mode can be used to access the N-PE if the U-PE has no bridging capability so that the VPLS access service can be provided on the U-PE for the user.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **l2 vfi** *name*	Enters VPLS configuration mode.
Ruijie(config-vpls)# **neighbor** *ip-address* **encapsulation mpls** [vc-id *vc-id*] **spoke-vc** [**ethernet** | **ethernetvlan**]	Configures a PW for user access.
Ruijie(config-vpls)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves the configuration.

For one VPLS instance, you can configure multiple PWs for user access.

Caution When accessing VPLS services through PWs, you must specify the **spoke-vc** keyword in the **neighbor** command to configure PWs, enable the **label-switching** command on the Spoke PW access interface, and enable fast forwarding for routers.

Configuring VPLS access mode for routers

A created VPLS instance takes effect only after the user configured with the VPLS instance is connected with the link.

- Ethernet interface access

This mode applies when the user service packets transmitted on ACs carry private VLAN tags or do not carry VLAN tags in the case of VPLS service access. In this mode, all packets received by PEs from the interface are forwarded according to the destination MAC address and the private tags are considered part of the data. In such case, PEs provide port-based VPLS service. The address learning mode of the VPLS instance of the bound port is the free mode. MAC address overlapping in the user VLAN is not supported.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters the specified physical interface.
Ruijie(config-if-type ID)# **ip ref**	The interface's fast forwarding function must be enabled for routers.
Ruijie(config-if-*type ID*)# **xconnect vfi** *vpls-name*	Binds VLAN to the VPLS instance.
Ruijie(config-if-*type ID*)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves configuration.

Caution For the VPLS service of the Ethernet interface access mode, we recommend setting the PW type to **ethernet**, and both ends of the PW in the same PW type.
The same VPLS instance can be bound to different interfaces to realize local connection.
If a VPLS instance is configured on different PEs with Ethernet interface and sub-interface access modes, we recommend setting all PWs of the VPLS instance to the **ethernetvlan** type.

- Sub-interface access

This mode applies when multiple VPLS services are transmitted on a physical AC. Each sub-interface corresponds to a VPLS instance. PE devices can match packets with VPLS instances according to VLAN tags carried by the user packets to provide the multiplexing of access interfaces.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters the specified physical interface.
Ruijie(config-if-*type ID*)# **encapsulation dot1Q**	Sets the VIP encapsulated by the sub-interface.
Ruijie(config-if-type ID)# **ip ref**	The interface's fast forwarding function must be enabled for routers.
Ruijie(config-if-*type ID*)# **xconnect vfi** *vpls-name*	Binds VLAN to the VPLS instance.
Ruijie(config-if-*type ID*)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves configuration.

Caution If a VPLS instance is used to transmit flows of multiple VLANs of the user, MAC address overlapping between VLANs of the user is not supported.
The same VPLS instance can be bound to different interfaces to realize local connection.
For the VPLS service of the sub-interface access mode, we recommend setting the PW type to **ethernetvlan**, and both ends of the PW in the same PW type.

- PW access

This mode applies when the user's access network is the MPLS network and no direct link is set up between the user and VPLS PEs. In the H-VPLS model, the PW access mode can be used to access the N-PE when the U-PE has no bridging capability so that the VPLS access service can be provided on the U-PE for the user.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **l2 vfi** *name*	Enters VPLS configuration mode.
Ruijie(config-vfi)# **neighbor** *ip-address* **encapsulation mpls** [**vc-id** *vc-id*] **spoke-vc** [**ethernet | ethernetvlan**]	Configures the PW to be accessed by user.
Ruijie(config-vfi)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves configuration.

Caution One VPLS instance can be configured with multiple PWs for user access.
When accessing VPLS services through PWs, you must specify the **spoke-vc** keyword in the **neighbor** command to configure PWs.

☑ For routers, the **label-switching** and **ip ref** commands must be enabled on the interface where Spoke PW is located.

Caution If the Ethernet access mode is adopted, the PW type must be **ethernet**. If the Ethernet sub-interface access mode is adopted, the PW type must be **ethernetvlan**.

Verifying Martini VPLS Configuration

After completing the configuration of the VPLS, use the following commands to check the operation of VPLS.

Command	Function
Ruijie# **show mpls vfi**	Displays VPLS information.
Ruijie# **show mpls l2transport vc** [[*vc_id* [*ip-address*]] | [**interface** *interface-name*]] [**detail**]	Displays information about the PW (including VPWS PW and VPLS PW).
Ruijie# **show ip ref mpls forwarding-table vfi** [*vpls_name*] [**mac-address-table** [*H.H.H*] [**statistics**]	Displays all MAC addresses under the VPLS instance including static MAC addresses learned from PWs and ACs and configured by the user, and statistics of VPLS forwarding.
Ruijie# **show mpls forwarding-table**	Displays PW-related ILM and FTN forwarding table entries.
Ruijie# **show mpls ldp neighbor**	Displays all LDP neighbor information.
Ruijie# **show mpls ldp vc**	Displays all LDP VC information.

Configuring Kompella VPLS

Configuring the Public Network Tunnel Between PEs

You must set up an LSP tunnel must be set up on the public network to provide VPLS services. To run MPLS on the backbone network, you must enable LDP on Ps and PEs to establish a public network tunnel. This means that you have to configure LDP for MPLS devices and enable MPLS forwarding on each interface. The configuration procedure is as follows:

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie# **mpls ip**	Enables MPLS forwarding globally. Caution This command is not applicable to switch chip forwarding.
Ruijie(config)# **mpls router ldp**	Enables LDP and enters LDP configuration mode.

Command	Function
Ruijie(config-mpls-router)# **ldp router-id interface loopback** *id* [**force**]	Configures LDP's router ID, which is usually the IP address of the loopback interface.
Ruijie(config-mpls-router)# **exit**	Exits the LDP configuration mode.
Ruijie(config)# **interface** *type ID*	Enters public network interface configuration mode.
Ruijie(config-if-*type ID*)# **label-switching**	Enables the interface's MPLS forwarding function.
Ruijie(config-if-*type ID*)# **mpls ip**	Enables the interface's LDP function and MPLS forwarding function.
Ruijie(config-if-*type ID*)# **ip ref**	Enables the fast forwarding function for routers.
Ruijie(config-if-type ID)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves configuration.

Configure the public network tunnel between PEs.

```
Ruijie# configure terminal
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 1/1
Ruijie(config-if-GigabitEthernet 1/1)# label-switching
Ruijie(config-if-GigabitEthernet 1/1)# mpls ip
Ruijie(config-if-GigabitEthernet 1/1)# end
Ruijie# copy running-config startup-config
```

Caution LDP is a topology-driven protocol. To ensure normal working of the LDP, enable IPv4 routing protocols and ensure their normal operations.

Configuring L2VPN VPLS Address Family

Kompella VPLS uses MP-BGP4 as signaling and auto-discovery mechanism. PE devices in one VPLS instance must exchange VPLS information through the L2VPN address family. By default, the L2VPN VPLS address family is not supported. The procedure for enabling the L2VPN address family is as follows:

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *asn-num*	Creates the BGP and enters BGP configuration mode.
Ruijie(config)# **neighbor** *peer-address* **remote-as** *asn-number*	Sets up an IBGP session.
Ruijie(config)# **neighbor** *peer-adddress* **update-source i***nterface-name*	Enables the IBGP session to use the address of the loopback interface as the session's source address.
Ruijie(config-router)# **address-family l2vpn vpls**	Enters the L2VPN VPLS address family.

Command	Function
Ruijie(config-router-af)# **neighbor** *ip-address* **activate**	Activates switching of VPLS information on the BGP session.
Ruijie(config-router-af)# **neighbor** { *ip-address* | *peer-group-name* } **send-community** [**both | standard | extended**]	Specifies the extended community attribute to be sent to BGP neighbors.
Ruijie(config-router-af)# **end**	Returns from address family configuration mode to privileged mode.
Ruijie# **show bgp l2vpn vpls** { **all** [**id:offset | neighbor ip-address | summary**] }	Displays L2VPN VPLS address family information.

Configure the L2VPN address family and enable VPLS information switching.

```
Ruijie# configure terminal
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 10.10.10.1 remote-as 100
Ruijie(config-router)# neighbor 10.10.10.1 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpls
Ruijie(config-router-af)# neighbor 10.10.10.1 activate
Ruijie(config-router-af)# neighbor 10.10.10.1 send-community extended
Ruijie(config-router-af)# end
Ruijie# show bgp l2vpn vpls all
```

Configuring Kompella VPLS instance

The **l2 vfi** command can be used to create Kompella VPLS instances or enter Kompella VPLS configuration mode. The **no l2 vfi** command can be used to delete VPLS instances. The unique local VPLS instance name and the unique local device VPN ID must be specified when the instance is being created. The auto-discovery function must be enabled for the specified VPLS instance. Each VPLS name corresponds to a VPN ID. In auto-discovery mode, BGP is the default signaling.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **l2 vfi** *vpls-name* **vpnid** *vpn-id* **autodiscovery**	Creates the Kompella VPLS instance and enters VPLS configuration mode.
Ruijie(config-vfi)# **signal bgp**	Configures the VPLS instance signaling, which is BGP by default.
Ruijie(config-vfi)# **rd** *rd_value*	Configures the RD value. Configure the RD first.
Ruijie(config-vfi)# **encapsulation mpls** [**ethernet | ethernetvlan**]	Specifies the encapsulation mode of Kompella VPLS PWs, which is Ethernet (that is, raw mode) by default. If the sub-interface VPLS access mode is adopted, we recommend the **ethernetvlan** encapsulation mode (that is, tag mode).
Ruijie(config-vfi)# **route-target** { **import | export | both** } *rt_value*	Configures RTs. Multiple RTs can be configured.

Command	Function
Ruijie(config-vfi)# **site-id** *id* [**site-range** *size*]	Configures VE IDs of VPLS sites and the site range. If the site range is not configured, the default value 16 will be adopted.
Ruijie(config-vfi-site)# **xconnect interface** *interface-id*	Configures the interface bound by the site.
Ruijie(config-vfi-site)# **end**	Exits site configuration mode.
Ruijie# **copy running-config startup-config**	Saves configuration.

Configure a Kompella VPLS instance.

```
Ruijie#configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# rd 100:1
Ruijie(config-vfi)# route-target both 4500:2
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface gigabitethernet 1/1
Ruijie(config-vfi-site)#end
Ruijie# copy running-config startup-config
```

Caution

The **autodiscovery** keyword must be specified after the **l2 vfi** command to create a Kompella VPLS instance.

The auto-discovery between PEs in a VPLS instance is based on MP-BGP. To configure the Kompella VPLS, specify the VPLS PW signaling protocol as BGP.

VPLS instances of one VPN must be configured with the same ID to facilitate management.

PEs on one VPLS must be configured with the same VPLS PW encapsulation mode. Otherwise, VPLS packets cannot be forwarded. Assuming that a VPLS-X exists, if the VPLS-X encapsulation mode on PE1 is **ethernet** (that is, raw mode), the VPLS encapsulation mode on PE2 must not be **ethernetvlan** (that is, tag mode).

☑ For switches, DHCP packets cannot be transmitted transparently after **ip dhcp snooping** is enabled globally.

Configuring User Access VPLS

Configuring VPLS Access Mode for Switches

A created VPLS instance takes effect only after the user configured with the VPLS instance is connected to the link. Currently, there are the following three ways for switch users to access VPLS services:

☑ For switches, a VPLS instance can bind only one SVI interface because VPLS is supported only by the SVI interface.

Caution

When the port protection mode is enabled on the AC-end member port of L2VPN, the port protection mode does not take effect on the member port if the corresponding member port is not a Trunk interface.

- VLAN access interface access

This mode applies when user packets transmitted on the VPLS AC are not encapsulated by 802.1Q (that is, the packets do not carry VLAN tags).

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters the specified physical interface.
Ruijie(config-if-*type ID*)# **switchport mode access**	Enables the interface to work in access mode.
Ruijie(config-if-*type ID*)# **switchport access** *vlan-id*	Sets the interface as a VLAN member port.
Ruijie(config-if-*type ID*)# **exit**	Exits interface configuration mode.
Ruijie(config)# **interface vlan** *vlan-id*	Enters VLAN interface mode.
Ruijie(config-if-*type ID*)# **exit**	Returns to global configuration mode.
Ruijie(config)# **l2 vfi** *vfi_name* **vpnid** *vpn_id* **autodiscovery**	Enters VFI configuration mode.
Ruijie(config-vfi)# **site-id i***d* [**site-range** *size*]	Configures site information of the VFI.
Ruijie(config-vfi-site)# **xconnect interface vlan** *id*	Configures the AC interface bound by the VPLS site.
Ruijie(config-vfi-site)# **end**	Returns to privileged configuration mode.
Ruijie# **copy running-config startup-config**	Saves configuration.

Caution For the access interface access mode, we recommend setting the VPLS PW encapsulation mode to **ethernet** (that is, raw mode).

VLAN trunk interface access

This mode applies when multiple VPLS services are transmitted on a physical AC. Each VLAN corresponds to a VPLS instance. PE devices can match packets with VPLS instances according to VLAN tags carried by the user packets to provide the multiplexing of access interfaces.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters the specified physical interface.
Ruijie(config-if-*type ID*)# **switchport mode trunk**	Enables the interface to work in trunk mode.
Ruijie(config-if-*type ID)*# **switchport trunk allow vlan add** *vlan-list*	Sets the VLAN flows allowed to be transmitted on the trunk link.
Ruijie(config-if-*type ID*)# **exit**	Exits interface configuration mode.
Ruijie(config)# **interface vlan** *vlan-id*	Enters VLAN interface mode.
Ruijie(config-if-*type ID*)# **exit**	Returns to global configuration mode.
Ruijie(config)# **l2 vfi** *vfi_name* **vpnid** *vpn_id* **autodiscovery**	Enters VFI configuration mode.
Ruijie(config-vfi)# **site-id** *id* [**site-range** *size*]	Configures site information of the VFI.
Ruijie(config-vfi-site)# **xconnect interface vlan** *id*	Configures the AC interface bound by the VPLS site.
Ruijie(config-vfi-site)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves configuration.

Caution For the Trunk interface access mode, we recommend setting the VPLS PW encapsulation mode to **ethernetvlan** (that is, tag mode).
The L2 VPN service cannot be bound to the Native VLAN of the trunk interface.

- VLAN tunnel interface access

This mode applies when user service packets transmitted on ACs carry private VLAN tags if the user is connected to the VPLS service. In this mode, all packets received by PEs from the interface are forwarded without being processed. This mode requires the VLAN member port between PEs and CEs to work in tunnel mode.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters the specified physical interface.
Ruijie(config-if-*type ID*)# **switchport access** *vlan-id*	Sets the interface as a VLAN member port.
Ruijie(config-if-*type ID*)# **switchport mode dot1q-tunnel**	Enable the interface to work in tunnel mode.
Ruijie(config-if-*type ID*)# **exit**	Exits interface configuration mode.
Ruijie(config)# **interface vlan** *vlan-id*	Enters VLAN interface mode.
Ruijie(config-if-*type ID*)# **exit**	Returns to global configuration mode.
Ruijie(config)# **l2 vfi** *vfi_name* **vpnid** *vpn_id* **autodiscovery**	Enters VFI configuration mode.
Ruijie(config-vfi)# **site-id** *id* [**site-range** *size*]	Configures site information of the VFI.
Ruijie(config-vfi-site)# **xconnect interface vlan** *id*	Configures the AC interface bound by the VPLS site.
Ruijie(config-vfi-site)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves configuration.

Caution For the VLAN tunnel interface access mode, we recommend setting the VPLS PW encapsulation mode to **ethernet** (that is, raw mode).
For the VLAN tunnel interface access mode, only the basic QinQ is supported.

Configuring VPLS Access Mode for Routers

A created VPLS instance takes effect only after the user configured with the VPLS instance is connected with the link.

There are the following two ways to access VPLS services:

- Ethernet interface access

This mode applies user service packets transmitted on ACs carry private VLAN tags or do not carry VLAN tags in the case of VPLS service access. In this mode, all packets received by PEs from the interface are forwarded according to the destination MAC address and the private tags are considered part of the data. In such case, PEs provide port-based VPLS services. The address learning mode of the VPLS instance of the bound port is the free mode. MAC address overlapping in the user VLAN is not supported.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters the specified physical interface.

Command	Function
Ruijie(config-if-*type ID*)# **ip ref**	Enables the fast forwarding function for routers.
Ruijie(config-if-*type ID*)# **end**	Returns to privileged mode.
Ruijie(config-if-*type ID*)# **exit**	Returns to global configuration mode.
Ruijie(config)# **l2 vfi** *vfi_name* **vpnid** *vpn_id* **autodiscovery**	Enters VFI configuration mode.
Ruijie(config-vfi)# **site-id** *id* [**site-range** *size*]	Configures site information of the VFI.
Ruijie(config-vfi-site)#**xconnect interface** *interface-id*	Configures the AC interface bound by the VPLS site.
Ruijie(config-vfi-site)#**end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves configuration.

Configure Ethernet interface VPLS access.

```
Ruijie# configure terminal
Ruijie(config)# interface gigabitethernet 1/2
```

Enable the fast forwarding function of the interface for routers.

```
Ruijie(config-if-GigabitEthernet 1/2)# ip ref
Ruijie(config-if-GigabitEthernet 1/2)# exit
Ruijie(config)# l2 vfi vfiA vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 2:2
Ruijie(config-vfi)# route-target both 2:2
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface gigabitethernet 1/2
Ruijie(config-vfi-site)#end
Ruijie# copy running-config startup-config
```

Caution For the Ethernet access mode, we recommend using the **encapsulation mpls ethernet** command to specify the Kompella VPLS PW encapsulation mode as **ethernet** (that is, raw mode). If the packets of imported PEs carry VLAN tags, the tags will be transmitted transparently as private tags.

☑ For routers, a VPLS instance can be configured with mixed access modes. For example, PEs in a VPLS instance are configured with both Ethernet and sub-interface access modes. In such case, we recommend setting the VPLS PW encapsulation mode on the PEs to **ethernetvlan** (that is, tag mode).

■ Sub-interface access

PE devices can access a VPLS instance through sub-interfaces.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters the specified physical interface.
Ruijie(config-if-*type ID*)# **ip ref**	For routers, the fast forwarding function must be enabled on the master interface of the sub-interface.
Ruijie(config-if-*type ID*)# **end**	Returns to privileged mode.
Ruijie(config-if-*type ID*)# e**xit**	Returns to global configuration mode.

Ruijie(config)# **l2 vfi** *vfi_name* **vpnid** *vpn_id* **autodiscovery**	Enters VFI configuration mode.
Ruijie(config-vfi)# **site-id** *id* [**site-range** *size*]	Configures site information of the VFI.
Ruijie(config-vfi-site)#**xconnect interface** *interface-id*	Configures the AC interface bound by the VPLS site.
Ruijie(config-vfi-site)#**end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves configuration.

Configure sub-interface VPLS access.

```
Ruijie# configure terminal
```

Enable the fast forwarding function of the sub-interface for routers.

```
Ruijie(config)# interface gigabitethernet 1/2
Ruijie(config-if-GigabitEthernet 1/2)# ip ref
Ruijie(config-if-GigabitEthernet 1/2)# exit
Ruijie(config)# interface gigabitethernet 1/2.10
Ruijie(config-if-GigabitEthernet 1/2.10)# encapsulation dot1Q 10
Ruijie(config-if-GigabitEthernet 1/2.10)#exit
Ruijie(config)# l2 vfi vfiA vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 2:2
Ruijie(config-vfi)# route-target both 2:2
Ruijie(config-vfi)# encapsulation mpls ethernetvlan
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface gigabitethernet 1/2.10
Ruijie(config-vfi-site)#end
Ruijie# copy running-config startup-config
```

Caution For the sub-interface access mode, we recommend using the **encapsulation mpls ethernetvlan** command to specify the Kompella VPLS PW encapsulation mode as **ethernetvlan** (that is, tag mode).

Configuring Kompella VPLS's Compatibility (Optional)

By default, the PW's mtu value provided by L2VPN is 1500 bytes. If the same PW's mtu values on two PEs are different, PW connection cannot be set up between the two PEs. Some manufacturers' devices do not support configuring mtu in L2VPN instances. When such devices perform Kompella communication with devices of other manufacturers, the **ingore match l2-extcommunity** command can be used to ignore received mtu and matching detection of **Control Flag**, ensuring that the VC link is UP.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **l2 vfi** *vpls-name* **vpnid** *vpn-id* **autodiscovery**	Creates the Kompella VPLS instance and enters VPLS configuration mode.
Ruijie(config-vfi)# **ingore match l2-extcommunity**	Configures ignoring detection of L2VPN expanded community attribute members.
Ruijie# **copy running-config startup-config**	Saves configuration.

Caution This command takes effect only on Kompella L2VPN.

Verifying Kompella VPLS Configuration

Command	Function
show bgp l2vpn vpls all	Displays NLRI information about all VPWS instances.
show bgp l2vpn vpls all connections	Displays all connection information of Komplla VPLS.
show mpls l2transport vc [*vc_id* [*ip-address*]] | [**interface** *interface_name*] [**detail**]	Displays VC information established by Kompella VPLS.
show mpls vfi [*name*]	Displays VPLS instance information.
Ruijie# **show ip ref mpls forwarding-table vfi** [*vpls_name*] [**mac-address-table** [*H.H.H*] **| statistics**]	Displays all MAC addresses under the VPLS instance including static MAC addresses learned from PWs and ACs and configured by the user, and statistics of VPLS forwarding.
Ruijie# **show mpls forwarding-table**	Displays PW-related ILM and FTN forwarding table entries.

Configuring Other VPLS Parameters

Configuring VPLS Instance Descriptors (Optional)

You can configure the descriptive information of each VPLS instance.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **l2 vfi** *vpls-name*	Enters VPLS configuration mode.
Ruijie(config-vfi)# **description** *vpls-description*	(Optional) Configures descriptive information of the VPLS.
Ruijie(config-vfi)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves configuration.

Configuring mtu of VPLS Instance (Optional)

You can configure each VPLS instance's mtu value, which is **1500** by default. The mtu value of VPLS indicates the length of the packet that can be transmitted by the PW, or the length of the user's layer-2 packet plus the length of the PW-encapsulated packet. By default, if the PW does not enable the control word, assuming that two labels are encapsulated, the length of an Ethernet packet that can be transmitted is 1492 bytes, of which 8 bytes are encapsulated by the PW (2 labels).

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **l2 vfi** *vpls-name*	Enters VPLS configuration mode.
Ruijie(config-vfi)# **mtu** *mtu*	(Optional) Configures the mtu value of the VPLS.
Ruijie(config-vfi)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves configuration.

Caution

The mtu values of one VPLS instance on different PEs must be the same. Otherwise, the signaling protocol cannot establish PWs.

Currently, transmission of VPLS fragments is not supported. If the PW signaling protocol negotiation's mtu is modified, the mtu of the user access service interface must be adjusted (generally adjusted to the PW mtu length minus the encapsulated length); the PW's public-network-end output interface's mtu, MPLS mtu and PW mtu must be the same to ensure proper forwarding. The **mtu** command can be used on an interface to modify the interface's mtu. Use the **mpls mtu** command to modify MPLS mtu of the interface.

Configuring VPLS Transparent Transmission Bridge Protocol Control Packet (Optional)

You can control whether the VPLS interface transparently transmits bridge protocol control packets to meet application needs.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type ID*	Enters specified interface mode.
Ruijie(config-if-*type ID*)# **l2 vfi tunnel-protocol stp**	Enables the interface to transparently transmit STP packets.
Ruijie(config-if-*type ID*)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves configuration.

Caution

Generally, BPDU packets do not carry VLAN Tag. If CEs access PEs through a trunk interface or sub-interface and the BPDU transparent transmission function is enabled on the access interface, the BPDU packets sent by CEs must carry corresponding VLAN tags so that the BPDU packets can be identified by the corresponding VPLS instances and transmitted transparently in the VPLS instances.

Configuring MAC Address Aging Time (Optional)

You can configure each VPLS instance's address aging time, which is 300 seconds by default.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **l2 vfi** *vpls-name*	Enters VPLS configuration mode.
Ruijie(config-vfi)# **mac-address aging-time** *interval*	(Optional) Configures the address aging time of the VPLS.
Ruijie(config-vfi)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves configuration.

Caution If the aging time of MAC addresses is changed, all the MAC addresses will be aged according to the new aging time. If the aging time is set to *m*, MACs that have not performed communication will be aged after *m*.

Configuring MAC Address Capacity Volume Limit (Optional)

You can configure each VPLS instance's MAC address capacity limit and behavior to be performed when the limit is exceeded.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **l2 vfi** *vpls-name*	Enters VPLS configuration mode.
Ruijie(config-vfi)# **mac-limit** { **action** { **discard | forward** } **| alarm** { **disable | enable** } **| maximum** *count*	(Optional) Configures each VPLS instance's MAC address capacity limit and behavior to be performed when the limit is exceeded.
Ruijie(config-vfi)# **end**	Returns to privileged mode.
Ruijie# **copy running-config startup-config**	Saves configuration.

Caution By default, the message warning of exceeding the capacity is disabled. If it is enabled, the Log message will be displayed when the MAC capacity of the VPLS instance is exceeded for the first time. The Log message will be displayed again when the VPLS MAC capacity drops to below the limit.

Configuring Static MAC Addresses (Optional)

You can configure static MAC addresses for VPLS instances. When conflicts exist in static MAC addresses and dynamically learned ones, dynamically learned MAC addresses are overwritten.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie(config)# **mpls static vfi** *vpls-name* **mac-address** *H.H.H* **neighbor** *ip-address*	Configures MAC addresses for a VPLS instance.
Ruijie(config)# **end**	Returns to the privileged mode.
Ruijie# **copy running-config startup-config**	Saves the configuration.

Caution Static MAC addresses configured through configuration of relate PWs of neighbor addresses can work properly only in the following scenario: The L2VPN instance has only a PW for the neighbor configured. If the L2VPN instance is configured with multiple PWs for the neighbor, the configured static MAC address will bind with a PW randomly, leading to incorrect forwarding.

Clearing Dynamic MAC Addresses (Optional)

A VPLS instance can dynamically learn MAC addresses from ACs and PWs. You can clear the MAC addresses learned dynamically by VPLS instances, including the local and remote VPLS instances.

Command	Function
Ruijie# **config terminal**	Enters global configuration mode.
Ruijie# **clear l2 vfi** *vpls-name* mac-**address local**	Clears the MAC addresses learned dynamically by the local (local PE) VPLS instance.
Ruijie# **clear l2 vfi** *vpls-name* mac-address **remote**	Clears the MAC addresses learned dynamically by the remote (another PE) VPLS instance.

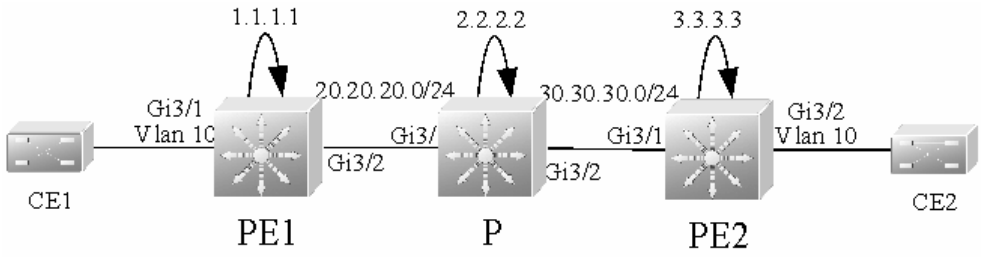
Caution Clearing MAC addresses of remote PEs is effective for Martini VPLS only.

Typical Examples of Martini VPLS Configuration for Switches

Basic VPLS

As shown in the following figure, CE1 and CE2 access the same VPLS network through PE1 and PE2. PE1, P, and PE2 form a public MPLS network that provides VPLS services. On PE1 and PE2, bind VLAN 10 to the VPLS instance.

Figure 80



The configuration procedure is as follows:

Configuring PE1:

Configure the loopback interface.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# neighbor 3.3.3.3
```

```
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on the public network interface.

```
Ruijie(config)# interface gigabitEthernet 3/2
Ruijie(config-if-Gigabitethernet 3/2)# no switchport
Ruijie(config-if-Gigabitethernet 3/2)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 3/2)# mpls ip
Ruijie(config-if-Gigabitethernet 3/2)# label-switching
Ruijie(config-if-Gigabitethernet 3/2)# exit
```

Configure a VPLS instance and specify the peer PE.

```
Ruijie(config)# l2 vfi vfi_a vpnid 1
Ruijie(config-vpls)# neighbor 3.3.3.3 encapsulation mpls
Ruijie(config-vpls)# exit
```

Bind the VLAN interface to the VPLS instance.

```
Ruijie(config)# vlan 10
Ruijie(config-vlan)# exit
Ruijie(config)# interface vlan 10
Ruijie(config-if-Vlan 10)# xconnect vfi vfi_a
Ruijie(config-if-Vlan 10)# exit
```

Configure the interface between PEs and CEs.

```
Ruijie(config)# interface gigabitEthernet 3/1
Ruijie(config-if-GigabitEthernet 3/1)# switchport access vlan 10
Ruijie(config-if-GigabitEthernet 3/1)# exit
```

Configuring P:

Configure the loopback interface.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 2.2.2.2 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# network 30.30.30.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on an interface.

```
Ruijie(config)# interface gigabitEthernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# no switchport
Ruijie(config-if-Gigabitethernet 3/1)# ip address 20.20.20.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 3/1)# mpls ip
Ruijie(config-if-Gigabitethernet 3/1)# label-switching
Ruijie(config-if-Gigabitethernet 3/1)# exit
Ruijie(config)# interface gigabitEthernet 3/2
Ruijie(config-if-Gigabitethernet 3/2)# no switchport
Ruijie(config-if-Gigabitethernet 3/2)# ip address 30.30.30.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 3/2)# mpls ip
Ruijie(config-if-Gigabitethernet 3/2)# label-switching
Ruijie(config-if-Gigabitethernet 3/2)# exit
```

Configuring PE2:

Configure the loopback interface.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 3.3.3.3 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# network 30.30.30.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# neighbor 1.1.1.1
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on the public network interface.

```
Ruijie(config)# interface gigabitEthernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# no switchport
Ruijie(config-if-Gigabitethernet 3/1)# ip address 30.30.30.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 3/1)# mpls ip
Ruijie(config-if-Gigabitethernet 3/1)# label-switching
Ruijie(config-if-Gigabitethernet 3/1)# exit
```

Configure a VPLS instance and specify the peer PE.

```
Ruijie(config)# l2 vfi vfi_a vpnid 1
Ruijie(config-vpls)# neighbor 1.1.1.1 encapsulation mpls
Ruijie(config-vpls)# exit
```

Bind the VLAN interface to the VPLS instance.

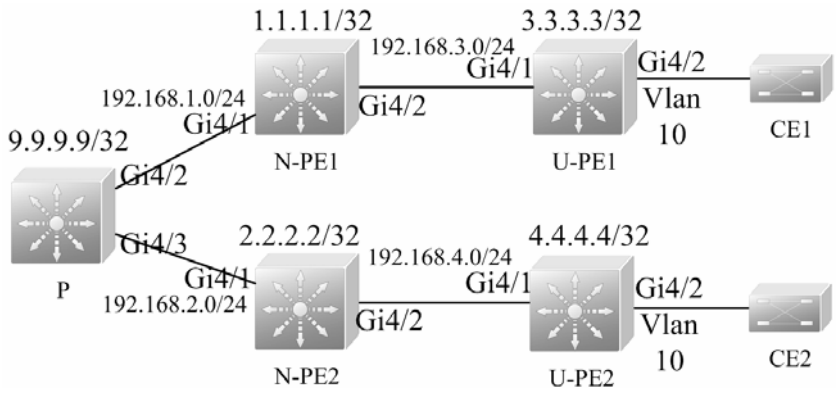
```
Ruijie(config)# vlan 10
Ruijie(config-vlan)# exit
Ruijie(config)# interface vlan 10
Ruijie(config-if-Vlan 10)# xconnect vfi vfi_a
Ruijie(config-if-Vlan 10)# exit
```

Configure the interface between PEs and CEs.

```
Ruijie(config)# interface gigabitEthernet 3/2
Ruijie(config-if-Gigabitethernet 3/2)#  switchport access vlan 10
Ruijie(config-if-Gigabitethernet 3/2)# exit
```

H-VPLS (PW Access)

Figure 81



As shown in the preceding figure, CE1 and CE2 access the same H-VPLS network through U-PE1 and U-PE2, which are connected to N-PE1 and N-PE2 respectively. The N-PEs and U-PEs are connected through PWs. All U-PEs and N-PEs belong to the MPLS network and work together to provide VPLS services.

When setting up PWs between N-PEs and U-PEs, you must specify the PW of the N-PEs with the U-PEs as a Spoke PW. On the U-PE end, the PW type is not restricted. If U-PEs support VPLS, the PW between U-PEs and N-PEs can be either a Hub PW or a Spoke PW. If the U-PEs do not support VPLS, the VPWS PW can also be configured.

In this example, U-PE1 and N-PE1 are connected through a Hub PW whereas U-PE2 and N-PE2 are connected through a VPWS PW.

- Configuring U-PE1:

Configure the loopback interface.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 3.3.3.3 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
```

```
Ruijie(config-router)# network 192.168.3.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# neighbor 1.1.1.1
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on the public network interface.

```
Ruijie(config)# interface gigabitEthernet 4/1
Ruijie(config-if-GigabitEthernet 4/1)# no switchport
Ruijie(config-if-GigabitEthernet 4/1)# ip address 192.168.3.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 4/1)# mpls ip
Ruijie(config-if-GigabitEthernet 4/1)# label-switching
Ruijie(config-if-GigabitEthernet 4/1)# exit
```

Configure a VPLS instance and enable a PW to connect the peer N-PE.

```
Ruijie(config)# l2 vfi vfi_a vpnid 1
Ruijie(config-vpls)# neighbor 1.1.1.1 encapsulation mpls
Ruijie(config-vpls)# exit
```

Bind the VLAN interface to the VPLS instance.

```
Ruijie(config)# vlan 10
Ruijie(config-vlan)# exit
Ruijie(config)# interface vlan 10
Ruijie(config-if-Vlan 10)# xconnect vfi vfi_a
Ruijie(config-if-Vlan 10)# exit
```

Configure the interface between PEs and CEs.

```
Ruijie(config)# interface gigabitEthernet 4/2
Ruijie(config-if-GigabitEthernet 4/2)# switchport access vlan 10
Ruijie(config-if-GigabitEthernet 4/2)# exit
```

- Configuring N-PE1:

Configure the loopback interface.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 192.168.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.168.3.0 0.0.0.255 area 0
```

```
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# neighbor 2.2.2.2
Ruijie(config-mpls-router)# neighbor 3.3.3.3
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on the public network interface.

```
Ruijie(config)# interface gigabitEthernet 4/1
Ruijie(config-if-GigabitEthernet 4/1)# no switchport
Ruijie(config-if-GigabitEthernet 4/1)# ip address 192.168.1.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 4/1)# mpls ip
Ruijie(config-if-GigabitEthernet 4/1)# label-switching
Ruijie(config-if-GigabitEthernet 4/1)# exit
Ruijie(config)# interface gigabitEthernet 4/2
Ruijie(config-if-GigabitEthernet 4/2)# no switchport
Ruijie(config-if-GigabitEthernet 4/2)# ip address 192.168.3.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 4/2)# mpls ip
Ruijie(config-if-GigabitEthernet 4/2)# label-switching
Ruijie(config-if-GigabitEthernet 4/2)# exit
```

Configure a VPLS instance, a Hub PW to connect another N-PE, and the Spoke PW to connect the peer U-PE.

```
Ruijie(config)# l2 vfi vfi_a vpnid 1
Ruijie(config-vpls)# neighbor 2.2.2.2 encapsulation mpls
Ruijie(config-vpls)# neighbor 3.3.3.3 encapsulation mpls spoke-vc
Ruijie(config-vpls)# exit
```

- Configuring P:

Configure the loopback interface.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 9.9.9.9 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 9.9.9.9 0.0.0.0 area 0
Ruijie(config-router)# network 192.168.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.168.2.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
```

```
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on an interface.

```
Ruijie(config)# interface gigabitEthernet 4/2
Ruijie(config-if-GigabitEthernet 4/2)# no switchport
Ruijie(config-if-GigabitEthernet 4/2)# ip address 192.168.1.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 4/2)# mpls ip
Ruijie(config-if-GigabitEthernet 4/2)# label-switching
Ruijie(config-if-GigabitEthernet 4/2)# exit
Ruijie(config)# interface gigabitEthernet 4/3
Ruijie(config-if-GigabitEthernet 4/3)# no switchport
Ruijie(config-if-GigabitEthernet 4/3)# ip address 192.168.2.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 4/3)# mpls ip
Ruijie(config-if-GigabitEthernet 4/3)# label-switching
Ruijie(config-if-GigabitEthernet 4/3)# exit
```

- Configuring N-PE2:

Configure the loopback interface.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 2.2.2.2 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 192.168.2.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.168.4.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# neighbor 1.1.1.1
Ruijie(config-mpls-router)# neighbor 4.4.4.4
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on the public network interface.

```
Ruijie(config)# interface gigabitEthernet 4/1
Ruijie(config-if-GigabitEthernet 4/1)# no switchport
Ruijie(config-if-GigabitEthernet 4/1)# ip address 192.168.2.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 4/1)# mpls ip
Ruijie(config-if-GigabitEthernet 4/1)# label-switching
Ruijie(config-if-GigabitEthernet 4/1)# exit
Ruijie(config)# interface gigabitEthernet 4/2
```

```
Ruijie(config-if-GigabitEthernet 4/2)# no switchport
Ruijie(config-if-GigabitEthernet 4/2)# ip address 192.168.4.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 4/2)# mpls ip
Ruijie(config-if-GigabitEthernet 4/2)# label-switching
Ruijie(config-if-GigabitEthernet 4/2)# exit
```

Configure a VPLS instance, enable a Hub PW to connect another N-PE, and enable the Spoke PW to connect the peer U-PE.

```
Ruijie(config)# l2 vfi vfi_a vpnid 1
Ruijie(config-vpls)# neighbor 1.1.1.1 encapsulation mpls
Ruijie(config-vpls)# neighbor 4.4.4.4 encapsulation mpls  spoke-vc
Ruijie(config-vpls)# exit
```

- Configuring U-PE2:

Configure the loopback interface.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 4.4.4.4 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 4.4.4.4 0.0.0.0 area 0
Ruijie(config-router)# network 192.168.4.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# neighbor 2.2.2.2
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on the public network interface.

```
Ruijie(config)# interface gigabitEthernet 4/1
Ruijie(config-if-GigabitEthernet 4/1)# no switchport
Ruijie(config-if-GigabitEthernet 4/1)# ip address 192.168.4.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 4/1)#mpls ip
Ruijie(config-if-GigabitEthernet 4/1)# label-switching
Ruijie(config-if-GigabitEthernet 4/1)#  exit
```

Configure a VPWS PW for a VLAN interface.

```
Ruijie(config)# vlan 10
Ruijie(config-vlan)# exit
Ruijie(config)# interface vlan 10
Ruijie(config-if-Vlan 10)# xconnect 2.2.2.2 1 encapsulation mpls ethernet
Ruijie(config-if-Vlan 10)# exit
```

Configure the interface between PEs and CEs.

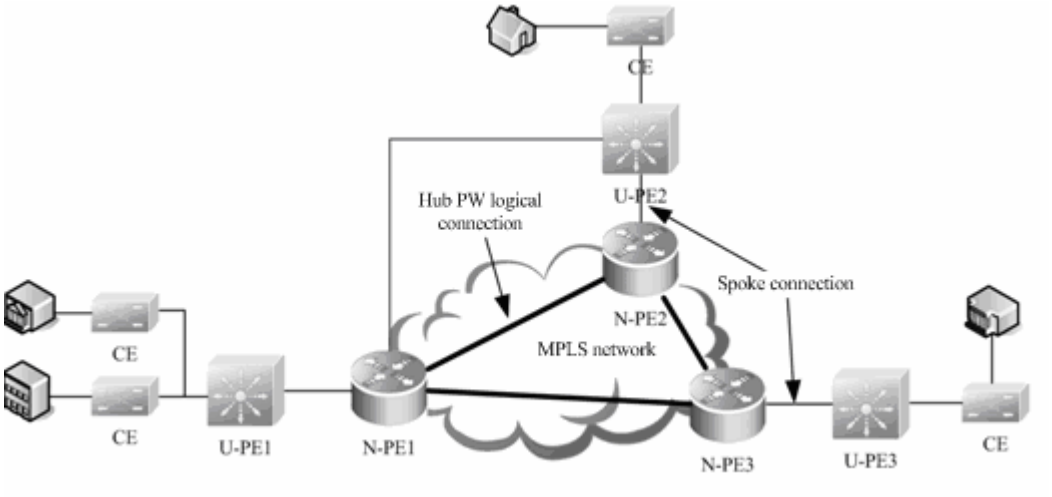
```
Ruijie(config)# interface gigabitEthernet 4/2
Ruijie(config-if-GigabitEthernet 4/2)# switchport access vlan 10
Ruijie(config-if-GigabitEthernet 4/2)# exit
```

H-VPLS (QinQ Access and Dual-Homed)

If the U-PE and N-PE are connected through only one Spoke, the U-PE communication with the external network is discontinued if the Spoke connection fails. To solve this problem, you can connect the U-PE to N-PEs in dual-homed mode. In this mode, the U-PE is connected to different N-PEs, which belong to the same VPLS network, through two (or more) Spoke connections. In normal situations, only one of the Spoke connections is working. It is called the active connection and the others are backup ones. If the active connection fails, one backup connection is chosen to take over the task.

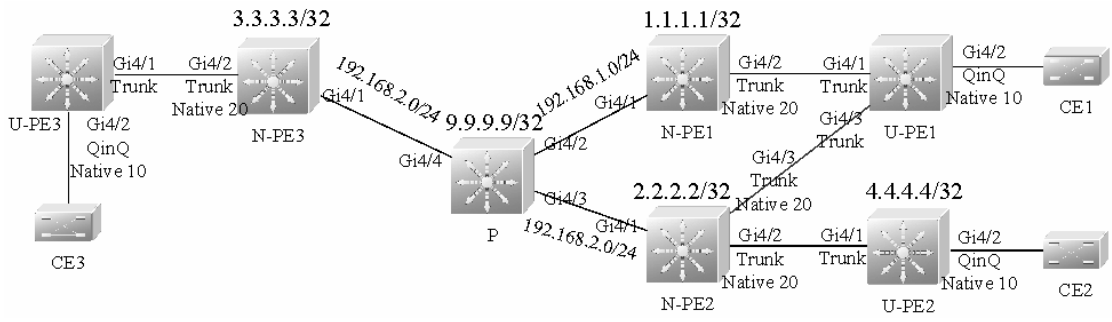
The following shows a schematic diagram of an H-VPLS network in dual-homed mode.

Figure 82



On an H-VPLS network in QinQ and dual-homed access mode, you can use the STP to switch over the active and standby connections. The STP, however, does not belong to users and is transmitted only over the carrier's network (U-PEs and N-PEs). To avoid the impact of STP protocol packets (BPDUs) on user packets, you must create a special VPLS instance on the N-PE to transparently transmit BPDU packets in dual-homed mode.

Figure 83



The preceding figure shows an H-VPLS topology in dual-homed mode. The CE is connected to U-PEs on the same H-VPLS network and the U-PEs are connected to N-PEs through the QinQ tunnel. The N-PEs belong to the MPLS

network and the U-PEs do not run MPLS, but the N-PEs and U-PEs work together to provide VPLS services. The upstream interface on the U-PE works in trunk mode and allows the traffic of the VLAN to which the U-PE interface connected to the CE belongs to pass through. Enable QinQ on the interfaces that connect U-PEs and CEs. This QinQ native LVAN cannot be the same as the native VLAN on the U-PE1 interface connected to the N-PE or the native VLAN on the N-PE interface connected to the U-PE. This is because the QinQ native VLAN on the interfaces that connect U-PEs and CEs is used to identify VPLS instances provided for a user whereas the native VLAN on the N-PE trunk interface connected to the U-PE is used to identify the VPLS instance for transparently transmitting BPDU packets in dual-homed mode. Set up Hub PWs between N-PEs. Enable dual-homed mode on U-PE1 and you can find that U-PE1 is connected to both N-PE1 and N-PE2.

As shown in Figure 1-27, only one VPLS instance is provided for the user. You are required to create a special VPLS instance to transparently transmit BPDU packets in dual-homed mode. You only need to enable this VPLS instance on the N-PEs to which the U-PE is connected.

Configuring U-PE1:

Configure a Spoke connection to the peer N-PE1.

```
Ruijie(config)# interface gigabitEthernet 4/1
Ruijie(config-if-GigabitEthernet 4/1)# switchport mode trunk
Ruijie(config-if-GigabitEthernet 4/1)# exit
```

Configure a Spoke connection to the peer N-PE2.

```
Ruijie(config)# interface gigabitEthernet 4/3
Ruijie(config-if-GigabitEthernet 4/3)# switchport mode trunk
Ruijie(config-if-GigabitEthernet 4/3)# exit
```

Configure the interface between PEs and CEs.

```
Ruijie(config)# interface gigabitEthernet 4/2
Ruijie(config-if-GigabitEthernet 4/2)# switchport access vlan 10
Ruijie(config-if-GigabitEthernet 4/2)# switchport mode dot1q-tunnel
Ruijie(config-if-GigabitEthernet 4/2)# exit
```

Enable STP only on the U-PEs that adopt the dual-homed access mode.

```
Ruijie(config)# spanning-tree
```

Configuring N-PE1:

Configure the loopback interface.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 192.168.1.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# neighbor 2.2.2.2
Ruijie(config-mpls-router)# neighbor 3.3.3.3
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on the public network interface.

```
Ruijie(config)# interface gigabitEthernet 4/1
Ruijie(config-if-GigabitEthernet 4/1)# no switchport
Ruijie(config-if-GigabitEthernet 4/1)# ip address 192.168.1.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 4/1)# mpls ip
Ruijie(config-if-GigabitEthernet 4/1)# label-switching
Ruijie(config-if-GigabitEthernet 4/1)# exit
```

Configure the N-PE interface connected to the U-PE.

```
Ruijie(config)# interface gigabitEthernet 4/2
Ruijie(config-if-GigabitEthernet 4/2)# switchport mode trunk
Ruijie(config-if-GigabitEthernet 4/2)# switchport trunk native vlan 20
Ruijie(config-if-GigabitEthernet 4/2)# exit
```

Configure a VPLS instance for the user and enable Hub PWs to connect the N-PEs in the same VPLS instance.

```
Ruijie(config)# l2 vfi vfi_a vpnid 1
Ruijie(config-vpls)# neighbor 2.2.2.2 encapsulation mpls
Ruijie(config-vpls)# neighbor 3.3.3.3 encapsulation mpls
Ruijie(config-vpls)# exit
```

Bind the QinQ VLAN interface to the VPLS instance.

```
Ruijie(config)# vlan 10
Ruijie(config-vlan)# exit
Ruijie(config)# interface vlan 10
Ruijie(config-if-Vlan 10)# xconnect vfi vfi_a
Ruijie(config-if-Vlan 10)# exit
```

Configure the VPLS instance to transparently transmit BPDU packets and enable Hub PWs to connect other N-PEs in dual-homed mode.

```
Ruijie(config)# l2 vfi vfi_bpdu vpnid 100
Ruijie(config-vpls)# neighbor 2.2.2.2 encapsulation mpls
Ruijie(config-vpls)# exit
```

Bind the native VLAN interface, which is used to transparently transmit BPDUs, to the VPLS instance.

```
Ruijie(config)# vlan 20
Ruijie(config-vlan)# exit
Ruijie(config)# interface vlan 20
```

```
Ruijie(config-if-Vlan 20)# xconnect vfi vfi_bpdu
Ruijie(config-if-Vlan 20)# l2 vfi tunnel-protocol stp
Ruijie(config-if-Vlan 20)# exit
```

Configuring P:

Configure the loopback interface.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 9.9.9.9 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 9.9.9.9 0.0.0.0 area 0
Ruijie(config-router)# network 192.168.1.0 0.0.0.255  area 0
Ruijie(config-router)# network 192.168.2.0 0.0.0.255  area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on an interface.

```
Ruijie(config)# interface gigabitEthernet 4/2
Ruijie(config-if-GigabitEthernet 4/2)#  no switchport
Ruijie(config-if-GigabitEthernet 4/2)#  ip address 192.168.1.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 4/2)#  mpls ip
Ruijie(config-if-GigabitEthernet 4/2)#  label-switching
Ruijie(config-if-GigabitEthernet 4/2)#  exit
Ruijie(config)# interface gigabitEthernet 4/3
Ruijie(config-if-GigabitEthernet 4/3)#  no switchport
Ruijie(config-if-GigabitEthernet 4/3)#  ip address 192.168.2.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 4/3)#  mpls ip
Ruijie(config-if-GigabitEthernet 4/3)#  label-switching
Ruijie(config-if-GigabitEthernet 4/3)# exit
```

Configuring N-PE2:

Configure the loopback interface.

```
Ruijie(config)#  interface loopback 0
Ruijie(config-if-Loopback 0)# # ip address 2.2.2.2 255.255.255.255
Ruijie(config-if-Loopback 0)#  exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
```

```
Ruijie(config-router)# network 2.2.2.2 0.0.0.0  area 0
Ruijie(config-router)# network 192.168.2.0 0.0.0.255  area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# neighbor 1.1.1.1
Ruijie(config-mpls-router)# neighbor 3.3.3.3
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on the public network interface.

```
Ruijie(config)# interface gigabitEthernet 4/1
Ruijie(config-if-GigabitEthernet 4/1)# no switchport
Ruijie(config-if-GigabitEthernet 4/1)# ip address 192.168.2.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 4/1)# mpls ip
Ruijie(config-if-GigabitEthernet 4/1)# label-switching
Ruijie(config-if-GigabitEthernet 4/1)# exit
```

Configure the N-PE interface connected to U-PEs (to two U-PEs at the same time).

```
Ruijie(config)# interface gigabitEthernet 4/2
Ruijie(config-if-GigabitEthernet 4/2)# switchport mode trunk
Ruijie(config-if-GigabitEthernet 4/2)# switchport trunk native vlan 20
Ruijie(config-if-GigabitEthernet 4/2)# exit
Ruijie(config)# interface gigabitEthernet 4/3
Ruijie(config-if-GigabitEthernet 4/3)# switchport mode trunk
Ruijie(config-if-GigabitEthernet 4/3)#  switchport trunk native vlan 20
Ruijie(config-if-GigabitEthernet 4/3)#  exit
```

Configure a VPLS instance for the user and enable Hub PWs to connect the N-PEs in the same VPLS instance.

```
Ruijie(config)# l2 vfi vfi_a vpnid 1
Ruijie(config-vpls)#  neighbor 1.1.1.1 encapsulation mpls
Ruijie(config-vpls)# neighbor 3.3.3.3 encapsulation mpls
Ruijie(config-vpls)# exit
```

Bind the QinQ VLAN interface to the VPLS instance.

```
Ruijie(config)# vlan 10
Ruijie(config-vlan)# exit
Ruijie(config)# interface vlan 10
Ruijie(config-if-Vlan 10)# xconnect vfi vfi_a
Ruijie(config-if-Vlan 10)# exit
```

Enable the VPLS instance to transparently transmit BPDU packets and enable Hub PWs to connect other N-PEs in dual-homed mode.

```
Ruijie(config)# l2 vfi vfi_bpdu vpnid 100
```

```
Ruijie(config-vpls)# neighbor 1.1.1.1 encapsulation mpls
Ruijie(config-vpls)# exit
```

Bind the native VLAN interface, which is used to transparently transmit BPDU packets, to the VPLS instance.

```
Ruijie(config)# vlan 20
Ruijie(config-vlan)# exit
Ruijie(config)# interface vlan 20
Ruijie(config-if-Vlan 20)# xconnect vfi vfi_bpdu
Ruijie(config-if-Vlan 20)# l2 vfi tunnel-protocol stp
Ruijie(config-if-Vlan 20)# exit
```

Configuring U-PE2:

Refer to U-PE1. Since U-PE2 is connected to only one N-PE, STP is not required.

Configuring U-PE3:

Refer to U-PE2.

Configuring N-PE3:

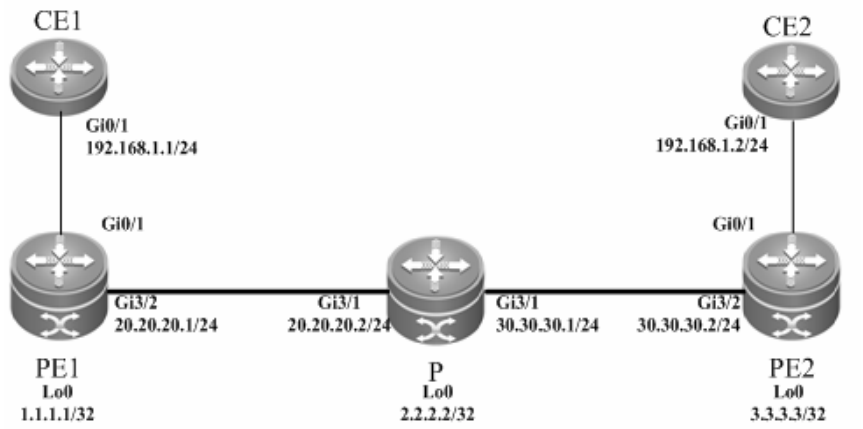
Refer to N-PE1.

Typical Examples of Martini VPLS Configuration for Routers

Basic VPLS (Ethernet Interface Access)

As shown in the following figure, CE1 and CE2 access the same VPLS network through PE1 and PE2. PE1, P, and PE2 form a public MPLS network to provide VPLS services. Gi0/1 is bound on PE1 and PE2 to the VPLS instance.

Figure 84



The configuration procedure is as follows:

Configuring PE1:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routess.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# neighbor 3.3.3.3
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on the public network interface.

```
Ruijie(config)# interface gigabitEthernet 3/2
Ruijie(config-if-Gigabitethernet 3/2)# ip ref
Ruijie(config-if-Gigabitethernet 3/2)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 3/2)# mpls ip
Ruijie(config-if-Gigabitethernet 3/2)# label-switching
Ruijie(config-if-Gigabitethernet 3/2)# exit
```

Configure a VPLS instance and specify the peer PE.

```
Ruijie(config)# l2 vfi vfi_a vpnid 1
Ruijie(config-vpls)# neighbor 3.3.3.3 encapsulation mpls ethernet
Ruijie(config-vpls)# exit
```

Configure the interface that connects PEs and CEs to bind the VPLS instance.

```
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)# ip ref
Ruijie(config-if-Gigabitethernet 0/1)# xconnect vfi vfi_a
Ruijie(config-if-Gigabitethernet 0/1)# exit
```

Configuring P:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 2.2.2.2 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routess.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# network 30.30.30.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on an interface.

```
Ruijie(config)# interface gigabitEthernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# ip ref
Ruijie(config-if-Gigabitethernet 3/1)# ip address 20.20.20.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 3/1)# mpls ip
Ruijie(config-if-Gigabitethernet 3/1)# label-switching
Ruijie(config-if-Gigabitethernet 3/1)# exit
Ruijie(config)# interface gigabitEthernet 3/2
Ruijie(config-if-Gigabitethernet 3/2)# ip ref
Ruijie(config-if-Gigabitethernet 3/2)# ip address 30.30.30.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 3/2)# mpls ip
Ruijie(config-if-Gigabitethernet 3/2)# label-switching
Ruijie(config-if-Gigabitethernet 3/2)# exit
```

Configuring PE2:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 3.3.3.3 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routess.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# network 30.30.30.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# neighbor 1.1.1.1
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on the public network interface.

```
Ruijie(config)# interface gigabitEthernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# ip ref
Ruijie(config-if-Gigabitethernet 3/1)# ip address 30.30.30.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 3/1)# mpls ip
Ruijie(config-if-Gigabitethernet 3/1)# label-switching
```

```
Ruijie(config-if-Gigabitethernet 3/1)# exit
```

Configure a VPLS instance and specify the peer PE.

```
Ruijie(config)# l2 vfi vfi_a vpnid 1
Ruijie(config-vpls)# neighbor 1.1.1.1 encapsulation mpls ethernet
Ruijie(config-vpls)# exit
```

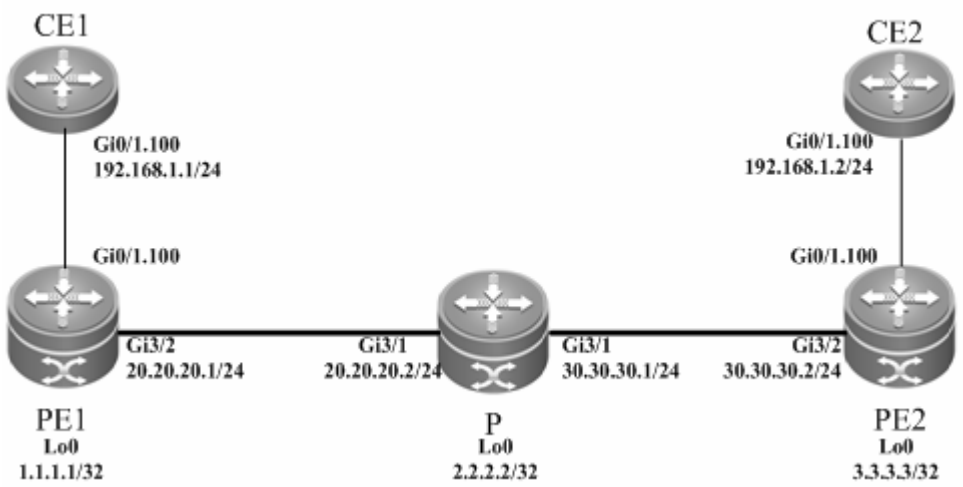
Configure the interface that connects PEs and CEs to bind the VPLS instance.

```
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)# ip ref
Ruijie(config-if-Gigabitethernet 0/1)# xconnect vfi vfi_a
Ruijie(config-if-Gigabitethernet 0/1)# exit
```

Basic VPLS (Ethernet Sub-interface Access)

As shown in the following figure, CE1 and CE2 access the same VPLS network through PE1 and PE2. PE1, P, and PE2 form a public MPLS network to provide VPLS services. VLAN 10 is bound on PE1 and PE2 to the VPLS instance.

Figure 85



The configuration procedure is as follows:

Configuring PE1:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routess.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# neighbor 3.3.3.3
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on the public network interface.

```
Ruijie(config)# interface gigabitEthernet 3/2
Ruijie(config-if-Gigabitethernet 3/2)# ip ref
Ruijie(config-if-Gigabitethernet 3/2)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 3/2)# mpls ip
Ruijie(config-if-Gigabitethernet 3/2)# label-switching
Ruijie(config-if-Gigabitethernet 3/2)# exit
```

Configure a VPLS instance and specify the peer PE.

```
Ruijie(config)# l2 vfi vfi_a vpnid 1
Ruijie(config-vpls)# neighbor 3.3.3.3 encapsulation mpls ethernetvlan
Ruijie(config-vpls)# exit
```

Configure the interface that connects PEs and CEs to bind the VPLS instance.

```
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)# ip ref
Ruijie(config-if-Gigabitethernet 0/1)# exit
Ruijie(config)# interface gigabitethernet 0/1.100
Ruijie(config-if-Gigabitethernet 0/1.100)# encapsulation dot1Q 100
Ruijie(config-if-Gigabitethernet 0/1.100)# xconnect vfi vfi_a
Ruijie(config-if-Gigabitethernet 0/1.100)# exit
```

Configuring P:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 2.2.2.2 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routess.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# network 30.30.30.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
```

```
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on an interface.

```
Ruijie(config)# interface gigabitEthernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# ip ref
Ruijie(config-if-Gigabitethernet 3/1)# ip address 20.20.20.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 3/1)# mpls ip
Ruijie(config-if-Gigabitethernet 3/1)# label-switching
Ruijie(config-if-Gigabitethernet 3/1)# exit
Ruijie(config)# interface gigabitEthernet 3/2
Ruijie(config-if-Gigabitethernet 3/2)# ip ref
Ruijie(config-if-Gigabitethernet 3/2)# ip address 30.30.30.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 3/2)# mpls ip
Ruijie(config-if-Gigabitethernet 3/2)# label-switching
Ruijie(config-if-Gigabitethernet 3/2)# exit
```

Configuring PE2:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 3.3.3.3 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routess.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# network 30.30.30.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# neighbor 1.1.1.1
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on the public network interface.

```
Ruijie(config)# interface gigabitEthernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# ip ref
Ruijie(config-if-Gigabitethernet 3/1)# ip address 30.30.30.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 3/1)# mpls ip
Ruijie(config-if-Gigabitethernet 3/1)# label-switching
Ruijie(config-if-Gigabitethernet 3/1)# exit
```

Configure a VPLS instance and specify the peer PE.

```
Ruijie(config)# l2 vfi vfi_a vpnid 1
```

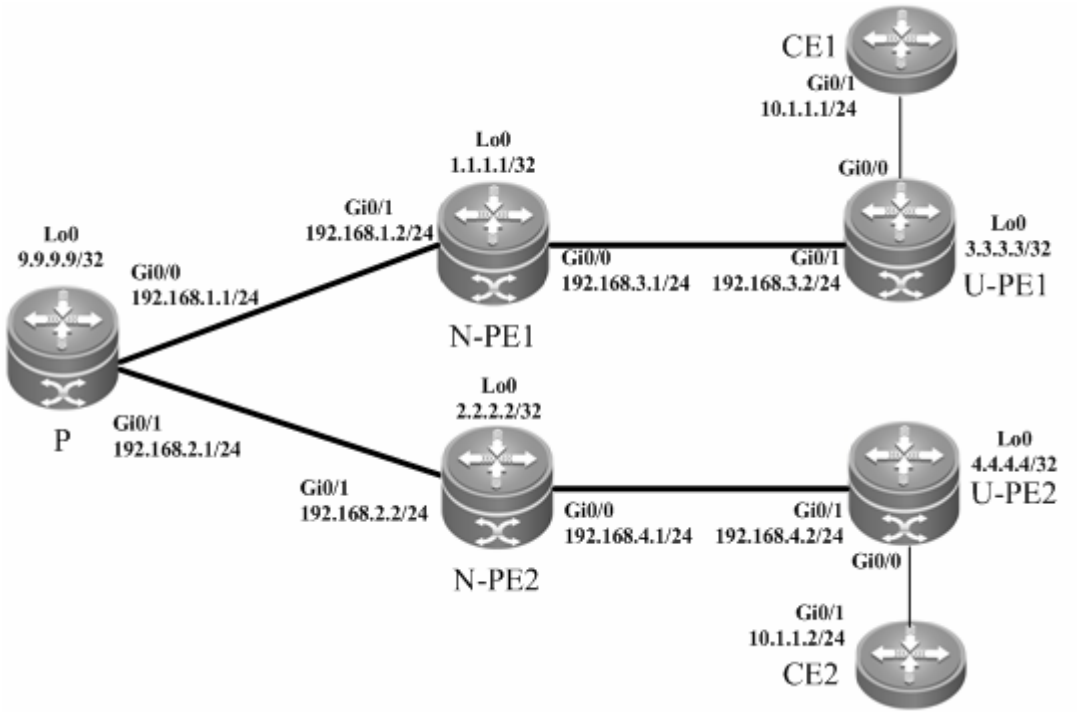
```
Ruijie(config-vpls)# neighbor 1.1.1.1 encapsulation mpls ethernetvlan
Ruijie(config-vpls)# exit
```

Configure the interface that connects PEs and CEs to bind the VPLS instance.

```
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if-Gigabitethernet 0/1)# ip ref
Ruijie(config-if-Gigabitethernet 0/1)# exit
Ruijie(config)# interface gigabitethernet 0/1.100
Ruijie(config-if-Gigabitethernet 0/1.100)# encapsulation dot1Q 100
Ruijie(config-if-Gigabitethernet 0/1.100)# xconnect vfi vfi_a
Ruijie(config-if-Gigabitethernet 0/1.100)# exit
```

H-VPLS (PW Access)

Figure 86



As shown in the preceding figure, CE1 and CE2 access the same H-VPLS network through U-PE1 and U-PE2, which are connected to N-PE1 and N-PE2 respectively. The N-PEs and U-PEs are connected through PWs. All U-PEs and N-PEs belong to the MPLS network and work together to provide VPLS services.

When setting up PWs between N-PEs and U-PEs, you must specify the PW of the N-PEs with the U-PEs as a Spoke PW. On the U-PE end, the PW type is not restricted. If U-PEs support VPLS, the PW between U-PEs and N-PEs can be either a Hub PW or a Spoke PW. If the U-PEs do not support VPLS, the VPWS PW can also be configured.

In this example, U-PE1 and N-PE1 are connected through a Hub PW whereas U-PE2 and N-PE2 are connected through a VPWS PW.

Configuring U-PE1:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 3.3.3.3 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# network 192.168.3.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# neighbor 1.1.1.1
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on the public network interface.

```
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)# ip ref
Ruijie(config-if-GigabitEthernet 0/1)# ip address 192.168.3.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/1)# mpls ip
Ruijie(config-if-GigabitEthernet 0/1)# label-switching
Ruijie(config-if-GigabitEthernet 0/1)# exit
```

Configure a VPLS instance and enable PWs to connect to the peer N-PE

```
Ruijie(config)# l2 vfi vfi_a vpnid 1
Ruijie(config-vpls)# neighbor 1.1.1.1 encapsulation mpls
Ruijie(config-vpls)# exit
```

Configure the interface that connects PEs and CEs to bind the VPLS instance.

```
Ruijie(config)# interface gigabitEthernet 0/0
Ruijie(config-if-GigabitEthernet 0/0)# ip ref
Ruijie(config-if-GigabitEthernet 0/0)# exit
```

Configuring N-PE1:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 192.168.1.0 0.0.0.255 area 0
```

```
Ruijie(config-router)# network 192.168.3.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# neighbor 2.2.2.2
Ruijie(config-mpls-router)# neighbor 3.3.3.3
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on the public network interface.

```
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)# ip ref
Ruijie(config-if-GigabitEthernet 0/1)# ip address 192.168.1.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/1)# mpls ip
Ruijie(config-if-GigabitEthernet 0/1)# label-switching
Ruijie(config-if-GigabitEthernet 0/1)# exit
Ruijie(config)# interface gigabitEthernet 0/0
Ruijie(config-if-GigabitEthernet 0/0)# ip ref
Ruijie(config-if-GigabitEthernet 0/0)# ip address 192.168.3.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/0)# mpls ip
Ruijie(config-if-GigabitEthernet 0/0)# label-switching
Ruijie(config-if-GigabitEthernet 0/0)# exit
```

Configure a VPLS instance, enable a Hub PW to connect another N-PE, and enable a Spoke PW to connect the peer U-PE.

```
Ruijie(config)# l2 vfi vfi_a vpnid 1
Ruijie(config-vpls)# neighbor 2.2.2.2 encapsulation mpls
Ruijie(config-vpls)# neighbor 3.3.3.3 encapsulation mpls spoke-vc
Ruijie(config-vpls)# exit
```

Configuring P:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 9.9.9.9 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 9.9.9.9 0.0.0.0 area 0
Ruijie(config-router)# network 192.168.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.168.2.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on an interface.

```
Ruijie(config)# interface gigabitEthernet 0/0
Ruijie(config-if-GigabitEthernet 0/0)# ip ref
Ruijie(config-if-GigabitEthernet 0/0)# ip address 192.168.1.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/0)# mpls ip
Ruijie(config-if-GigabitEthernet 0/0)# label-switching
Ruijie(config-if-GigabitEthernet 0/0)# exit
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)# ip ref
Ruijie(config-if-GigabitEthernet 0/1)# ip address 192.168.2.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/1)# mpls ip
Ruijie(config-if-GigabitEthernet 0/1)# label-switching
Ruijie(config-if-GigabitEthernet 0/1)# exit
```

Configuring N-PE2:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 2.2.2.2 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 192.168.2.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.168.4.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# neighbor 1.1.1.1
Ruijie(config-mpls-router)# neighbor 4.4.4.4
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on the public network interface.

```
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)# ip ref
Ruijie(config-if-GigabitEthernet 0/1)# ip address 192.168.2.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/1)# mpls ip
```

```
Ruijie(config-if-GigabitEthernet 0/1)# label-switching
Ruijie(config-if-GigabitEthernet 0/1)# exit
Ruijie(config)# interface gigabitEthernet 0/0
Ruijie(config-if-GigabitEthernet 0/0)# ip ref
Ruijie(config-if-GigabitEthernet 0/0)# ip address 192.168.4.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/0)# mpls ip
Ruijie(config-if-GigabitEthernet 0/0)# label-switching
Ruijie(config-if-GigabitEthernet 0/0)# exit
```

Configure a VPLS instance, enable a Hub PW to connect another N-PE, and enable a Spoke PW to connect the peer U-PE.

```
Ruijie(config)# l2 vfi vfi_a vpnid 1
Ruijie(config-vpls)# neighbor 1.1.1.1 encapsulation mpls
Ruijie(config-vpls)# neighbor 4.4.4.4 encapsulation mpls  spoke-vc
Ruijie(config-vpls)# exit
```

Configuring U-PE2:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 4.4.4.4 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 4.4.4.4 0.0.0.0 area 0
Ruijie(config-router)# network 192.168.4.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# neighbor 2.2.2.2
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on the public network interface.

```
Ruijie(config)# interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)# ip ref
Ruijie(config-if-GigabitEthernet 0/1)# ip address 192.168.4.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/1)#mpls ip
Ruijie(config-if-GigabitEthernet 0/1)# label-switching
Ruijie(config-if-GigabitEthernet 0/1)#  exit
```

Configure the interface that connects PEs and CEs to enable VPWS.

```
Ruijie(config)# interface gigabitEthernet 0/0
```

```
Ruijie(config-if-GigabitEthernet 0/0)# ip ref
Ruijie(config-if-GigabitEthernet 0/0)# xconnect 2.2.2.2 1 encapsulation mpls ethernet
Ruijie(config-if-GigabitEthernet 0/0)# exit
```

Typical Examples of Kompella VPLS Configuration for Switches

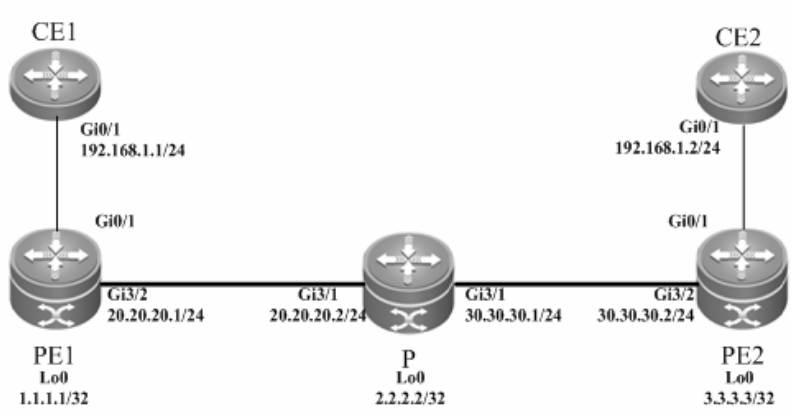
Basic VPLS

Networking Requirements

- CE1 and CE2 access the same VPLS network through PE1 and PE2.
- PE1, P and PE2 form the public MPLS network.
- VLAN 10 is bound on PE1 and PE2 to the VPLS instance.

Networking Topology

Figure 87



Configuration Tips

Before configuring Kompella VPLS, complete the following tasks:

- Run IGP in the carrier's network to realize connection between PE1 and PE2.
- Obtain Kompella VPLS configuration information including VPLS instance descriptive information, RT value, VE ID, maximum planned site number, VE ID deviation, and interface information from the network administrator.

Configuration Steps

Configuring PE1:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
```

```
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# neighbor 3.3.3.3
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on the public network interface.

```
Ruijie(config)# interface gigabitEthernet 3/2
Ruijie(config-if-Gigabitethernet 3/2)# no switchport
Ruijie(config-if-Gigabitethernet 3/2)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 3/2)# mpls ip
Ruijie(config-if-Gigabitethernet 3/2)# label-switching
Ruijie(config-if-Gigabitethernet 3/2)# exit
```

Configure a VLAN interface.

```
Ruijie(config)# vlan 10
Ruijie(config-vlan)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 3.3.3.3 remote-as 100
Ruijie(config-router)# neighbor 3.3.3.3 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpls
Ruijie(config-router-af)# neighbor 3.3.3.3 activate
Ruijie(config-router-af)# neighbor 3.3.3.3 send-community extended
Ruijie(config-router-af)# exit
```

Configure the interface that connects PEs and CEs.

```
Ruijie(config)# interface gigabitEthernet 3/1
Ruijie(config-if-GigabitEthernet 3/1)# switchport access vlan 10
Ruijie(config-if-GigabitEthernet 3/1)# exit
```

Configure a VPLS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 1:1
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface vlan 10
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)# eixt
```

Configuring P:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 2.2.2.2 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# network 30.30.30.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on an interface.

```
Ruijie(config)# interface gigabitEthernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# no switchport
Ruijie(config-if-Gigabitethernet 3/1)# ip address 20.20.20.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 3/1)# mpls ip
Ruijie(config-if-Gigabitethernet 3/1)# label-switching
Ruijie(config-if-Gigabitethernet 3/1)# exit
Ruijie(config)# interface gigabitEthernet 3/2
Ruijie(config-if-Gigabitethernet 3/2)# no switchport
Ruijie(config-if-Gigabitethernet 3/2)# ip address 30.30.30.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 3/2)# mpls ip
Ruijie(config-if-Gigabitethernet 3/2)# label-switching
Ruijie(config-if-Gigabitethernet 3/2)# exit
```

Configuring PE2:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 3.3.3.3 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# network 30.30.30.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# neighbor 1.1.1.1
Ruijie(config-mpls-router)# exit
```

Enable LDP and MPLS on the public network interface.

```
Ruijie(config)# interface gigabitEthernet 3/1
Ruijie(config-if-Gigabitethernet 3/1)# no switchport
Ruijie(config-if-Gigabitethernet 3/1)# ip address 30.30.30.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 3/1)# mpls ip
Ruijie(config-if-Gigabitethernet 3/1)# label-switching
Ruijie(config-if-Gigabitethernet 3/1)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 100
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpls
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# neighbor 1.1.1.1 send-community extended
Ruijie(config-router-af)# exit
```

Configure a VLAN interface.

```
Ruijie(config)# vlan 10
Ruijie(config-vlan)# exit
```

Configure the interface that connects PEs and CEs.

```
Ruijie(config)# interface gigabitEthernet 3/2
Ruijie(config-if-Gigabitethernet 3/2)#  switchport access vlan 10
Ruijie(config-if-Gigabitethernet 3/2)# exit
```

Configure a VPLS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 1:1
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 2
Ruijie(config-vfi-site)# xconnect interface vlan 10
Ruijie(config-vfi-site)# exit-site-mode
Ruijie(config-vfi)# exit
```

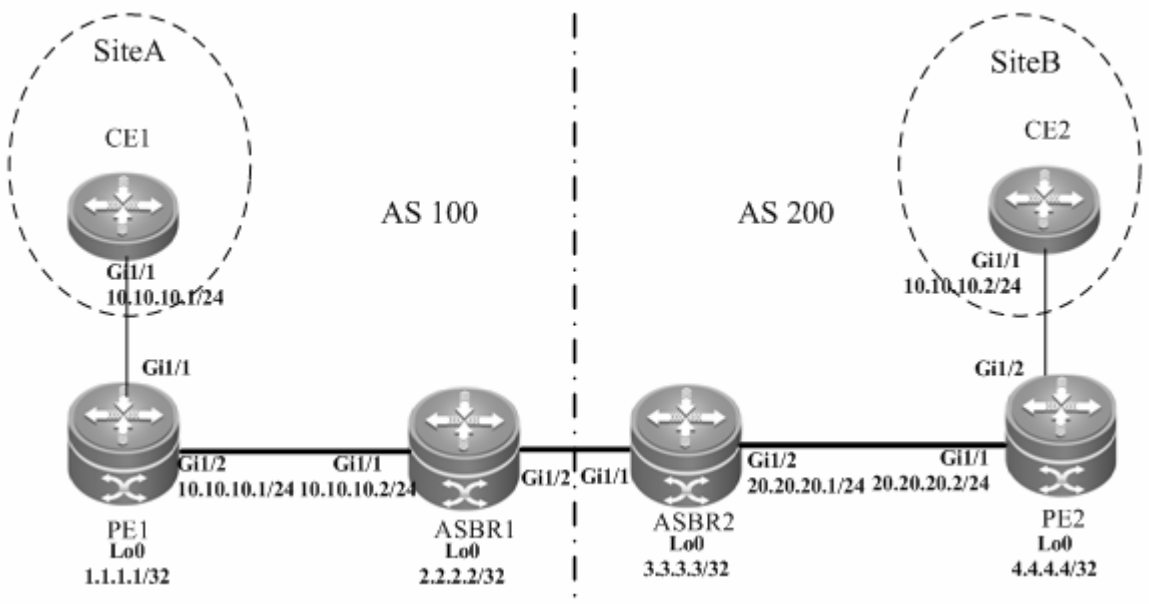
Inter-AS Configuration Examples – Option A Solution

Networking Requirements

- LAN segments of customer S in site A and site B are connected with each other through the carrier's PE1 in AS100 and PE2 in AS 200, forming a virtual and simulative LAN service, or VPLS service.
- PE1 and PE2 are in different ASs. ASBR1 and ASBR2 are considered CE devices by each other, which means that the interface between ASBRs connects the AC to the VPLS instance;

Networking Topology

Figure 88 Kompella VPLS inter-AS networking topology



The preceding figure shows the structure of the Kompella VPLS inter-AS networking topology in Option A. The intermediate interface is considered by ASBRs as AC connection.

Configuration Tips

Before configuring Kompella VPLS, complete the following tasks:

- Run IGP in the carrier's network to realize connection between PE and ASBR devices.
- Establish the MP-IBGP peer relationship between PEs and intra-AS ASBRs.
- Obtain Kompella VPLS configuration information including VPLS instance descriptive information, RT value, VE ID, maximum planned site number, VE ID deviation, and interface information from the network administrator.

Configuration Steps

- Configuring CE1

See "Configuring CE1" in basic configuration examples.

- Configuring PE1:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
```

```
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes so that PEs can ping with ASBRs in the same AS.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-Gigabitethernet 1/2)# ip address 10.10.10.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/2)# mpls ip
Ruijie(config-if-Gigabitethernet 1/2)# label-switching
Ruijie(config-if-Gigabitethernet 1/2)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 2.2.2.2 remote-as 100
Ruijie(config-router)# neighbor 2.2.2.2 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpls
Ruijie(config-router-af)# neighbor 2.2.2.2 activate
Ruijie(config-router-af)# neighbor 2.2.2.2 send-community extended
Ruijie(config-router-af)# exit
```

Configure a VLAN interface.

```
Ruijie(config)# vlan 10
Ruijie(config-vlan)# exit
```

Configure the interface between CEs and PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-GigabitEthernet 1/1)# switchport access vlan 10
Ruijie(config-if-GigabitEthernet 1/1)# exit
```

Configure a VPLS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 100:1
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
```

```
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface vlan 10
Ruijie(config-vfi-site)#exit-site-mode
```

- Configuring ASBR1:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 2.2.2.2 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF protocol and establish public network routes so that PEs can ping with ASBRs in the same AS.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

#Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip address 10.10.10.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 100
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpls
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# neighbor 1.1.1.1 send-community extended
Ruijie(config-router-af)# exit
```

Configure a VLAN interface.

```
Ruijie(config)# vlan 10
Ruijie(config-vlan)# exit
```

Configure the interface between ASBR1 and ASBR2.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-GigabitEthernet 1/2)# switchport access vlan 10
Ruijie(config-if-GigabitEthernet 1/2)# exit
```

Configure a VPLS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 100:1
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# mtu 1500
Ruijie(config-vfi)# site-id 2
Ruijie(config-vfi-site)# xconnect interface vlan 10
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

- Configuring ASBR2:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 3.3.3.3 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes so that PEs can ping with ASBRs in the same AS.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-Gigabitethernet 1/2)# ip address 20.20.20.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/2)# mpls ip
Ruijie(config-if-Gigabitethernet 1/2)# label-switching
Ruijie(config-if-Gigabitethernet 1/2)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 200
Ruijie(config-router)# neighbor 4.4.4.4 remote-as 200
Ruijie(config-router)# neighbor 4.4.4.4 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpls
Ruijie(config-router-af)# neighbor 4.4.4.4 activate
Ruijie(config-router-af)# neighbor 4.4.4.4 send-community extended
```

```
Ruijie(config-router-af)# exit
```

Configure a VLAN interface.

```
Ruijie(config)# vlan 10
Ruijie(config-vlan)# exit
```

Configure the interface between ASBR1 and ASBR2.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-GigabitEthernet 1/1)#  switchport access vlan 10
Ruijie(config-if-GigabitEthernet 1/1)# exit
```

Configure a VPLS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 200:1
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 3
Ruijie(config-vfi-site)# xconnect interface vlan 10
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

- Configuring PE2:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 4.4.4.4 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes so that PEs can ping with ASBRs in the same AS.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 4.4.4.4 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
```

```
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 200
Ruijie(config-router)# neighbor 3.3.3.3 remote-as 200
Ruijie(config-router)# neighbor 3.3.3.3 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpls
Ruijie(config-router-af)# neighbor 3.3.3.3 activate
Ruijie(config-router-af)# neighbor 3.3.3.3 send-community extended
Ruijie(config-router-af)# exit
```

Configure a VLAN interface.

```
Ruijie(config)# vlan 10
Ruijie(config-vlan)# exit
```

Configure the interface that connects PE2 and a CE.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-GigabitEthernet 1/2)# switchport access vlan 10
Ruijie(config-if-GigabitEthernet 1/2)# exit
```

Configure a VPLS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 200:1
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 4
Ruijie(config-vfi-site)# xconnect interface vlan 10
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

- Configuring CE2:

See "Configuring CE2" in basic configuration examples.

Verification

After the configuration, CE1 can ping with CE2.

After completing the configuration of Kompella VPLS, use the following commands to check the operation of VPLS.

Command	Function
Ruijie# **show bgp l2vpn vpls all**	Displays all the VPLS information.
Ruijie# **show mpls l2transport vc** [*vc_id* [*ip-address*]] | [**interface** *interface_name*] [**detail**]	Displays information about the PW (including VPWS PW and VPLS PW).
Ruijie# **show bgp l2vpn** { **vpls | vpws** } **all connections** [**neighbor** *address*] | [**interface** *interface_name*] | [**site-id** *id*] [**detail**]	Displays VPLS PW information.

Ruijie# **show mpls vfi** [*name*]	Displays all the configured or specified VFI information.

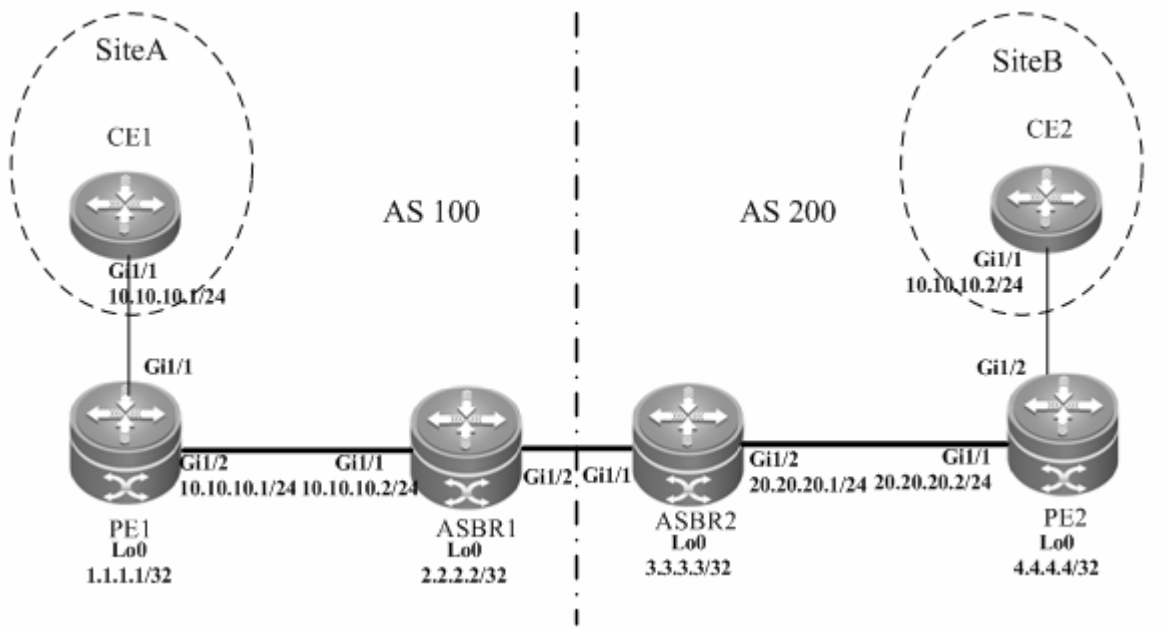
Inter-AS Configuration Examples – Option C Solution

Networking Requirements

- LAN segments of customer S in site A and site B are connected with each other through the carrier's PE1 in AS 1 and PE2 in AS 2, forming a virtual and simulative LAN service or VPLS service.
- PE1 and PE2 are in different ASs and can automatically detect PE devices involved in the VPLS instance.
- ASBR is not responsible for maintaining VPLS label block messages.
- VPLS label block messages are directly exchanged between PEs.

Networking Topology

Figure 89 Kompella VPLS Option C inter-AS networking topology



The preceding figure shows the structure of Kompella VPLS Option C inter-AS networking topology. Customer S's LAN segments in site A and site B are connected to each other through PE1 in AS 100 and PE2 in AS200 as one LAN.

Configuration Tips

Before configuring Kompella VPLS, complete the following tasks:

- Run IGP in the carrier's network to realize connection between VPLS-PE and ASBR devices in the same AS.
- Establish a public network tunnel between PE and ASBR devices in the same AS and enable MPLS on the ASBR interface.
- Establish IBGP between PE and ASBR in the same AS.
- Establish EBGP between ASBR devices and enable send-label.
- Obtain Kompella VPLS configuration information including VPLS instance descriptive information, RT value, VE ID, planned site number, VE ID deviation, and interface information from the network administrator.

Caution When Option C (multihop MP-EBGP) is applied to realize inter-AC Kompella L2VPN applications, the next hop will be changed to itself by default when such information is sent to the peer EBGP if the MP-EBGP connection is set up by the route reflector between ASs to switch NLRI information of L2VPN. To realize the Kompella L2VPN through Option C solution, the **neighbor next-hop-unchanged** command must be configured on the route reflector so that the reflector does not change the next hop when NLRI information is sent. Otherwise, the inter-AS forwarding fails.

Configuration Steps

- Configuring CE1:

See "Configuring CE1" in basic configuration examples.

- Configuring PE1:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-Gigabitethernet 1/2)# ip address 10.10.10.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/2)# mpls ip
Ruijie(config-if-Gigabitethernet 1/2)# label-switching
Ruijie(config-if-Gigabitethernet 1/2)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 4.4.4.4 remote-as 200
Ruijie(config-router)# neighbor 4.4.4.4 update-source loopback 0
Ruijie(config-router)# neighbor 4.4.4.4  ebgp-multihop
```

```
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# no neighbor 4.4.4.4  activate
Ruijie(config-router-af)# exit
Ruiije(config-router)# address-family l2vpn vpls
Ruijie(config-router-af)# neighbor 4.4.4.4 activate
Ruijie(config-router-af)# neighbor 4.4.4.4 send-community extended
Ruijie(config-router-af)# exit
```

Configure a VLAN interface.

```
Ruijie(config)# vlan 10
Ruijie(config-vlan)# exit
```

Configure the interface that connects CEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-GigabitEthernet 1/1)# switchport access vlan 10
Ruijie(config-if-GigabitEthernet 1/1)# exit
```

Configure a VPLS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 100:1
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface vlan 10
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

- Configuring ASBR1:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 2.2.2.2 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# redistribute bgp subnets
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
```

```
Ruijie(config-mpls-router)# advertise-labels for bgp-routes
Ruijie(config-mpls-router)# exit
```

#Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip address 10.10.10.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Configure the interface that connects ASBRs.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-Gigabitethernet 1/2)# ip address 192.168.1.1 255.255.255.252
Ruijie(config-if-Gigabitethernet 1/2)# label-switching
Ruijie(config-if-Gigabitethernet 1/2)# exit
```

Enable ASBRs to allocate labels for PEs' routes.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 192.168.1.2 remote-as 200
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 192.168.1.2 send-label
Ruijie(config-router-af)# network 1.1.1.1 mask 255.255.255.255
Ruijie(config-router-af)# end
```

- Configuring ASBR2:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 3.3.3.3 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 20
Ruijie(config-router)# redistribute bgp subnets
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# advertise-labels for bgp-routes
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/2
```

```
Ruijie(config-if-Gigabitethernet 1/2)# ip address 20.20.20.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/2)# mpls ip
Ruijie(config-if-Gigabitethernet 1/2)# label-switching
Ruijie(config-if-Gigabitethernet 1/2)# exit
```

Configure the interface that connects ASBRs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip address 192.168.1.1 255.255.255.252
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Enable ASBRs to allocate labels for PEs' routes.

```
Ruijie(config)# router bgp 200
Ruijie(config-router)# neighbor 192.168.1.1 remote-as 100
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 192.168.1.1  send-label
Ruijie(config-router-af)# network 4.4.4.4 mask 255.255.255.255
Ruijie(config-router-af)# end
```

- Configuring PE2:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 4.4.4.4 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 20
Ruijie(config-router)# network 4.4.4.4 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
```

```
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 200
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruijie(config-router)# neighbor  1.1.1.1  ebgp-multihop
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# no neighbor  1.1.1.1 activate
Ruijie(config-router-af)# exit
Ruiije(config-router)# address-family l2vpn vpls
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# neighbor 1.1.1.1 send-community extended
Ruijie(config-router-af)# exit
```

Configure a VLAN interface.

```
Ruijie(config)# vlan 10
Ruijie(config-vlan)# exit
```

Enable the interface that connects PEs and CEs to bind the VPLS instance.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-GigabitEthernet 1/2)# switchport access vlan 10
Ruijie(config-if-GigabitEthernet 1/2)# exit
```

Configure a VPLS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 200:1
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# mtu 1500
Ruijie(config-vfi)# site-id 2
Ruijie(config-vfi-site)# xconnect interface vlan 10
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

- Configuring CE2:

See "Configuring CE2" in basic configuration examples.

Verification

After the configuration, CE1 can ping with CE2.

After completing the configuration of Kompella VPLS, use the following commands to check the operation of VPLS.

Command	Function
Ruijie# **show bgp l2vpn vpls all**	Displays all the VPLS information.
Ruijie# **show mpls l2transport vc** [*vc_id* [*ip-address*]] | [**interface** *interface_name*] [**detail**]	Displays information about the PW (including VPWS PW and VPLS PW)

Ruijie# **show bgp l2vpn** { **vpls | vpws** } **all connection**s [**neighbor** *address*] | [**interface** *interface_name*] | [**site-id** *id*] [**detail**]	Displays VPLS PW information.
Ruijie# s**how mpls vfi** [*name*]	Displays all the configured or specified VFI information.

Typical Examples of Kompella VPLS Configuration for Routers

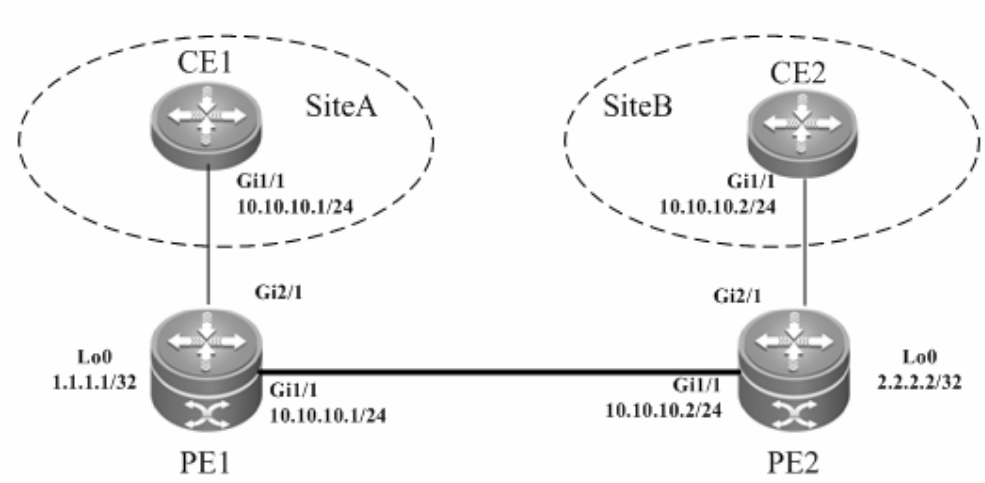
Basic Configuration Examples (Ethernet Access)

Networking Requirements

- LAN segments of customer S in site A and site B are connected with each other through the carrier's network devices, PE1 and PE2, forming a virtual and simulative LAN service or VPLS service.
- PE1 and PE2 are in the same AS and can automatically detect PE devices involved in the VPLS instance.
- Customer S's long-term network deployment plan is to connect LANs in five sites at most.
- The signaling protocol adopted by the carrier is the MP-BGP4 protocol.
- PEs are connected to CEs through the Ethernet interface.

Networking Topology

Figure 90 Basic Kompella VPLS configuration networking topology



Configuration Tips

Before configuring Kompella VPLS, complete the following tasks:

- Configure the public network tunnel that transmits data frames between VPLS PEs.
- Enable the L2VPN address family on PEs.
- Obtain Kompella VPLS configuration information including VPLS instance descriptive information, RT value, VE ID, planned site number, VE ID deviation, and interface information from the network administrator, and configure the Kompella VPLS instance.
- Configure the user access VPLS.

Configuration Steps

- Configuring CE1:

Configure OSPF.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure the interface between CEs and PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip ref
Ruijie(config-if-Gigabitethernet 1/1)# ip address 10.10.10.1 255.255.255.0
Ruijie(config-router)# exit
```

- Configuring PE1

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip ref
Ruijie(config-if-Gigabitethernet 1/1)# ip address 10.10.10.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 2.2.2.2 remote-as 100
Ruijie(config-router)# neighbor 2.2.2.2 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpls
Ruijie(config-router-af)# neighbor 2.2.2.2 activate
Ruijie(config-router-af)# neighbor 2.2.2.2 send-community extended
Ruijie(config-router-af)# exit
```

Configure a VPLS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 1:1
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface gigabitEthernet 2/1
Ruijie(config-vfi-site)#exit-site-id
Ruijie(config-vfi)# exit
```

Configure the interface.

```
Ruijie(config)# interface gigabitEthernet 2/1
Ruijie(config-if-GigabitEthernet 2/1)# ip ref
Ruijie(config-if-GigabitEthernet 2/1)# exit
```

- Configuring PE2:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 2.2.2.2 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip ref
Ruijie(config-if-Gigabitethernet 1/1)# ip address 10.10.10.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 100
```

```
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpls
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# neighbor 1.1.1.1 send-community extended
Ruijie(config-router-af)# exit
```

Configure a VPLS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 2:2
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 2
Ruijie(config-vfi-site)# xconnect interface gigabitEthernet 2/1
Ruijie(config-vfi-site)#exit-site-id
Ruijie(config-vfi)#exit
```

Configure the interface.

```
Ruijie(config)# interface gigabitEthernet 2/1
Ruijie(config-if-GigabitEthernet 2/1)# ip ref
Ruijie(config-if-GigabitEthernet 2/1)# exit
```

- Configuring CE2:

Configure OSPF.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure the interface between CEs and PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip ref
Ruijie(config-if-Gigabitethernet 1/1)# ip address 10.10.10.2 255.255.255.0
Ruijie(config-router)# exit
```

Verification

After the configuration, CE1 can ping with CE2.

After completing the configuration of Kompella VPLS, use the following commands to check the operation of VPLS.

Command	Function
Ruijie# **show bgp l2vpn vpls all**	Displays all the VPLS information.
Ruijie# **show mpls l2transport vc** [*vc_id* [*ip-address*]] | [**interface** *interface_name*] [**detail**]	Displays information about PW (including VPWS PW and VPLS PW)

Ruijie# **show bgp l2vpn** { **vpls | vpws** } **all connections** [**neighbor** *address*] | [**interface** *interface_name*] | [**site-id** *id*] [**detail**]	Displays VPLS PW information.
Ruijie# **show mpls vfi** [*name*]	Displays all the configured or specified VFI information.

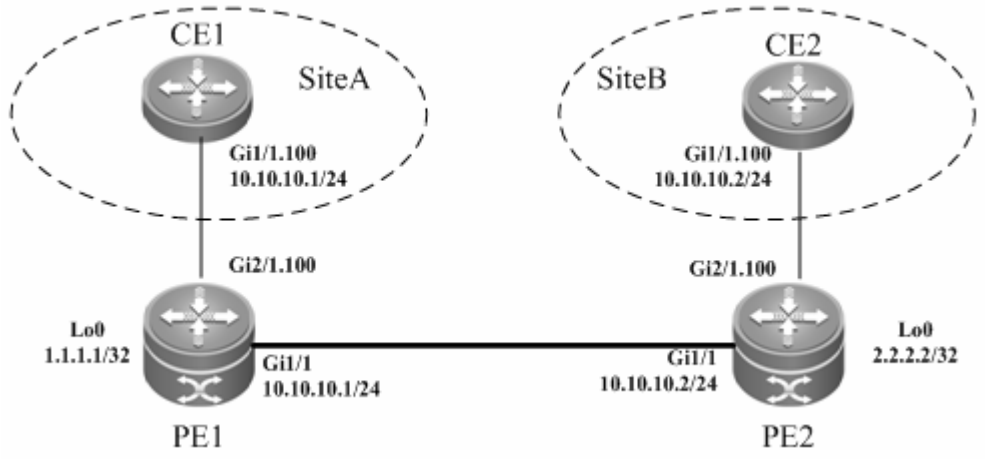
Basic Configuration Examples (Ethernet Sub-interface Access)

Networking Requirements

- LAN segments of customer S in site A and site B are connected with each other through the carrier's network devices, PE1 and PE2, forming a virtual and simulative LAN service or VPLS service.
- PE1 and PE2 are in the same AS and can automatically detect PE devices involved in the VPLS instance.
- Customer S's long-term network deployment plan is to connect LANs in five sites at most.
- The signaling protocol adopted by the carrier is the MP-BGP4 protocol.
- PEs are connected to CEs through the Ethernet sub-interface.

Networking Topology

Figure 91 Basic Kompella VPLS configuration networking topology



Configuration Tips

Before configuring Kompella VPLS, complete the following tasks:

- Configure the public network tunnel that transmits data frames between VPLS PEs.
- Enable the L2VPN address family on PEs.
- Obtain Kompella VPLS configuration information including VPLS instance descriptive information, RT value, VE ID, planned site number, VE ID deviation, and interface information from the network administrator, and configure the Kompella VPLS instance.
- Configure the user access VPLS.

Configuration Steps

- Configuring CE1:

Configure OSPF.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
```

```
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure the interface between CEs and PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip ref
Ruijie(config-if-Gigabitethernet 1/1)# exit
Ruijie(config)# interface gigabitEthernet 1/1.100
Ruijie(config-if-Gigabitethernet 1/1.100)# encapsulation dot1Q 100
Ruijie(config-if-Gigabitethernet 1/1.100)# ip address 10.10.10.1 255.255.255.0
Ruijie(config-router)# exit
```

- Configuring PE1:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip ref
Ruijie(config-if-Gigabitethernet 1/1)# ip address 10.10.10.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 2.2.2.2 remote-as 100
Ruijie(config-router)# neighbor 2.2.2.2 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpls
Ruijie(config-router-af)# neighbor 2.2.2.2 activate
Ruijie(config-router-af)# neighbor 2.2.2.2 send-community extended
Ruijie(config-router-af)# exit
```

Configure an interface.

```
Ruijie(config)# interface gigabitethernet 2/1
Ruijie(config-if-Gigabitethernet 2/1)# ip ref
Ruijie(config-if-Gigabitethernet 2/1)# exit
Ruijie(config)# interface gigabitEthernet 2/1.100
Ruijie(config-if-Gigabitethernet 2/1.100)# encapsulation dot1Q 100
Ruijie(config-if-GigabitEthernet 2/1.100)# exit
```

Configure a VPLS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 1:1
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernetvlan
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface gigabitEthernet 2/1.100
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

- Configuring PE2:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 2.2.2.2 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip ref
Ruijie(config-if-Gigabitethernet 1/1)# ip address 10.10.10.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 100
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpls
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# neighbor 1.1.1.1 send-community extended
Ruijie(config-router-af)# exit
```

Bind the interface to the VPLS instance.

```
Ruijie(config)# interface gigabitEthernet 2/1
Ruijie(config-if-GigabitEthernet 2/1)# ip ref
Ruijie(config-if-GigabitEthernet 2/1)# exit
Ruijie(config)# interface gigabitEthernet 2/1.100
Ruijie(config-if-Gigabitethernet 2/1.100)# encapsulation dot1Q 100
Ruijie(config-if-GigabitEthernet 2/1.100)# exit
```

Configure a VPLS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 2:2
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernetvlan
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 2
Ruijie(config-vfi-site)# xconnect interface gigabitEthernet 2/1.100
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

- Configuring CE2:

Configure OSPF.

```
Ruijie# configure terminal
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure the interface between CEs and PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1.100
Ruijie(config-if-Gigabitethernet 1/1.100)# encapsulation dot1Q 100
Ruijie(config-if-Gigabitethernet 1/1.100)# ip ref
Ruijie(config-if-Gigabitethernet 1/1.100)# ip address 10.10.10.2 255.255.255.0
Ruijie(config-router)# exit
```

Verification

After the configuration, CE1 can ping with CE2.

After completing the configuration of Kompella VPLS, use the following commands to check the operation of VPLS.

Command	Function
Ruijie# **show bgp l2vpn vpls all**	Displays all the VPLS information.
Ruijie# **show mpls l2transport vc** [*vc_id* [*ip-address*]] | [**interface** *interface_name*] [**detail**]	Displays information about the PW (including VPWS PW and VPLS PW).
Ruijie# **show bgp l2vpn** { **vpls | vpws** } **all connections** [**neighbor** *address*] | [**interface** *interface_name*] | [**site-id** *id*] [**detail**]	Displays VPLS PW information.
Ruijie# s**how mpls vfi** [*name*]	Displays all the configured or specified VFI information.

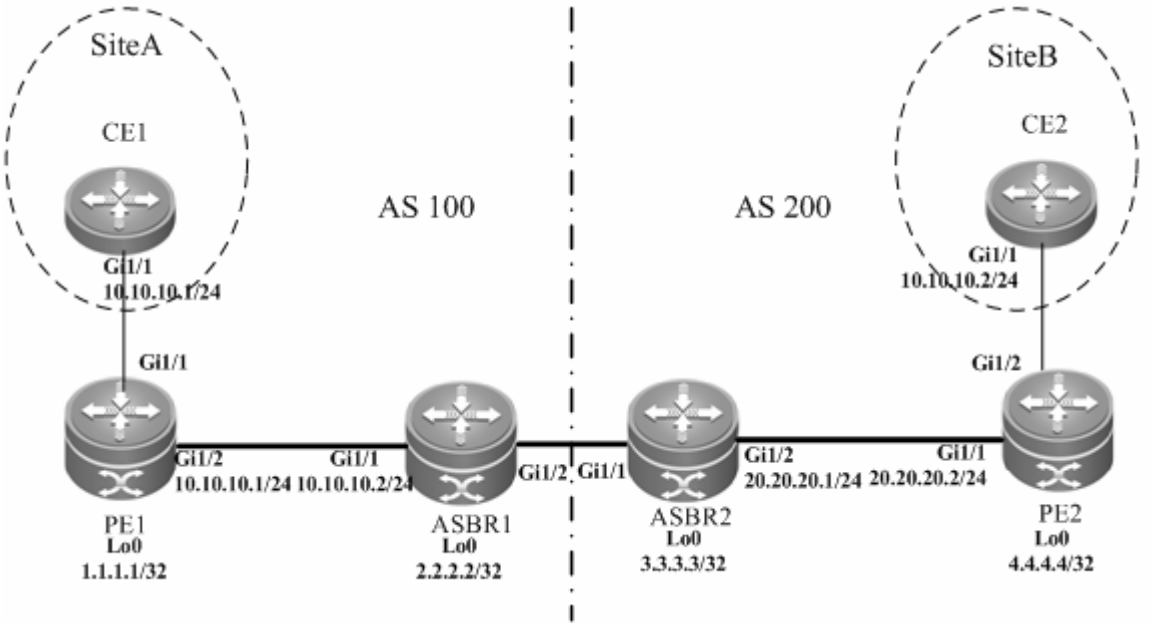
Inter-AS Configuration Examples – Option A Solution

Networking Requirements

- LAN segments of customer S in site A and site B are connected with each other through the carrier's PE1 in AS 100 and PE2 in AS 200, forming a virtual and simulative LAN service or VPLS service;
- PE1 and PE2 are in different ASs. ASBR1 and ASBR2 are considered CE devices by each other, which means that the interface between ASBRs connects the AC to the VPLS instance.

Networking Topology

Figure 92 Kompella VPLS inter-AS networking topology



The preceding figure shows the structure of the Kompella VPLS inter-AS networking topology in Option A. The intermediate interface is considered by ASBRs as AC connection.

Configuration Tips

Before configuring Kompella VPLS, complete the following tasks:

- Run IGP in the carrier's network to realize connection between PE and ASBR devices.
- Establish the MP-IBGP peer relationship between PEs and intra-domain ASBRs in the domain.

- Obtain Kompella VPLS configuration information including VPLS instance descriptive information, RT value, VE ID, maximum planned site number, VE ID deviation, and interface information from the network administrator.

Configuration Steps

- Configuring CE1:

See "Configuring CE1" in basic configuration examples.

- Configuring PE1:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes so that PEs can ping with ASBRs in the same AS.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-Gigabitethernet 1/2)# ip ref
Ruijie(config-if-Gigabitethernet 1/2)# ip address 10.10.10.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/2)# mpls ip
Ruijie(config-if-Gigabitethernet 1/2)# label-switching
Ruijie(config-if-Gigabitethernet 1/2)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 2.2.2.2 remote-as 100
Ruijie(config-router)# neighbor 2.2.2.2 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpls
Ruijie(config-router-af)# neighbor 2.2.2.2 activate
Ruijie(config-router-af)# neighbor 2.2.2.2 send-community extended
Ruijie(config-router-af)# exit
```

Configure the interface between CEs and PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
```

```
Ruijie(config-if-GigabitEthernet 1/1)# exit
```

Configure a VPLS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 100:1
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface gigabitEthernet 1/1
Ruijie(config-vfi-site)#exit-site-mode
```

- Configuring ASBR1:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 2.2.2.2 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes so that PEs can ping with ASBRs in the same AS.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip ref
Ruijie(config-if-Gigabitethernet 1/1)# ip address 10.10.10.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 100
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpls
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# neighbor 1.1.1.1 send-community extended
```

```
Ruijie(config-router-af)# exit
```

Configure the interface between ASBR1 and ASBR2.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-GigabitEthernet 1/2)# ip ref
Ruijie(config-if-GigabitEthernet 1/2)# exit
```

Configure a VPLS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 100:1
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# mtu 1500
Ruijie(config-vfi)# site-id 2
Ruijie(config-vfi-site)# xconnect interface gigabitEthernet 1/2
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

- Configuring ASBR2:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 3.3.3.3 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes so that PEs can ping with ASBRs in the same AS.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-Gigabitethernet 1/2)# ip ref
Ruijie(config-if-Gigabitethernet 1/2)# ip address 20.20.20.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/2)# mpls ip
Ruijie(config-if-Gigabitethernet 1/2)# label-switching
Ruijie(config-if-Gigabitethernet 1/2)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 200
Ruijie(config-router)# neighbor 4.4.4.4 remote-as 200
Ruijie(config-router)# neighbor 4.4.4.4 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpls
Ruijie(config-router-af)# neighbor 4.4.4.4 activate
Ruijie(config-router-af)# neighbor 4.4.4.4 send-community extended
Ruijie(config-router-af)# exit
```

Configure the interface between ASBR1 and ASBR2.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# exit
```

Configure a VPLS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 200:1
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 3
Ruijie(config-vfi-site)# xconnect interface gigabitEthernet 1/1
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

- Configuring PE2:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 4.4.4.4 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes so that PEs can ping with ASBRs in the same AS.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 4.4.4.4 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip ref
Ruijie(config-if-Gigabitethernet 1/1)# ip address 20.20.20.1 255.255.255.0
```

```
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 200
Ruijie(config-router)# neighbor 3.3.3.3 remote-as 200
Ruijie(config-router)# neighbor 3.3.3.3 update-source loopback 0
Ruiije(config-router)# address-family l2vpn vpls
Ruijie(config-router-af)# neighbor 3.3.3.3 activate
Ruijie(config-router-af)# neighbor 3.3.3.3 send-community extended
Ruijie(config-router-af)# exit
```

Configure the interface that connects PE2 and a CE.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-GigabitEthernet 1/2)# ip ref
Ruijie(config-if-GigabitEthernet 1/2)# exit
```

Configure a VPLS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 200:1
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 4
Ruijie(config-vfi-site)# xconnect interface gigabitEthernet 1/2
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

- Configuring CE2:

See "Configuring CE2" in basic configuration examples.

Verification

After the configuration, CE1 can ping with CE2.

After completing the configuration of Kompella VPLS, use the following commands to check the operation of VPLS.

Command	Function
Ruijie# **show bgp l2vpn vpls all**	Displays all the VPLS information.
Ruijie# **show mpls l2transport vc** [*vc_id* [*ip-address*]] | [**interface** *interface_name*] [**detail**]	Displays information about PW (including VPWS PW and VPLS PW)
Ruijie# **show bgp l2vpn** { **vpls | vpws** } **all connections** [**neighbor** *address*] | [**interface** *interface_name*] | [**site-id** *id*] [**detail**]	Displays VPLS PW information.
Ruijie# **show mpls vfi** [*name*]	Displays all the configured or specified VFI information.

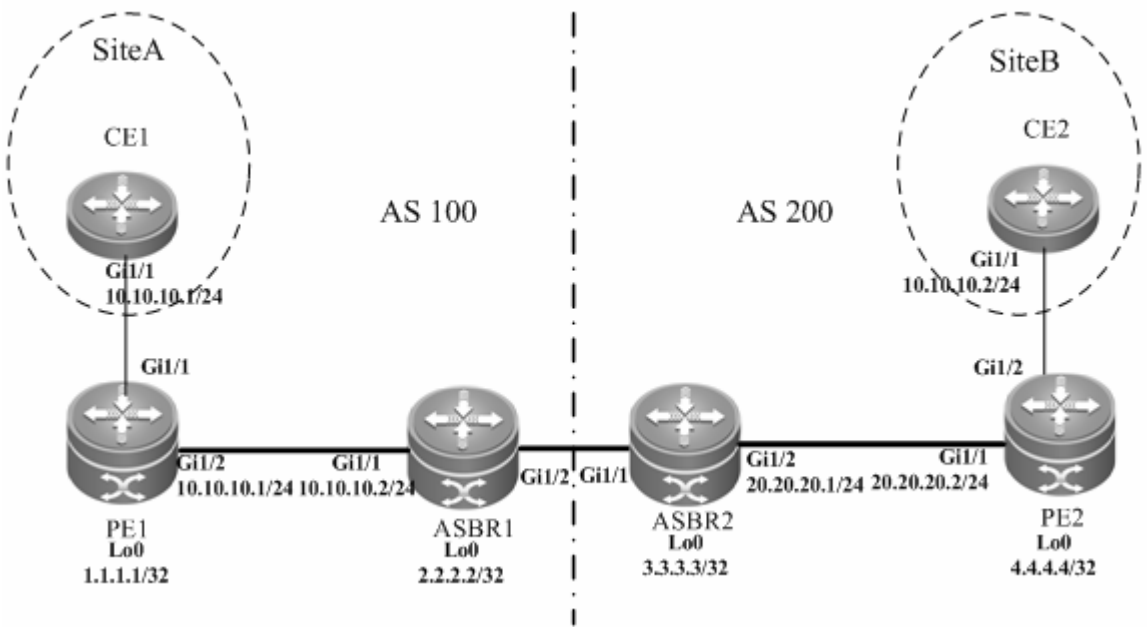
Inter-AS Configuration Examples – Option C Solution

Networking Requirements

- LAN segments of customer S in site A and site B are connected with each other through the carrier's PE1 in AS 1 and PE2 in AS 2, forming a virtual and simulative LAN service or VPLS service.
- PE1 and PE2 are in different ASs and can automatically detect PE devices involved in the VPLS instance.
- ASBR is not responsible for maintaining VPLS label block messages.
- VPLS label block messages are directly exchanged between PEs.

Networking Topology

Figure 93 Kompella VPLS Option C inter-AS networking topology



The preceding figure shows the structure of Kompella VPLS Option C inter-AS networking topology. Customer S's LAN segments in site A and site B are connected to each other through PE1 in AS 100 and PE2 in AS 200 as one LAN.

Configuration Tips

Before configuring Kompella VPLS, complete the following tasks:

- Run IGP in the carrier's network to realize connection between VPLS-PE and ASBR devices in the same AS.
- Establish a public network tunnel between PE and ASBR devices in the same AS and enable MPLS on the ASBR interface.
- Establish IBGP between PE and ASBR devices in the same AS.
- Establish EBGP between ASBR devices and enable send-label.
- Obtain Kompella VPLS configuration information including VPLS instance descriptive information, RT value, VE ID, planned site number, VE ID deviation, and interface information from the network administrator.

Caution

When Option C (multihop MP-EBGP) is applied to realize Inter-AC Kompella L2VPN applications, the next hop will be changed to itself by default when such information is sent to the peer EBGP if the MP-EBGP connection is set up by the route reflector between ASs to switch NLRI information of L2VPN. To realize the

Kompella L2VPN through Option C solution, the **neighbor next-hop-unchanged** command must be configured on the route reflector so that the reflector does not change the next hop when NLRI information is sent. Otherwise, inter-AS forwarding fails.

Configuration Steps

- Configuring CE1:

See "Configuring CE1" in basic configuration examples.

- Configuring PE1:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-Gigabitethernet 1/2)# ip ref
Ruijie(config-if-Gigabitethernet 1/2)# ip address 10.10.10.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/2)# mpls ip
Ruijie(config-if-Gigabitethernet 1/2)# label-switching
Ruijie(config-if-Gigabitethernet 1/2)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 4.4.4.4 remote-as 200
Ruijie(config-router)# neighbor 4.4.4.4 update-source loopback 0
Ruijie(config-router)# neighbor 4.4.4.4  ebgp-multihop
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# no neighbor 4.4.4.4  activate
Ruijie(config-router-af)# exit
Ruiije(config-router)# address-family l2vpn vpls
```

```
Ruijie(config-router-af)# neighbor 4.4.4.4 activate
Ruijie(config-router-af)# neighbor 4.4.4.4 send-community extended
Ruijie(config-router-af)# exit
```

Configure the interface that connects CEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-GigabitEthernet 1/1)# ip ref
Ruijie(config-if-GigabitEthernet 1/1)# exit
```

Configure a VPLS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 100:1
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# site-id 1
Ruijie(config-vfi-site)# xconnect interface gigabitEthernet 1/1
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

- Configuring ASBR1:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 2.2.2.2 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 10
Ruijie(config-router)# redistribute bgp subnets
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 10.10.10.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# advertise-labels for bgp-routes
Ruijie(config-mpls-router)# exit
```

#Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip ref
Ruijie(config-if-Gigabitethernet 1/1)# ip address 10.10.10.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
```

```
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Configure the interface that connects ASBRs.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-Gigabitethernet 1/2)# ip ref
Ruijie(config-if-Gigabitethernet 1/2)# ip address 192.168.1.1 255.255.255.252
Ruijie(config-if-Gigabitethernet 1/2)# label-switching
Ruijie(config-if-Gigabitethernet 1/2)# exit
```

Enable ASBRs to allocate labels for PEs' routes.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 192.168.1.2 remote-as 200
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 192.168.1.2 send-label
Ruijie(config-router-af)# network 1.1.1.1 mask 255.255.255.255
Ruijie(config-router-af)# end
```

- Configuring ASBR2:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 3.3.3.3 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 20
Ruijie(config-router)# redistribute bgp subnets
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# advertise-labels for bgp-routes
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-Gigabitethernet 1/2)# ip ref
Ruijie(config-if-Gigabitethernet 1/2)# ip address 20.20.20.2 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/2)# mpls ip
Ruijie(config-if-Gigabitethernet 1/2)# label-switching
Ruijie(config-if-Gigabitethernet 1/2)# exit
```

Configure the interface that connects ASBRs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip ref
Ruijie(config-if-Gigabitethernet 1/1)# ip address 192.168.1.1 255.255.255.252
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Enable ASBRs to allocate labels for PEs' routes.

```
Ruijie(config)# router bgp 200
Ruijie(config-router)# neighbor 192.168.1.1 remote-as 100
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 192.168.1.1  send-label
Ruijie(config-router-af)# network 4.4.4.4 mask 255.255.255.255
Ruijie(config-router-af)# end
```

- Configuring PE2:

Configure the loopback interface address.

```
Ruijie(config)# interface loopback 0
Ruijie(config-if-Loopback 0)# ip address 4.4.4.4 255.255.255.255
Ruijie(config-if-Loopback 0)# exit
```

Configure OSPF and establish public network routes.

```
Ruijie(config)# router ospf 20
Ruijie(config-router)# network 4.4.4.4 0.0.0.0 area 0
Ruijie(config-router)# network 20.20.20.0 0.0.0.255 area 0
Ruijie(config-router)# exit
```

Configure LDP and globally enable MPLS.

```
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id interface loopback 0  force
Ruijie(config-mpls-router)# exit
```

Configure the public network tunnel between PEs.

```
Ruijie(config)# interface gigabitEthernet 1/1
Ruijie(config-if-Gigabitethernet 1/1)# ip ref
Ruijie(config-if-Gigabitethernet 1/1)# ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-Gigabitethernet 1/1)# mpls ip
Ruijie(config-if-Gigabitethernet 1/1)# label-switching
Ruijie(config-if-Gigabitethernet 1/1)# exit
```

Configure the L2VPN address family.

```
Ruijie(config)# router bgp 100
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 200
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
```

```
Ruijie(config-router)# neighbor  1.1.1.1  ebgp-multihop
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# no neighbor  1.1.1.1 activate
Ruijie(config-router-af)# exit
Ruiije(config-router)# address-family l2vpn vpls
Ruijie(config-router-af)# neighbor 1.1.1.1 activate
Ruijie(config-router-af)# neighbor 1.1.1.1 send-community extended
Ruijie(config-router-af)# exit
```

Enable the interface that connects PEs and CEs to bind the VPLS instance.

```
Ruijie(config)# interface gigabitEthernet 1/2
Ruijie(config-if-GigabitEthernet 1/2)# ip ref
Ruijie(config-if-GigabitEthernet 1/2)# exit
```

Configure a VPLS instance.

```
Ruijie# configure terminal
Ruijie(config)# l2 vfi vpls-1 vpnid 1 autodiscovery
Ruijie(config-vfi)# rd 200:1
Ruijie(config-vfi)# signal bgp
Ruijie(config-vfi)# encapsulation mpls ethernet
Ruijie(config-vfi)# route-target both 10000:1
Ruijie(config-vfi)# mtu 1500
Ruijie(config-vfi)# site-id 2
Ruijie(config-vfi-site)# xconnect interface gigabitEthernet 1/2
Ruijie(config-vfi-site)#exit-site-mode
Ruijie(config-vfi)#exit
```

- Configuring CE2:

See "Configuring CE2" in basic configuration examples.

Verification

After the configuration, CE1 can ping with CE2.

After completing the configuration of Kompella VPLS, use the following commands to check the operation of VPLS.

Command	Function
Ruijie# **show bgp l2vpn vpls all**	Displays all the VPLS information.
Ruijie# **show mpls l2transport vc** [*vc_id* [*ip-address*]] | [**interface** *interface_name*] [**detail**]	Displays information about the PW (including VPWS PW and VPLS PW)
Ruijie# **show bgp l2vpn** { **vpls | vpws** } **all connections** [**neighbor** *address*] | [**interface** *interface_name*] | [**site-id** *id*] [**detail**]	Displays VPLS PW information.
Ruijie# **show mpls vfi** [*name*]	Displays all the configured or specified VFI information.

MPLS GR Configuration


Note

Routers and router icons contained in this chapter refer to routers and layer-3 switches with the routing protocol enabled.

LDP GR

Overview

The Internet Engineering Task Force (IETF) has extended the Label Distribution Protocol (LDP), which is a signaling protocol of Multiprotocol Label Switching (MPLS), so that a device may instruct neighbors to keep related MPLS forwarding entries and set an "old" flag for these MPLS forwarding entries when the LDP is restarted on the device. After the LDP is restarted, neighbors assist the device to implement information synchronization so that the device is restored to the status before the LDP restart within the shortest possible time. The packet forwarding path does not change and data forwarding is not interrupted in the system throughout the LDP restart, guaranteeing the high reliability of MPLS application services.

Basic Concepts

GR Routers Classified by Capability

GR routers are classified by capability into GR-capable routers, GR-aware routers, and GR-unaware routers.

- GR-Capable Router

A GR-capable router is a router that has GR capability. In general, a GR-capable router is equipped with two management boards which work in 1+1 master/slave mode. The GR-capable router can send an advertisement packet to neighboring routers during master/slave switchover of the management boards, so that neighboring routers keep forwarding entries related to the GR-capable router. After master/slave switchover, routing tables are re-established without causing route flapping or changing the packet forwarding path, guaranteeing uninterrupted data forwarding in the system.

- GR-Aware Router

A GR-aware router is a router that has GR detection capability. It may be not equipped with two management boards but can detect that its neighbors are experiencing GR and can assist its neighbors to complete GR.

- GR-Unaware Router

A GR-unaware router is a router that does not have GR detection capability. It cannot detect that its neighbors are experiencing GR, cannot assist its neighbors to complete GR, and does not have GR capability. Generally, if a router has no awareness capability, it is because the system software does not provide the GR feature or the GR feature is disabled.

GR Routers Classified by Role

GR routers are classified by role during router restart into GR restarters and GR helpers.

- GR Restarter

The GR restarter has GR capability and its restart is triggered by administrators or faults.

- GR Helper

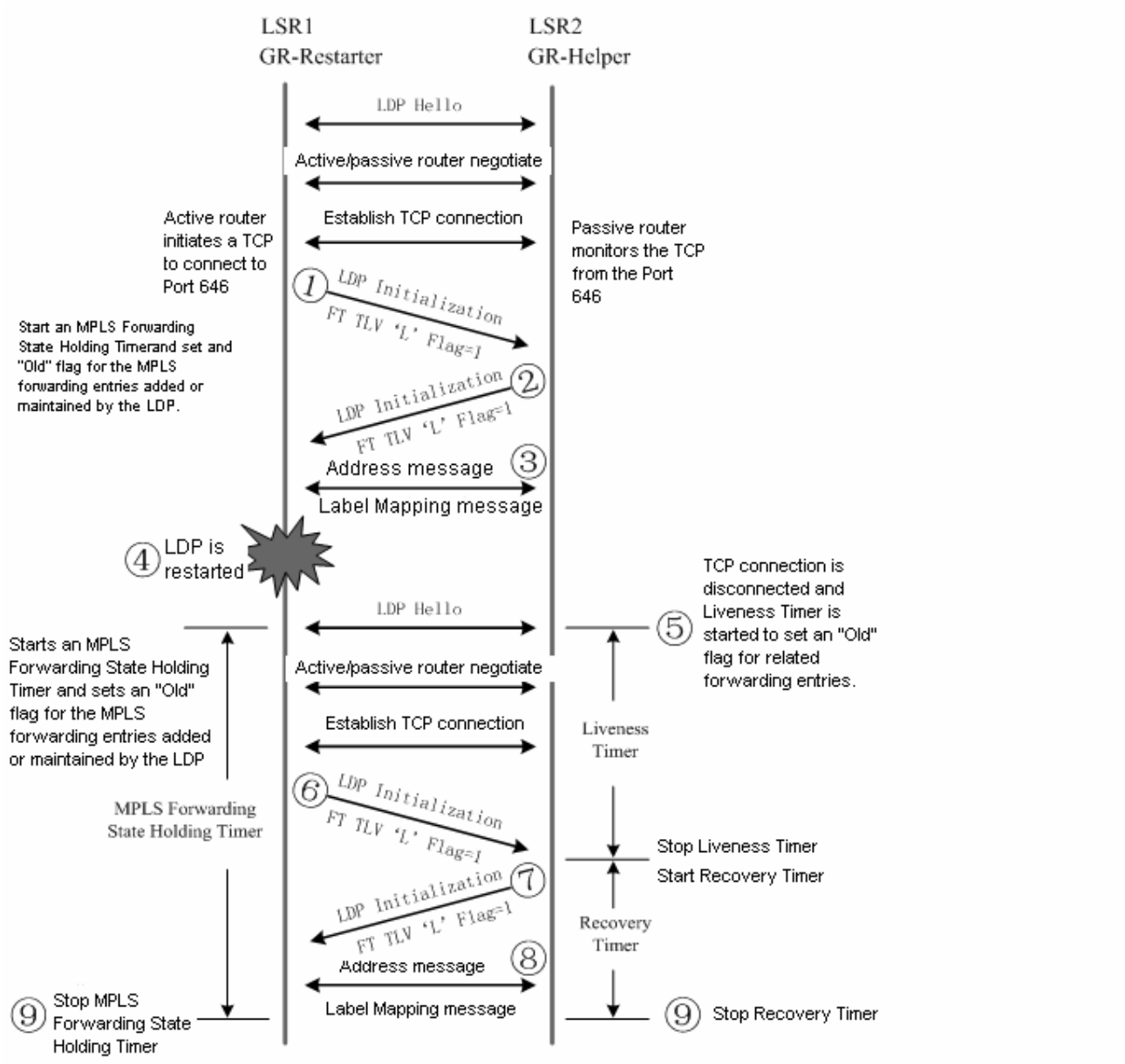
The GR helper is a neighbor of the GR restarter. It must be at least a GR-aware router.

Working Principle

The LDP GR function must be enabled on and supported by two routers in order to establish a GR-capable LDP session between them. If not, only a common LDP session can be established. If the initiator supports LDP GR and LDP GR is enabled on it during LDP session establishment, the initiator sends an Initialization message that carries an FT Session TLV.

If the passive router receives an Initialization message that carries an FT Session TLV during session establishment, it may choose to add or not add the FT Session TLV to the Initialization message to be sent to the initiator depending on its LDP GR capability. If the passive router supports LDP GR and LDP GR is enabled on it, the Initialization message will carry the FT Session TLV to establish a GR-capable LDP session. Otherwise, the Initialization message will not carry the FT Session TLV to establish a common GR-incapable LDP session LDP session. If the passive router receives an Initialization message that does not carry the FT Session TLV, a common GR-incapable LDP session is established, no matter whether the passive router adds the FT Session TLV to the Initialization message to be sent. Figure 1-1 shows the process of LDP session establishment between two Label Switching Routers (LSRs) with LDP GR capability.

Figure 1-1 LDP GR session establishment process



LSR 1 initiates an Initialization message that carries an optional FT Session TLV, indicating that LSR 1 itself supports LDP GR.

After LSR 2 that supports LDP GR receives the Initialization message that carries the FT Session TLV, it returns an Initialization message that also carries the FT Session TLV to LSR 1. When LSR 1 receives the Initialization message from LSR 2, a GR-capable LDP session is established.

LSR 1 and LSR 2 exchange LDP Address messages and Label Mapping messages with each other.

The LDP on LSR 1 is restarted for a certain reason. LSR 1 keeps all MPLS forwarding entries added or maintained by the LDP, sets an "old" flag for these forwarding entries, and starts an MPLS Forwarding State Holding Timer.

After LSR 2 with LDP GR capability detects that the GR-capable LDP session with LSR 1 is disconnected, LSR 2 keeps the MPLS forwarding entries related to this session and sets an "old" flag for these forwarding entries. At the same time, LSR 2 selects a smaller value of its Liveness Timer and the FT Reconnect Timeout in the received FT Session TLV to start a Liveness Timer, and keeps these "old" forwarding entries before the Liveness Timer is triggered.

To re-establish a session with LSR 2, LSR 1 sets the Recovery Time in the FT Session TLV of the Initialization message to the remaining value of the MPLS Forwarding State Holding Timer.

After receiving the Initialization message that carries the FT Session TLV from LSR 1, LSR 2 detects that Recovery Time is not 0, LSR 2 continues to keep the "old" forwarding entries, stops the Liveness Timer, selects a smaller value of the its Recovery Time and the Recovery Time in the received FT Session TLV to start a Recovery Timer, and keeps these "old" forwarding entries before the Recovery Timer is triggered.

LSR 1 and LSR 2 exchange LDP Address and Label Mapping messages with each other, and keep or remove the "old" flag set for MPLS forwarding entries.

The GR process ends. LSR 1 and LSR 2 delete the MPLS forwarding entries with the "old" flag from themselves respectively.

Protocols and Specifications

The protocols or specifications involved are as follows:

- RFC 3036: LDP Specification
- RFC 3037: LDP Applicability
- RFC 3215: LDP State Machine
- RFC 3478: Graceful Restart Mechanism for LDP
- RFC 3479: Fault Tolerance for LDP

Configuring LDP GR

Network Environment

The GR function of the MPLS LDP is configured to maintain the neighborhood and sessions between routers and recover sessions and label information when faults occur on MPLS devices.

Prerequisites

Complete the following tasks before configuring MPLS LDP GR:

- Configure IGP GR.
- Configure MPLS LDP session information.

Data Preparations

Prepare the following data before configuring MPLS LDP GR:

- LDP session re-connection time
- LDP neighbor keep-alive time
- LDP session recovery time

Configuring the LDP GR

By default, the LDP GR function is disabled on a device. To enable the LDP GR function on a device, enter privileged user mode and run the following commands:

Command	Function
Ruijie#**configure terminal**	Enters global configuration mode.

Ruijie(config)#**mpls ip**	Enables global MPLS forwarding.  Caution This command is not applicable to forwarding on switch chips.
Ruijie(config)#**interface type ID**	Enters interface configuration mode.
Ruijie(config-if-type ID)#**no switchport**	Sets ports to L3 ports (Switch configuration).
Ruijie(config-if-type ID)#**mpls ip**	Enables LDP forwarding on interfaces.
Or:	
Ruijie(config-if-type ID)#**mpls ip**	Enables LDP forwarding on interfaces (Router configuration).
Ruijie(config-if-type ID)#**ip ref**	Enables fast forwarding on interfaces.
Ruijie(config-if-type ID)#**label-switching**	Enables MPLS packet processing on interfaces.
Ruijie(config)#**mpls router ldp**	Enters LDP configuration mode.
Ruijie(config-mpls-router)#l**dp router-id** *Loopback ID* **force**	Sets the router ID to a loopback ID (The settings immediately take effect).
Ruijie(config-mpls-router)#**graceful-restart**	Enables LDP GR. By default, LDP GR is disabled.
Ruijie(config-mpls-router)#**end**	Exits LDP configuration mode.
Ruijie#s**how mpls ldp graceful-restart**	Displays LDP GR sessions and session parameters.

To disable LDP GR, run the **no graceful-restart** command.


Note The existing LDP session is not affected when LDP GR is enabled. For example, the LDP session does not restart. The LDP GR takes effect only after the LDP session restarts..

Configuring Parameters Related to LDP GR (Optional)

Enter LDP configuration mode and run the following commands:

Command	Function
Ruijie#**configure terminal**	Enters global configuration mode.
Ruijie(config)#**mpls router ldp**	Enables the LDP and enters LDP configuration mode.
Ruijie(config-mpls-router)**#graceful-restart timer reconnect** *seconds*	Sets the LDP session re-connection time. By default, the LDP session reconnection time is 300 seconds.
Ruijie(config-mpls-router)#**graceful-restart timer neighbor-liveness** *seconds*	Sets the LDP neighbor keep-alive time. By default, the LDP neighbor keep-alive time is 120 seconds.
Ruijie(config-mpls-router)#**graceful-restart timer recovery** *seconds*	Sets the LDP session recovery time. By default, the LDP session recovery time is 120 seconds.
Ruijie(config-mpls-router)#**end**	Exits LDP configuration mode.
Ruijie#**show mpls ldp graceful-restart**	Displays LDP GR sessions and session parameters.

To restore the default settings of parameters related to LDP GR, run the **no graceful-restart timer reconnect, no graceful-restart timer neighbor-liveness**, and **no graceful-restart timer recovery** commands.

Verification

To display LDP GR configuration and running information, run the following commands.

Command	Function
show mpls ldp graceful-restart	Displays LDP GR sessions and session parameters.
show mpls ldp bindings [all | **vrf** *vrf-name*] [*ip-address/mask*|label *label*] **[remote | local]**	Displays the mapping between Forwarding Equivalence Classes (FECs) and labels.
show mpls ldp neighbor [all | **vrf** *vrf-name*] [*ip-address*] [**detail]**	Displays the status of LDP neighbors.

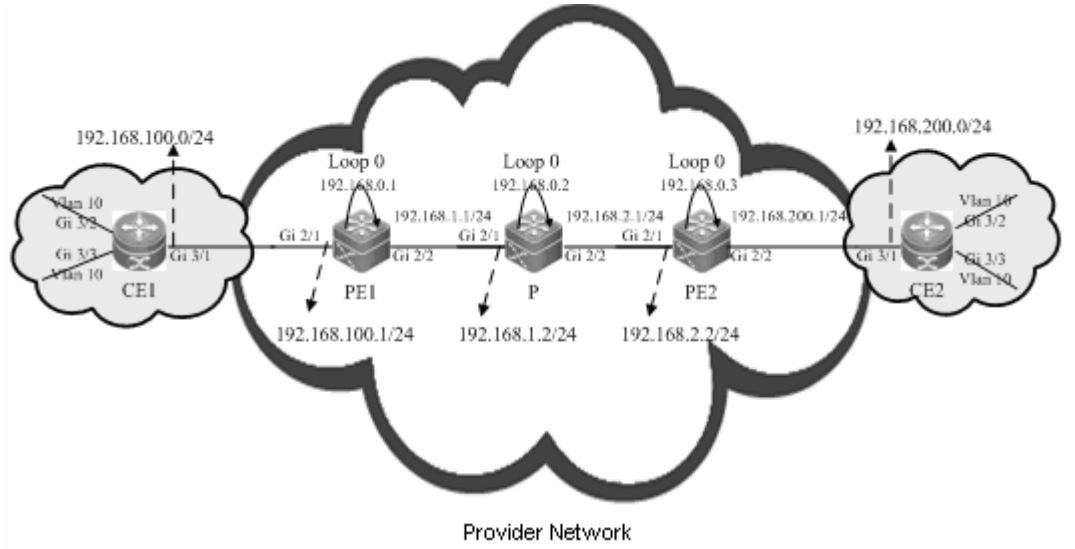
Configuration Examples

Networking Requirements

- An MPLS network consists of Provider Edge (PE) and Provider (P) devices.
- PE and P devices support the LDP and are capable of GR.
- This following describes how to configure LDP GR on PE 1 and a P device. PE 1 is a GR-capable router and the GR restarter. The P device is a GR-aware router and the GR helper.

Networking Topology

Figure 1-2 Networking topology for configuring LDP GR



Configuration Tips

Configure PE 1 and the P device as follows:

- Configure interface IP addresses and the Open Shortest Path First (OSPF) protocol.
- Enable global MPLS packet forwarding on devices, MPLS forwarding, and the LDP on interfaces.
- Configure the LDP to enable the network to forward MPLS traffic.
- Enable the LDP GR protocol.

- Configure parameters related to LDP GR.
- Restart the LDP session for the configurations to take effect.

Configuration Steps

- Configure interface IP addresses and the OSPF protocol.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
```

The **no switchport** command is used on a switch to switch to Routed Port mode. It is not applicable to routers, and therefore you do not need to run this command on routers.

```
Ruijie(config)#interface gigabitEthernet 2/1
Ruijie(config-if-GigabitEthernet 2/1)#no switchport
Ruijie(config-if-GigabitEthernet 2/1)#ip address 192.168.100.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 2/1)#exit
```

The **no switchport** command runs on a switch to switch to Routed Port mode. It is not applicable to routers, and therefore you do not need to run this command on routers.

```
Ruijie(config)#interface gigabitEthernet 2/2
Ruijie(config-if-GigabitEthernet 2/2)#no switchport
Ruijie(config-if-GigabitEthernet 2/2)#ip address 192.168.1.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 2/2)#exit
Ruijie(config)#interface loopback 0
Ruijie(config-Loopback 0)#ip address 192.168.0.1 255.255.255.255
Ruijie(config-Loopback 0)#exit
Ruijie(config)#router ospf 1
Router(config-router)#network 192.168.100.1 255.255.255.0 area 0
Router(config-router)#network 192.168.1.1 255.255.255.0 area 0
Router(config-router)#network 192.168.0.1 255.255.255.255 area 0
Router(config-router)#exit
```

Configure the P device by running the same commands as those on PE 1.

- Enable global MPLS forwarding on devices, MPLS packet forwarding, and the LDP on interfaces.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls ip
```

The **ip ref** command is used on a router to enable MPLS fast forwarding on the router. You do not need to run this command on switches.

```
Ruijie(config)#interface gigabitEthernet 2/2
Ruijie(config-if-GigabitEthernet 2/2)#label-switching
Ruijie(config-if-GigabitEthernet 2/2)#mpls ip
Ruijie(config-if-GigabitEthernet 2/2)#ip ref
```

```
Router(config-if-GigabitEthernet 2/2)#exit
```

Configure the P device.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls ip
```

The **ip ref** command is used on a router to enable MPLS fast forwarding on the router. You do not need to run this command on switches.

```
Ruijie(config)#interface gigabitEthernet 2/1
Ruijie(config-if-GigabitEthernet 2/1)#label-switching
Ruijie(config-if-GigabitEthernet 2/1)#mpls ip
Ruijie(config-if-GigabitEthernet 2/1)#ip ref
Router(config-if-GigabitEthernet 2/1)#exit
```

The **ip ref** command is used on a router to enable MPLS fast forwarding on the router. You do not need to run this command on switches.

```
Ruijie(config)#interface gigabitEthernet 2/2
Ruijie(config-if-GigabitEthernet 2/2)#label-switching
Ruijie(config-if-GigabitEthernet 2/2)#mpls ip
Ruijie(config-if-GigabitEthernet 2/2)#ip ref
Router(config-if-GigabitEthernet 2/2)#exit
```

- Configure the LDP to enable the network to forward MPLS traffic.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls router ldp
Ruijie(config-mpls-router)#ldp router-id interface loopback 0 force
```

Configure the P device.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls router ldp
Ruijie(config-mpls-router)#ldp router-id interface loopback 0 force
```

- Enable the LDP GR protocol.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls router ldp
Ruijie(config-mpls-router)#graceful-restart
```

Configure the P device.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
```

```
Ruijie(config)#mpls router ldp
Ruijie(config-mpls-router)#graceful-restart
```

- Configure parameters related to LDP GR.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls router ldp
```

Set the LDP reconnection time to 300 seconds, LDP neighbor keep-alive time to 120 seconds, and LDP recovery time to 120 seconds.

```
Ruijie(config-mpls-router)#graceful-restart timer reconnect 300
Ruijie(config-mpls-router)#graceful-restart timer neighbor-liveness 120
Ruijie(config-mpls-router)#graceful-restart timer recovery 120
Ruijie(config-mpls-router)#exit
```

Configure the P device.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls router ldp
```

Set the LDP reconnection time to 300 seconds, LDP neighbor keep-alive time to 120 seconds, and LDP recovery time to 120 seconds.

```
Ruijie(config-mpls-router)#graceful-restart timer reconnect 300
Ruijie(config-mpls-router)#graceful-restart timer neighbor-liveness 120
Ruijie(config-mpls-router)#graceful-restart timer recovery 120
Ruijie(config-mpls-router)#exit
```

- Restart the LDP session for the configurations to take effect.

Restart the LDP session on PE 1.

```
Ruijie#clear mpls ldp neighbor all
```

Restart the LDP session on the PE device.

```
Ruijie#clear mpls ldp neighbor all
```

Verification

Run the following commands to view configurations on PE 1:

View LDP GR information on PE 1.

```
Ruijie#show mpls ldp graceful-restart
Default VRF:
  LDP Graceful Restart is enabled
  Neighbor Liveness Timer: 120 seconds
  Max Recovery Time: 120 seconds
  Forwarding State Holding Time: 300 seconds
  Down Neighbor Database (1 records):
```

```
   Peer LDP Ident: 192.168.0.2:0; Local LDP Ident: 192.168.0.1:0
      Status: recovering (86 seconds left)
      Address list contains 3 addresses:
        192.168.1.2   192.168.2.1   192.168.0.2
 Graceful Restart-enabled Sessions:
   Peer LDP Ident: 192.168.0.2:0, State: estab
```

View LDP GR neighbor information on PE 1.

```
Ruijie#show mpls ldp neighbor
Default VRF:
   Peer LDP Ident: 192.168.0.2:0; Local LDP Ident: 192.168.0.1:0
      TCP connection: 192.168.0.2.15532 - 192.168.0.1.646
      State: OPERATIONAL; Msgs sent/recv: 23/27; UNSOLICITED
      Up time: 00:04:12
      Graceful Restart enabled; Peer reconnect time (msecs): 0
```

View LDP binding information on PE 1.

```
Router#show mpls ldp bindings
Default VRF:
   lib entry: 192.168.0.2/32
      local binding:  to lsr:  192.168.0.2:0, label: 1024
      remote binding: from lsr: 192.168.0.2:0, label: imp-null stale
lib entry: 192.168.1.2/24
      local binding:  to lsr:  192.168.0.2:0, label: 1025
      remote binding: from lsr: 192.168.0.2:0, label: imp-null stale
   lib entry: 192.168.2.1/24
      local binding:  to lsr:  192.168.0.2:0, label: 1026
      remote binding: from lsr: 192.168.0.2:0, label: imp-null stale
```

L3VPN GR

Overview

L3 VPN GR (VPN GR) implements uninterrupted forwarding of Virtual Private Network (VPN) services. It ensures that the data of VPN services can be normally forwarded when the control plane on a device fails, protecting VPN services on the network.

The following prerequisites must be met for VPN GR:

- Devices support 1+1 management board redundancy.
- Devices support uninterrupted forwarding of routing protocols.
- Devices support the BGP/MPLS GR protocol.
- Devices support the LDP GR protocol.

The objectives of VPN GR are to:

- Minimize routing protocol flapping during master/slave management board switchover.

- Minimize the impact on VPN services.
- Minimize Single-Point Failures (SPFs) on access devices and improve VPN network reliability.
- Minimize the packet loss rate of VPN traffic.

Note GR must be supported in unicast routing to implement uninterrupted forwarding of routing protocols. In other words, the device must support OSPF GR, IS-IS GR, or BGP GR.

Basic Concepts

GR Routers Classified by Capability

GR routers are classified by capability into GR-capable routers, GR-aware routers, and GR-unaware routers.

- GR-Capable Router

A GR-capable router is a router that has GR capability. In general, a GR-capable router is equipped with two management boards which work in 1+1 master/slave mode. The GR-capable router can send an advertisement packet to neighboring routers during master/slave switchover of the management boards, so that neighboring routers keep forwarding entries related to the GR-capable router. After master/slave switchover, routing tables are re-established without causing route flapping or changing the packet forwarding path, guaranteeing uninterrupted data forwarding in the system.

- GR-Aware Router

A GR-aware router is a router that has GR detection capability. It may be not equipped with two management boards but can detect that its neighbors are experiencing GR and can assist its neighbors to complete GR.

- GR-Unaware Router

A GR-unaware router is a router that does not have GR detection capability. It cannot detect that its neighbors are experiencing GR, cannot assist its neighbors to complete GR, and does not have GR capability. Generally, if a router has no awareness capability, it is because the system software does not provide the GR feature or the GR feature is disabled.

GR Routers Classified by Role

GR routers are classified by role during router restart into GR restarters and GR helpers.

- GR Restarter

The GR restarter has GR capability and its restart is triggered by administrators or faults.

- GR Helper

The GR helper is a neighbor of the GR restarter. It must be at least a GR-aware router.

Working Principle

Both the control plane and the forwarding plane on a traditional device are implemented by the same processor which simultaneously maintains a routing table and a forwarding table. To improve forwarding performance and reliability of devices, a multi-processor architecture is used on high-end and mid-range devices. The processors of control modules such as the routing protocol module are located on a master management board and data forwarding processors are located on line cards. In this manner,, the control plane and the forwarding plane are separated from each other so that data forwarding on line cards is not affected when the control plane is restarted. This technology provides a prerequisite

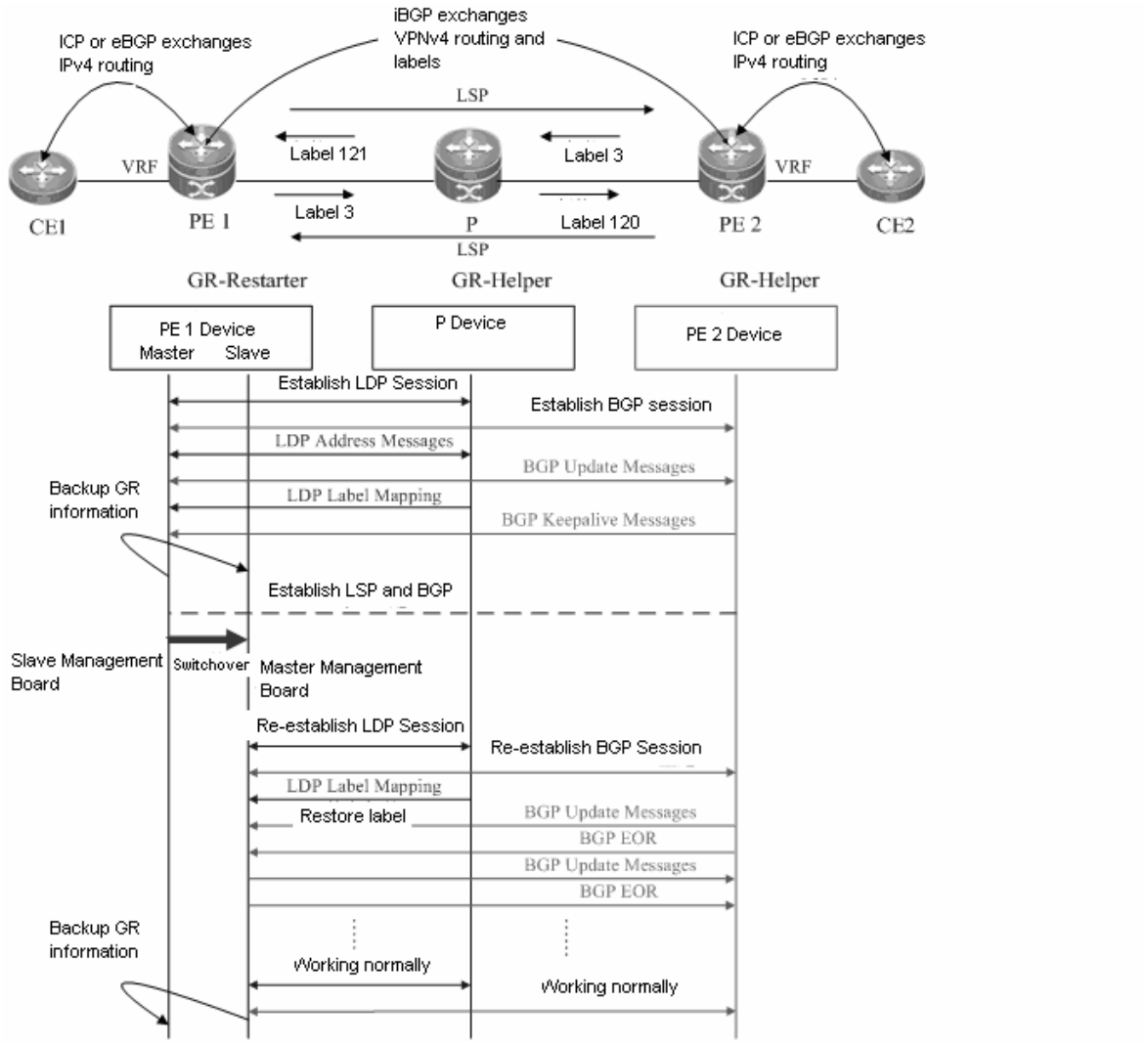
for implementing GR. The GR-capable routers mentioned in this document are such routers where the control plane and the forwarding plane are separated from each other.

The VPN network shown in Figure 1-3 has the following features:

- Customer Edge (CE) devices represent a customer network. The Interior Gateway Protocol (IGP) or Exterior Border Gateway Protocol (eBGP) runs on the CE devices.
- PE and P devices form a provider network. The IGP runs on these devices.
- Public network tunnels and Label Switching Paths (LSPs) are established using the LDP between PE 1, PE 2, and the P device.
- Private network tunnels are established using the Interior Border Gateway Protocol (iBGP) between PE 1 and PE 2.
- The IGP, BGP, and LDP have GR capability.
- PE devices are GR-capable routers, and the P device is a GR-aware router.

Note For details about IGP GR, BGP GR, and LDP GR, see related sections in *OSPF*, *BGP*, and *LDP GR*.

Figure 1-3 VPN networking topology



The following describes the GR process of the access device PE 1 of a provider network. Master/slave management board switchover occurs on PE 1. PE 1 works as a GR restarter and PE 2 and the P device works as GR helpers.. The process of master/slave management board switchover is as follows:

- Before master/slave management board switchover

PE 1 performs IGP GR or eBGP GR negotiation with the connected CE device, IGP GR and LDP GR negotiation with the P device, and iBGP GR negotiation with PE 2.

PE 1 sends an Initialization message that carries the optional FT Session TLV to the P device to establish a GR-capable LDP session. After the LDP session is established, they exchange LDP Address messages and Label Mapping messages with each other. In this manner, GR-capable LSPs are established for data forwarding.

PE 1 sends an Open message to PE 2 to establish a GR-capable iBGP session. The Open message carries GR capability parameters <AFI=IPv4, SAFI=Unicast> and <AFI=IPv4, SAFI=VPNv4>.

When the master management board works, the GR information is backed up to the slave management board. In this manner, the GR backup enables the system to access these original data during GR protocol restart and apply the data to the protocol GR process after master/slave management board switchover.

- During master/slave management board switchover

After the GR information on PE 1 is backed up to the slave management board,, the master/slave management board switchover is performed.

After detecting that the Transfer Control Protocol (TCP) session is down, the P device sets an "old" flag for the respective LSPs and starts a forwarding entry aging timer to continue to forward data before this aging timer expires.

After detecting that the TCP connection is broken, PE 2 immediately marks the route learned from PE 1 as "old" and starts a restart timer for PE 1. If PE 2 does not receive an Open message within the restart timer, it deletes the "old" flag for the route. If PE 2 receives an Open message, it deletes the restart timer. In this period of time, PE 1 and PE 2 continue to forward traffic along the original route.

- After master/slave management board switchover

The slave management board on PE 1 becomes the new master management board, and the original master management board becomes the new slave management board. The new master management board checks the GR information backed up and determines whether forwarding entries before the restart are retained. Then the Command Line Interface (CLI) configuration initialization process and the GR process continue. During IGP GR, BGP GR, and LDP GR, all the devices send notification messages to all IGP, BGP, and LDP neighbors for connection re-establishment.

113) IGP convergence

PE 1 sends an Initialization message that carries the FT Session TLV to the P device, and re-establishes a session upon receiving a response to obtain topology and routing information. PE 1 re-computes the routing table and deletes the "old" routes. The IGP convergence is completed.

114) BGP processing

PE 1 and CE 1 exchange routing information with each other. PE 1 updates its routing table and forwarding entries based on the new routing and forwarding information, substitutes invalid routes. The BGP convergence is completed.

PE 1 and PE 2 start to re-establish a BGP session with each other. PE 1 sends an Open message to PE 2. The Open message carries GR capability parameters. PE 1 receives and processes an Update message from PE 2. These

messages carry IP prefix information. PE 1 does not start BGP route preference until receiving an EOR flag from PE2. PE 1 sends an Update message that carries prefix information to PE 2. After sending the Update message, PE 1 sends the EOR flag to PE 2. After receiving the EOR flag, PE 2 starts BGP route preference. The network convergence is completed.

115) LDP processing

PE 1 sends an Initialization message that carries the FT Session TLV to the neighboring P device. A GR-capable LDP session is established after the P device receives the Initialization message. Then PE 1 and the P device exchange LDP Address and Label Mapping messages again with each other, and keep or remove the "old" flag set for MPLS forwarding entries. When the GR process ends, both devices delete their "old" MPLS forwarding entries respectively.

Note The preceding IGP GR, BGP GR, and LDP GR processes do not follow a strict priority sequence. In terms of route convergence, unicast routes converge first and converged routes are advertised to the LDP.

Before all protocols complete the GR process, only Routing Information Base (RIB) information on the master management board is updated. The Forwarding Information Base (FIB) information on interface boards is not updated.

The FIB information on interface boards is updated only after all protocols complete the GR process.

Protocols and Specifications

The protocols or specifications involved are as follows:

- RFC 4724: Graceful Restart Mechanism for BGP
- RFC 4781: Graceful Restart Mechanism for BGP with MPLS

Configuring L3VPN GR

Network Environment

On an MPLS network, L3VPN GR is required for the devices carrying L3VPN services. In this manner, data forwarding is not interrupted during master/slave management board switchover on devices, guaranteeing traffic continuity.

Note The GR capability does not guarantee traffic continuity when master/slave management board switchover also occurs on neighboring devices.

Prerequisites

Complete the following tasks before configuring L3VPN GR:

- Build an L3VPN environment and configure L3VPN.
- Ensure that devices support management board redundancy.
- Ensure that the IGP has GR capability.
- Ensure that the BGP has GR capability.
- Ensure that the LDP has GR capability.

Note For details about L3VPN configuration, see related sections in *BGP/MPLS VPN Configuration*.

Data Preparations

Prepare the following data before configuring L3VPN GR:

- IGP GR parameters
- BGP GR parameters
- LDP GR parameters

Configuring IGP GR

Note For details about IGP GR configuration, see related sections in *OSPF*.

Configuring BGP GR

Note For details about BGP GR configuration, see related sections in *BGP*.

Configuring LDP GR

Note For details about LDP GR configuration, see the "LDP GR" section in this document.

Verification

To display L3VPN GR configuration and running information, run the following commands:

Command	Function
show ip vrf [*vrf_name*]	Displays VRF configuration information.
show ip bgp vpnv4 {**all** | **rd** *route-distinguish* | **vrf** *vrf_name*} [*network-address*] **[summary**] [**neighbor] [label]**	Displays VPN routing information.
show ip bgp summary	Displays the status of all BGP connections.
show ip route vrf *vrf_name* [**A.B.C.D** | **bgp** | c**onnected | isis | ospf | rip | static | weight]**	Displays VRF routing information.
show mpls ldp graceful-restart [all | vrf *vrf-name***]**	Displays LDP GR sessions and session parameters.

Note All the preceding commands can be configured in any mode except for user mode.

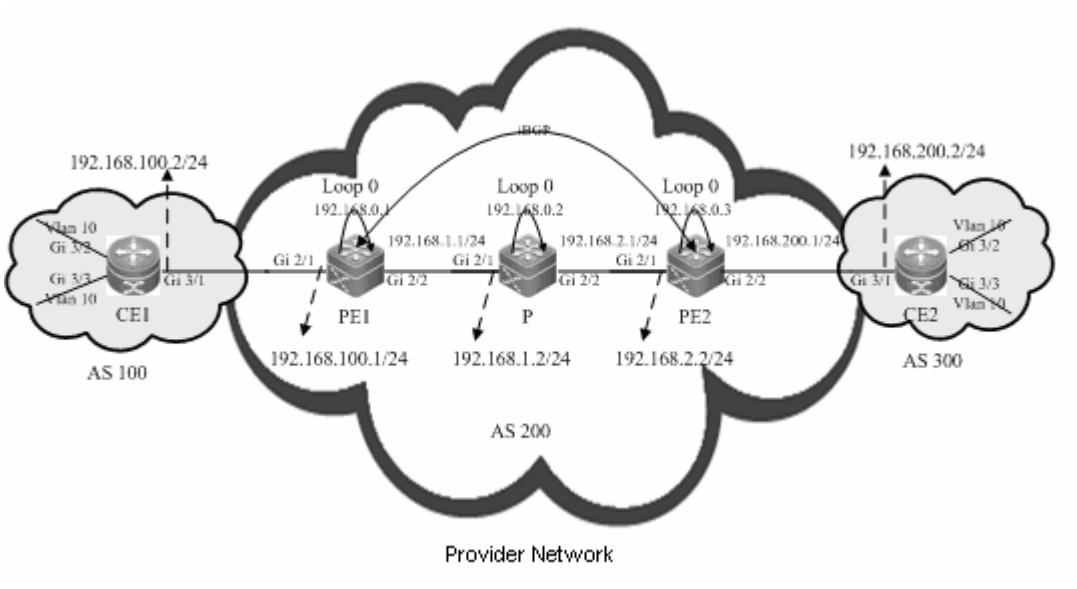
Configuration Examples

Networking Requirements

- CE devices represent a customer network. The IGP or eBGP runs on the CE devices.
- PE and P devices form a provider network. The IGP runs on these devices.
- Public network tunnels and LSPs are established using the LDP between PE 1, PE 2, and the P device.
- Private network tunnels are established using the iBGP between PE 1 and PE 2.
- The IGP, BGP, and LDP have GR capability.
- PE devices are GR-capable routers, and the P device is a GR-aware router.

Networking Topology

Figure 1-4 Networking topology for configuring L3VPN GR



Configuration Tips

Configure PE 1, PE 2, and the P device as follows:

- Configure VRF.
- Configure interface IP addresses and the OSPF protocol.
- Enable global MPLS forwarding on devices, MPLS packet forwarding, and the LDP on interfaces.
- Configure the LDP to enable the network to forward MPLS traffic.
- Enable the LDP GR protocol and configure parameters related to LDP GR.
- Configure L3VPN.
- Enable the BGP GR protocol.
- Restart the LDP session for the configurations to take effect.

Configuration Steps

- Configure VRF.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
```

Define VRF.

```
Ruijie(config)#ip vrf 10
Ruijie(config-vrf)#rd 1:100
Ruijie(config-vrf)#route-target both 1:100
Ruijie(config-vrf)#exit
```

Configure the P device. VRF configuration is not required on the P device.

Configure PE 2 by running the same commands as those on PE 1.

- Configure interface IP addresses and the OSPF protocol.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
```

The **no switchport** command is used on a switch to switch to Routed Port mode. It is not applicable to routers and therefore you do not need to run the command on routers.

```
Ruijie(config)#interface gigabitEthernet 2/1
Ruijie(config-if-GigabitEthernet 2/1)#no switchport
Ruijie(config-if-GigabitEthernet 2/1)#ip vrf forwarding 10
Ruijie(config-if-GigabitEthernet 2/1)#ip address 192.168.100.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 2/1)#exit
```

The **no switchport** command is used on a switch to switch to Routed Port mode. It is not applicable to routers and therefore you do not need to run the command on routers.

```
Ruijie(config)#interface gigabitEthernet 2/2
Ruijie(config-if-GigabitEthernet 2/2)#no switchport
Ruijie(config-if-GigabitEthernet 2/2)#ip address 192.168.1.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 2/2)#exit
```

Configure the loopback interface **loopback 0**.

```
Ruijie(config)#interface loopback 0
Ruijie(config-Loopback 0)#ip address 192.168.0.1 255.255.255.255
Ruijie(config-Loopback 0)#exit
```

Activate the OSPF protocol and enter OSPF mode.

```
Ruijie(config)#router ospf 10
Ruijie(config-router)#network 192.168.0.1 255.255.255.255 area 0
Ruijie(config-router)#network 192.168.1.0 255.255.255.0 area 0
Ruijie(config-router)#end
```

Configure the P device.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
```

The **no switchport** command is used on a switch to switch to Routed Port mode. It is not applicable to routers and therefore you do not need to run the command on routers.

```
Ruijie(config)#interface gigabitEthernet 2/1
Ruijie(config-if-GigabitEthernet 2/1)#no switchport
Ruijie(config-if-GigabitEthernet 2/1)#ip address 192.168.1.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 2/1)#exit
```

The **no switchport** command is used on a switch to switch to Routed Port mode. It is not applicable to routers and therefore you do not need to run the command on routers.

```
Ruijie(config)#interface gigabitEthernet 2/2
Ruijie(config-if-GigabitEthernet 2/2)#no switchport
Ruijie(config-if-GigabitEthernet 2/2)#ip address 192.168.2.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 2/2)#exit
```

Configure the loopback interface **loopback 0**.

```
Ruijie(config)#interface loopback 0
Ruijie(config-Loopback 0)#ip address 192.168.0.2 255.255.255.255
Ruijie(config-Loopback 0)#exit
```

Activate the OSPF protocol and enter OSPF mode.

```
Ruijie(config)#router ospf 10
Ruijie(config-router)#network 192.168.1.0 255.255.255.0 area 0
Ruijie(config-router)#network 192.168.2.0 255.255.255.0 area 0
Ruijie(config-router)#network 192.168.0.2 255.255.255.255 area 0
Ruijie(config-router)#end
```

Configure PE 2 by running the same commands as those on PE 1.

- Enable global MPLS forwarding on devices, MPLS packet forwarding, and the LDP on interfaces.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls ip
```

The **ip ref** command is used on a router to enable MPLS fast forwarding on the router. You do not need to run this command on switches.

```
Ruijie(config)#interface gigabitEthernet 2/2
Ruijie(config-if-GigabitEthernet 2/2)#label-switching
Ruijie(config-if-GigabitEthernet 2/2)#mpls ip
Ruijie(config-if-GigabitEthernet 2/2)#ip ref
Router(config-if-GigabitEthernet 2/2)#exit
```

Configure the P device.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
```

```
Ruijie(config)#mpls ip
```

The **ip ref** command is used on routers to enable MPLS fast forwarding on the router. You do not need to run this command on switches.

```
Ruijie(config)#interface gigabitEthernet 2/1
Ruijie(config-if-GigabitEthernet 2/1)#label-switching
Ruijie(config-if-GigabitEthernet 2/1)#mpls ip
Ruijie(config-if-GigabitEthernet 2/1)#ip ref
Router(config-if-GigabitEthernet 2/1)#exit
```

The **ip ref** command is used on a router to enable MPLS fast forwarding on the router. You do not run this command on switches.

```
Ruijie(config)#interface gigabitEthernet 2/2
Ruijie(config-if-GigabitEthernet 2/2)#label-switching
Ruijie(config-if-GigabitEthernet 2/2)#mpls ip
Ruijie(config-if-GigabitEthernet 2/2)#ip ref
Router(config-if-GigabitEthernet 2/2)#exit
```

Configure PE 2 by running the same commands as those on PE 1.

- Configure the LDP to enable the network to forward MPLS traffic.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls router ldp
Ruijie(config-mpls-router)#ldp router-id interface loopback 0 force
```

Configure the P device.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls router ldp
Ruijie(config-mpls-router)#ldp router-id interface loopback 0 force
```

Configure PE 2.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls router ldp
Ruijie(config-mpls-router)#ldp router-id interface loopback 0 force
```

Enable the LDP GR protocol, and configure parameters related to LDP GR.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls router ldp
Ruijie(config-mpls-router)#graceful-restart
```

Set the LDP reconnection time to 300 seconds, LDP neighbor keep-alive time to 120 seconds, and LDP recovery time to 120 seconds.

```
Ruijie(config-mpls-router)#graceful-restart timer reconnect 300
Ruijie(config-mpls-router)#graceful-restart timer neighbor-liveness 120
Ruijie(config-mpls-router)#graceful-restart timer recovery 120
Ruijie(config-mpls-router)#exit
```

Configure the P device.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls router ldp
Ruijie(config-mpls-router)#graceful-restart
```

Set the LDP reconnection time to 300 seconds, LDP neighbor keep-alive time to 120 seconds, and LDP recovery time to 120 seconds.

```
Ruijie(config-mpls-router)#graceful-restart timer reconnect 300
Ruijie(config-mpls-router)#graceful-restart timer neighbor-liveness 120
Ruijie(config-mpls-router)#graceful-restart timer recovery 120
Ruijie(config-mpls-router)#exit
```

Configure PE 2 by running the same commands as those on PE 1.

- Configure L3VPN.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
```

Configure the eBGP peer CE.

```
Ruijie(config)#router bgp 200
Ruijie(config-router)#address-family ipv4 vrf 10
Ruijie(config-router-af)#neighbor 192.168.100.2 remote-as 100
Ruijie(config-router-af)#neighbor 192.168.100.2 update-source GigabitEthernet 2/1
Ruijie(config-router-af)#neighbor 192.168.200.2 activate
Ruijie(config-router-af)#exit-address-family
Ruijie(config-router)#exit
```

Configure the iBGP peer PE 2.

```
Ruijie(config-router)#address-family ipv4
Ruijie(config-router-af)#neighbor 192.168.0.3 remote-as 200
Ruijie(config-router-af)#neighbor 192.168.0.3 update-source loopback 0
Ruijie(config-router-af)#neighbor 192.168.0.3 activate
Ruijie(config-router-af)#exit-address-family
Ruijie(config-router)#address-family vpnv4 unicast
Ruijie(config-router-af)#neighbor 192.168.0.3 activate
Ruijie(config-router-af)#exit-address-family
```

```
Ruijie(config-router)#exit
```

Configure the P device. L3VPN configuration is not required on the P device.

Configure PE 2 by running the same commands as those on PE 1.

- Enable the BGP GR protocol.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
```

Enable the BGP and enter BPG configuration mode.

```
Ruijie(config)#router bgp 200
```

Enable BGP GR.

```
Ruijie(config-router)#bgp graceful-restart
```

Configure the P device. BGP GR does not need to be enabled on the P device.

Configure PE 2 by running the same commands as those on PE 1.

Restart the LDP session for the configurations to take effect.

Restart the LDP session on PE 1.

```
Ruijie#clear mpls ldp neighbor all
```

Restart the LDP session on the PE device.

```
Ruijie#clear mpls ldp neighbor all
```

Restart the LDP session on PE 1.

```
Ruijie#clear mpls ldp neighbor all
```

Verification

Run the following commands to view configurations on PE 1:

View LDP GR information on PE 1.

```
Ruijie#show mpls ldp graceful-restart
Default VRF:
  LDP Graceful Restart is enabled
  Neighbor Liveness Timer: 120 seconds
  Max Recovery Time: 120 seconds
  Forwarding State Holding Time: 300 seconds
  Down Neighbor Database (1 records):
    Peer LDP Ident: 192.168.0.2:0; Local LDP Ident: 192.168.0.1:0
        Status: recovering (86 seconds left)
        Address list contains 3 addresses:
          192.168.0.2   192.168.1.2   192.168.2.1
  Graceful Restart-enabled Sessions:
```

```
   Peer LDP Ident: 192.168.0.2:0, State: estab
```

View BGP GR information on PE 1.

```
Ruijie#show bgp vpnv4 unicast all neighbor
BGP neighbor is 192.168.0.3, remote AS 200, internal link
BGP version 4, remote router ID 192.168.0.3
BGP state = Established, up for 02:49:47
Last read 00:00:47, hold time is 180, keepalive interval is 60 seconds
Neighbor capabilities:
Route refresh: advertised and received(new)
Address family VPNv4 Unicast: advertised and received
Graceful Restart Capability: advertised and received
Remote Restart timer is 120 seconds
Address families preserved by peer:
VPNv4 Unicast
```

L2VPN GR

Note L2VPN GR described in this section indicates GR for Virtual Pseudo Wire Service (VPWS) and Virtual Private LAN Service (VPLS).

Overview

For VPWS and VPLS services, public network tunnels are established based on basic MPLS network services. In addition, the extended LDP is used to distribute VC labels for the establishment of virtual lines. Therefore, extended LDP GR must be implemented to ensure uninterrupted forwarding of VPWS and VPLS services. Extended LDP GR is implemented based on the same working principles as basic LDP GR, except that the MPLS forwarding entries to be backed up are different. Therefore, extended LDP GR and basic LDP GR can be uniformly implemented.

Note For details about LDP GR and configuration methods, see the "LDP GR" section in this document.
The working principles of VPWS GR are described in the following text. That of VPLS GR is not described in this document.

VPWS GR implements uninterrupted forwarding of VPWS services. It ensures that the data of VPWS services can be forwarded when the control plane on a device fails, protecting VPWS services on the network. The following prerequisites must be met for VPWS GR:

- Devices support 1+1 management board redundancy.
- Devices support uninterrupted forwarding of routing protocols.
- Devices support the LDP GR protocol.

The objectives of VPWS GR are to:

- Minimize routing protocol flapping during master/slave management board switchover.

- Minimize the impact on VPWS services.
- Minimize SPFs on access devices and improve VPWS network reliability.
- Minimize the packet loss rate of VPWS traffic.

Note GR must be supported in unicast routing to implement uninterrupted forwarding of routing protocols. In other words, the device must support OSPF GR, IS-IS GR, or BGP GR.

Basic Concepts

GR Routers Classified by Capability

GR routers are classified by capability into GR-capable routers, GR-aware routers, and GR-unaware routers.

- GR-Capable Router

A GR-capable router is a router that has GR capability. In general, a GR-capable router is equipped with two management boards which work in 1+1 master/slave mode. The GR-capable router can send an advertisement packet to neighboring routers during master/slave switchover of the management boards, so that neighboring routers keep forwarding entries related to the GR-capable router. After master/slave switchover, routing tables are re-established without causing route flapping or changing the packet forwarding path, guaranteeing uninterrupted data forwarding in the system.

- GR-Aware Router

A GR-aware router is a router that has GR detection capability. It may be not equipped with two management boards but can detect that its neighbors are experiencing GR and can assist its neighbors to complete GR.

- GR-Unaware Router

A GR-unaware router is a router that does not have GR detection capability. It cannot detect that its neighbors are experiencing GR, cannot assist its neighbors to complete GR, and does not have GR capability. Generally, if a router has no awareness capability, it is because the system software does not provide the GR feature or the GR feature is disabled.

GR Routers Classified by Role

GR routers are classified by role during router restart into GR restarters and GR helpers.

- GR Restarter

The GR restarter has GR capability and its restart is triggered by administrators or faults.

- GR Helper

The GR helper is a neighbor of the GR restarter. It must be at least a GR-aware router.

Working Principle

Both the control plane and the forwarding plane on a traditional device are implemented by the same processor which simultaneously maintains a routing table and a forwarding table. To improve forwarding performance and reliability of devices, a multi-processor architecture is used on high-end and mid-range devices. The processors of control modules such as the routing protocol module are located on a master management board and data forwarding processors are located on line cards. In this manner,, the control plane and the forwarding plane are separated from each other so that data forwarding on line cards is not affected when the control plane is restarted. This technology provides a prerequisite

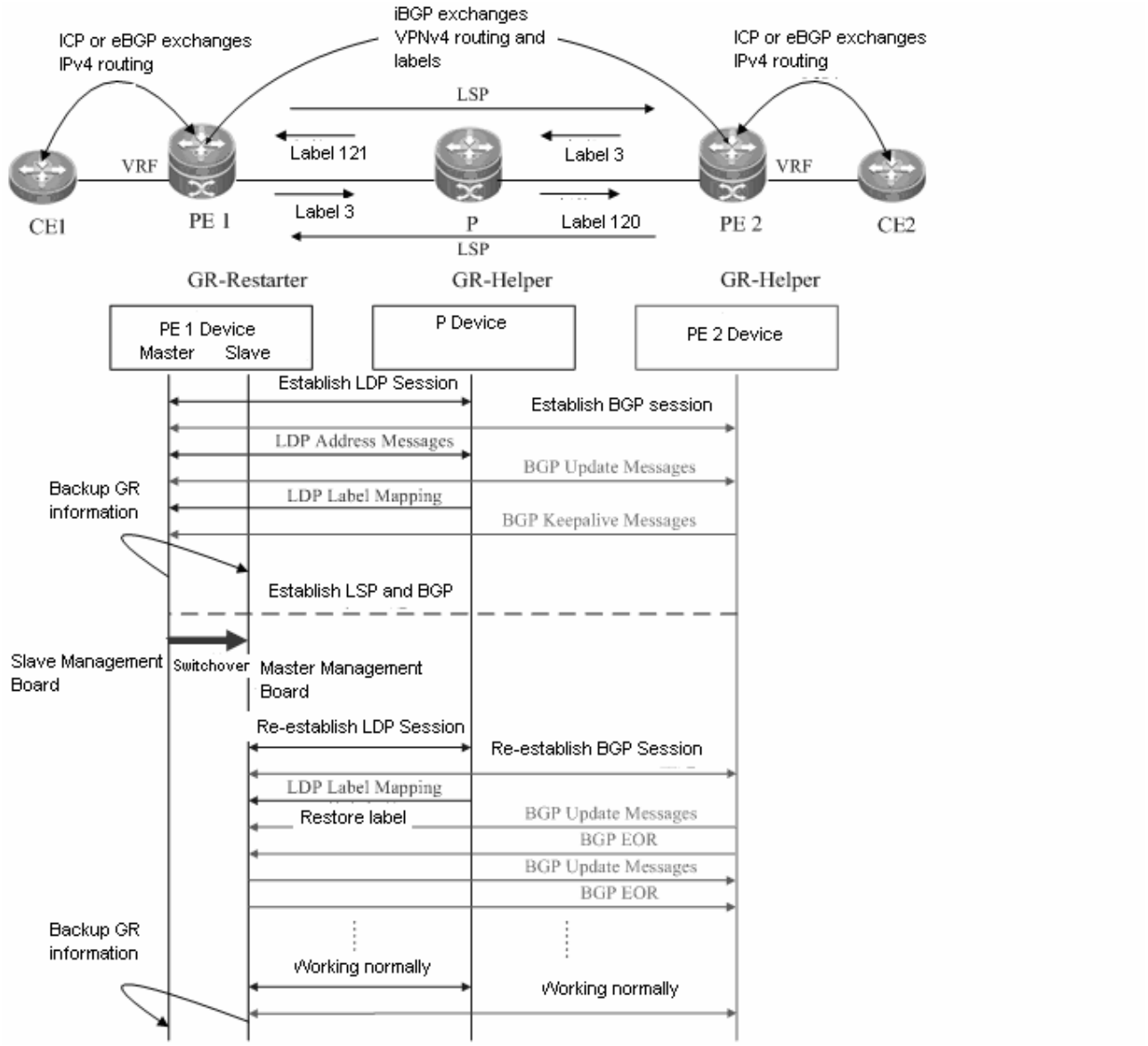
for implementing GR. The GR-capable routers mentioned in this document are such routers where the control plane and the forwarding plane are separated from each other.

The VPWS network shown in Figure 1-5 has the following features:

- CE devices represent a customer network. The IGP runs on the CE devices.
- PE and P devices form a provider network. The IGP and LDP run on these devices.
- Public network tunnels and LSPs are established using the LDP between PE 1, PE 2, and the P device.
- Private network tunnels are established using the LDP between PE 1 and PE 2.
- The IGP and LDP have GR capability.
- PE devices are GR-capable routers, and the P device is a GR-aware router.

Note For details about IGP GR and LDP GR, see related sections in *OSPF* and *LDP GR*.

Figure 1-5 VPWS networking topology



The following describes the GR process of the access device PE 1 of a provider network. Master/slave management board switchover occurs on PE 1. PE 1 works as a GR restarter, whereas PE 2 and the P device work as GR helpers. When master/slave management board switchover occurs on PE 1, a certain procedure applies. The procedure consists of the following three phases:

Before Master/Slave Management Board Switchover

PE 1 performs LDP GR and IGP GR negotiation with the P device, IGP GR negotiation with the connected CE device, and extended LDP GR negotiation with PE 2. PE 1 sends an Initialization message that carries the optional FT Session TLV to the P device and PE 2 to establish a GR-capable LDP session.

After the LDP session is established, they exchange LDP Address and Label Mapping messages with each other. In this manner, GR-capable LSPs are established for data forwarding.

When the master management board works normally, it must back up GR information to the slave management board to support GR.

During Master/Slave Management Board Switchover

GR information on PE 1 has been backed up to the slave management board. The major task of PE 1 in this phase is to perform master/slave management board switchover.

The P device and PE 2 detect that the TCP session is down, and therefore set an "old" flag for the respective LSPs. They also start a forwarding entry aging timer and continue to forward data before this aging timer expires. The working process on CEs is similar, except that it is an IGP GR process.

After Master/Slave Management Board Switchover

The slave management board on PE 1 becomes the new master management board, and the original master management board becomes the new slave management board. The new master management board starts to check the GR information previously backed up and determines whether forwarding entries before the restart are retained. Then the CLI configuration initialization process and the GR process continue. During LDP GR and IGP GR, all the devices send notification messages to all IGP and LDP neighbors for connection re-establishment.

- IGP convergence
- PE 1 sends an Initialization message that carries the FT Session TLV to the P device, and re-establishes a session upon receiving a response to obtain topology and routing information. Then PE 1 re-computes the routing table, deletes the "old" routes, and therefore completes IGP convergence.
- LDP processing
- PE 1 sends an Initialization message that carries the FT Session TLV to the neighboring P device and PE 2. A GR-capable LDP session is established after the P device and PE 2 receive the Initialization message. Then the devices exchange LDP Address and Label Mapping messages again with each other, and keep or remove the "old" flag set for MPLS forwarding entries. When the GR process ends, the P device, PE 1, and PE 2 delete the "old" MPLS forwarding entries from themselves respectively.

Note The preceding IGP GR and LDP GR processes do not follow a strict priority sequence. In terms of route convergence, IGP routes converge first and converged routes are advertised to the LDP.

Before all protocols complete the GR process, only RIB information on the master management board is updated. The FIB information on interface boards do not be updated.

The FIB information on interface boards is updated only after all protocols complete the GR process.

Protocols and Specifications

The following protocols or specifications involved are as follows:

- RFC 3036: LDP Specification
- RFC 3037: LDP Applicability
- RFC 3215: LDP State Machine
- RFC 3478: Graceful Restart Mechanism for LDP
- RFC 3479: Fault Tolerance for LDP

Configuring VPWS GR

Network Environment

VPWS GR is required for VPWS applications on service bearing devices on an MPLS network. In this manner, data forwarding is not interrupted during master/slave management board switchover on devices, guaranteeing traffic continuity.

Note The GR capability does not guarantee traffic continuity when master/slave management board switchover also occurs on neighboring devices.

Prerequisites

Complete the following tasks before configuring VPWS GR:

- Build a VPWS environment and configure VPWS.
- Ensure that the IGP has GR capability.
- Ensure that the LDP has GR capability.

Note For details about VPWS configuration, see the "Configuring VPWS" section in *MPLS*.

Data Preparations

Prepare the following data before configuring VPWS GR:

- IGP GR parameters
- LDP GR parameters

Configuring IGP GR

Note For details about IGP GR configuration, see related sections in *OSPF*.

Configuring LDP GR

Note For details about LDP GR configuration, see the "LDP GR" section in this document.

Verification

To display VPWS GR configuration and running information, run the following commands:

Command	Function
show mpls ldp graceful-restart [all | vrf *vrf-name*]	Displays LDP GR sessions and session parameters.
show mpls ldp vc [all | vpws | hub | spoke] [*vc-id*]	Displays LDP Pseudo Wire (PW) information.

Note All the preceding commands can be configured in any mode except for the user mode.

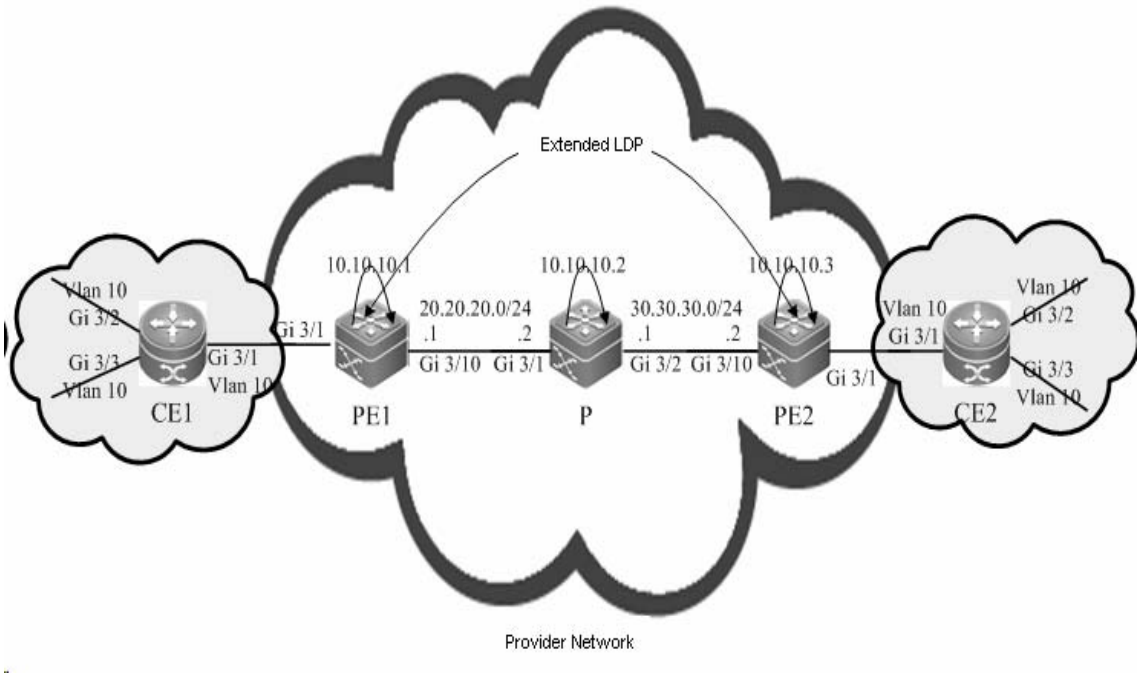
Configuration Examples

Networking Requirements

- Interconnection ports between PE and CE devices work in access mode, so that each CE device is connected to the respective PE device through an access link. The respective PE device establishes PW services for the Virtual Local Area Network (VLAN) to which the access port belongs. Since the Ethernet mode is applied, frames transmitted on the PW between PE 1 and PE 2 do not carry the VLAN 10 tag.
- CE, PE, and P devices support the LDP and are capable of GR.
- PE and P devices support the LDP and are capable of GR.
- PE and P devices form a provider network.
- PE devices are GR-capable routers, and the P device is a GR-aware router.

Networking Topology

Figure 1-6 Networking topology for configuring L2VPN GR



Configuration Tips

Configure PE 1, PE 2, and the P device as follows:

- Configure interface IP addresses and the OSPF protocol.
- Enable global MPLS forwarding on devices, MPLS packet forwarding, and the LDP on interfaces.
- Configure the LDP to enable the network to forward MPLS traffic.
- Configure VPWS.
- Enable the LDP GR protocol, and configure parameters related to LDP GR.
- Restart the LDP session for the configurations to take effect.

Configuration Steps

- Configure interface IP addresses and the OSPF protocol.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
```

The **no switchport** command is used on a switch to switch to the Routed Port mode. It is not applicable to routers and therefore you do not need to run the command on routers.

```
Ruijie(config)#interface gigabitEthernet 3/10
Ruijie(config-if-GigabitEthernet 3/10)#no switchport
Ruijie(config-if-GigabitEthernet 3/10)#ip address 20.20.20.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 3/10)#exit
Ruijie(config)#interface loopback 0
Ruijie(config-Loopback 0)#ip address 10.10.10.1 255.255.255.255
Ruijie(config-Loopback 0)#exit
```

Activate the OSPF protocol and enter OSPF mode.

```
Ruijie(config)#router ospf 10
Ruijie(config-router)#network 20.20.20.0 255.255.255.0 area 0
Ruijie(config-router)#network 10.10.10.1 255.255.255.255 area 0
Ruijie(config-router)#end
```

Configure the P device.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
```

The **no switchport** command is used on a switch to switch to Routed Port mode. It is not applicable to routers and therefore you do not need to run the command on routers.

```
Ruijie(config)#interface gigabitEthernet 3/1
Ruijie(config-if-GigabitEthernet 3/1)#no switchport
Ruijie(config-if-GigabitEthernet 3/1)#ip address 20.20.20.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 3/1)#exit
```

The **no switchport** command is used on a switch to switch to Routed Port mode. It is not applicable to routers and therefore you do not need to run the command on routers.

```
Ruijie(config)#interface gigabitEthernet 3/2
Ruijie(config-if-GigabitEthernet 3/2)#no switchport
Ruijie(config-if-GigabitEthernet 3/2)#ip address 30.30.30.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 3/2)#exit
```

Configure the loopback interface **loopback 0**.

```
Ruijie(config)#interface loopback 0
Ruijie(config-Loopback 0)#ip address 10.10.10.1 255.255.255.255
Ruijie(config-Loopback 0)#exit
```

Activate the OSPF protocol and enter OSPF mode.

```
Ruijie(config)#router ospf 10
Ruijie(config-router)#network 20.20.20.0 255.255.255.0 area 0
Ruijie(config-router)#network 30.30.30.0 255.255.255.0 area 0
Ruijie(config-router)#network 10.10.10.2 255.255.255.255 area 0
Ruijie(config-router)#end
```

Configure PE 2.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
```

The **no switchport** command is used on a switch to switch to Routed Port mode. It is not applicable to routers and therefore you do not need to run the command on routers.

```
Ruijie(config)#interface gigabitEthernet 3/10
Ruijie(config-if-GigabitEthernet 3/10)#no switchport
Ruijie(config-if-GigabitEthernet 3/10)#ip address 30.30.30.2 255.255.255.0
Ruijie(config-if-GigabitEthernet 3/10)#exit
```

Configure the loopback interface **loopback 0**.

```
Ruijie(config)#interface loopback 0
Ruijie(config-Loopback 0)#ip address 10.10.10.3 255.255.255.255
Ruijie(config-Loopback 0)#exit
```

Activate the OSPF protocol and enter OSPF mode.

```
Ruijie(config)#router ospf 10
Ruijie(config-router)#network 30.30.30.0 255.255.255.0 area 0
Ruijie(config-router)#network 10.10.10.3 255.255.255.255 area 0
Ruijie(config-router)#end
```

- Enable global MPLS forwarding on devices, MPLS packet forwarding, and the LDP on interfaces.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls ip
```

The **ip ref** command is used on a router to enable MPLS fast forwarding on the router. You do not need to run the command on switches.

```
Ruijie(config)#interface gigabitEthernet 3/10
Ruijie(config-if-GigabitEthernet 3/10)#label-switching
Ruijie(config-if-GigabitEthernet 3/10)#mpls ip
Ruijie(config-if-GigabitEthernet 3/10)#ip ref
Router(config-if-GigabitEthernet 3/10)#exit
```

Configure the P device.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls ip
```

The **ip ref** command is used on a router to enable MPLS fast forwarding on the router. You do not need to run the command on switches.

```
Ruijie(config)#interface gigabitEthernet 3/1
Ruijie(config-if-GigabitEthernet 3/1)#label-switching
Ruijie(config-if-GigabitEthernet 3/1)#mpls ip
Ruijie(config-if-GigabitEthernet 3/1)#ip ref
Router(config-if-GigabitEthernet 3/1)#exit
```

The **ip ref** command is run a router to enable MPLS fast forwarding on the router. You do not need to run this command on switches.

```
Ruijie(config)#interface gigabitEthernet 3/2
Ruijie(config-if-GigabitEthernet 3/2)#label-switching
Ruijie(config-if-GigabitEthernet 3/2)#mpls ip
Ruijie(config-if-GigabitEthernet 3/2)#ip ref
Router(config-if-GigabitEthernet 3/2)#exit
```

Configure PE 2 by running the same commands as those on PE 1.

- Configure the LDP to enable the network to forward MPLS traffic.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls router ldp
Ruijie(config-mpls-router)#ldp router-id interface loopback 0 force
```

Configure a remote LDP neighbor.

```
Ruijie(config-mpls-router)#neighbor 10.10.10.3
Ruijie(config-mpls-router)#exit
```

Configure the P device.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls router ldp
Ruijie(config-mpls-router)#ldp router-id interface loopback 0 force
```

Configure PE 2.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls router ldp
Ruijie(config-mpls-router)#ldp router-id interface loopback 0 force
```

Configure a remote LDP neighbor.

```
Ruijie(config-mpls-router)#neighbor 10.10.10.1
Ruijie(config-mpls-router)#exit
```

- Configure VPWS.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
```

Switch configurations

Configure access ports between PE 1 and CE 1.

```
Ruijie(config)#interface gigabitEthernet 3/1
Ruijie(config-if-GigabitEthernet 3/1)#switchport mode access
Ruijie(config-if-GigabitEthernet 3/1)#switchport access vlan 10
Ruijie(config-if-GigabitEthernet 3/1)#exit
```

Configure PW services for VLAN 10 on PE 1.

```
Ruijie(config)#interface vlan 10
Ruijie(config-if-VLAN 10)#xconnect 10.10.10.3 2 encapsulation mpls ethernet
Ruijie(config-if-VLAN 10)#exit
```

Router configurations

Configure PW services for the GE interface 3/1 on PE 1.

```
Ruijie(config)#interface gigabitEthernet 3/1
Ruijie(config-if-GigabitEthernet 3/1)#ip ref
Ruijie(config-if-GigabitEthernet 3/1)#xconnect 10.10.10.3 2 encapsulation mpls ethernet
Ruijie(config-if-GigabitEthernet 3/1)#exit
```

Configure PE 2.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
```

Switch configurations

Configure access ports between PE 2 and CE 2.

```
Ruijie(config)#interface gigabitEthernet 3/1
Ruijie(config-if-GigabitEthernet 3/1)#switchport mode access
Ruijie(config-if-GigabitEthernet 3/1)#switchport access vlan 10
Ruijie(config-if-GigabitEthernet 3/1)#exit
```

Configure PW services for VLAN 10 on PE 2.

```
Ruijie(config-if-VLAN 10)#interface vlan 10
Ruijie(config-if-VLAN 10)#xconnect 10.10.10.1 2 encapsulation mpls ethernet
Ruijie(config-if-VLAN 10)#exit
```

Router configurations

Configure PW services for the GE interface 3/1 on PE 2.

```
Ruijie(config)#interface gigabitEthernet 3/1
Ruijie(config-if-GigabitEthernet 3/1)#ip ref
Ruijie(config-if-GigabitEthernet 3/1)#xconnect 10.10.10.1 2 encapsulation mpls ethernet
Ruijie(config-if-GigabitEthernet 3/1)#exit
```

- Enable the LDP GR protocol, and configure parameters related to LDP GR.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls router ldp
Ruijie(config-mpls-router)#graceful-restart
```

Set the LDP reconnection time to 300 seconds, LDP neighbor keep-alive time to 120 seconds, and LDP recovery time to 120 seconds.

```
Ruijie(config-mpls-router)#graceful-restart timer reconnect 300
Ruijie(config-mpls-router)#graceful-restart timer neighbor-liveness 120
Ruijie(config-mpls-router)#graceful-restart timer recovery 120
Ruijie(config-mpls-router)#exit
```

Configure the P device.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls router ldp
Ruijie(config-mpls-router)#graceful-restart
```

Set the LDP reconnection time to 300 seconds, LDP neighbor keep-alive time to 120 seconds, and LDP recovery time to 120 seconds.

```
Ruijie(config-mpls-router)#graceful-restart timer reconnect 300
Ruijie(config-mpls-router)#graceful-restart timer neighbor-liveness 120
Ruijie(config-mpls-router)#graceful-restart timer recovery 120
Ruijie(config-mpls-router)#exit
```

Configure PE 2 by running the same commands as those on PE 1.

- Restart the LDP session for the configurations to take effect.

Restart the LDP session on PE 1.

```
Ruijie#clear mpls ldp neighbor all
```

Restart the LDP session on the PE device.

```
Ruijie#clear mpls ldp neighbor all
```

Restart the LDP session on PE 1.

```
Ruijie#clear mpls ldp neighbor all
```

Verification

Run the following commands to view configurations on PE 1:

View LDP GR information on PE 1.

```
Ruijie#show mpls ldp graceful-restart
Default VRF:
  LDP Graceful Restart is enabled
  Neighbor Liveness Timer: 120 seconds
  Max Recovery Time: 120 seconds
  Forwarding State Holding Time: 300 seconds
  Down Neighbor Database (1 records):
    Peer LDP Ident: 10.10.10.2:0; Local LDP Ident: 10.10.10.1:0
        Status: recovering (86 seconds left)
        Address list contains 3 addresses:
          10.10.10.2    20.20.20.2    30.30.30.1
  Graceful Restart-enabled Sessions:
Peer LDP Ident: 10.10.10.2:0, State: estab
```

MPLS BFD Configuration


Note

The routers or router icons involved in this chapter represent common routers or L3 switches where routing protocols are running.

☑ Currently, switches already support RGOS10.4(3).

Overview


Note

MPLS Bidirectional Forwarding Detection (BFD) is implemented in accordance with *BFD For MPLS LSPs* as defined by IETF. As a component of BFD applications, MPLS BFD describes a method for detecting MPLS LSPs. For details about BFD, see related sections in *BFD*.

In general, the following methods are used to detect LSP faults on an MPLS network:

- MPLS OAM mechanism. It can effectively detect, confirm, and locate internal defects or faults on an MPLS network. Currently, the standardization for MPLS OAM is still under way and various OAM mechanisms are in a starting-off phase in terms of practical network applications. Therefore, not all devices on a network can support the OAM.
- Hello packet mechanism of the MPLS signaling protocol. It takes a long time for the mechanism to detect a fault. In general, the detection time is a matter of seconds. Therefore, plenty of traffic is lost if the hello mechanism is applied.

MPLS BFD can resolve all the preceding problems. It has the following features:

- MPLS BFD supports interworking and provides a unified detection mechanism for the entire network.
- MPLS BFD provides fast detection. It makes possible lightly-loaded fast detection to quicken the start of a backup forwarding path and therefore improves MPLS network reliability.
- MPLS BFD can detect MPLS LSP faults on the data plane. BFD uses a fixed packet format which facilitates hardware implementation and firewall transversal.

EFD Session Establishment

BFD uses a local discriminator My Discriminator and a remote discriminator Your Discriminator to differentiate BFD sessions between a pair of systems. The discriminators can be configured in either manual or auto mode.

- Manual configuration: The local discriminator and the remote discriminator are manually configured for BFD. In this manner, the LSP Ping Echo packet to be sent before BFD session establishment does not need to carry any discriminator to perform negotiation and learn the remote discriminator. Instead, a BFD session is directly established.

- Auto configuration: The LSP Ping Echo packet to be sent before BFD session establishment carries a discriminator to perform negotiation and learn the remote discriminator before a BFD session is established.

At the initial stage of BFD session establishment, the roles of devices at both ends are classified into initiators and passive LSRs. Whether the ingress/egress LSR is an initiator or a passive LSR depends on specific applications, but at least one of them must be the initiator. Therefore, the following two scenarios may exist at the initial stage:

Both Are Initiators

If both the ingress LSR and the egress LSR are initiators, LSPs are unidirectional. Therefore, this scenario can be further divided into the following two cases:

- BFD is applied to detect both LSPs from the ingress LSR to the egress LSR and from the egress LSR to the ingress LSR

The ingress LSR sends an LSP Ping echo request that carries a local discriminator to the egress LSR. When the egress LSR receives the echo request, it obtains a remote discriminator from the echo request, so that the egress LSR owns both a local discriminator generated by itself and a remote discriminator. Then the egress LSR sends a BFD control packet to the ingress LSR. When the ingress LSR receives the BFD control packet, it obtains a remote discriminator from the received BFD control packet. Therefore, the ingress LSR also owns a local discriminator generated by itself and a remote discriminator, and then sends a BFD control packet to the egress LSR. Till now, both LSRs proceed to the initial stage of BFD session establishment.

You must noted that the egress LSR may return or not return an echo reply upon receipt of the echo request. If the egress LSR returns an echo reply, the echo reply must carry a local discriminator generated by the egress LSR itself. In this manner, the ingress LSR can obtain a remote discriminator from either the BFD control packet or the echo reply.

Note The working process on the egress LSR is similar to that on the ingress LSR.

- BFD is applied to detect the LSP from the ingress LSR to the egress LSR, and detect IP addresses (in a multi-hop situation) from the egress LSR to the ingress LSR

In this case, discriminators are manually configured on the ingress LSR and the egress LSR to establish a BFD session. In other words, the BFD session is established without experiencing automatic discriminator negotiation but the session establishment process directly starts after discriminators are manually configured on the two LSRs.

One Is the Initiator and the Other Is a Passive LSR

The initiator sends an LSP Ping echo request that carries a local discriminator to the passive LSR. When the passive LSR receives the echo request, it obtains a remote discriminator from the echo request, so that it owns both a local discriminator generated by itself and a remote discriminator. Then the passive LSR sends a BFD control packet to the initiator. When the initiator receives the BFD control packet, it obtains a remote discriminator from the received BFD control packet. Therefore, the initiator also owns a local discriminator generated by itself and a remote discriminator, and then sends a BFD control packet to the passive LSR. Till now, both LSRs proceed to the initial stage of BFD session establishment.

You must noted that the passive LSR may return or not return an echo reply upon receipt of the echo request. If the passive LSR returns an echo reply, the echo reply must carry a local discriminator generated by the passive LSR

itself. In this manner, the initiator can obtain a remote discriminator from either the BFD control packet or the echo reply.

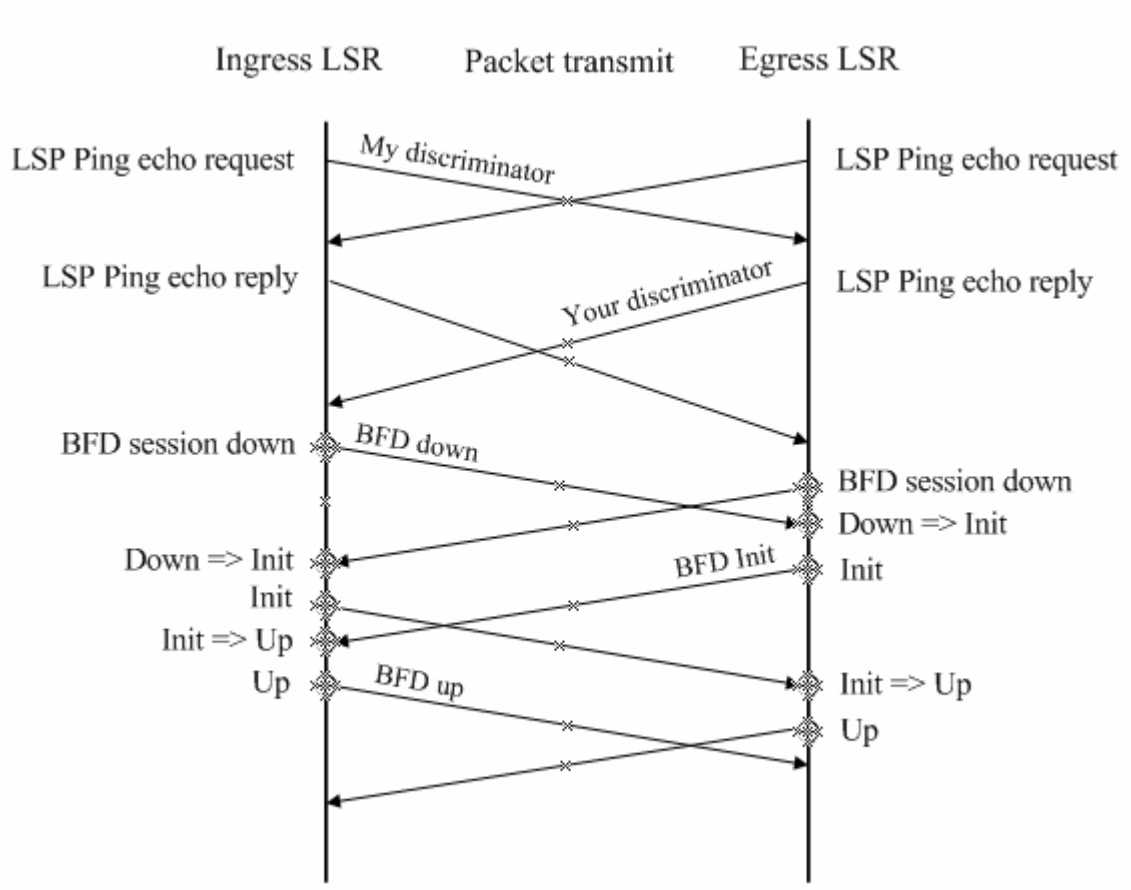
The passive LSR does not send any BFD control packet to the initiator unless it has received the echo request from the initiator.

Note Currently, only the first case is supported for BFD+LSP. That is, both LSRs must be initiators.

Example

This section describes the BFD session establishment process when both LSRs are initiators and BFD is applied to detect both LSPs from the ingress LSR to the egress LSR and from the egress LSR to the ingress LSR.

Figure 2-1 BFD session establishment process



- Before the ingress LSR and the egress LSR start BFD, they must learn the remote discriminator from each other and ensure that the LSPs are up. As shown in Figure 2-1, the ingress LSR sends an LSP Ping echo request that carries a local discriminator to the egress LSR. Upon receipt of the echo request, the egress LSR returns an echo reply that carries the local discriminator generated by the egress LSR itself to the ingress LSR. This is the same for the egress LSR. You must note that an LSR needs to learn the remote discriminator from the LSP Ping echo request if discriminators are not manually specified on both LSRs. If both the local discriminator and the remote discriminator are specified on both LSRs, this step does not apply during BFD

session establishment but the next step directly continues. For details about discriminator configuration, see the "BFD+LSP" section in this document.

- The ingress LSR and the egress LSR start the BFD mechanism. The initial BFD status is Down on both LSRs. Each LSR sends a BFD packet that carries the Down status.
- Upon receipt of the BFD packet that carries the Down status, the egress LSR transits its local BFD status to "Init" and sends a BFD packet that carries the Init status.
- The egress LSR no longer processes any received BFD packet that carries the Down status after its local BFD status changes to the Init state.
- The same BFD status transition process applies on the ingress LSR.
- When receiving a BFD packet that carries the Init status, the egress LSR changes its local BFD status to the Up status.
- The same BFD status transition process applies on the ingress LSR.
- The status of the local BFD session status is Up, indicating that a BFD session has been successfully established.

BFD Modes

Before two LSRs exchange BFD control packets, a BFD session must be established on the condition that the control plane and the data plane take the same path. The following two modes exist for BFD session operations:

- Asynchronous mode
- Inquiry mode

In addition to the two operation modes, an echo function is defined for BFD. The echo function can be applied to both the asynchronous mode and the inquiry mode.

Note Currently, only the asynchronous mode is supported for BFD+LSP. The inquiry mode and the echo function are not supported in the BFD+LSP scenario.

BFD+LSP

A BFD session is identified by a local discriminator My Discriminator and a remote discriminator Your Discriminator. The following two configuration modes can be applied to BFD+LSP based on the way by which the local discriminator and the remote discriminator are specified:

- Manual configuration
- In manual configuration mode, the local discriminator and remote discriminator are manually configured for BFD, so that the LSP Ping Echo packet to be sent before BFD session establishment does not need to carry any discriminator to perform negotiation and learn the remote discriminator. Instead, a BFD session is directly established.
- Auto configuration
- In automatic configuration mode, the LSP Ping Echo packet to be sent before BFD session establishment carries a discriminator to perform negotiation and learn the remote discriminator before a BFD session is established.

Currently, BFD+LSP is classified into BFD for static LSPs and BFD for LDP LSPs based on LSP type.

BFD for Static LSPs

BFD for static LSPs can be configured in manual or automatic mode. Since LSPs are unidirectional links but BFD is a bidirectional mechanism, reverse link detection can be performed based on one of the following detection methods when BFD is used to detect static LSPs:

- IP address mode for reverse link detection
- Static LSP mode for reverse link detection

BFD for LDP LSPs

BFD for static LSPs can be configured in manual or automatic mode. Since LSPs are unidirectional links but BFD is a bidirectional mechanism, reverse link detection can be performed based on one of the following detection methods when BFD is used to detect LDP LSPs:

- IP address mode for reverse link detection
- LDP LSP mode for reverse link detection

LDP LSPs bear basic VPN/PW public network services, so BFD for LDP LSPs is a mechanism for detecting faults of basic VPN/PW public network services. It provides fast detection for MPLS-based applications, such as VPN FRR and PW FRR, to protect services and guarantee MPLS network reliability.

Default Settings

Feature	Default
BFD session establishment mode	Active mode. Both LSRs must be initiators during BFD+LSP applications.
BFD mode	Asynchronous mode. Currently, only the asynchronous mode is supported for BFD+LSP. The inquiry mode and the echo function are not supported in the BFD+LSP scenario.
BFD session parameters	No default values are available. The BFD session parameters must be configured.
BFD authentication mode	Disabled. BFD authentication is not supported.

Protocols and Specifications

The following protocols or specifications involved are as follows:

- draft-ietf-bfd-base-09: Bidirectional Forwarding Detection
- draft-ietf-bfd-generic-05: Generic Application of BFD
- draft-ietf-bfd-mib-06: Bidirectional Forwarding Detection Management Information Base
- draft-ietf-bfd-v4v6-1hop-09: BFD for IPv4 and IPv6 (Single Hop)
- draft-ietf-bfd-multihop-07: BFD for IPv4 and IPv6 (Multihop)
- draft-ietf-bfd-mpls-07: BFD For MPLS LSPs

Configuring MPLS BFD

Configuring BFD for Static LSPs

Network Environment

BFD can be used to detect the continuity of static LSPs. When BFD is used for static LSPs, a static LSP that is down is not selected as the forwarding path of a private network route.

Prerequisites

Complete the following tasks before configuring BFD for static LSPs:

- Enable MPLS.
- Configure static LSPs.

Data Preparations

Prepare the following data before configuring BFD for static LSPs:

- My Discriminator and Your Discriminator of the BFD session
- Selection of the reverse link detection method
- BFD session parameters: BFD control packet sending interval, BFD control packet receiving interval, and the detection multiplier of BFD control packets

Configuring BFD on the Ingress LSR

By default, BFD for static LSPs is disabled on a device. To enable BFD for static LSPs on a device, enter privileged user mode to run the following commands:

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface type ID**	Enters the interface configuration mode.
Ruijie(config-if-type ID)# **bfd interval** *milliseconds* min_rx *milliseconds* multiplier *multiplier-value*	Sets BFD session parameters.
Ruijie(config-if-type ID)# **exit**	Exits interface configuration mode.
Ruijie(config)# **bfd bind static-lsp peer-ip** *ip-address* s**ource-ip** *ip-address* [l**ocal-discriminator** *discr-value* **remote-discriminato**r *discr-value*] [**process-state**]	Sets BFD for static LSPs along with BFD session status handling. If manual configuration is applied on the ingress LSR, manual configuration must also be applied on the egress LSR. In other words, the configuration modes on both LSRs must be symmetrical.

To disable BFD for static LSPs, run the **no bfd bind static-lsp peer-ip** *ip-address* command.

Caution Only static LSPs established by host route triggering are supported in BFD for static LSPs.
The *process-state* parameter must be specified for applications using BFD for fault detection, for

example, when BFD is combined with LSP.

If discriminators are manually configured, the local and remote discriminators configured on the ingress LSR must match with those configured on the egress LSR.

Configuring BFD on the Egress LSR

By default, BFD for static LSPs is disabled on a device. To enable BFD for static LSPs on a device, enter privileged user mode to run the following commands:

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface type ID**	Enters interface configuration mode.
Ruijie(config-if-type ID)# **bfd interval** *milliseconds* min_rx *milliseconds* **multiplier** *multiplier-value*	Sets BFD session parameters.
Ruijie(config-if- type ID)# exit	Exits interface configuration mode.
Ruijie(config)# **bfd bind static-lsp peer-ip** *ip-address* **source-ip** *ip-address* [**local-discriminator** *discr-value* re**mote-discriminator** *discr-value*] **[process-state]**	Sets BFD for static LSPs without BFD session status handling. If manual configuration is applied on the ingress LSR, manual configuration must also be applied on the egress LSR. In other words, the configuration modes on both LSRs must be symmetrical.
Or:	
bfd bind backward-lsp-with-ip peer-ip *ip-address* **[vrf** *vrf-name*] **interface** *interface-type interface-number* **[source-ip** *ip-address*] {l**ocal-discriminator** *discr-valu***e remote-discriminator** *discr-value*}	Sets the IP address mode for reverse link detection in BFD for LSPs. If the IP mode is applied for LSP reverse link detection during configuration, a local discriminator and a remote discriminator must be manually specified for the forward LSP.
Ruijie(config)# **exit**	Exits global configuration mode.

To disable BFD for static LSPs, run the **no bfd bind static-lsp peer-ip** *ip-address* or no bfd bind **backward-lsp-with-ip peer-ip** *ip-address* [**vrf** *vrf-name*] command.

Caution Only static LSPs established by host route triggering are supported in BFD for static LSPs.

The IP detection mode can be applied on the reverse link during BFD for LSPs.

If discriminators are manually configured, the local and remote discriminators configured on the egress LSR must match with those configured on the ingress LSR.

Verification

To display configuration and running information about BFD for static LSPs, run the following commands:

Command	Function
show bfd neighbors [vrf *vrf-name*] [i**pv4** *ip-address* [**details]	client {static-lsp	backward-lsp-with-**ip} **[ipv4** *ip-address* [**details]	[details**]]	Displays BFD session information.

Configuring BFD for LDP LSPs

Network Environment

BFD can be used to detect the continuity of LDP LSPs. When BFD is used with LDP LSPs, an LDP LSP that is Down is not selected as the forwarding path of a private network route.

Prerequisites

Complete the following tasks before configuring BFD for LDP LSPs:

- Enable MPLS.
- Enable LDP.

Data Preparations

Prepare the following data before configuring BFD for LDP LSPs:

- My Discriminator and Your Discriminator of the BFD session
- Selection of the reverse link detection method
- BFD session parameters: BFD control packet sending interval, BFD control packet receiving interval, and the detection multiplier of BFD control packets

Configuring BFD on the Ingress LSR

By default, BFD for LDP LSPs is disabled on a device. To enable BFD for LDP LSPs on a device, enter privileged user mode to run the following commands:

Command	Function
Ruijie# **configure terminal**	Enters the global configuration mode
Ruijie(config)# **interface type ID**	Enters interface configuration mode.
Ruijie(config-if-type ID)# **bfd interval** *milliseconds* min_rx *milliseconds* **multiplier** *multiplier-value*	Sets BFD session parameters.
Ruijie(config-if-type ID)# **exit**	Exits interface configuration mode.
Ruijie(config)**#mpls router ldp**	Enters LDP configuration mode.
Ruijie(config-mpls-router)# **bfd bind ldp-lsp peer-ip** *ip-address* **nexthop** *ip-address* **[interface** *interface-type interface-number*] **source-ip** *ip-address* **[local-discriminator** *discr-value* **remote-discriminato**r *discr-value*] [**process-state**]	Sets BFD for LDP LSPs along with BFD session status handling. If manual configuration is applied on the ingress LSR, manual configuration must also be applied on the egress LSR. In other words, the configuration modes on both LSRs must be symmetrical.

To disable BFD for LDP LSPs, run the **no bfd bind ldp-lsp peer-ip** *ip-address* command.

Caution

Only LDP LSP established by host route triggering is supported in BFD for LDP LSPs.
One LSP can be bound to only one BFD session.
BFD binding can be performed only on the ingress LSR of the LDP LSP.
The *process-state* parameter must be specified for applications using BFD for fault detection, for example, when BFD is combined with LSP.
If discriminators are manually configured, the local and remote discriminators configured on the ingress LSR must match with those configured on the egress LSR.

Configuring BFD on the Egress LSR

By default, BFD for LDP LSPs is disabled on a device. To enable BFD for LDP LSPs on a device, enter the privileged user mode to run the following commands:

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface type ID**	Enters interface configuration mode.
Ruijie(config-if-type ID)# **bfd interval** *milliseconds* min_rx *milliseconds* **multiplier** *multiplier-value*	Sets BFD session parameters.
Ruijie(config-if-type ID)# **exit**	Exits interface configuration mode.
Ruijie(config)# **bfd bind backward-lsp-with-ip peer-ip** *ip-address* [**vrf** *vrf-name*] **interface** *interface-type interface-number* **[source-ip** *ip-address*] l**ocal-discriminator** *discr-value* **remote-discriminato**r *discr-value*	Sets the IP address mode for reverse link detection in BFD for LSPs. If the IP mode is applied for LSP reverse link detection during configuration, a local discriminator and a remote discriminator must be manually specified for the forward LSP.
Or:	
Ruijie(config)#**mpls router ldp**	Enters LDP configuration mode.
Ruijie(config-mpls-router)# **bfd bind ldp-lsp peer-i**p *ip-address* **nexthop** *ip-address* [i**nterface** *interface-type interface-number*] **source-ip** *ip-address* **[local-discriminator** *discr-value* **remote-discriminato**r *discr-value*] [**process-state**]	Sets BFD for LDP LSPs without BFD session status handling. If manual configuration is applied on the ingress LSR, manual configuration must also be applied on the egress LSR. In other words, the configuration modes on both LSRs must be symmetrical.
Ruijie(config-bfd-router)# **exit**	Exits the LDP configuration mode.

To disable BFD for LDP LSPs, run the **no bfd bind backward-lsp-with-ip peer-ip** *ip-address* [**vrf** *vrf-name*] or **no bfd bind ldp-lsp peer-ip** *ip-address* command.

Caution

The IP detection mode can be applied on the reverse link during BFD for LSPs.
Or BFD can be configured to detect the other LSP.
1. Only LDP LSPs established by host route triggering are supported in BFD for LDP LSPs.
2. One LSP can be bound to only one BFD session.

3. BFD binding can be performed only on the ingress LSR of the LDP LSP.
If discriminators are manually configured, the local and remote discriminators configured on the egress LSR must match with those configured on the ingress LSR.

Verification

To display configuration and running information about BFD for LDP LSPs, run the following commands:

Command	Function
show bfd neighbors [**vrf** *vrf-name*] [**ipv4** *ip-address* [**details]	client {ldp-lsp	backward-lsp-with-**ip} [**ipv4** *ip-address* [**details]	[details]**]	Displays BFD session information.

Configuration Examples

Configuring BFD for Static LSPs

Networking Requirements

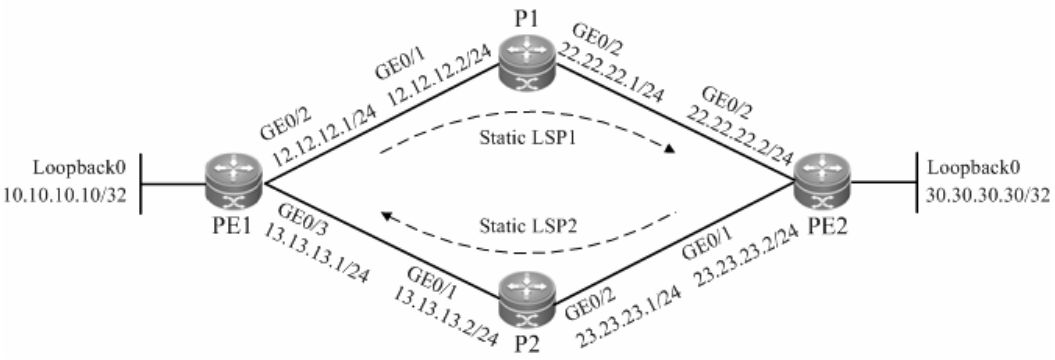
BFD can be configured to detect the continuity of static LSPs. Two links exist between PE 1 and PE 2, as shown in Figure 2-2.

- PE 1, PE 2, P1, and P2 form an MPLS network.
- A static LSP (LSP 1) exists and spans PE 1, P1 and PE 2 in turn. BFD is configured to detect this static LSP.
- A static LSP (LSP 2) exists and spans PE 2, P2 and PE 1 in turn. BFD is configured to detect this static LSP and notify faults if any to PE 1. This static LSP is used on the reverse link.

If LSP 1 fails, PE 1 can quickly receive a fault notification and handle the fault by deleting respective static MPLS routes.

Networking Topology

Figure 2-2 Networking topology for configuring BFD for static LSPs



Configuration Tips

Configure all devices as follows:

- Configure interface IP addresses and the OSPF protocol on devices.

- Enable global MPLS forwarding on all devices, and MPLS packet forwarding on interfaces.
- Configure static MPLS routes on the devices to enable the network to forward MPLS traffic.
- Configure BFD on PE 1 to detect static LSP 1.
- Configure BFD on PE 2 to detect static LSP 2, which is used as the LSP on the reverse link.

Configuration Steps

Configure interface IP addresses and the OSPF protocol on devices.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#interface gigabitEthernet 0/2
Ruijie(config-if-GigabitEthernet 0/2)#no switchport
Ruijie(config-if-GigabitEthernet 0/2)#ip address 12.12.12.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/2)#exit
Ruijie(config)#interface gigabitEthernet 0/3
Ruijie(config-if-GigabitEthernet 0/3)#no switchport
Ruijie(config-if-GigabitEthernet 0/3)#ip address 13.13.13.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/3)#exit
Ruijie(config)#interface loopback 0
Ruijie(config-Loopback 0)#ip address 10.10.10.10 255.255.255.255
Ruijie(config-Loopback 0)#exit
Ruijie(config)#router ospf 1
Router(config-router)#network 12.12.12.1 255.255.255.0 area 0
Router(config-router)#network 13.13.13.1 255.255.255.0 area 0
Router(config-router)#network 10.10.10.10 255.255.255.255 area 0
Router(config-router)#exit
```

Configure the other devices by running the same commands as those on PE 1.

Enable global MPLS forwarding on all devices, and MPLS packet forwarding on interfaces.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls ip
Ruijie(config)#interface gigabitEthernet 0/2
Ruijie(config-if-GigabitEthernet 0/2)#label-switching
Ruijie(config-if-GigabitEthernet 0/2)#mpls ip
Router(config-if-GigabitEthernet 0/2)#exit
Ruijie(config)#interface gigabitEthernet 0/3
Ruijie(config-if-GigabitEthernet 0/3)#label-switching
Ruijie(config-if-GigabitEthernet 0/3)#mpls ip
Router(config-if-GigabitEthernet 0/3)#exit
```

Configure the other devices by running the same commands as those on PE 1.

Configure static MPLS routes on the devices to enable the network to forward MPLS traffic.

Configure static LSP 1: PE1->P1->PE2.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls static ftn 30.30.30.30/32 out-label 16 nexthop gigabitEthernet 0/2
12.12.12.2
```

Configure P1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls static ilm in-label 16 forward-action swap-label 3 nexthop
gigabitEthernet 0/2 22.22.22.2 fec 30.30.30.30/32
```

Run the **ping mpls ipv4** *30.30.30.30* command on PE 1 after the preceding configurations are complete. Ensure that the ping operation is successful.

Configure static LSP 2: PE2->P2->PE1.

Configure PE 2.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls static ftn 10.10.10.10/32 out-label 16 nexthop gigabitEthernet 0/1
23.23.23.1
```

Configure P2.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls static ilm in-label 16 forward-action swap-label 3 nexthop
gigabitEthernet 0/1 13.13.13.1 fec 10.10.10.10/32
```

Run the **ping mpls ipv4** *10.10.10.10* command on PE 2 after the preceding configurations are complete. Ensure that the ping operation is successful.

Configure BFD on PE 1 to detect LSP 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#interface gigabitEthernet 0/2
Ruijie(config-if-GigabitEthernet 0/2)#bfd interval 50 min_rx 50 multiplier 3
Ruijie(config-if-GigabitEthernet 0/2)#exit
Ruijie(config)#bfd bind static-lsp peer-ip 30.30.30.30 source-ip 10.10.10.10
local-discriminator 1 remote-discriminator 2 process-state
Ruijie(config)#exit
```

Configure BFD on PE 2 to detect LSP 2, which is used as the LSP on the reverse link.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)#bfd interval 50 min_rx 50 multiplier 3
Ruijie(config-if-GigabitEthernet 0/1)#exit
Ruijie(config)#bfd bind static-lsp peer-ip 10.10.10.10 source-ip 30.30.30.30
local-discriminator 2 remote-discriminator 1
Ruijie(config)#exit
```

Verification

View BFD session establishment information.

View BFD session establishment information on PE 1.

```
Ruijie# show bfd neighbors details
OurAddr        NeighAddr      LD/RD   RH  Holdown(mult)  State   Int
10.10.10.10    30.30.30.30    1/2        1      532 (3 )       Up      Ge2/1
Local Diag: 0, Demand mode: 0, Poll bit: 0
MinTxInt: 200000, MinRxInt: 200000, Multiplier: 3
Received MinRxInt: 50000, Received Multiplier: 3
Holdown (hits): 600(22), Hello (hits): 200(84453)
Rx Count: 49824, Rx Interval (ms) min/max/avg: 208/440/332
Tx Count: 84488, Tx Interval (ms) min/max/avg: 152/248/196
Registered protocols: static-lsp
Uptime: 02:18:49
Last packet:   Version: 1            - Diagnostic: 0
I Hear You bit: 1     - Demand bit: 0
Poll bit: 0           - Final bit: 0
Multiplier: 3             - Length: 24
My Discr.: 2          - Your Discr.: 1
Min tx interval: 50000    - Min rx interval: 50000
Min Echo interval: 0
```

View BFD session establishment information on PE 2.

```
Ruijie# show bfd neighbors details
OurAddr        NeighAddr      LD/RD   RH  Holdown(mult)  State   Int
30.30.30.30    10.10.10.10    1/2        1      532 (3 )       Up      Ge2/1
Local Diag: 0, Demand mode: 0, Poll bit: 0
MinTxInt: 200000, MinRxInt: 200000, Multiplier: 3
Received MinRxInt: 50000, Received Multiplier: 3
Holdown (hits): 600(22), Hello (hits): 200(84453)
Rx Count: 49824, Rx Interval (ms) min/max/avg: 208/440/332
Tx Count: 84488, Tx Interval (ms) min/max/avg: 152/248/196
Registered protocols: static-lsp
Uptime: 02:18:49
Last packet:   Version: 1            - Diagnostic: 0
```

```
I Hear You bit: 1      - Demand bit: 0
Poll bit: 0            - Final bit: 0
Multiplier: 3              - Length: 24
My Discr.: 2           - Your Discr.: 1
Min tx interval: 50000     - Min rx interval: 50000
Min Echo interval: 0
```

Configuring BFD for LDP LSPs

Networking Requirements

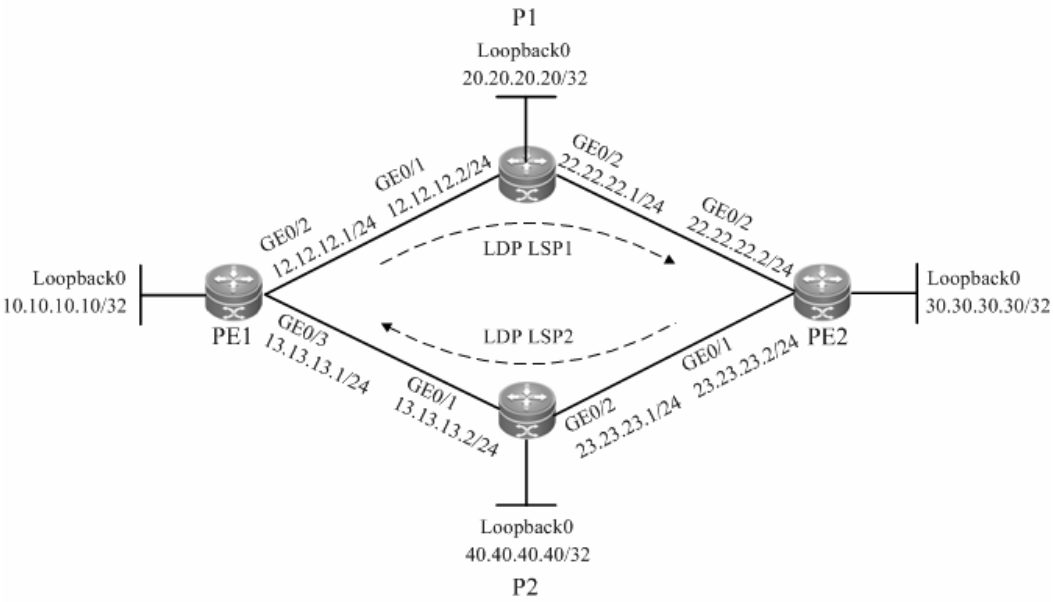
BFD can be configured to detect the continuity of LDP LSPs. Two links exist between PE 1 and PE 2, as shown in Figure 2-3.

- PE 1, PE 2, P1, and P2 form an MPLS network.
- Costs are configured for the interfaces on PE 1 and PE 2, so that two LSPs can be established between PE 1 and PE 2, as shown in Figure 2-3.
- An LDP LSP (LDP LSP 1) exists and spans PE 1, P1 and PE 2 in turn. BFD is configured to detect this LDP LSP.
- An LDP LSP (LDP LSP 2) exists and spans PE 2, P2 and PE 1 in turn. BFD is configured to detect this LDP LSP and notify faults if any to PE 1. This LDP LSP is used on the reverse link.

If LDP LSP 1 fails, PE 1 can quickly receive a fault notification and handle the fault by deleting respective MPLS routes.

Networking Topology

Figure 2-3 Networking topology for configuring BFD for LDP LSPs



Configuration Tips

Configure all devices as follows:

- Configure interface IP addresses and the OSPF protocol on devices.

- Enable global MPLS forwarding on devices, MPLS packet forwarding, and the LDP on interfaces.
- Configure the LDP to enable the network to forward MPLS traffic.
- Configure BFD on PE 1 to detect LDP LSP 1.
- Configure BFD on PE 2 to detect LDP LSP 2, which is used as the LSP on the reverse link.

Configuration Steps

Configure interface IP addresses and the OSPF protocol on devices.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
```

The **no switchport** command is used on a switch to switch to Routed Port mode. It is not applicable to routers, and therefore you do not need to run this command on routers.

```
Ruijie(config)#interface gigabitEthernet 0/2
Ruijie(config-if-GigabitEthernet 0/2)#no switchport
Ruijie(config-if-GigabitEthernet 0/2)#ip address 12.12.12.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/2)#exit
```

The **no switchport** command is used on a switch to switch to Routed Port mode. It is not applicable to routers, and therefore you do not need to run this command on routers.

```
Ruijie(config)#interface gigabitEthernet 0/3
Ruijie(config-if-GigabitEthernet 0/3)#no switchport
Ruijie(config-if-GigabitEthernet 0/3)#ip address 13.13.13.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/3)#exit
Ruijie(config)#interface loopback 0
Ruijie(config-Loopback 0)#ip address 10.10.10.10 255.255.255.255
Ruijie(config-Loopback 0)#exit
Ruijie(config)#router ospf 1
Router(config-router)#network 12.12.12.1 255.255.255.0 area 0
Router(config-router)#network 13.13.13.1 255.255.255.0 area 0
Router(config-router)#network 10.10.10.10 255.255.255.255 area 0
Router(config-router)#exit
```

Configure the other devices by running the same commands as those on PE 1.

Enable global MPLS forwarding on devices, MPLS packet forwarding, and the LDP on interfaces.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#mpls ip
```

The **ip ref** command is run a router to enable MPLS fast forwarding on the router. You do not need to run this command on switches..

```
Ruijie(config)#interface gigabitEthernet 0/3
```

```
Ruijie(config-if-GigabitEthernet 0/3)#label-switching
Ruijie(config-if-GigabitEthernet 0/3)#mpls ip
Ruijie(config-if-GigabitEthernet 0/3)#ip ref
Router(config-if-GigabitEthernet 0/3)#exit
```

The **ip ref** command is run a router to enable MPLS fast forwarding on the router. You do not need to run this command on switches.

```
Ruijie(config)#interface gigabitEthernet 0/3
Ruijie(config-if-GigabitEthernet 0/3)#label-switching
Ruijie(config-if-GigabitEthernet 0/3)#mpls ip
Ruijie(config-if-GigabitEthernet 0/3)#ip ref
Router(config-if-GigabitEthernet 0/3)#exit
```

Configure P1.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#mpls ip
```

The **ip ref** command is run a router to enable MPLS fast forwarding on the router. You do not need to run this command on switches.

```
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)#label-switching
Ruijie(config-if-GigabitEthernet 0/1)#mpls ip
Ruijie(config-if-GigabitEthernet 0/1)#ip ref
Router(config-if-GigabitEthernet 0/1)#exit
```

The **ip ref** command is run a router to enable MPLS fast forwarding on the router. You do not need to run this command on switches..

```
Ruijie(config)#interface gigabitEthernet 0/2
Ruijie(config-if-GigabitEthernet 0/2)#label-switching
Ruijie(config-if-GigabitEthernet 0/2)#mpls ip
Ruijie(config-if-GigabitEthernet 0/2)#ip ref
Router(config-if-GigabitEthernet 0/2)#exit
```

Configure the other devices by running the same commands as those on PE 1.

Enable global MPLS forwarding on devices, MPLS packet forwarding, and the LDP on interfaces.

Configure PE1

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#mpls router ldp
Ruijie(config-mpls-router)#ldp router-id interface loopback 0 force
```

Configure P1.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#mpls router ldp
Ruijie(config-mpls-router)#ldp router-id interface loopback 0 force
```

Configure the other devices by running the same commands as those on PE 1.

Configure BFD on PE 1 to detect LDP LSP 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface gigabitEthernet 0/2
Ruijie(config-if-GigabitEthernet 0/2)#bfd interval 50 min_rx 50 multiplier 3
Ruijie(config-if-GigabitEthernet 0/2)#exit
Ruijie(config)#mpls router ldp
Ruijie(config-mpls-router)#bfd bind ldp-lsp peer-ip 30.30.30.30 nexthop 12.12.12.2
interface gigabitEthernet 0/2 source-ip 10.10.10.10 local-discriminator 1
remote-discriminator 2 process-state
Ruijie(config-mpls-router)#exit
```

Configure BFD on PE 2 to detect LDP LSP 2, which is used as the LSP on the reverse link.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)#bfd interval 50 min_rx 50 multiplier 3
Ruijie(config-if-GigabitEthernet 0/1)#exit
Ruijie(config)#mpls router ldp
Ruijie(config-mpls-router)#bfd bind ldp-lsp peer-ip 10.10.10.10 nexthop 23.23.23.1
interface gigabitEthernet 0/1 source-ip 30.30.30.30 local-discriminator 2
remote-discriminator 1
Ruijie(config-mpls-router)#exit
```

Verification

View BFD session establishment information.

View BFD session establishment information on PE 1.

```
Ruijie# show bfd neighbors details
OurAddr        NeighAddr      LD/RD   RH  Holdown(mult)  State   Int
10.10.10.10    30.30.30.30    1/2        1       532 (3 )       Up      Ge2/1
Local Diag: 0, Demand mode: 0, Poll bit: 0
MinTxInt: 200000, MinRxInt: 200000, Multiplier: 3
Received MinRxInt: 50000, Received Multiplier: 3
Holdown (hits): 600(22), Hello (hits): 200(84453)
Rx Count: 49824, Rx Interval (ms) min/max/avg: 208/440/332
Tx Count: 84488, Tx Interval (ms) min/max/avg: 152/248/196
Registered protocols: ldp-lsp
Uptime: 02:18:49
Last packet:   Version: 1            - Diagnostic: 0
I Hear You bit: 1     - Demand bit: 0
Poll bit: 0           - Final bit: 0
Multiplier: 3             - Length: 24
My Discr.: 2          - Your Discr.: 1
```

```
Min tx interval: 50000    - Min rx interval: 50000
Min Echo interval: 0
```

View BFD session establishment information on PE 2.

```
Ruijie# show bfd neighbors details
OurAddr        NeighAddr      LD/RD   RH  Holdown(mult)  State   Int
30.30.30.30    10.10.10.10    1/2        1       532 (3 )       Up      Ge2/1
Local Diag: 0, Demand mode: 0, Poll bit: 0
MinTxInt: 200000, MinRxInt: 200000, Multiplier: 3
Received MinRxInt: 50000, Received Multiplier: 3
Holdown (hits): 600(22), Hello (hits): 200(84453)
Rx Count: 49824, Rx Interval (ms) min/max/avg: 208/440/332
Tx Count: 84488, Tx Interval (ms) min/max/avg: 152/248/196
Registered protocols: ldp-lsp
Uptime: 02:18:49
Last packet:   Version: 1            - Diagnostic: 0
I Hear You bit: 1      - Demand bit: 0
Poll bit: 0            - Final bit: 0
Multiplier: 3              - Length: 24
My Discr.: 2           - Your Discr.: 1
Min tx interval: 50000    - Min rx interval: 50000
Min Echo interval: 0
```

LDP FRR Configuration

Note

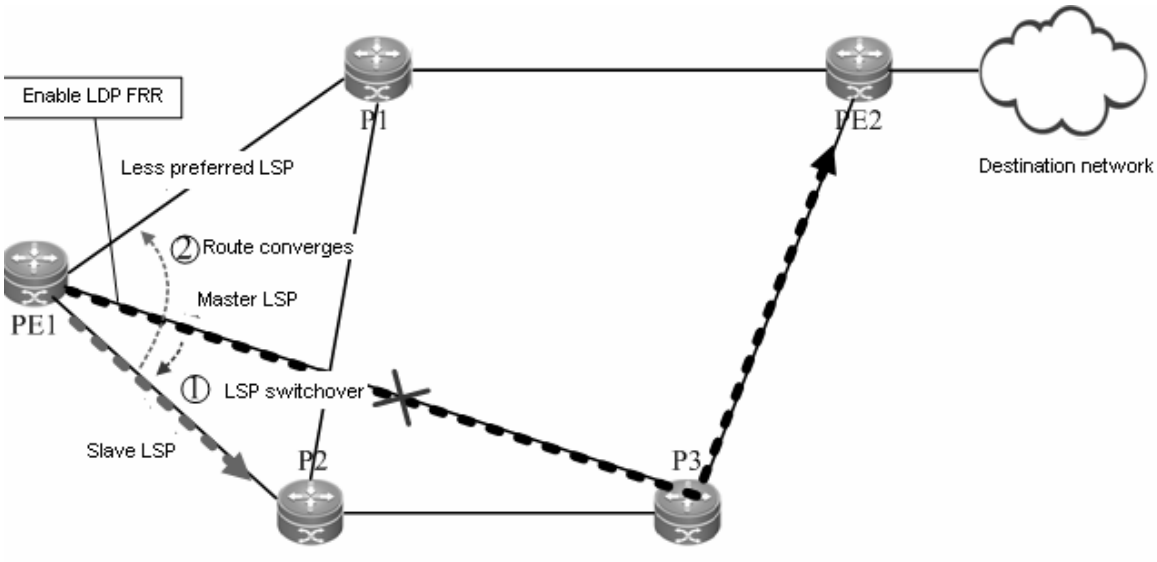
The routers or router icons involved in this chapter represent common routers or L3 switches where routing protocols are running.

☑ Currently, routes already support RGOS10.4(3).

Overview

LDP Fast Rerouting (FRR) ensures that traffic can switch over from a master LSP to a backup LSP within a very short time when the master LSP fails and that traffic switches back to a new LSP from the backup LSP during route convergence. In this manner, traffic is not interrupted in the short time before network convergence, improving MPLS network reliability and protecting key services on the MPLS network.

Figure 3-1 Working principles of LDP FRR



LDP FRR is an extension of the LDP. The LDP works in free label retention mode. LDP FRR backs up retained labels (i.e. LSPs). When a link fails, the system can quickly detect the failure of the master LSP using a fast link failure detection technology such as BFD. While the LDP regenerates a new LSP, traffic on the master LSP switches back to the backup LSP to implement uninterrupted traffic forwarding. After the new LSP is generated, traffic is forwarded on the new LSP.

As shown in Figure 3-1. LDP FRR involves three types of LSPs: master LSP, less preferred LSP, and backup LSP. The master LSP is the optimal LSP along which traffic is forwarded when the network is stable and routes are converged. The less preferred LSP is one that has a cost value larger than the cost value of the master LSP. When

the master LSP fails, routes converge on the less preferred LSP. The backup LSP is a backup LSP with a specified next hop. The three LSPs have different cost values.

In the LDP FRR solution, the next hop of the backup LSP interface is specified on the master LSP interface and BFD is configured on the master link to quickly detect faults of the master link. If the master link fails suddenly and a long time is required for routes to converge on the less preferred LSP, the quick link fault detection mechanism detects that the master link fails and therefore immediately switches traffic from the master LSP to the backup LSP, so that traffic is not discarded. In this manner, traffic to the destination network is forwarded by the backup LSP before routes converge on the less preferred LSP.

In the following several seconds, the master link fault is detected by the routing protocol and rerouting is performed through information exchange between routers. Finally, a notification message is sent to the LDP. The LDP regenerates a less preferred LSP based on the new next hop carried in the notification, and changes the path of the traffic to the destination network to the less preferred LSP, so that traffic smoothly switches over to the less preferred LSP from the backup LSP. If the less preferred LSP is just the backup LSP, traffic does not need to switch back to the less preferred LSP from the backup LSP. Even so, traffic still experiences the backup LSP phase and the less preferred LSP phase after route convergence, except that traffic just passes the same link in the two phases.

Configuring LDP FRR

Network Environment

When the LDP cannot effectively protect traffic on an MPLS network, LDP FRR can be configured on ports to protect the traffic and avoid traffic loss.

Prerequisites

Complete the following tasks before configuring LDP FRR:

- Enable MPLS.
- Configure MPLS LDP.

Data Preparations

Prepare the following data before configuring LDP FRR:

- Interface of the backup LSP, which is also the master interface
- Next-hop IP address of the backup LSP
- Name of the access control list (ACL)
- Priority of the backup LSP
- Length of the LDP FRR protection timer (optional)
- BRD single-hop detection parameters (optional)

Configuring the LDP FRR

By default, LDP FRR is disabled on a device. To enable the LDP FRR function on a device, enter the privileged user mode to run the following commands:

Command	Function
Ruijie#**configure terminal**	Enters global configuration mode.
Ruijie(config)#**mpls ip**	Enables MPLS forwarding. Caution This command is not applicable to forwarding on switch chips.
Ruijie(config)**#interface type ID**	Enters interface configuration mode.
Ruijie(config-if-type ID)#**mpls ip**	Enables LDP forwarding on interfaces (router configuration).
Ruijie(config-if-type ID)**#ip ref**	Enables fast forwarding on interfaces.
Ruijie(config-if-type ID)#**label-switching**	Enables MPLS packet processing on interfaces.
Ruijie(config-if-type ID)#**exit**	Exits the interface configuration mode.
Ruijie(config)**#mpls router ldp**	Enters the LDP configuration mode.
Ruijie(config-mpls-router)#**ldp router-id** *Loopback ID* **force**	Sets the router ID to a loopback ID (the settings immediately take effect).
Ruijie(config-mpls-router)#**exit**	Exits LDP configuration mode.
Ruijie(config)**#interface type ID**	Enters interface configuration mode.
Ruijie(config-if-type ID)# **mpls ldp frr nexthop** *nexthop-address* [**interface** *interface-type interface-number*] [**acl** *acl-name*] [**priority** *priority*]	Enables LDP FRR on interfaces.

To disable LDP FRR, run the **no mpls ldp frr** [**nexthop** *nexthop-address*] [**acl** *acl-name*] [**priority** *priority*] command.

Note Do not enable or disable LDP FRR during LDP GR.

Caution You must specify labels to work in free retention mode during LDP FRR configuration.

Configuring the LDP FRR Protection Timer (Optional)

If the master LSP link is recovered within the LDP FRR protection timer, traffic switches over to the master LSP link only after the LDP FRR protection timer expires. To configure the LDP FRR protection timer, enter the interface configuration mode to run the following commands in turn:

Command	Function
Ruijie**#configure terminal**	Enters global configuration mode.
Ruijie(config)**#mpls ip**	Enables MPLS forwarding. This command is not applicable to forwarding on switch chips.
Ruijie(config)#**interface type ID**	Enters the interface configuration mode.

Command	Function
Ruijie(config-if-type ID)**#mpls ip**	Enables LDP forwarding on interfaces.
Ruijie(config-if-type ID)#**ip ref**	Enables fast forwarding on interfaces.
Ruijie(config-if-type ID)#**label-switching**	Enables MPLS packet processing on interfaces.
Ruijie(config-if-type ID)**#exit**	Exits the interface configuration mode.
Ruijie(config)#**mpls router ldp**	Enters the LDP configuration mode.
Ruijie(config-mpls-router)#**ldp router-id** *Loopback ID* **force**	Sets the router ID to a loopback ID (the settings immediately take effect).
Ruijie(config-mpls-router)**#exit**	Exits the LDP configuration mode.
Ruijie(config)#**interface type ID**	Enters the interface configuration mode.
Ruijie(config-if-type ID)# **mpls ldp frr nexth**op *nexthop-address* [**acl** *acl-name*] [**priority** *priority*]	Enables LDP FRR on interfaces.
Ruijie(config-if-type ID)# **mpls ldp frr timer protect-time {infinity** | *seconds*}	Sets the LDP FRR protection timer on interfaces.

To enable the LDP FRR protection timer, run the **no mpls ldp frr timer protect-time** command.

Configuring Single-Hop BFD (Optional)

Run the **bfd bind peer-ip** command to configure single-hop BFD. After single-hop BFD is configured, the status of a BFD session is indicated in interface status information. Then LDP FRR detects the interface status and perform switchover. By default, single-hop BFD is disabled on a device. You can run the **no bfd bind peer-ip** command to disable single-hop BFD if necessary.

Note Single-hop BFD is optional during LDP FRR configuration. For details about single-hop BFD configuration, see related sections in *BFD Configuration*.

Configuring DLDP (Optional)

Run the **dldp ip** command to configure the Device Link Detection Protocol (DLDP) function on a device. By default, probes are tried three times every 100 milliseconds. You can run the **no dldp ip** command to restore the default DLDP settings.

Note For details about DLDP and configuration methods, see related sections in *DLDP*.

Verification

After configuring LDP FRR, run the following command to show LSP information:

Command	Function
show mpls rib	Displays MPLS routing information.

Configuration Examples

Networking Requirements

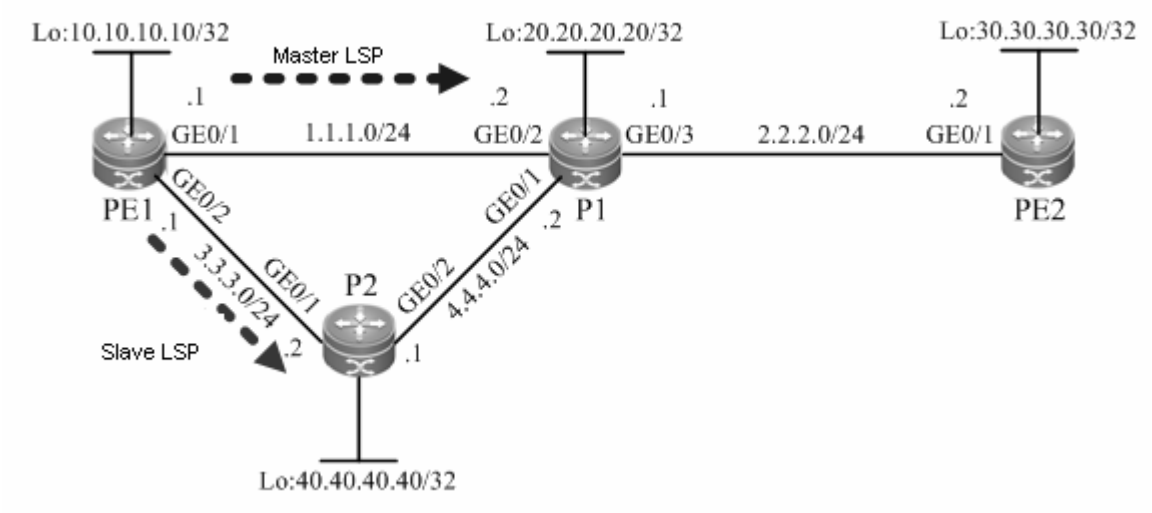
At least two links to the destination network are required when the LDP FRR is configured. Two links exist between PE 1 and PE 2, as shown in Figure 3-2.

- The PE1->P1->PE2 link is the master LSP.
- The PE1->P2->P1->PE2 link is the backup LSP.

LDP FRR can be configured on PE 1 and P1 to protect links between PE 1 and P1 and therefore avoid traffic loss.

Networking Topology

Figure 3-2 Networking topology for configuring LDP FRR



Configuration Tips

Configure all devices as follows:

- Configure interface IP addresses and the OSPF protocol on devices.
- Enable global MPLS forwarding on devices, MPLS packet forwarding, and the LDP on interfaces.
- Configure the LDP to enable the network to forward MPLS traffic.
- Configure LDP FRR.

116) Enable LDP FRR on the interfaces of PE 1 and P1 to generate the backup LSP.

117) Configure the LDP FRR protection timer on the interfaces of PE 1 and P1.

118) Configure single-hop BFD on the interfaces of PE 1 and P1.

Configuration Steps

- Configure interface IP addresses and the OSPF protocol on devices.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#interface gigabitEthernet 0/1
```

```
Ruijie(config-if-GigabitEthernet 0/1)#no switchport
Ruijie(config-if-GigabitEthernet 0/1)#ip address 1.1.1.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/1)#exit
Ruijie(config)#interface gigabitEthernet 0/2
Ruijie(config-if-GigabitEthernet 0/2)#no switchport
Ruijie(config-if-GigabitEthernet 0/2)#ip address 3.3.3.1 255.255.255.0
Ruijie(config-if-GigabitEthernet 0/2)#exit
Ruijie(config)#interface loopback 0
Ruijie(config-Loopback 0)#ip address 10.10.10.10 255.255.255.255
Ruijie(config-Loopback 0)#exit
Ruijie(config)#router ospf 1
Router(config-router)#network 1.1.1.1 255.255.255.0 area 0
Router(config-router)#network 3.3.3.1 255.255.255.0 area 0
Router(config-router)#network 10.10.10.10 255.255.255.255 area 0
Router(config-router)#exit
```

Configure the other devices by running the same commands as those on PE 1.

- Enable global MPLS forwarding on devices, MPLS packet forwarding, and the LDP on interfaces.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls ip
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)#label-switching
Ruijie(config-if-GigabitEthernet 0/1)#mpls ip
Router(config-if-GigabitEthernet 0/1)#exit
Ruijie(config)#interface gigabitEthernet 0/2
Ruijie(config-if-GigabitEthernet 0/2)#label-switching
Ruijie(config-if-GigabitEthernet 0/2)#mpls ip
Router(config-if-GigabitEthernet 0/2)#exit
```

Configure the other devices by running the same commands as those on PE 1.

- Configure the LDP so that the network can forward MPLS traffic.

Configure PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#mpls router ldp
Ruijie(config-mpls-router)#ldp router-id interface loopback 0 force
```

Configure the other devices by running the same commands as those on PE 1.

- Configure LDP FRR.

Configure PE 1.

Enable LDP FRR on the interface of PE 1 to generate the backup LSP.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)#mpls ldp frr nexthop 3.3.3.2
Ruijie(config-if-GigabitEthernet 0/1)#exit
```

Configure the LDP FRR protection timer on the interface of PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)#mpls ldp frr timer protect-time 15
Ruijie(config-if-GigabitEthernet 0/1)#exit
```

Configure single-hop BFD on the interface of PE 1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#interface gigabitEthernet 0/1
Ruijie(config-if-GigabitEthernet 0/1)#no bfd echo
Ruijie(config-if-GigabitEthernet 0/1)#bfd interval 50 min_rx 50 multiplier 3
Ruijie(config-if-GigabitEthernet 0/1)#bfd bind peer-ip 20.20.20.20 source-ip 1.1.1.1
process-pst
Ruijie(config-if-GigabitEthernet 0/1)#exit
```

Configure P1.

Enable LDP FRR on the interface of P1 so as to generate the backup LSP.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#interface gigabitEthernet 0/2
Ruijie(config-if-GigabitEthernet 0/2)#mpls ldp frr nexthop 4.4.4.1
Ruijie(config-if-GigabitEthernet 0/2)#exit
```

Configure the LDP FRR protection timer on the interface of P1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#interface gigabitEthernet 0/2
Ruijie(config-if-GigabitEthernet 0/2)#mpls ldp frr timer protect-time 15
Ruijie(config-if-GigabitEthernet 0/2)#exit
```

Configure single-hop BFD on the interface of P1.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#interface gigabitEthernet 0/2
Ruijie(config-if-GigabitEthernet 0/2)#no bfd echo
```

```
Ruijie(config-if-GigabitEthernet 0/2)#bfd interval 50 min_rx 50 multiplier 3
Ruijie(config-if-GigabitEthernet 0/2)#bfd bind peer-ip 1.1.1.1 source-ip 1.1.1.2
process-pst
Ruijie(config-if-GigabitEthernet 0/2)#exit
```

Verification

View MPLS routing information.

View MPLS routing information on PE 1.

```
Ruijie#show mpls rib
Status codes: m – main entry, b – backup entry, * - active, s – stale.
Default VRF:
LSP Information    Total
STATIC LSP         0
LDP LSP           2
RSVP LSP          0
BGP LSP           0
L3VPN LSP         0
LDP LSP:
-------------------------------------------------------------------------------
----------------
FEC            In/Out Label    In/Out IF      Nexthop
m* 2.2.2.0/24      -/1024          -/Gi0/1        1.1.1.2
b  2.2.2.0/24      -/1025          -/Gi0/2        3.3.3.2
m* 30.30.30.30/32  -/1026          -/Gi0/1        1.1.1.2
b  30.30.30.30/32  -/1031          -/Gi0/2        3.3.3.2
-------------------------------------------------------------------------------
----------------
```

MPLS-TE Configuration Configuration

Introduction to MPLS-TE

Overview

In recent years, with the booming development of multimedia, video, online games, e-business and various Internet applications, the Internet service providers have to expand the link and adjust network infrastructure continually in order to meet the demands of new services. Network congestion is one of the major problems that can degrade your network backbone performance. It may occur either when network resources are inadequate or when load distribution is unbalanced, which may result in partial congestion. Traffic engineering can effectively address the congestion problem caused by unbalanced load distribution through traffic management and control.

RFC2702 (Requirements for Traffic Engineering Over MPLS) introduces the key performance objectives associated with traffic engineering, which can be classified as being either:

Traffic oriented: minimization of packet loss, minimization of delay and maximization of throughput.

Resource oriented: optimization of resource utilization.

Since the existing IGP protocols consider only network connectivity without considering link load status, the shortest paths of multiple traffic streams will inevitably converge on a specific link. This may cause the congestion of this link, while other links leading to the destination address may remain idle.

The traditional approach to circumvent the inadequacies of current IGPs is through the use of an overlay model, such as IP over ATM. However, due to its poor scalability, this approach is not widely applied.

MPLS TE refers to Multi-Protocol Label Switch Traffic Engineering, which utilizes MPLS to manage and control the traffic. Since MPLS boasts robust scalability, it can be deployed in large-scale backbone network.

MPLS TE boasts the following characteristics:

It can create explicit label switched paths (LSP) and doesn't rely on the routes calculated by IGPs.

Since MPLS is used to forward the traffic, the forwarding path on MPLS network is already determined at the ingress, and it is easier to maintain and manage than the traditional hop-by-hop IP packet forwarding mechanism.

MPLS-TE creates the LSP to the specified destination address along the specified path (or the dynamically calculated path that meets the restrictions), and will reserve resources on the path passed by LSP, so that the traffic can avoid congested stations and allow traffic balancing.

Since MPLS-TE supports FRR (Fast ReRoute), the links or nodes passed by LSP can be protected, and the traffic can quickly switched without interruption if there is any fault.

Basic concepts of MPLS-TE

1.1.1.1 LSP tunnel

On an LSP, the nodes make forwarding decision for labeled packets based on label. The traffic thus is transparent to the transits nodes on the LSP. In this sense, an LSP can be regarded as a LSP tunnel.

1.1.1.2 MPLS-TE tunnel

For MPLS-TE, reroute and transmission over multiple paths may involve multiple LSP tunnels. A set of such LSP tunnels is called a Traffic Engineered Tunnel (TE tunnel). Such LSP tunnels have two IDs: 1) Tunnel ID for identifying the only TE tunnel; 2) LSP ID for identifying one LSP.

1.1.1.3 Traffic Trunk

A traffic trunk is an aggregation of traffic flows of the same class which are placed inside one (or multiple) Label Switched Path.

1.1.1.4 Explicit Path

An explicit path is specified by the user to request MPLS-TE tunnel to use this path to create LSP. This path can be fully specified or partially specified.

1.1.1.5 Affinity Attributes

Affinity attributes indicate the affinity between traffic trunk and a certain resource on the path. A certain resource can be explicitly included or excluded.

Working principle

The implementation of MPLS-TE involves: information advertisement, path calculation, path establishment and traffic forwarding.

1.1.1.6 Information advertisement

MPLS-TE must be aware of dynamic TE attributes of each link on the entire MPLS TE network. This is achieved by extending link state-based IGPs such as OSPF and IS-IS.

OSPF and IS-IS extensions add to link states such TE attributes as link bandwidth, management group and etc, among which maximum reservable link bandwidth and non-reserved bandwidth with a particular priority are most important.

Each router collects the TE attributes of all links on all routers within the local routing area to build up a TDB (TE Database).

OSPF extension uses Type 10 LSAs (Opaque Area-Local) to advertise TE attributes.

ISIS extension uses Type 22 TLVs to advertise TE attributes.

Note

Since the Type 10 LSAs of OSPF can contain the information about a single link, they will be flooded only after the link state has changed. Since the Type 22 TLVs of ISIS contain information about all links on the router, such information will be flooded even if only one link has changed.

1.1.1.7 Path calculation

Link state-based routing protocols use Shortest Path First (SPF) to calculate the shortest path to each network node.

In MPLS TE, the Constrain Shortest Path First (CSPF) algorithm is used to calculate the shortest path to a certain node.

CSPF algorithm is derived from SPF algorithm and makes calculation based on two conditions:

Constraints on the TE tunnel to be set up with respect to bandwidth, affinity, preemption/holding priority, explicit path and other constraints.

Traffic engineering database (TDB).

The calculation process of CSPF is shown below:

Step 1 Pruning TE attribute incompliant links from the TEDB according to the requirements to establish TE tunnel;

Step 2 Using SPF algorithm to identify the shortest path to an LSP egress.

-- End

1.1.1.8 Path establishment

When setting up MPLS TE tunnels, you may use two types of signaling: CR-LDP and RSVP-TE. Both can carry constraints such as LSP bandwidth, explicit route and affinity attributes. Both can accomplish the same goal.

CR-LDP establishes LSPs by creating TCP sessions, while RSVP-TE establishes LSPs right through raw IP.

After years' development, RSVP has become a well-established technology in terms of its architecture, protocol procedures and support to various services; while CR-LDP has been abandoned in RFC3468.

1.1.1.9 Traffic forwarding

After the MPLS TE tunnel is established, the traffic needs to be directed to tunnel ingress, or else the tunnel established will become useless. There are three ways to direct traffic into the tunnel: static routing, policy routing and automatic routing.

1.1.1.1.1 Static routing

Static routing is the easiest way to route traffic to the ingress of MPLS TE tunnel. You only need to create a static route to the TE tunnel.

1.1.1.1.2 Policy routing

By configuring certain criteria in policy routing, only certain types of traffic will be allowed to pass the tunnel.

1.1.1.1.3 Automatic routing

Two approaches are available to automatic route advertisement: IGP shortcut and forwarding adjacency. In both approaches, TE Tunnel interface will participate in SPF calculation of IGP, and TE tunnel is considered a point-to-point link.

IGP Shortcut: The router on which this feature is enabled will use TE LSP as the outgoing interface, but it will not advertise this link to the upstream adjacent routers. Therefore, this path won't exist in the link-state database of other routers and is thus unusable. Only the ingress of TE tunnel can use TE tunnel to forward traffic.

Forwarding Adjacency (FA): The router on which this feature is enabled will use TE LSP as the outgoing interface and advertise this LSP to the upstream adjacent routers as an ordinary LSA (LSP). Therefore, this path will be stored in the link-state database of other routers, and TE LSP can be used to forward traffic.

Caution

Since MPLS TE tunnel is unidirectional and FA will only function after both ends of the link have received the refresh message, in order to use FA, the TE tunnel must be created in both directions, or else the route passing through TE tunnel won't calculated.

RSVP-TE

RSVP (Resource Reservation Protocol) is designed for the Integrated Service model. It reserves resources on each node along a path. RSVP operates at the transport layer (IPv4 or IPv6) but does not participate in data transmission. Essentially, RSVP is an Internet control protocol similar to ICMP (Internet Control Message Protocol) and IGMP (Internet Group Management protocol), or a routing protocol.

Generally speaking, RSVP boasts the following features:

Only reserving resources for unidirectional traffic;

Receiver oriented. The receiver initiates resource reservation requests and is responsible for maintaining the reservation state;

Using "soft state" mechanism to maintain path state and reservation state.

Extended RSVP can support MPLS label distribution and allow resource reservation information to be transmitted with label bindings. This extended RSVP is called RSVP-TE, which can be used to set up LSP tunnel in MPLS TE network.

Basic concepts of RSVP-TE are introduced below.

Soft state

"Soft state" is a mechanism used in RSVP-TE to periodically refresh the path state and reservation state on a node through the corresponding messages. The path state is refreshed through RSVP Path messages, and the reservation state is refreshed through RSVP Resv messages. A state is to be removed if no refresh messages are received for it in certain interval. If the path state is removed, the corresponding reservation state will be deleted as well, namely the reservation state cannot exist independently without path state.

Resource reservation style

The resource reservation style refers to the way of reserving resources. Each TE LSP set up using RSVP-TE is assigned a resource reservation style. During the creation of TE LSP, the receiver decides which reservation style can be used for this session.

Currently, two reservation styles are supported by Ruijie products:

- **FF (Fixed-Filter style)**: Exclusive style, where resources are reserved for each sender and cannot be shared with other senders.

- SE (Shared-Explicit style): Shared style, where resources are reserved for multiple LSPs on the same TE Tunnel and shared among them.

Since multiple LSPs will only exist during reroute of TE Tunnel, SE is thereby mainly used for reroute.

1.1.1.10 Make-before-break

Make-before-break is a mechanism to change MPLS TE tunnel attributes with minimum data loss and without extra bandwidth by establishing new path before the original path is torn down. For example: If there is a better constraint-based route or if TE LSP needs to be reestablished due to the bandwidth change of TE tunnel, the original TE LSP won't be torn down before the new TE LSP is established, namely the original TE LSP will still forward traffic. Upon successful creation of the new TE LSP, traffic is switched to the new path and the original TE LSP is torn down

When the LSP is being created, it may overlap with the original LSP on certain link and thus compete with original LSP for resources. The new LSP may fail in competition and cannot be created. Through the mechanism of make-before-break, resource competition on the overlapped

link can be avoided. If the new LSP overlaps with the original LSP, the available bandwidth will be the difference between the bandwidth needed by new LSP and that needed by the original LSP, namely the new LSP will share the bandwidth reserved by the original LSP on the link.

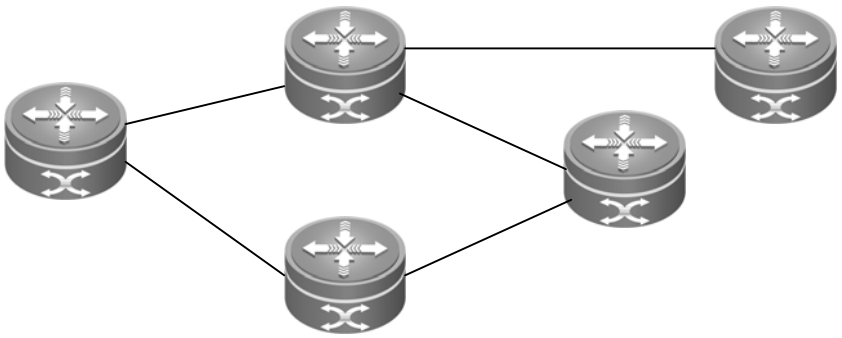


Fig 1 Diagram for make-before-break

45Mbps

In Fig 1, assuming that a path from R1 to R5 with requested bandwidth being 30Mbps is needed, then R1->R2->R5 path can be used. Now if 80 Mbps path bandwidth is requested, the R1->R3->R4->R2->R5 path can be established, but the reserved bandwidth on the link between R2 and R5 is only 70Mbps (inadequate to meet the need for 80Mbps bandwidth). The mechanism of make-before-break can well address this problem.

Through make-before-break mechanism, you only need to reserve 50Mbps bandwidth on the link between R2 and R5. Upon creation of the new path, traffic is switched to the new path and the previous path is torn down.

R1 100Mbps

1.1.1.11 Preemption

When the resources are inadequate, MPLS TE can preempt the bandwidth resources of low-priority TE tunnel in order to meet the needs of high-bandwidth application or critical services.

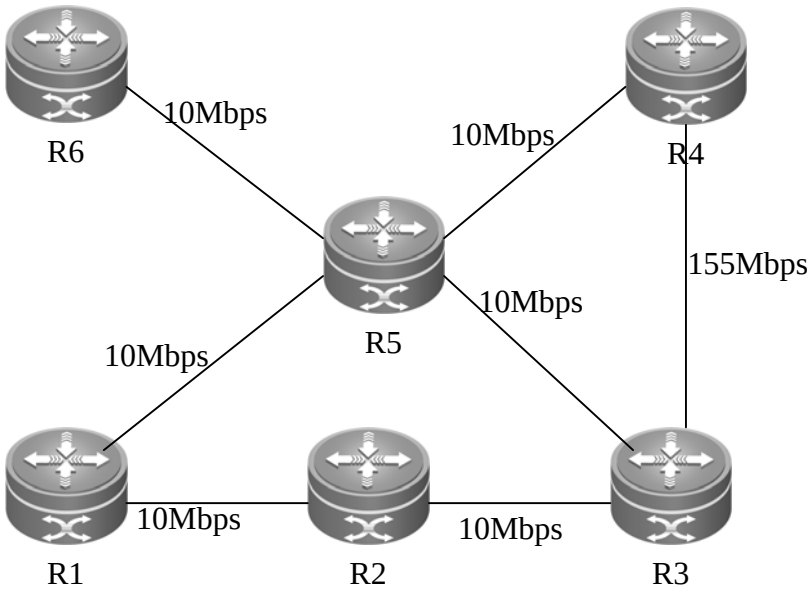


Fig 2 Diagram for preemption

In Fig 2, assuming that there are two TE tunnels: 1) T1 (R6->R5->R3), with reserved bandwidth being 100Mbps; 2) T2 (R1->R5->R4), with reserved bandwidth being 10Mbps. Both the setup priority and holding priority of T1 are 0, and both the setup priority and holding priority of T2 are 7.

Assuming that the reserved bandwidth and metric are the same in both directions of the link, when the link between R5 and R3 is down, R5 will re-advertise link information to R6 via OSPF protocol, and R6 will recalculate R6->R5->R4->R3 path for T1. Since the reserved bandwidth between R5 and R4 is insufficient to meet the needs of both T1 and T2, and the holding priority of T2 is lower than the setup priority of T1, T2 will be preempted.

1.1.1.12 Type of messages

RSVP-TE uses RSVP messages with extensions:

Path messages: transmitted along the path of data transmission downstream by each sender to save path state information on each node along the path. New objects of path messages include: LABEL_REQUEST, EXPLICIT_ROUTE, RECORD_ROUTE and SESSION_ATTRIBUTE.

Resv messages: sent by each receiver upstream towards senders to request resource reservation and to create and maintain reservation state on each node along the reverse of data transmission path. New objects of Resv messages include: LABEL and RECORD_ROUTE.

PathTear messages: generally created by sender and sent downstream in same direction as Path messages to remove the corresponding path state and reservation state on each node along the path.

ResvTear messages: generally created by receiver and sent upstream in same direction as Resv messages to remove the corresponding reservation state on each node along the path.

PathErr messages: sent upstream to report Path message processing errors. PathErr messages won't affect the state of the nodes along the path (unless the user uses "ip rsvp signaling patherr state-removal" command to configure to remove the corresponding path state after receiving PathErr messages); it only transmit the errors to senders.

ResvErr messages: sent downstream to notify the downstream nodes that error occurs during Resv message processing or the corresponding reservation state runs out of time.

ResvConf messages: sent to receivers to confirm Resv messages.

ACK messages: used to confirm messages of the extended refresh mechanism.

Srefresh messages: summary refresh messages. The path state and reservation state can also be refreshed without sending standard Path messages and Resv messages.

Integrity Challenge: the messages used by the receiver to confirm the initial sequence number used by sender during RSVP authentication.

Integrity Response: messages used by the sender to reply to the Integrity Challenge messages sent by the receiver, informing the receiver of its initial sequence number.

Hello messages: fast detection of link or node failure when FRR is enabled.

1.1.1.13 Set up TE-LSP tunnel

Fig 3 shows how to use RSVP-TE to set up TE LSP tunnel.

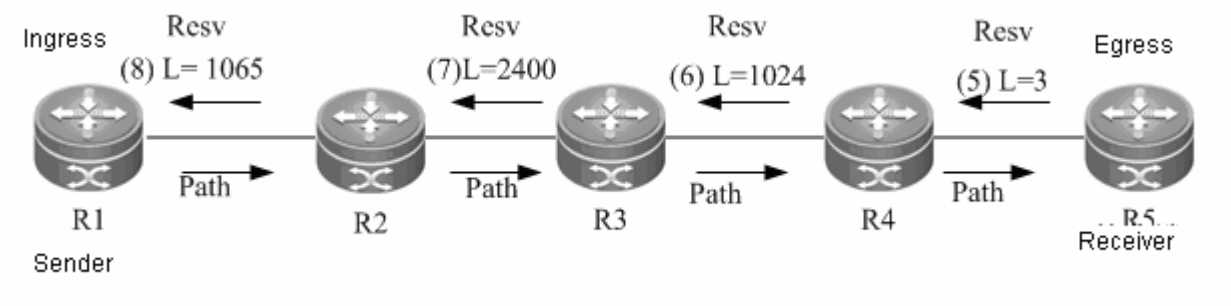


Fig 3 Set up TE-LSP

In the above figure, assuming that R1 has used CSPF to obtain the path of R1->R2->R3->R4->R5 to reach R5, and RSVP-TE is supported by every router.

The process of setting up TE-LSP tunnel can be simply described as:

Path message is generated on the ingress R1 and is sent towards R5 along the path calculated;

After Path message is received on each node along the path, the corresponding path is generated;

After Path message is received by the egress R5, the corresponding Resv message is generated and sent towards R4 along the reverse direction. Assuming that it carries the label of “3”.

After Resv message is received by R4, the corresponding reservation state is established and resource is reserved. The corresponding Resv message is generated and sent to R3. Assuming that it carries the label of “1024”.

After R2 receives Resv message, it will do as R4 does.

After R1 receives the Resv message from R2, TE LSP is established successfully.

1.1.1.14 Refresh mechanism

Given the soft state of RSVP-TE, we will need to use refresh mechanism to maintain the corresponding path state and reservation state. On one hand, the refresh mechanism is used to achieve state synchronization among adjacent node; on the other hand, it can also be used to recover lost RSVP messages.

Since the refresh mechanism needs to periodically transmit Path and Resv messages, there would be excessive refresh messages if many RSVP sessions are present, thus increasing network burden.

RFC2961 (RSVP Refresh Overhead Reduction Extensions) has defined several new extended mechanisms to address the problems caused by such refresh mechanism.

Enhanced reliability

RSVP-TE uses Raw IP to send messages. Message_ID object and Message_ID_ACK object have been introduced in RFC2961. The Message_ID_ACK object is used to acknowledge RSVP messages that contain Message_ID object. If no reply message is received within a certain interval, the sender will retransmit the corresponding message. Through this mechanism, the transmission reliability of RSVP messages can be improved.

Summary refresh

The RSVP soft state can still be refreshed by sending summary refreshes (Srefresh) rather than retransmitting standard Path or Resv messages. This reduces refresh traffic and allows nodes to make faster processing.

To use summary refresh, you must use the Message_ID extension. Only states advertised using MESSAGE_ID that includes Path and Resv messages can be refreshed using summary refreshes.

Timeout

While creating a TE LSP tunnel, the sender sends a Path message with a LABEL_REQUEST object to the receiver. After receiving this Path message, the receiver assigns a label for the path and puts the label binding in the LABEL object in the returned Resv message.

The LABEL_REQUEST object is stored in the Path State Block (PSB) on the upstream nodes, while the LABEL object is stored in the Reservation State Block (RSB) on the downstream nodes. The state stored in the PSB or RSB object times out and is removed after the number of consecutive Path or Resv non-refreshing times exceeds the PSB or RSB timeout keep-multiplier.

1.1.1.15 Authentication mechanism

RFC 2747 (RSVP Cryptographic Authentication) introduces the authentication function for RSVP. By enabling the authentication between neighbors, we can enhance security while avoiding reserving resources for suspect neighbors.

RSVP-TE uses Integrity Challenge and Integrity Response messages to enable the receiver to get the initial sequence number of sender during authentication. This is generally called the handshake process.

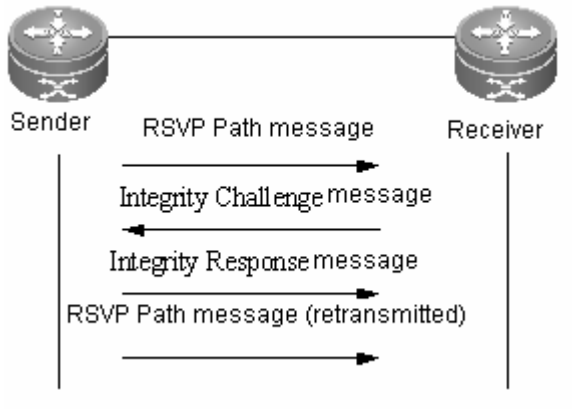


Fig 4 Handshake process

Fig 4 shows the handshake process between two neighboring nodes.

1. The sender sends a path message containing Integrity Object to the receiver.

2. The receiver receives the Path message in which the HF flag is 1, and sends Integrity Challenge object to the sender in order to obtain the initial sequence number used for authentication.

3. After the sender receives the Integrity Challenge message sent by the receiver, it will reply with Integrity Response object, which contains the latest sequence number used by the sender.

4. After the receiver receives the Integrity Response message, it will compare the Challenge object thereof with the Challenge object included in the Integrity Challenge message sent. If they are same, the initial sequence number of the sender will be recorded to acknowledge the validity of RSVP message; otherwise, the Integrity Response message will be discarded. If the corresponding Integrity Response message is not received within the specified interval, the sender will retransmit the Integrity Challenge message.

After authentication is enabled, the node will only accept RSVP-TE packets that have a larger sequence number than the previous packet. Therefore, when out-of-order message delivery is caused by network congestion, the authentication may not pass. To address this problem, the mechanism of Message Window is introduced. The message window introduces a window with size being N. As long as the message received is within the window and no message with such sequence number is received before, this message is considered valid.

1.1.1.16 Fast reroute

Fast Reroute (FRR) provides per-link or per-node protection in MPLS-TE. Since FRR can happen as fast as 500 milliseconds when the fault occurs, the data loss caused by network failure can be minimized to the maximum extent.

FRR protects the primary tunnel by setting up a backup tunnel in advance. When a fault occurs, the traffic will be switched to the backup tunnel; once the primary tunnel is recovered or rebuilt, the traffic will then be switched to the main tunnel.

There are several important concepts about FRR:

Primary LSP: the protected LSP.

Bypass LSP: An LSP used to protect the primary LSP.

Point of Local Repair (PLR): The node applied with local repair. This node must be the ingress of the bypass LSP and must be located on the primary LSP. It can be the ingress node or intermediate node of primary LSP but must not be the egress node.

Merge point (MP): The egress of the bypass LSP. This node must be located on the primary LSP but must not be the ingress. It can be the intermediate node or egress node of primary LSP.

Currently, there two local repair modes: One-to-One mode and Facility mode. The major difference between them is: When One-to-One mode is used, a protection path must be created on PLR for the primary LSP; when Facility mode is used, the PLR can use one protection path to protect multiple primary LSPs.

Depending on the object to be protected, FRR can be divided into the following two classes:

Link protection, where the PLR and the MP are connected through a direct link and the primary LSP traverses this link. When the link fails, traffic is switched to the bypass LSP. As shown in Figure 5, the primary LSP is R1->R2->R3->R4, and the bypass LSP is R2->R5-R3. When the link between R2 and R3 fails, R2 will switch the traffic received from R1 from primary LSP to Bypass LSP in order to reach R3.

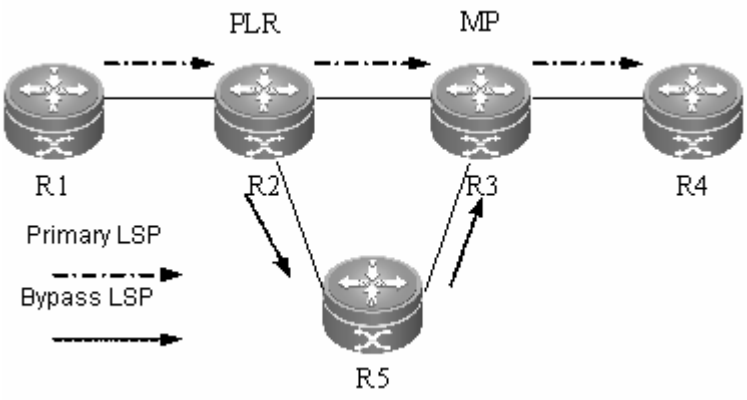


Fig 5 Link protection

Node protection, where the PLR and the MP are connected through a node and the primary LSP traverses this node. As shown in Fig 6: the primary LSP is R1->R2->R3->R4->R5, the Bypass LSP is R2->R6->R4 and node R3 is the protected router. When R3 fails, R2 will switch the traffic received from R1 from primary LSP to bypass LSP in order to reach R4.

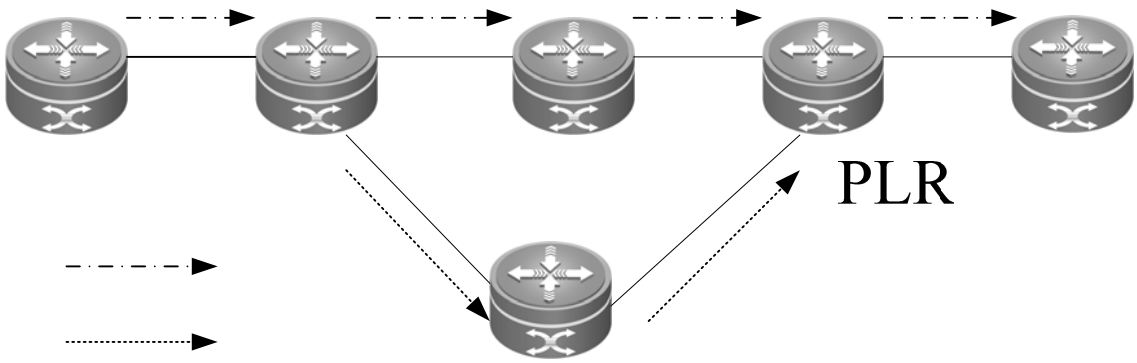


Fig 6 Node protection

Since the bypass LSP is not protected, if the primary LSP is switched to the bypass LSP which is "down", then the primary LSP will be removed.

Since the bypass LSP needs to be created in advance, the fast reroute mechanism will consume extra bandwidth. Therefore, when there is no much residual network bandwidth, it is suggested to apply FRR protection on key links or key nodes only.

1.1.1.17 Automatic fast reroute

When configuring primary LSP, FRR requires that a bypass LSP shall be configured at PLR and be bound with primary LSP. Only after the bypass LSP is created in advance and bound with primary LSP, the FRR can then direct the traffic to the bypass LSP when the link or node fails.

Due to the complexity of manual configuration and the need for manual removal of bypass LSP when reroute is not needed, the automatic reroute is therefore introduced.

After automatic FRR is enabled and the primary LSP requiring FRR protection is established, if the node has no bypass LSP to protect the primary LSP, the node will automatically create a bypass LSP, which will be bound with the primary LSP automatically.

Caution

Currently, Ruijie products can only establish MPLS TE tunnel using RSVP-TE.

In respect of TE FRR, only Facility mode is supported by Ruijie products.

LDP over TE

In the existing MPLS network, not all devices support MPLS TE. Therefore, MPLS TE may only be supported by core component of the network, while the edge devices only support LDP. To use the feature of TE, the application scenario of LDP over TE is introduced. In this scenario, TE tunnel is regarded as "one hop" of LDP LSP.

In MPLS network, LDP is regarded as the public tunnel of MPLS VPN. To avoid congestion of VPN traffic on certain node, the feature of LDP over TE can be used.

The operating process of LDP over TE can be described as:

After TE tunnel is created using RSVP-TE Tunnel, enable MPLS on the corresponding interface of the ingress node of TE Tunnel, and enable "target hello" passive reception on the egress node of tunnel, so that extended LDP peer is established between the ingress node and egress node of TE Tunnel.

Configure static route or policy route, or enable IGP Shortcut or Forwarding Adjacency, so that the egress of route is the TE Tunnel.

LDP sends label bindings through the extended peer and establishes the LDP LSP with egress being TE Tunnel egress.

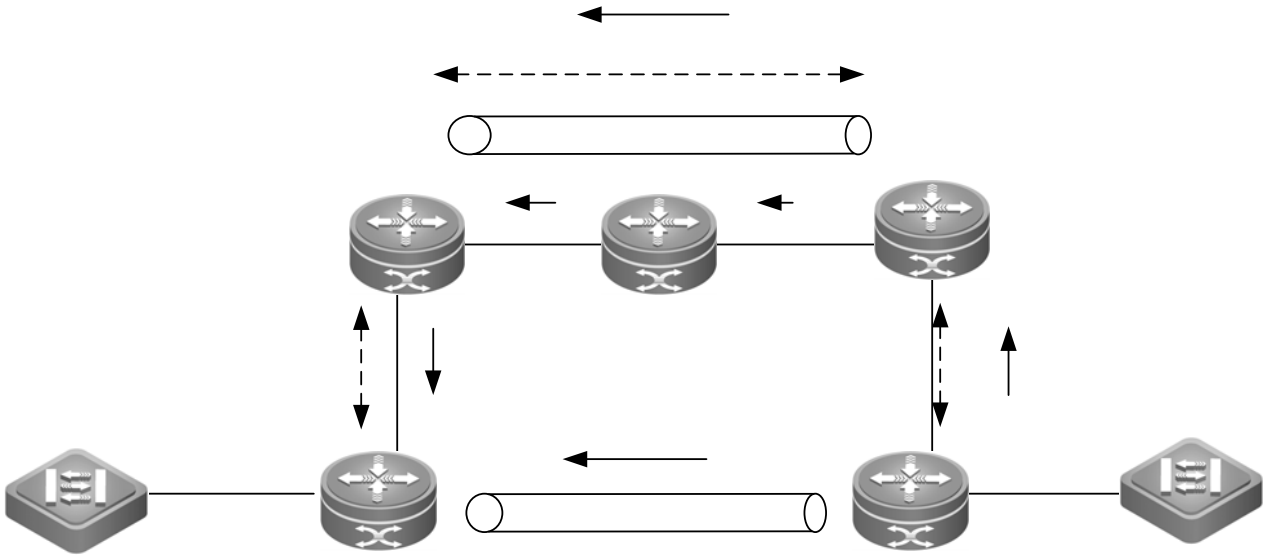


Fig 7 Typical application of LDP over TE

Fig 7 shows an MPLS VPN network. R1 and R5 only supports LDP (PE devices in VPN), while R2, R3 and R4 supports MPLS TE (P devices in VPN). In such a circumstance, we only need to establish TE LSP between R2 and R4 and then extended peer between R2 and R4; configure on R2 so that the next hop of the route to R5 is TE Tunnel. During the forwarding process, when R2 receives the MPLS VPN packets from R1, it only needs to switch the LDP label and then insert the egress label of TE tunnel.

Protocol specification

Related protocol specifications include:

RFC2702: Requirements for Traffic-Engineering Over MPLS

RFC2205: Resource ReserVation Protocol(RSVP)

RFC2747: RSVP Cryptographic Authentication

RFC2961: RSVP Refresh Overhead Reduction Extensions

RFC3209: Extensions to RSVP for LSP Tunnels(RSVP-TE)

RFC3603: Traffic Engineering(TE) Extensions to OSPF Version 2

RFC3784: Intermediate System to Intermediate System(IS-IS) Extensions for Traffic Engineering(TE)

RFC4090: Fast Reroute Extensions to RSVP-TE for LSP Tunnels

Default configurations

The following table describes the default configurations of MPLS-TE.

Function	Default setting
Global TE	Not enabled by default
Interface TE	Not enabled by default
Router ID of TE	Not configured
Type of IGP TE	OSPF-TE
OSPF TE	OSPF-TE in the specified area is not enabled by default.
ISIS TE	Not enabled by default
FRR	Not enabled by default
FRR bypass tunnel preemption algorithm	Optimize-bw
Interval for FRR bypass tunnel to select shorter path	300 seconds
IP address of the tunnel created automatically by FRR	Address of the Loopback 0 interface will be borrowed.
The timer to remove unused tunnel created automatically by FRR	3600 seconds
TE metric of the link	Same as the link metric of IGP

Reservable bandwidth change flooding thresholds	The threshold of reservable bandwidth decrease reaches 100%, 99%, 98%, 97%, 96%, 95%, 90%, 85%, 80%, 75%, 60%, 45%, 30% and 15% of the maximum reservable bandwidth; or the threshold of reservable bandwidth increase reaches 15%, 30%, 45%, 60%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98%, 99% or 100% of the maximum reservable bandwidth.
IGP-TE periodic flooding time	180 seconds
CSPF failed link timer	By default, when CSPF detects a LSP establishment error, CSPF will regard this link unavailable for 10 seconds.
Link metric used in CSPF path calculation	TE Metric of the link
Interface authentication	Interface authentication is not enabled by default
Summary refresh	Summary refresh of the node is not enabled by default
Hello detection	Not enabled by default
Hello transmission interval	If there is any LSP requiring partial protection between RSVP neighbors, then the default transmission interval is 200 milliseconds; otherwise, the default transmission interval is 2 seconds.
Advertise explicit null labels	Disabled. By default, when acting as the egress node of TE tunnel, the device will advertise implicit null labels.
Soft state refresh time	30 seconds
Soft state timeout timer	157 seconds
RSVP interface message pacing	Not configured
Resource reservation confirmation	Not enabled by default
Loop detection	Disabled
Reoptimization interval	Enabled by default. The interval is 3600 seconds.
Event triggered reoptimization	Disabled by default.
Rule for CSPF equal cost path selection	Random
Name of the tunnel carried by RSVP Path message	Router_tnum; num refer to the ID of tunnel interface.

TE tunnel	No TE tunnel by default.
Priority of tunnel	Both setup priority and holding priority are 7.
Affinity attributes of tunnel	All are 0 by default.
Administrative group attribute of the link	0 by default.
Reserved bandwidth of tunnel	0 by default.
Maximum reservable bandwidth of interface	Same as the actual bandwidth of this interface.

Configure basic functions of MPLS-TE

The following sections describe how to configure TE functions:

Create configuration tasks

Enable MPLS TE

Create MPLS TE tunnel

Configure the path used by TE tunnel

Configure to direct traffic into TE tunnel

Display configurations

Create configuration tasks

1.1.1.18 Application environment

MPLS TE configuration tasks include the basic configurations which must be done during MPLS TE configuration.

1.1.1.19 Prerequisites

Before configuring MPLS TE basic capabilities, the following tasks must be completed:

Configure OSPF or ISIS protocol and ensure that LSRs are interconnected at the network layer

Enable MPLS on the node and enable MPLS forwarding on the interface

1.1.1.20 Data preparation

Before configuring MPLS TE basic capabilities, the following data must be prepared:

Identify the link to be passed by MPLS TE tunnel

Identify the serial number of tunnel interface

Identify the destination address of tunnel

Configure MPLS TE

By default, MPLS TE is disabled. Enter privileged user mode and enable MPLS TE.

Command	Function
Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **mpls ip**	Enable MPLS forwarding.
Ruijie(config)# **mpls router ldp**	Enable LDP.
Ruijie(config-mpls-router)# **ldp router-id** *interface-name* **force**	Specify the router id used by LDP.
Ruijie(config-mpls-router)# **exit**	Exit mpls router configuration mode.
Ruijie(config)# **mpls te**	Enable global MPLS TE and enter TE mode. Enabling global MPLS TE will enable global RSVP-TE at the same time.
Ruijie(config-te)# **exit**	Exit TE configuration mode.
Ruijie(config)# **router ospf** *process-id*	Enable OSPF and enter OSPF configuration mode.
Ruijie(config-router)# **mpls te area** *area-num*	Enable OSPF-TE in the specified area.
Ruijie(config-router)# **mpls te router-id** *interface-name*	Configure the interface name of TE Router ID used by OSPF-TE; the Loopback0 interface is generally used.
Ruijie(config-router)# **network** *prefix mask* **area** *area-id*	Enable OSPF interface.
Ruijie(config-router)# **exit**	Exit OSPF configuration mode.
Ruijie(config)# **router isis** [*tag*]	Create ISIS instance and enter ISIS configuration mode.
Ruijie(config-router)# **metric-style** {**narrow** | **wide**| **transition**} [**level-1**|**level-1-2**|**level-2**]	Configure ISIS metric style.
Ruijie(config-router)# **mpls te** {**level-1**| **level-2**}	Enable ISIS-TE.
Ruijie(config-router)# **mpls te router-id** *interface-name*	Configure the interface name of TE Router ID used by ISIS-TE; the Loopback0 interface is generally used.
Ruijie(config-router)# **exit**	Exit ISIS configuration mode.
Ruijie(config)# **interface** *interface-name*	Enter interface configuration mode.
Ruijie(config-if)# **ip router isis**	Enable ISIS on the interface.
Ruijie(config- if)# **exit**	Exit interface configuration mode.

Ruijie(config)# **interface** *interface-name*	Enter interface configuration mode.
Ruijie(config-if)# **mpls te**	Enable MPLS TE on the interface. Enabling MPLS TE will enable RSVP-TE on the interface at the same time.
Ruijie(config-if)# **label switching**	Enable MPLS forwarding on the interface.
Ruijie(config-if)# **ip ref**	As for router, enable fast forwarding on this interface.

Note

As for the link-state information distribution protocol for TE, simply select between OSPF and ISIS. By default, OSPF is used as the link-state information distribution protocol for TE, and only OSPF TE is required to be enabled. If you intend to use ISIS-TE, please execute "**preferred-igp isis**".

To disable MPLS TE configured on the device, execute the corresponding "no" command.

Configuration example:

Configure to enable OSPF-TE in area 0 of OSPF instance 1, and specify OSPF-TE to use Loopback 0 as TE Router ID.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)#router ospf 1

Ruijie(config-router)#mpls te area 0

Ruijie(config-router)#mpls te router-id loopback 0
```

Configure to enable ISIS-TE on ISIS level-2, and specify ISIS-TE to use Loopback 0 as TE Router ID.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)#router isis

Ruijie(config-router)#metric-style wide

Ruijie(config-router)#mpls te level-2
```

```
Ruijie(config-router)#mpls te router-id loopback 0
```

Enable TE on GigabitEthernet 0/1.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)#interface gigabitEthernet 0/1
```

```
Ruijie(config-if)#mpls te
```

If global MPLS TE is not enabled, even if MPLS TE is enabled on the interface, the device won't be able to implement relevant TE functions.

If MPLS TE is disabled in privilege mode, all TE LSPs passing through this device will be removed.

If MPLS TE is disabled on in interface mode, all TE LSPs passing through this interface will be removed.

If IGP TE being used by the device is disabled in IGP mode, all TE LSPs taking this device as the head node will be removed; meanwhile, all other devices will remove the TE LSPs calculated with CSPF algorithm and passing through this device.

Configure MPLS TE tunnel

By default, TE tunnel is not created. Execute the following steps to create TE tunnel.

Command	Function
Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface tunnel** *tunnel-number*	Create Tunnel interface and enter Tunnel interface configuration mode.
Ruijie(config-if)# **label-switching**	Configure the tunnel to allow handling of MPLS packets.
Ruijie(config-if)# **ip ref**	Enable fast forwarding on the tunnel interface of router (not applicable to the switch).
Ruijie(config-if)# **tunnel mode mpls te**	Configure the tunnel protocol as MPLS TE.
Ruijie(config-if)# **tunnel destination** *ip-address*	Configure the destination address of tunnel.

Ruijie(config-if)# **ip address** *ip-address mask* 或者 Ruijie(config-if)# **ip unnumbered** *interface-name*	Configure the IP address of tunnel interface. To enable traffic forwarding, the tunnel interface must have an IP address. Since MPLS TE tunnel is unidirectional, there is no problem of peer address. Therefore, it is unnecessary to configure a separate IP address for Tunnel interface. In the common practice, the Tunnel interface uses device address as the address of Loopback interface of LSR ID.

To remove the TE tunnel created, execute "**no interface tunnel** *tunnel-num*" in the global mode or execute "**no tunnel mode**" in Tunnel interface configuration mode.

Create TE Tunnel 1, with destination address being 4.4.4.4; use the IP address of Loopback 0 as the IP address of tunnel.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)#interface tunnel 1
```

```
Ruijie(config-if)#label-switching
```

Enable fast forwarding on the tunnel interface of router (not applicable to the switch)

```
Ruijie(config-if)#ip ref
```

```
Ruijie(config-if)#tunnel mode mpls te
```

```
Ruijie(config-if)#tunnel destination 4.4.4.4
```

```
Ruijie(config-if)#ip unnumbered loopback 0
```

Caution

Since the MPLS TE tunnel is unidirectional and is used to forward MPLS packets, it is invalid to execute IP packet forwarding related commands on the TE tunnel interface (for example: the URPF check command).

Configure the path used by TE tunnel

After completing the aforementioned configurations, MPLS TE tunnel is still not established yet. The path used by TE tunnel must be specified, and static explicit path or dynamic path can be used. Besides specifying multiple paths at the same time, you can also identify the priority for each path and select the high-priority path first. When the high-priority path is not available, the low-priority

paths will be selected as per the sequence of priority. The following section will describe the steps to configure dynamic path and static path.

Dynamic path configuration steps:

By default, no dynamic path is specified for the TE tunnel. Execute the following steps to specify the dynamic path used by TE tunnel.

Command	Function
Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface tunnel** *tunnel-number*	Create Tunnel interface and enter Tunnel interface configuration mode.
Ruijie(config)# **tunnel mpls te path-option** *number* **dynamic** [**lockdown**]	Specify dynamic path for TE tunnel, with number being the priority value (1-100) of this path. The lower the value is, the higher the priority will be. Lockdown: Indicating that no further optimization is allowed after TE LSP is established.

Static explicit path configuration steps

When specifying static explicit path for TE tunnel, if you expects to establish TE LSP along the static path, then you must create static explicit path first. There are several ways to create explicit path:

Specify the IP address which must be passed by the explicit path

Specify the IP address which must be excluded by the explicit path

Specify the loose or strict path in the explicit path

Dynamically insert or replace the address of a designated position in the explicit path

Combination of above ways

Execute the following commands to create static explicit path.

Command	Function
Ruijie# **configure terminal**	Enter global configuration mode.

Ruijie(config)# **ip explicit-path** {**name** *path-name* **| identifier** *id-num*} [**disable**|**enable**]	Create static explicit path or enter static explicit path configuration mode. "**Name**" refers to the name of this static explicit path; "**identifier**" refers to the ID (1-65535) of this static explicit path. By default, the static explicit path is enabled; use the optional key word of "**disable**" to disable static explicit path.
Ruijie(cfg-ip-expl-path)# **next-address** [**loose**|**strict**] *ip-address*	Use this command to add an IP address in the static explicit path. If the optional key word is not contained, the default setting will be strict; use "loose" key word to specify the IP address as a loose one. This step can be skipped if there is no IP address which must be passed.
Ruijie(cfg-ip-expl-path)# **exclude-address** *ip-address*	Use this command to add an excluded IP address to the static explicit path. The exclude address refers to the excluded address which must not be passed by the LSP of TE tunnel using this path. This step can be skipped if there is no address to be excluded.
Ruijie(cfg-ip-expl-path)# **append-after** *index* {**next-address** [**loose**|**strict**] | **exclude-address**} *A.B.C.D*	(Optional) Append an IP address after the designated position in the static explicit path; "index" refers to the previous position (0-254) of the inserted address.
Ruijie(cfg-ip-expl-path)# **index** *index* {**next-address**[**loose**|**strict**] |**exclude-address**} *A.B.C.D*	(Optional) replace the IP address of the designated position in the static path (index: 1-255). If this index position doesn't exist, the IP address will be inserted directly.
Ruijie(cfg-ip-expl-path)# **no index** *index*	(Optional) delete one IP address from the designated position in the existing explicit path.
Ruijie(cfg-ip-expl-path)# **list** [*starting-index-num*]	(Optional) display nodes in the static explicit path from the designated position (display all by default).

After the explicit path has been created, execute the following steps to associate the path with TE tunnel, so that TE LSP is created along the static path:

Command	**Function**
Ruijie# **configure terminal**	Enter global configuration mode.

Ruijie(config)# **interface tunnel** *tunnel-number*	Create Tunnel interface and enter Tunnel interface configuration mode.
Ruijie(config)# **tunnel mpls te path-option** *number* **explicit** {**name** *path-name* |**identifier** *path-number*} [**lockdown**]	Specify static path for TE tunnel, with *number* being the priority value (1-100) of this path. The lower the value is, the higher the priority will be. lockdown: Indicating that no further optimization is allowed after TE LSP is established.

To remove the path specified for TE tunnel, execute "**no tunnel mpls te path-option** *number*" command to remove the specified path.

Specify a static path t_1 (priority: 10) and a dynamic path (priority: 20) for TE Tunnel 1. The static path must pass 2.2.2.2 and must not pass 3.3.3.3.

```
Ruijie#configure terminal

Enter configuration commands, one per line.   End with CNTL/Z.

Ruijie(config)#ip explict-path name t_1

Ruijie(cfg-ip-expl-path)#next-address 2.2.2.2

Ruijie(cfg-ip-expl-path)#exclude-address 3.3.3.3

Ruijie(cfg-ip-expl-path)#exit

Ruijie(config)#interface tunnel 1

Ruijie(config)#tunnel mpls te path-option 10 explicit name t_1

Ruijie(config)#tunnel mpls te path-option 20 dynamic
```

Configure to direct traffic into TE tunnel

You can create the fundamental TE tunnel after completing the aforementioned steps. To truly use TE features, you must introduce services into TE tunnel. There are four ways to introduce services into TE tunnel:

Static routing

The configuration steps are shown below:

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **ip route** *ip-address mask-address* **tunnel** *tunnel-num*	Configure the egress of route as TE Tunnel.

Please refer to section of static route configuration in product manual for details.

Policy-based routing

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# Ruijie(config)# **route-map** *route-map-name* [**permit** | **deny**] *sequence*	Define policy route map.
Ruijie(config-route-map)# **match ip address** {*access-list-number* | *access-list-name*} Or ： Ruijie(config-route-map)# **match length** *min* *max*	Configure matching conditions, such as the address in access list or length of packet.
Ruijie(config-route-map)# **set interface tunnel** *tunnel-num*	Configure the egress interface of packets as TE Tunnel interface.
Ruijie(config-route-map)# exit	Exit route map configuration mode.
Ruijie(config)# **interface** *interface-name*	Enter interface configuration mode
Ruijie(config-if)# **ip policy route-map** *route-map-name*	Apply PBR to the interface

Please refer to section of PBR configuration in product manual for details.

IGP Shortcut

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface tunnel** *tunnel-num*	Enter Tunnel configuration mode.
Ruijie(config-if) # **tunnel mpls te autoroute announce**	Enable IGP Shortcut on the Tunnel interface.

Please refer to section of IGP Shortcut configuration in this document for details.

Forwarding Adjacency

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface tunnel** *tunnel-num*	Enter Tunnel configuration mode.
Ruijie(config-if) # **tunnel mpls te forwarding-adjacency**	Enable forwarding adjacency on the Tunnel interface.

Please refer to section of forwarding adjacency configuration in this document for details.

Display configurations

After configuring the basic functions of TE, execute the following command to display configurations and status information:

Command	Function
show ip ospf mpls te fragement	Display TE information of the link.
show ip rsvp interface	Display RSVP-TE related information of interface.
show mpls te link-management {**admission-control**| **advertisements**| **bandwidth-allocation**| **igp-neighbors**| **interfaces**} [*interface-name*]	Display the bandwidth allocation status and IGP neighbors of the interface.
show mpls te tunnels	Display information related to TE Tunnel.

Configure RSVP-TE features

The following sections describe how to configure the optional features of RSVP-TE:

Create configuration tasks

Configure the length of output queue and burst size

Configure RSVP-TE summary refresh

Configure RSVP-TE reservation confirmation

Configure RSVP-TE hello extension

Configure RSVP-TE authentication

Configure to advertise explicit null labels

Configure to remove the correspond path state upon receipt of Patherr

Create configuration tasks

1.1.1.21 Application environment

RSVP-TE has extended the original RSVP by adding Label_Request object in Path messages and Label object in Resv messages, so that TE LSP can be established.

Generally, after RSVP-TE is enabled, default configurations will meet your needs. Meanwhile, RSVP-TE also provides rich options for applications related to reliability, network resources and

advanced features of MPLS TE. Before implementing the configuration tasks introduced in this section, please carefully learn about the purpose of respective configuration tasks and their potential impacts on the network.

1.1.1.22 Prerequisites

Before configuring the optional configurations of RSVP-TE, the following tasks must be completed:

Configure basic functions of RSVP-TE

1.1.1.23 Data preparation

Before configuring the optional configurations of RSVP-TE, the following data must be prepared:

Length of RSVP output queue and burst size

RSVP retransmission timer and increment

Hello message transmission interval and the maximum number of lost messages allowed

RSVP authentication key and authentication mode

Configure the length of output queue and burst size

By default, RSVP-TE message pacing is not configured. Execute the following commands to enable RSVP-TE message pacing:

Command	Function
Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **ip rsvp msg-pacing** [**burst** [*burst-size* [**maxsize** [*max-szie*]]]| **maxsize** [*max-size*]]	Enable RSVP-TE message pacing.

To disable RSVP-TE message pacing, execute "**no ip rsvp msg-pacing**" command.

Configuration example:

Configure RSVP-TE burst size to 100 and the maximum length of output message queue to 200.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)#ip rsvp msg-pacing burset 100 maxsize 200
```

Execute the following commands to display information related to message pacing:

Command	Function
show ip rsvp msg-pacing	Display message pacing related information.

This command is generally used to reduce the number of packets in the message input queue when the transmission rate of the interface of neighboring device doesn't match that of the device, so as to avoid that RSVP-TE packets are discarded when the input queue is full.

Caution

When summary refresh function is enabled, it is suggested not to set an excessively low burst size, or else excessive retransmitted messages will arise between the device and the neighbor.

Configure RSVP-TE summary refresh

By default, RSVP-TE summary refresh is not enabled. Execute the following commands to enable summary refresh. When RSVP-TE summary refresh is also enabled by the neighbor router, the overhead caused by message refreshing will be reduced.

Command	Function
Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **ip rsvp signalling refresh reduction** [**ack-delay** *delay-time*]	Enable RSVP-TE summary refresh or change the delay time for sending ACK message.
Ruijie(config)# **ip rsvp signalling initial-retransmit-delay** *delay-time*	Change the delay time for the initial retransmission of RSVP-TE packets.

To disable the corresponding configuration, execute the corresponding "no" command.

Configuration example:

Enable summary refresh and change the delay time for sending ACK message to 500 ms.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)#ip rsvp signaling refresh reduction ack-delay 500
```

Set the delay time for the initial retransmission of RSVP-TE packets to 1500 ms.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)#ip rsvp signaling initial-retransmit-delay 1500
```

Execute the following commands to display information related to summary refresh:

Command	Function

show ip rsvp signaling refresh reduction	Display information related to summary refresh.

After summary refresh is enabled, if no ACK message is received within the initial retransmission delay time, the corresponding message will be retransmitted. The retransmission delay is calculated using the approach of exponential backoff. The initial retransmission will follow the retransmission delay configured. After that, the message will be retransmitted at an exponentially increased retransmission interval until the corresponding ACK message is received or the number of maximum retries is reached.

Caution

It is suggested that the initial retransmission delay shall be larger than the delay time for sending ACK message, or else the message will be retransmitted due to the delay for sending ACK message by the neighbor, thus causing unnecessary system overhead or network load.

Configure RSVP-TE reservation confirmation

By default, RSVP-TE reservation confirmation mechanism is not enabled. Execute the following commands to enable reservation confirmation.

Command	Function
Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **ip rsvp resvconfirm**	Enable reservation confirmation.

To disable reservation confirmation, execute "**no ip rsvp resvconfrim**" command in the global configuration mode.

Configuration example:

Enable reservation confirmation.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)#ip rsvp resvconfirm
```

RSVP-TE reservation confirmation mechanism is implemented through the following ways:

When the device acts as the egress node of TE tunnel and sends the Resv message, if the reservation confirmation mechanism is enabled, the Resv message will carry Resvconfim object requesting reservation confirmation.

If the ingress node of TE tunnel receives the Resv message containing Resvconfirm object, it will reply with a ResvConf message to confirm the reservation.

Note

Receiving the ResvConf message does not mean resource reservation is established. It only indicates that resources are reserved on the farthest upstream node where the Resv message arrived and the resources can still be preempted by other applications.

Configure RSVP-TE hello extension

By default, hello extension is not enabled. Execute the following commands to enable hello extension on the interface.

Command	Function
Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **ip rsvp hello**	Enable global hello extension.
Ruijie(config)# **interface** *interface-name*	Enter interface configuration mode.
Ruijie(config-if)# **ip rsvp hello**	Enable interface hello extension.
Ruijie(config-if)# **ip rsvp hello** {**hello-interval fast-reroute**|**reroute** *interval-time*|**misses** *times*}	(Optional) Change the refresh interval of interface RSVP-TE hello extension or the maximum number of hello reply messages that can be lost.

To disable RSVP-TE Hello extension mechanism, execute the corresponding "no" command.

Configuration example:

Enable global hello extension.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)#ip rsvp hello
```

Enable Hello extension on GigabitEthernet 0/1.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)#interface gigabitEthernet 0/1
```

```
Ruijie(config-if)#ip rsvp hello
```

Configure the Hello refresh interval of GigabitEthernet 0/1 to 100 ms.

```
Ruijie(config-if)#ip rsvp hello refresh interval 100
```

RSVP: Note that a Hello interval shorter than 200ms,

may result in Hello falsely detecting a neighbor

down event and triggering Fast Reroute unnecessarily.

Execute the following commands to display information related to RSVP-TE Hello extension mechanism:

Command	Function
show ip rsvp hello instance [**detail**]	Display information related to device Hello extension.
show ip rsvp interface detail [*interface-name*]	Display information related to interface Hello extension.

RSVP-TE hello extension mechanism is used to quickly detect the reachability of RSVP neighbors when MPLS TE FRR needs to be enabled.

When Hello extension is enabled, the default refresh interval of Hello messages is 200 ms. If Hello reply message is not received for four consecutive times, the neighboring node is considered failed, and the corresponding TE tunnel will be torn down.

Configure RSVP-TE authentication

By default, RSVP-TE authentication is not enabled on the interface. Execute the following commands to enable RSVP-TE authentication.

Command	Function
Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface** *interface-name*	Enter interface configuration mode.
Ruijie(config-if)# **ip rsvp authentication key** *key-string*	Configure the key used for interface RSVP-TE authentication.
Ruijie(config-if)# **ip rsvp authentication challenge**	(Optional) configure authentication challenge.
Ruijie(config-if)# **ip rsvp authentication lifetime** *hh:mm:ss*	(Optional) configure the lifetime of RSVP-TE authentication between interface and neighbor.
Ruijie(config-if)# **ip rsvp authentication type** [**md5**|**sha-1**]	(Optional) configure the authentication algorithm used by the interface.
Ruijie(config-if)# **ip rsvp authentication widwon-size** *size*	(Optional) configure the authentication window size of the interface.
Ruijie(config-if)# **ip rsvp authentication**	Enable authentication on the interface.

To disable the above configurations, execute the corresponding "no" command.

Configuration example:

Configure GigabitEthernet 0/1 and use the authentication key of 12345678 to enable authentication.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)#interface gigabitEthernet 0/1
```

```
Ruijie(config-if)#ip rsvp authentication key 12345678
```

```
Ruijie(config-if)#ip rsvp authentication
```

RSVP adopts hop-by-hop authentication mechanism to prevent fake resource reservation requests from occupying network resources.

It requires that the interfaces at the two ends of a link must share the same authentication key and authentication algorithm in order to exchange RSVP messages.

Enable authentication challenge on GigabitEthernet 0/1.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)#interface gigabitEthernet 0/1
```

```
Ruijie(config-if)#ip rsvp authentication challenge
```

After this function is configured, the challenge message will be sent after message carrying RSVP-TE authentication object is received in order to obtain the initial sequence number used for peer authentication. This function can guarantee that valid RSVP messages can pass the authentication after router restart or after it is interconnected with routers made by other manufacturers. This function must be enabled on interfaces at two ends of the link, or else challenge may not function properly.

Configure the authentication lifetime of GigabitEthernet 0/1 to 1 hour.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)#interface gigabitEthernet 0/1
```

```
Ruijie(config-if)#ip rsvp authentication lifetime 01:00:00
```

This command is used to specify how long the interface will keep the authentication information. The default value is 30 minutes.

Configure GigabitEthernet 0/1 to use sha-1 authentication algorithm.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)#interface gigabitEthernet 0/1

Ruijie(config-if)#ip rsvp authentication type sha-1
```

This configuration is used to control the authentication algorithm used by the interface. By default, the interface will use md5 algorithm. Sha-1 algorithm is a comparatively new and safer authentication algorithm. Normal communication between interfaces at two ends of the link can only be guaranteed after the same authentication algorithm and authentication key are configured on these two interfaces.

Configure the message window size of GigabitEthernet 0/1 to 32.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)#interface gigabitEthernet 0/1

Ruijie(config-if)#ip rsvp authentication window-size 32
```

Configure authentication window size. When the sequence number of RSVP-TE message received from neighbor is smaller than the maximum sequence number stored locally, if the difference is within the message window and the interface has never received any message with the corresponding sequence number from the neighbor, then this message can pass sequence number check.

Execute the following commands to display information related to summary refresh:

Command	Function
show ip rsvp authentication [**detail** [*ip-address*]|*ip-address*]	Display the authentication information between local device and neighbor.
show ip rsvp interface [**detail**[*interface-name*]|*interface-name*]	Display RSVP-TE related information of interface.

Caution

It is not suggested to enable authentication on the egress of bypass LSP at PLR (Point of Local Repair), as Path message authentication may fail at the MP (MergePoint) when the Path message of primary LSP protected by this bypass LSP is forwarded by this bypass LSP. In like manner, it is also not suggested to enable authentication on the ingress of bypass LSP on MP device, or else the authentication of primary LSP's Path message as forwarded by PLR may fail.

Configure to advertise explicit null labels

By default, the device will not advertise explicit null labels for the TE tunnel. Execute the following commands to advertise explicit null labels for TE tunnel.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **mpls te**	Enable global TE and enter TE configuration mode.
Ruijie(config)# **signalling advertise explicit-null** [*acl-name*]	Advertise explicit null labels for all TE tunnels, or only advertise explicit null labels for the specified TE tunnel.

To disable advertising explicit null labels for TE tunnel, execute "**no signaling advertise explicit-null**" command in TE configuration mode.

By default, when acting as the egress node of TE tunnel, the device will advertise implicit null labels to upstream nodes.

Configuration example:

Configure the device to advertise explicit null labels when acting as the egress node of TE tunnel.

```
Ruijie #configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# mpls te
```

```
Ruijie(config-te)# signaling advertise explicit-null
```

Configure to advertise explicit null labels only for TE tunnel with source address being 1.1.1.1, and advertise implicit null labels for other TE tunnels.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)#ip access-list standard exp_acl
```

```
Ruijie(config-std-nacl)#permit host 1.1.1.1
```

```
Ruijie(config-std-nacl)#exit

Ruijie(config)#mpls te

Ruijie(config-te)#signalling advertise explicit-null exp_acl
```

Configure to remove the correspond path state upon receipt of Patherr

By default, the device won't remove the corresponding path state upon receipt of Patherr messages. Execute the following commands to enable the device to remove the corresponding path state upon receipt of Patherr messages.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **ip rsvp signalling patherr state-removal** [**neighbor** *acl-name*]	Remove the corresponding path state upon receipt of Patherr messages.

To disable path state removal upon receipt of Patherr messages, execute "**no ip rsvp signaling patherr state-removal**" command.

Configuration example:

Configure to remove the corresponding path state upon receipt of Patherr messages.

```
Ruijie#configure terminal

Enter configuration commands, one per line.   End with CNTL/Z.

Ruijie(config)#ip rsvp signaling patherr state-removal
```

Configure to remove the corresponding path state only upon receipt of Patherr messages sent by neighbor 192.168.20.10.

```
Ruijie#configure terminal

Enter configuration commands, one per line.   End with CNTL/Z.

Ruijie(config)# ip access-list standard nbr_acl

Ruijie(config-std-nacl)# permit host 192.168.20.10

Ruijie(config-std-nacl)# exit

Ruijie(config)# ip rsvp signaling patherr state-removal neighbor nbr_acl
```

Enabling this function can enhance processing efficiency and quicken the convergence speed of TE tunnel.

Note

This command is only valid for the error (Patherr) messages upon receipt of which the ingress node of TE tunnel will rebuild the TE tunnel. For Patherr messages advertising certain incidents, the corresponding path state won't be removed.

Adjust TE-LSP establishment

The following sections describe how to adjust relevant configurations for establishing TE-LSP:

Create configuration tasks

Configure CSPF equal cost path selection

Configure path lockdown

Configure administrative group and affinity attribute

Configure TE-LSP reoptimization

Change TE metric of the link

Configure metric style for TE Tunnel path selection

Create configuration tasks

1.1.1.24 Application environment

CSPF uses TED and constraints to calculate the constraint-based path to the destination address and establishes TE LSP through the signaling protocol of RSVP-TE. Generally, default configurations will meet your needs. MPLS TE also provides multiple ways to affect CSPF path calculation and adjust the establishment of TE LSP.

Equal cost path selection

CSPF will only calculate the constraint-based shortest path to the end of tunnel. When multiple paths with equal weight are present in the calculation, you only need to select one of the paths.

The currently available methods for equal-cost path selection include most-fill, least-fill, least-hop and random.

Path lockdown

After TE-LSP is successfully established using the path specified by the user, the path being used won't be changed or reoptimized in the future, unless the specified path is not available.

Administrative group and affinity attribute

The affinity attribute of an MPLS-TE tunnel identifies the properties of the links that the tunnel can use, and is used in conjunction with the link administrative group. IF the affinity attribute of TE

tunnel is specified, then only the link with administrative group attribute meeting the requirements of affinity attribute can be used.

Reoptimization

Optimization involves periodic and event-triggered recalculation of shorter path for the TE tunnel by CSPF. If there is a shorter path, the signalling protocol will use the new path to establish TE LSP and then switch the services to the new TE LSP before removing the original TE LSP.

1.1.1.25 Prerequisites

Before configuring the features introduced herein, the following tasks must be completed:

Configure basic functions of MPLS-TE

1.1.1.26 Data preparation

Before configuring the features introduced herein, the following data must be prepared:

Rule for CSPF equal cost path selection

Administrative group attribute and affinity attribute of the link

TE LSP reoptimization cycle and trigger event

Configure CSPF equal cost path selection

By default, most-fill is used for the equal cost path selection of TE tunnel. Execute the following commands to change the rule for equal cost path selection of TE tunnel.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface tunnel** *tunnel-num*	Enter TE tunnel interface configuration mode.
Ruijie(config-if)# **tunnel mpls te tie-break** {**random**|**least-fill**|**most-fill**|**least-hop**}	Configure the rule for equal cost path selection of TE tunnel.

When the user needs to disable the rule specified for equal cost path selection, execute "**no tunnel mpls te tie-break**" command in TE Tunnel configuration mode.

Configuration example:

Configure TE Tunnel 1 to use least-fill mode to select equal cost path.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)#interface tunnel 1
```

```
Ruijie(config-if)# tunnel mpls te tie-break least-fill
```

Configure path lockdown

By default, TE tunnel path lockdown is not enabled. Execute the following steps to configure TE tunnel path lockdown.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface tunnel** *tunnel-num*	Enter TE tunnel interface configuration mode.
Ruijie(config-if)# **tunnel mpls te path-option** *number* {**dynamic**|**explicit**{**name** *path-name*|**identifier** *path-number*}} [**lockdown**]	Configure TE tunnel path lockdown.

To disable path lockdown, execute this command without the key word of "**lockdown**".

Configuration example:

Configure TE Tunnel 1 to use explicit path t_1 to establish TE tunnel and lock down t_1.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# ip explicit-path name t_1
```

```
Ruijie(cfg-ip-expl-path)# next-address 2.2.2.2
```

Explicit Path name t_1:

1: next address 2.2.2.2

```
Ruijie(cfg-ip-expl-path)# next-address 3.3.3.3
```

Explicit Path name t_1:

1: next address 2.2.2.2

2: next address 3.3.3.3

```
Ruijie(cfg-ip-expl-path)# exit
```

```
Ruijie(config)# interface tunnel 1
```

```
Ruijie(config-if)# tunnel mpls te path-option explicit name t_1 lockdown
```

After configuration, use the following command to view configuration:

Command	Function

show mpls te tunnels tunnel *num*	Display information related to TE Tunnel.

Caution

When path lockdown is enabled and if the path currently used by TE tunnel is locked down, the path won't be recalculated as long as the current path it available, even if reoptimization has been configured.

Configure administrative group and affinity attribute

By default, the administrative group attribute and affinity attribute of the link are not specified, namely the administrative group attribute of link is 0 by default. Among the affinity attributes of tunnel, include-all is 0x0, include-any is 0x0 and exclude-all is 0x0. Execute the following steps to change the administrative group attribute of interface and affinity attributes of tunnel.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface** *interface-name*	Enter interface configuration mode.
Ruijie(config-if)# **mpls te attribute-flags** *attributes*	Configure administrative group attribute of interface.
Ruijie(config-if)# **exit**	Exit interface configuration mode.
Ruijie(config) # **interface tunnel** *tunnel-num*	Enter TE Tunnel configuration mode.
Ruijie(config-if) # **tunnel mpls te affinity** *exclude-any include-any include-all*	Configure the affinity attributes of TE tunnel.

If you intend to restore to the default administrative group attribute of the link, execute "**no mpls te attribute-flags**" command; if you intend to restore to the default affinity attributes of tunnel, execute "**no tunnel mpls te affinity**" command.

Configuration example:

Configure the administrative group attribute of GigabitEthernet 0/1 to 0x6 (110), namely it belongs to administrative group 2 and administrative group 3.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# interface gigabitethernet 0/1
```

```
Ruijie(config-if)# mpls te attribute-flags 6
```

Configure the affinity attribute of TE Tunnel 1 not to include administrative group 1 (01) but to include administrative group 3 (100).

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# interface tunnel 1

Ruijie(config-if)# tunnel mpls te affinity 1 4 0
```

After configuration, use the following command to view configuration:

Command	Function
show mpls te tunnels	Display information related to TE Tunnel.

After configuring the affinity attributes of TE Tunnel, the administrative group attribute of the link must meet the following requirements:

If exclude_any is not 0, then the AND-operation between administrative group attribute of link and exclude_any must be 0.

If include_any is not 0, then the AND-operation between administrative group attribute of link and include_any must not be 0.

If include_all is not 0, then the AND-operation between administrative group attribute of link and include_all must equal to include_all.

Only the link meeting all the aforementioned three conditions can meet the affinity attribute of TE tunnel.

Caution After changing the affinity attribute of TE tunnel, the TE LSP already established by this Tunnel will be removed immediately, and CSPF will recalculate the path for this TE Tunnel.

Configure TE-LSP reoptimization

By default, the reoptimization interval of TE tunnel is 1 hour, and TE tunnel reoptimization when the link is UP (reoptimization triggered by event) is not enabled. Execute the following steps to change the TE tunnel reoptimization interval and enable reoptimization when the link is UP.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **mpls te**	Enable MPLS TE and enter global TE configuration mode.
Ruijie(config-te)# **reoptmize timers frequency** *interval*	Change the reoptimization interval of TE tunnel. The default interval is 1 hour. If the interval is set to 0, the reoptimization interval will be disabled.
Ruijie(config-te) # **reoptmize events link-up**	Execute reoptimization when the link is UP.

To restore to the default configurations, execute the corresponding "no" commands.

Configuration example:

Configure TE tunnel reoptimization interval to 2 hours, i.e., 7200 seconds.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)#mpls te
```

Ruijie(config-te)# reoptmize timers frequency *7200*

Execute TE tunnel reoptimization when the link is UP.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# mpls te
```

```
Ruijie(config-te)# reoptmize events link-up
```

After configuration, use the following command to view configuration:

Command	Function
show mpls te tunnels summary	Display summary information related to TE Tunnel.

Configure TE metric of the link

By default, the TE metric of link equals to the IGP metric. Execute the following command to change TE metric.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface** *interface-name*	Enter interface configuration mode.
Ruijie(config-if) # **mpls te administrative-weight** *weight*	Change TE metric of the interface.

To restore to the default TE metric of interface, execute "**no mpls te administrative-weight**" command.

Configuration example:

Configure the TE metric of GigabitEthernet 0/1 to 100.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# interface gigabitethernet 0/1

Ruijie(config-if)# mpls te administrative-weight 100
```

The larger the TE metric is, the less possible it is for the link to be used while calculating the constraint-based shortest path for TE tunnel.

While changing the TE metric of interface, only CSPF calculation of constraint-based shortest path for TE tunnel will be affected; SPF algorithm based ordinary route calculation for IGP-TE won't be affected.

Configure metric style for TE Tunnel path selection

By default, CSPF uses the TE metric of the link to calculate the constraint-based shortest path for TE tunnel. Execute the following steps to change the metric type used.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface tunnel** *tunnel-num*	Enter Tunnel interface configuration mode.
Ruijie(config-if) # **tunnel mpls te path-select metric** {**igp**|**te**}	Change the link metric used in CSPF calculation.

To restore to the default metric, execute "**no tunnel mpls te path-select metric**" command.

Configuration example:

Configure TE Tunnel 1 to use IGP metric to calculate the constraint-based shortest path.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# interface tunnel 1

Ruijie(config-if)# tunnel mpls te path-select metric igp
```

After configuration, use the following command to view configuration:

Command	Function
show mpls te tunnels	Display information related to TE Tunnel.

Adjust TE tunnel establishment

The following sections introduce the advanced configurations about TE tunnel establishment:

Create configuration tasks

Configure loop detection

Configure route and label recording

Configure the priority of TE tunnel

Configure the bandwidth needed by TE tunnel

Configure the name of TE tunnel

Create configuration tasks

1.1.1.27 Application environment

While establishing the TE tunnel, the default configurations will meet your needs. However, in certain circumstances, we may need to use the optional features introduced herein to establish the TE tunnel.

1.1.1.28 Prerequisites

Before configuring the features introduced herein, the following tasks must be completed:

Configure basic functions of MPLS

1.1.1.29 Data preparation

Before adjusting MPLS TE tunnel, the following data must be prepared:

Setup priority and holding priority of TE tunnel

The bandwidth needed by TE tunnel

Configure loop detection

By default, TE tunnel loop detection is not enabled. Execute the following steps to enable TE tunnel loop detection.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **mpls te**	Enable global TE and enter TE configuration mode.
Ruijie(config-te) # **loop-detection**	Enable loop detection.

If you intend to disable loop detection, execute "**no loop-detection**" in TE configuration mode.

Configuration example:

Enable loop detection of TE tunnel.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# mpls te

Ruijie(config-te)# loop-detection
```

After loop detection is enabled, if the Record Route object included in the corresponding Path message or Resv message already contains the record of native device or reaches the maximum hop count of 255, then a loop is considered present and LSP establishment will fail.

Note

Even if the loop detection is enabled, the loop detection cannot proceed if route recording is not enabled.

Configure route and label recording

By default, TE Tunnel route and label recording is not enabled. Execute the following steps to enable this feature.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface tunnel** *tunnel-num*	Enter Tunnel interface configuration mode.
Ruijie(config-if) # **tunnel mpls te** {**record-route**| **record-label**}	Enable route and label recording of TE tunnel.

If you intend to disable route and label recording, execute the corresponding "no" command.

Configuration example:

Configure TE Tunnel 1 to enable route recording

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# interface tunnel 1

Ruijie(config-if)# tunnel mpls te record-route
```

Configure TE Tunnel 1 to enable label recording

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# interface tunnel 1

Ruijie(config-if)# tunnel mpls te record-label
```

After configuration, use the following command to view configuration:

Command	Function
show mpls te tunnels	Display information related to TE Tunnel.

Caution

Do not enable label recording if route recording is not enabled.

Configure the priority of TE tunnel

By default, both the setup priority and holding priority of TE tunnel are 7. Execute the following steps to change the setup priority and holding priority of TE tunnel.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface tunnel** *tunnel-num*	Enter Tunnel interface configuration mode.
Ruijie(config-if) # **tunnel mpls te priority** *setup-priority holdup-priority*	Configure the setup priority and holding priority of TE tunnel.

To restore to the default priority used by TE tunnel, execute "**no tunnel mpls te priority**" command.

Configuration example:

Configure the setup priority and holding priority of TE tunnel 1 to 4.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# interface tunnel 1
```

```
Ruijie(config-if)# tunnel mpls te priority 4 4
```

Specify the priority from 0 to 7. The larger the value is, the lower the priority will be.

After configuration, use the following command to view configuration:

Command	Function
show mpls te tunnels	Display information related to TE Tunnel.

Note

The setup priority must be lower than the holding priority, namely the setup priority must not be larger than the holding priority.

Changing the setup priority and holding priority of TE tunnel will lead to the immediate reestablishment of TE tunnel.

Configure the bandwidth needed by TE tunnel

By default, no bandwidth needed by TE tunnel is specified. Execute the following steps to configure the bandwidth needed by TE tunnel for establishment.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface tunnel** *tunnel-num*	Enter Tunnel interface configuration mode.
Ruijie(config-if) # **tunnel mpls te bandwidth** *bandwidth*	Configure the bandwidth needed for establishing TE Tunnel.

To disable the bandwidth specified for TE tunnel establishment, execute "no tunnel mpls te bandwidth" command.

Configuration example:

Configure the bandwidth needed for TE Tunnel establishment to 100Kbps.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# interface tunnel 1
```

```
Ruijie(config-if)# tunnel mpls te bandwidth 100
```

After configuration, use the following command to view configuration:

Command	Function
show mpls te tunnels	Display information related to TE Tunnel.

Note

While changing the bandwidth needed for TE tunnel establishment, TE LSP will be reestablished using make-before-break mechanism. If an appropriate path cannot be found for the new bandwidth, the TE LSP established previously won't be affected.

Configure the name of TE tunnel

By default, the name of "Router_t + tunnel-num" will be used when TE tunnel is established. Execute the following steps to change the name used when TE tunnel is established.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface tunnel** *tunnel-num*	Enter Tunnel interface configuration mode.
Ruijie(config-if) # **tunnel mpls te name** *name*	Change the name used when TE tunnel is established.

To restore to the default name, execute "no tunnel mpls te name" command.

Configuration example:

Change the default name of Router_t1 used when TE Tunnel 1 is established to SiteA_SiteB.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# interface tunnel 1
```

```
Ruijie(config-if)# tunnel mpls te name SiteA_SiteB
```

After configuration, use the following command to view configuration:

Command	Function
show mpls te tunnels	Display information related to TE Tunnel.

Configure traffic forwarding tuning parameters

The following sections introduce configurations related to traffic forwarding tuning:

Create configuration tasks

Configure failed link timer

Configure bandwidth change flooding thresholds

Configure periodic flooding time

Configure IGP Shortcut

Configure forwarding adjacency

Create configuration tasks

1.1.1.30 Application environment

In MPLS TE network, you may configure to tune IP traffic, change paths that MPLS traffic traverses or define the type of traffic that may travel down a TE tunnel.

1.1.1.31 Prerequisites

Before configuring traffic forwarding tuning parameters, the following feature must be enabled:

Enable MPLS TE basic functions

1.1.1.32 Data preparation

Before configuring traffic forwarding tuning parameters, the following data must be prepared:

Value of failed link timer

Bandwidth change flooding thresholds

Periodic flooding time

Configure failed link timer

Upon CSPF path calculation, the signaling protocol (such as RSVP) will establish the LSP path. If LSP establishment fails, the signaling protocol will report to CSPF that there is an error on a certain link (such as the change in the bandwidth of a certain link during this period), and CSPF will regard this link unavailable for a period of time in the subsequent path calculation. By default, this time is 10 seconds. Execute the following steps to change the value of timer.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **mpls te**	Enable global TE or enter TE global configuration mode.
Ruijie(config-te) # **topology holddown sigerr** *seconds*	Change the value of failed link timer.

To disable the failed link timer configured, execute "no topology holddown sigerr" to restore to the default configuration.

Configuration example:

Configure TE failed link timer to 5 seconds.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# mpls te
```

```
Ruijie(config-te)# topology holddown sigerr 5
```

Note

For the failed link timer specified by the user, CSPF will not consider this link in the subsequent calculation unless the timer expires or this link changes in TED before the timer expires.

Configure bandwidth change flooding thresholds

By default, the bandwidth information of the link will be flooded in the following two cases, or else the bandwidth information will be flooded only after the periodic flooding timer expires.

The threshold of reservable bandwidth decrease reaches 100%, 99%, 98%, 97%, 96%, 95%, 90%, 85%, 80%, 75%, 60%, 45%, 30% and 15% of the maximum reservable bandwidth;

Or the threshold of reservable bandwidth increase reaches 15%, 30%, 45%, 60%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98%, 99% and 100% of the maximum reservable bandwidth.

If the change in available bandwidth hasn't reached the flooding thresholds, flooding won't be effected immediately. Execute the following steps to change TE flooding thresholds.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface** *interface-name*	Enter interface configuration mode.
Ruijie(config-if) # **mpls te flooding thresholds** {**up**|**down**} *percent* [*percent*…]	Change the failed link timer. You can configure up to 14 available bandwidth increase flooding thresholds and 14 available bandwidth decrease flooding thresholds.

To restore to the default configurations, execute the corresponding "no" commands.

Configuration example:

Configure the available bandwidth increase flooding thresholds of Gigabitetherent 0/1 to 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# interface gigabitethernet 0/1
```

```
Ruijie(config-if)# mpls te flooding thresholds up 10 20 30 40 50 60 70 80 90 100
```

Configure the available bandwidth decrease flooding thresholds of Gigabitetherent 0/1 to 100, 90, 80, 70, 60, 50, 40, 30, 20 and 10.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# interface gigabitethernet 0/1
```

```
Ruijie(config-if)# mpls te flooding thresholds down 100 90 80 70 60 50 40 30 20 10
```

After configuration, use the following command to view configuration:

Command	Function
show mpls te link-management bandwidth-allocation [*interface-name*]	Display bandwidth allocation status.

Note

If the available bandwidth change of link hasn't reached the flooding thresholds, then flooding won't be effected immediately, unless the TE periodic flooding time configured runs out or the available bandwidth change of link during this period reaches the flooding thresholds.

Configure periodic flooding time

By default, the IGP-TE period flooding time is 180 seconds. Execute the following steps to change the periodic flooding time.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **mpls te**	Enable global TE or enter TE global configuration mode.
Ruijie(config-te) # **periodic-flooding** *seconds*	Configure IGP-TE periodic flooding time (0-3600 seconds). 0 means that periodic flooding is prohibited.

To restore to the default periodic flooding time, execute "**no periodic-flooding**" command.

Configuration guide:

Configure IGP-TE periodic flooding time to 300 seconds.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# mpls te
```

```
Ruijie(config-te)# periodic-flooding 300
```

Note

When the periodic flooding time runs out, the device will only flood the link which was not flooded during this period as the available bandwidth change hasn't reached the flooding thresholds.

Configure IGP Shortcut

By default, IGP Shortcut is not enabled. Execute the following steps to enable IGP Shortcut.

Ruijie# **configure terminal**	Enter global configuration mode.

Ruijie(config)# **interface tunnel** *tunnel-num*	Enter Tunnel configuration mode.
Ruijie(conifig-if)# **tunnel mpls te autoroute metric** {**absolute** | **relative**} *value*	(Optional) configure the metric of Tunnel interface. By default, the metric of Tunnel interface is the same as the metric of the link passed. While configuring "relative", the configurable scope of value is -10 to 10. The parameter of "absolute" is only used in the enhanced SPF algorithm of ISIS, and is invalid to OSPF.
Ruijie(config-if) # **tunnel mpls te autoroute announce**	Enable IGP Shortcut on the Tunnel interface.

To disable IGP Shortcut configured for TE Tunnel interface, execute "**no tunnel mpls te autoroute announce**" command.

Configuration example:

Configure TE Tunnel 1 to enable IGP Shortcut.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# interface tunnel 1
```

```
Ruijie(config-if)# tunnel mpls te autoroute announce
```

Configure TE Tunnel 1 to enable IGP Shortcut with relative metric being -5.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# interface tunnel 1
```

```
Ruijie(config-if)# tunnel mpls te autoroute metric relative -5
```

After configuration, use the following command to view configuration:

Command	Function
show ip route	Display the routing information of the device.

Caution

When the relative metric is a negative value, the absolute value of "value" must be less than or equal to the actual metric of the link passed.

Note

If IGP Shortcut has been configured, the forwarding adjacency cannot be configured at the same time.

Configure forwarding adjacency

By default, TE Tunnel forwarding adjacency is not enabled. Execute the following steps to enable forwarding adjacency.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface tunnel** *tunnel-num*	Enter Tunnel configuration mode.
Ruijie(config-if) # **tunnel mpls te forwarding-adjacency**	Enable forwarding adjacency on the Tunnel interface.

To disable TE Tunnel forwarding adjacency, execute "no tunnel mpls te forwarding-adjacency" command.

Configuration example:

Configure TE Tunnel 1 to enable forwarding adjacency.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# interface tunnel 1
```

```
Ruijie(config-if)# tunnel mpls te forwarding-adjacency
```

After configuration, use the following command to view configuration:

Command	Function
show ip route	Display the routing information of the device.

Since forwarding adjacency needs a bidirectional link and TE Tunnel is unidirectional, when forwarding adjacency of TE Tunnel is enabled, a TE Tunnel reaching the device must be established at the egress node of TE Tunnel, and forwarding adjacency shall be enabled at the same time.

Note

If forwarding adjacency has been configured, the IGP Shortcut cannot be configured at the same time.

Configure MPLS TE fast reroute

The following sections introduce configurations related to MPLS TE fast reroute:

Create configuration tasks

Configure TE tunnel to enable fast reroute

Configure a Bypass Tunnel on PLR

Enable RSVP-TE Hello detection

Create configuration tasks

1.1.1.33 Application environment

As a feature of MPLS TE, Fast Reroute (FRR) can provide temporary protection for the primary LSP.

Since the bypass tunnel used by FRR needs to be created before fault occurrence, it will consume extra bandwidth. Therefore, when there is no sufficient residual network bandwidth, it is suggested to apply FRR protection on key links or key devices only.

Bypass tunnel

The bypass tunnel can be configured to protect multiple physical interfaces, but it cannot protect its own egress interface (it should be noted that since the egress interface of bypass tunnel is only known after being established, the bypass tunnel can be configured to protect any physical interface during the configuration; however, during binding calculation, if the bypass tunnel has been specified to protect its own egress interface, the binding won't succeed.) Likewise, a physical interface can be protected by multiple bypass tunnels, and the number of such bypass tunnels relies on system memory.

The user can specify whether or not the bypass tunnel will provide bandwidth protection, the sum of protected bandwidth and the priority of primary LSP when the protected bandwidth is insufficient.

The bandwidth of a bypass tunnel is to protect its primary LSPs. If you expect that the bypass tunnel can protect all primary LSPs passing through a certain interface and provide bandwidth protection, then the bandwidth assigned to the bypass tunnel must be greater than or equal to the total bandwidth needed by all primary LSPs, or else the bypass tunnel cannot provide protection for all primary LSPs. Usually, the bypass tunnel is not used to forward traffic. To allow a bypass tunnel to forward data traffic while protecting the primary LSPs, you need to ensure that bypass tunnel is available with adequate bandwidth.

Switching

Fast reroute (including the automatic fast reroute introduced in the next section) adopts make-before-break mechanism to reestablish the path. When a fault is detected, PLR will send the corresponding PathErr message to the ingress node of TE tunnel, on which the LSP is reestablished, and the traffic will be switched to the new LSP only after its is established successfully. After that, the original LSP will be removed. During this period, PLR forwards the traffic and Path refresh messages of primary LSP through bypass tunnel.

1.1.1.34 Prerequisites

Before configuring MPLS TE fast reroute, the following tasks must be completed:

Configure OSPF or ISIS protocol and ensure that LSRs are interconnected at the network layer

Configure MPLS TE basic capabilities

Establish the primary LSP

1.1.1.35 Data preparation

Before configuring MPLS TE fast reroute, the following data must be prepared:

The bandwidth to be protected by bypass tunnel

The protection policy of fast reroute: link protection or node protection

Configure TE tunnel to enable fast reroute

By default, TE tunnel fast reroute is not enabled. Execute the following steps to enable TE tunnel fast reroute.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface tunnel** *tunnel-num*	Enter Tunnel configuration mode.
Ruijie(config-if) # **tunnel mpls te fast-reroute** [**bw-protect** | **node-protect**]	Enable TE Tunnel fast reroute.

To disable TE Tunnel fast reroute, execute "**no tunnel mpls te fast-reroute**" command.

Configuration example:

Configure TE Tunnel 1 to enable fast reroute.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)#interface tunnel 1
```

Ruijie(config-if)# tunnel mpls te fast-reroute

Configure TE Tunnel 1 to provide bandwidth protection.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# interface tunnel 1
```

```
Ruijie(config-if)#tunnel mpls te fast-reroute bw-protect
```

After configuration, use the following commands to view configurations:

Command	Function
show ip rsvp fast-reroute [**bw-protect**|**detail**]	Display information about the primary LSP requiring partial protection.
show mpls te fast-reroute database	Display information related to fast reroute.

Note

If the attribute of TE tunnel fast route is changed, the TE Tunnel will be reestablished using the make-before-break mechanism.

Configure a Bypass Tunnel on PLR

By default, bypass tunnel is not configured on PLR. Execute the following steps to configure bypass tunnel on PLR.

Command	Function
Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface tunnel** *tunnel-number*	Create Bypass Tunnel interface and enter Tunnel interface configuration mode.
Ruijie(config-if)# **label-switching**	Configure the tunnel to allow handling of MPLS packets.
Ruijie(config-if)# **ip ref**	Enable fast forwarding on the tunnel interface of router (not applicable to the switch).
Ruijie(config-if)# **tunnel mode mpls te**	Configure the tunnel protocol as MPLS TE.
Ruijie(config-if)# **tunnel destination** *ip-address*	Configure the destination address of tunnel.

Ruijie(config-if)# **ip address** *ip-address mask* 或者 Ruijie(config-if)# **ip unnumbered** *interface-name*	Configure the IP address of tunnel interface. To enable traffic forwarding, the tunnel interface must have an IP address. Since MPLS TE tunnel is unidirectional, there is no problem of peer address. Therefore, it is unnecessary to configure a separate IP address for Tunnel interface. In the common practice, the Tunnel interface uses device address as the address of Loopback interface of LSR ID.
Ruijie(config-if)# **tunnel mpls te path-option** *number* **explicit{name** *path-name*|**identifier** *path-number*}	Configure the path used to establish TE tunnel. Note: Generally, the explicit path is used to specify the bypass path instead of dynamic calculation, or else the bypass tunnel and the primary LSP may share the same egress interface and protection will be impossible.
Ruijie(config-if) # **tunnel mpls te back-bw** *bandwidth*	(Optional) configure the bandwidth protected by the bypass tunnel.
Ruijie(config-if)# **exit**	Exit interface configuration mode.
Ruijie(config)# **mpls te**	Enter TE configuration mode.
Ruijie(config-te)# **fast-reroute backup-prot-preemption optimize-bw**	(Optional) configure the preemption algorithm used by fast reroute for protecting primary LSP to minimize the amount of bandwidth that is wasted. By default, the algorithm to preempt the LSP that waste the least amount of bandwidth will be used.
Ruijie(config-te)# **fast-reroute timers promotion** *seconds*	(Optional) configure the interval for primary LSP to choose the shorter bypass tunnel. The default value is 300 seconds.
Ruijie(config-te)# **exit**	Exit TE configuration mode.
Ruijie(config)# **interface** *interface-name*	Enter the configuration mode of the interface to be protected.
Ruijie(config-if)# **mpls te back-path tunnel** *tunnel-num*	Configure the interface to use the Bypass Tunnel created to provide protection.

To disable the Bypass Tunnel configured, you must disable the bandwidth protection configured and disable using this Tunnel to protect the physical interface.

Configuration example:

Configure TE Tunnel 1 to provide bandwidth protection of 2500Kbps.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# interface tunnel 1
Ruijie(config-if)# tunnel mpls te back-bw 2500
```

Configure to use TE Tunnel 1 to protect GigabitEthernet 0/1.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te back-path tunnel 1
```

After configuration, use the following command to view configuration:

Command	Function
show mpls te tunnels backup	Display information related to Bypass Tunnel.

Once a physical interface has been configured to be protected by a certain TE Tunnel, this TE Tunnel will automatically become Bypass Tunnel, and the corresponding LSP will become Bypass LSP, which is generally established using explicit path.

Since no protection is provided for Bypass LSP, if the Bypass LSP is being used to forward traffic and this LSP becomes down for some reason, then the protected traffic cannot be forwarded by the bypass tunnel. The traffic is interrupted and FRR will fail.

Note

1、 Do not enable fast reroute on the Bypass Tunnel.

2、 Bypass LSP is generally established using explicit path instead of dynamic mode.

Enable RSVP-TE Hello detection

By default, RSVP-TE Hello extension is not enabled on the device. To ensure that PLR can quickly detect faults and switch the traffic to Bypass tunnel when FRR is enabled, the Hello extension must be enabled on the egress of primary LSP of PLR and the interface of neighboring device.

Configure MPLS TE automatic fast reroute

The following sections introduce configurations related to automatic fast reroute:

Create configuration tasks

Enable automatic fast reroute

Create configuration tasks

1.1.1.36 Application environment

In the core network, due to the high requirements on service reliability, the MPLS TE FRR is generally deployed to enhance network reliability. If the network topology is complicated, the configurations could be very complicated.

Automatic Fast Reroute (AutoFRR) can automatically establish the Bypass Tunnel meeting relevant conditions, thus reducing the workload of configuration. In addition, if the Bypass Tunnel created automatically is not used for a period of time, it will be removed automatically to avoid resource occupation.

1.1.1.37 Prerequisites

Before configuring automatic fast reroute, the following task must be completed:

Configure MPLS TE basic capabilities

1.1.1.38 Data preparation

Before configuring automatic fast reroute, the following data must be prepared:

Configure the protection policy of automatic fast reroute: link protection or node protection

Enable automatic fast reroute

By default, automatic fast reroute is not enabled. Execute the following steps to enable automatic fast reroute.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **mpls te**	Enable MPLS TE and enter TE configuration mode.
Ruijie(config-te)# **auto-tunnel backup** [**nhop-only**]	Enable automatic FRR. By default, the bypass tunnel for link protection and node protection will be established automatically. If "**nhop-only**" key word is used, then the tunnel for link protection only will be created (without node protection).
Ruijie(config-te)# **auto-tunnel backup config unnumbered-interface** *interface-name*	(Optional) configure the IP address borrowed by the bypass tunnel created automatically. By default, the IP address of Loopback0 will be borrowed.

Ruijie(config-te)#**auto-tunnel backup timers removal unused** *scan-sec unuse-sec*	(Optional) configure how frequently the bypass tunnel created automatically will be scanned and the time to remove tunnels that are not being used. By default, scanning will be implemented once every 3600s, and the automatically-created bypass tunnel left used for 3600s will be removed.

To disable automatic fast reroute, execute "**no auto-tunnel backup**" command.

Configuration example:

Enable autoamtic fast reroute on the device.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# mpls te
```

```
Ruijie(config-te)# auto-tunnel backup
```

After configuration, use the following command to view configuration:

Command	Function
show mpls te fast-reroute database	Display information related to Bypass Tunnel.

Note

1、 By default, if automatic fast reroute is enabled on the device, the Bypass Tunnel for node protection and the Bypass Tunnel for link protection will be created immediately when the primary LSP passing through a certain physical interface cannot get an appropriate Bypass Tunnel.

2、 If Loopback0 is not configured and "**auto-tunnel backup config unnumbered-interface**" is not executed to configure the borrowed IP address, the automatically created bypass tunnel won't be bound by the primary LSP.

Configure LDP over TE

The following sections introduce configurations related to LDP over TE.

Create configuration tasks

Configure TE tunnel to enable LDP

Configure the egress node of TE tunnel to receive extended LDP hello messages

Configure to direct traffic into TE Tunnel

Create configuration tasks

1.1.1.39 Application environment

Currently, LDP is widely applied in the MPLS VPN as the label distribution protocol. Since LDP cannot protect the bandwidth needed by traffic, the feature of LDP over TE can be enabled to avoid the congestion of VPN traffic on certain nodes in the public network.

1.1.1.40 Prerequisites

Before configuring LDP over TE, the following tasks must be completed:

Configure IGP protocol and ensure intercommunication at the network layer

Configure MPLS TE basic capabilities

Configure node and interface MPLS forwarding

Configure node and interface MPLS LDP

1.1.1.41 Data preparation

Before configuring LDP over TE, the following data must be prepared:

IP address and loopback address of interface

Destination address of Tunnel interface

Configure TE tunnel to enable LDP

By default, LDP is not enabled for the TE Tunnel. Execute the following steps to enable LDP for the TE Tunnel.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface tunnel** *tunnel-num*	Enter Tunnel interface configuration mode.
Ruijie(config-if)# **mpls ip**	Enable LDP on TE Tunnel interface.

To disable LDP for TE Tunnel, execute "**no mpls ip**" command.

Configuration example:

Configure TE Tunnel 1 to enable LDP.

```
Ruijie#configure terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# interface tunnel 1

Ruijie(config-if)# mpls ip
```

After configuration, use the following command to view configuration:

Command	Function
show mpls ldp interface [*interface-name*]	Display the information of LDP-enabled interfaces.

Note

When LDP is enabled on TE Tunnel interface, the LDP Hello messages sent will be extended Hello messages, and the destination address of Hello is the destination address of TE Tunnel. The device will not received extended Hello messages by default, unless the extended hello sender is configured as the extended peer or the receiver is configured to receive extended LDP Hello messages as introduced below.

Configure the egress node of TE tunnel to receive extended LDP hello messages

By default, the device won't receive extended LDP hello messages. Execute the following steps to enable the device to receive extended LDP hello messages.

Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **mpls router ldp**	Enter global LDP configuration mode.
Ruijie(config-mpls-router)# **discovery targeted-hello accept** [**from** *acl-name*]	Enable the device to receive extended LDP hello messages.

To disable the reception of extended LDP hello messages, execute "**no discovery targeted-hello accept**" command.

Configuration example:

Configure LDP to receive the extended LDP hello messages sent by all devices.

```
Ruijie#config terminal

Enter configuration commands, one per line.  End with CNTL/Z.

Ruijie(config)# mpls router ldp

Ruijie(config-mpls-router)# discovery targeted-hello accept
```

Configure LDP to receive only the extended LDP hello messages sent by neighbor 1.1.1.1.

```
Ruijie# config terminal
```

Enter configuration commands, one per line. End with CNTL/Z.

```
Ruijie(config)# ip access-list standard target_acl
Ruijie(config-std-nacl)# permit host 1.1.1.1
Ruijie(config-std-nacl)# exit
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# discovery targeted-hello accept from target_acl
```

After configuration, use the following command to view configuration:

Command	Function
show mpls ldp neighbor	Display the information of LDP neighbors.

Note

When the device is configured to receive extended LDP hello, if no extended LDP hello is received from the neighbor, then the device won't send extended LDP hello to the peer, namely the device will only reply with extended LDP hello upon receipt of the extended LDP hello sent by the neighbor.

Configure to direct traffic into TE tunnel

By default, no traffic will be directed into TE Tunnel. The configurations introduced in "Configure IGP Shortcut" and "Configure forwarding adjacency" can direct traffic into the TE Tunnel. Please refer to the section of "Configure to direct traffic into TE tunnel" for details about directing traffic into the TE tunnel.

Maintain MPLS TE

The following sections introduce configurations related to MPLS TE maintenance.

Clear operational information

Debug information

Clear operational information

Command	Function
clear ip rsvp counters	Clear statistics about RSVP-TE.
clear ip rsvp neighbor	Clear information about RSVP-TE neighbors.
clear mpls te tunnel counters	Clear statistics about TE Tunnel.

Debug information

In case of any operational fault, execute the following debug commands in the privilege mode to diagnose MPLS TE.

Command	Function
debug ip rsvp fsm	Turn on RSVP-TE state debugging switch.
debug ip rsvp message	Turn on RSVP-TE message debugging switch.
debug ip rsvp dump-message [**path**|**resv**]	Turn on the debugging switch to input RSVP-TE Path message and Resv message.
debug ip rsvp authentication	Turn on RSVP-TE authentication debugging switch.
debug mpls te path {**spf**|**verify**}	Turn on CSPF path calculation and verification debugging switch.
clear mpls te tunnel counters	Clear statistics about TE Tunnel.

Caution Turning on the debugging switch will affect system performance. After debugging, execute "**undo debug all**" command to turn off the debugging switch.

Typical MPLS-TE Configuration Example

The following examples will be introduced:

Example of establishing MPLS TE tunnel

Example of configuring RSVP-TE authentication

Example of configuring fast reroute

Example of configuring automatic fast reroute

Example of configuring MPLS-TE in MPLS VPN

Example of configuring LDP over TE

Example of establishing MPLS TE tunnel

1.1.1.42 Networking requirements

In the topology shown in Fig 8:

TE tunnel 1 with bandwidth being 1Mbps shall be established between router RA and router RD.

The setup priority and holding priority of TE tunnel shall be 4.

The tunnel shall be established using dynamic path.

OSPF supporting TE extension shall be deployed.

The maximum reservable link bandwidth shall all be 10Mbps, and the maximum bandwidth shall all be 100Mbps.

1.1.1.43 Network topology

Fig 8 Network topology for establishing MPLS TE tunnel

1.1.1.44 Configuration tips

Configure interface IP address on respective routers and the Loopback address of LSR ID.

Configure OSPF on respective routers and enable OSPF-TE.

Enable global TE on respective routers and enable TE on respective interfaces.

Enable MPLS forwarding on respective routers.

Configure the maximum reservable bandwidth and maximum bandwidth on the interface of respective routers.

Configure TE Tunnel on RA.

1.1.1.45 Configuration steps

1) Configure IP address on the interface of respective routers.

Loopback 0
1.1.1.1/32

Loopback 0
2.2.2.2/32

Gi0/1 192.17.1.2/24 Gi0/2 192

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface loopback 0
Ruijie(config-if)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/1
```

"no switchport" command is used to switch the port mode to "Routed Port" mode on switch products, and is not applicable to the router. Therefore, you don't need to execute this command on router products.

```
Ruijie(config-if)# no switchport
```

For router products, enable fast forwarding on the interface.

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 192.17.1.1 255.255.255.0
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
# The configurations of RB, RC and RD are the same as that of RA.
```

2) Configure OSPF to advertise routes and enable TE.

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 192.17.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

Configure RB

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 192.17.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.18.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

Configure RC

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
```

```
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# network 192.18.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.19.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

Configure RD

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 4.4.4.4 0.0.0.0 area 0
Ruijie(config-router)# network 192.19.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

3) Enable global TE on respective routers and enable TE on respective interfaces.

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
```

Configure RB

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
```

Configure RC

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
```

```
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
```

Configure RD

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
```

4) Configure MPLS forwarding on respective routers

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# label-switching
Ruijie(config-if)# exit
```

Configure RB

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# label-switching
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# label-switching
Ruijie(config-if)# exit
```

Configure RC

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls ip
```

```
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# label-switching
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# label-switching
Ruijie(config-if)# exit
```

Configure RD

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# label-switching
Ruijie(config-if)# exit
```

5) Configure the maximum reservable bandwidth and maximum bandwidth on respective interfaces

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# bandwidth 100000
Ruijie(config-if)# mpls te reservable-bandwidth 10000
Ruijie(config-if)# exit
```

Configure RB

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# bandwidth 100000
Ruijie(config-if)# mpls te reservable-bandwidth 10000
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# bandwidth 100000
Ruijie(config-if)# mpls te reservable-bandwidth 10000
Ruijie(config-if)# exit
```

Configure RC

```
Ruijie# configure terminal
```

```
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# bandwidth 100000
Ruijie(config-if)# mpls te reservable-bandwidth 10000
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# bandwidth 100000
Ruijie(config-if)# mpls te reservable-bandwidth 10000
Ruijie(config-if)# exit
```

Configure RD

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# bandwidth 100000
Ruijie(config-if)# mpls te reservable-bandwidth 10000
Ruijie(config-if)# exit
```

6) Configure TE Tunnel on RA.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface tunnel 1
Ruijie(config-if)# label-switching
# For router products, enable fast forwarding on the interface.
Ruijie(config-if)# ip ref
Ruijie(config-if)# tunnel mode mpls te
Ruijie(config-if)# ip unnumbered looback 0
Ruijie(config-if)# tunnel destination 4.4.4.4
Ruijie(config-if)# tunnel mpls te priority 4 4
Ruijie(config-if)# tunnel mpls te bandwidth 1000
Ruijie(config-if)# tunnel mpls te path-option 10 dynamic
Ruijie(config-if)# exit
```

1.1.1.46 Verification

After configuration, execute "show mpls te tunnels tunnel 1" command on RA to display the TE tunnel established between RA and RD.

```
Ruijie# show mpls te tunnels tunnel 1
Name: Router_t1                       (Tunnel1) Destination: 4.4.4.4
  Status:
    Admin: up        Oper: up    Path: Valid      Signalling: connected
    path option 10, type dynamic Basis for Setup, path weight 30

  Config Parameters:
    Bandwidth: 1000       kbps Priority: 4 4
    Affinity: exclude_any 0X00000000 include_any 0X00000000 include_all 0X00000000
```

```
  Metric Type: TE (default)

Inlabel  :  -
OutLabel : gigabitethernet 0/1, 1024
RSVP Signalling Info:
    Src 1.1.1.1, Dst 4.4.4.4, Tun_Id 1, Tun_Instance 1
  RSVP Path Info:
    My Address: 192.17.1.1
    Explicit Route: 192.17.1.2 192.18.1.1 192.18.1.2 192.19.1.1
                    192.19.1.2 4.4.4.4
    Record Route:  NONE
    Record Label:  NONE
    Tspec: ave rate =1000 kbits, burst =1000 bytes, peak rate =1000 kbits
  RSVP Resv Info:
    Record Route:  NONE
    Record Label:  NONE
    Fspec: ave rate=1000 kbits, burst=1000 bytes, peak rate=1000 kbits
History:
  Tunnel:
    Time since created: 0 hours, 3 minutes
    Time since path change: 1 minutes, 37 seconds
  Current LSP:
    Uptime: 1 minutes, 37 seconds
```

Example of configuring RSVP-TE authentication

1.1.1.47 Networking requirements

In the topology shown in Fig 9, a TE tunnel shall be established between RA and RC, and RSVP authentication shall be enabled between RA and RB.

1.1.1.48 Network topology

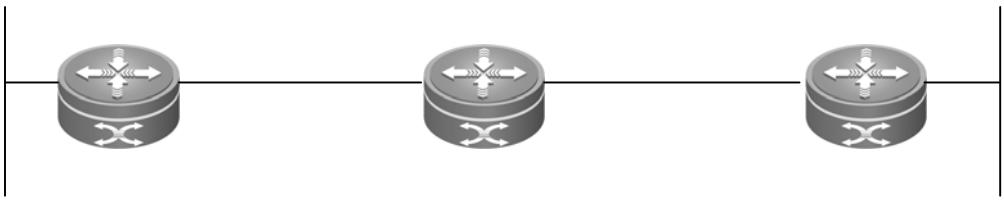


Fig 9 Network topology for RSVP-TE authentication

1.1.1.49 Configuration tips

Configure interface IP address on respective routers and the IP address of Loopback interface.

Configure ISIS on respective routers and enable ISIS TE.

Enable global TE on respective routers and enable TE on respective interfaces.

Enable MPLS forwarding on respective routers

Enable authentication on interfaces connecting RA and RB.

Configure window-size to 32 on interfaces connecting RA and RB.

Enable Challenge on interfaces connecting RA and RB.

Configure MPLS TE Tunnel on RA.

1.1.1.50 Configuration steps

1) Configure IP address on the interface of respective routers.

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface loopback 0
Ruijie(config-if)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/1
# "no switchport" command is used to switch the port mode to "Routed Port" mode on switch products, and is not applicable to the router. Therefore, you don't need to execute this command on router products.
Ruijie(config-if)# no switchport
# For router products, enable fast forwarding on the interface.
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 192.17.1.1 255.255.255.0
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
```

The configurations of RB and RC are the same as that of RA.

2) Configure ISIS on respective routers and enable ISIS TE.

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router isis
Ruijie(config-router)# net 49.000.0000.0000.0001.00
Ruijie(config-router)# mpls te level-1
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# ip router isis
Ruijie(config-if)# exit
```

Configure RB

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router isis
Ruijie(config-router)# net 49.000.0000.0000.0002.00
Ruijie(config-router)# mpls te level-1
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# ip router isis
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# ip router isis
Ruijie(config-if)# exit
```

Configure RC

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router isis
Ruijie(config-router)# net 49.000.0000.0000.0003.00
Ruijie(config-router)# mpls te level-1
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# ip router isis
Ruijie(config-if)# exit
```

3) Configure respective routers to enable TE.

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
```

Configure RB

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
```

```
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
```

Configure RC

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
```

4) Enable MPLS forwarding on respective routers

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# label-switching
Ruijie(config-if)# exit
```

Configure RB

Same as the configurations of RA.

Configure RC

Same as the configurations of RA.

5) Enable authentication on the interface.

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# ip rsvp authentication key xyz Q2Syac
Ruijie(config-if)# ip rsvp authentication
Ruijie(config-if)# exit
```

Configure RB

```
Ruijie# configure terminal
```

```
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# ip rsvp authentication key xyz Q2Syac
Ruijie(config-if)# ip rsvp authentication
Ruijie(config-if)# exit
```

6) Configure window-size on the interface.

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# ip rsvp authentication window-size 32
Ruijie(config-if)# exit
```

Configure RB

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# ip rsvp authentication window-size 32
Ruijie(config-if)# exit
```

7) Enable Challenge on the interface.

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# ip rsvp authentication challenge
Ruijie(config-if)# exit
```

Configure RB

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# ip rsvp authentication challenge
Ruijie(config-if)# exit
```

8) Configure to establish TE tunnel.

Configure TE Tunnel on RA.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface tunnel 1
Ruijie(config-if)# label-switching
# For router products, enable fast forwarding on the interface.
```

```
Ruijie(config-if)# ip ref
Ruijie(config-if)# tunnel mode mpls te
Ruijie(config-if)# ip unnumbered looback 0
Ruijie(config-if)# tunnel destination 3.3.3.3
Ruijie(config-if)# tunnel mpls te path-option 10 dynamic
Ruijie(config-if)# exit
```

1.1.1.51 Verification

After configuration, execute "show mpls te tunnels tunnel 1" command on RA to verify whether Tunnel 1 is UP.

```
Ruijie# show mpls te tunnels tunnel 1
Ruijie# show mpls te tunnels tunnel 1
Name: Router_t1                       (Tunnel1) Destination: 3.3.3.3
  Status:
    Admin: up        Oper: up     Path: Valid      Signalling: connected
    path option 10, type dynamic Basis for Setup, path weight 20

  Config Parameters:
    Bandwidth: 0       kbps Priority: 7 7
    Affinity: exclude_any 0X00000000 include_any 0X00000000 include_all 0X00000000
    Metric Type: TE (default)

  Inlabel  :  -
  OutLabel : gigabitethernet 0/1, 1024
  RSVP Signalling Info:
      Src 1.1.1.1, Dst 3.3.3.3, Tun_Id 1, Tun_Instance 1
    RSVP Path Info:
      My Address: 192.17.1.1
      Explicit Route: 192.17.1.2 192.18.1.1 192.18.1.2 3.3.3.3
      Record Route:  NONE
      Record Label:  NONE
      Tspec: ave rate =0 kbits, burst =1000 bytes, peak rate =0 kbits
    RSVP Resv Info:
      Record Route:  NONE
      Record Label:  NONE
      Fspec: ave rate=0 kbits, burst=1000 bytes, peak rate=0 kbits
  History:
    Tunnel:
      Time since created: 0 hours, 4 minutes
      Time since path change: 1 minutes, 27 seconds
    Current LSP:
      Uptime: 1 minutes, 27 seconds
```

Execute "show ip rsvp authentication" on RA to display the status of neighbor authentication.

Ruijie# show ip rsvp authentication

```
Neighbor        I/F     Key Type  Key ID (hex) Direction Expiration
192.17.1.2      Gi0/1     Static   c6c55984000  send     00h 28m 40s
192.17.1.2      Gi0/1     Static   160ce1f2000  recv     00h  29m 10s
```

Example of configuring fast reroute

1.1.1.52 Networking requirements

As shown in Fig 10:

The primary LSP is the explicit path created along RA->RB->RC->RD.

RB establishes Bypass tunnel to provide FRR node protection for RC, namely RB is the PLR and RD is the MP.

The Bypass Tunnel established by RB must not pass through node RC.

1.1.1.53 Network topology

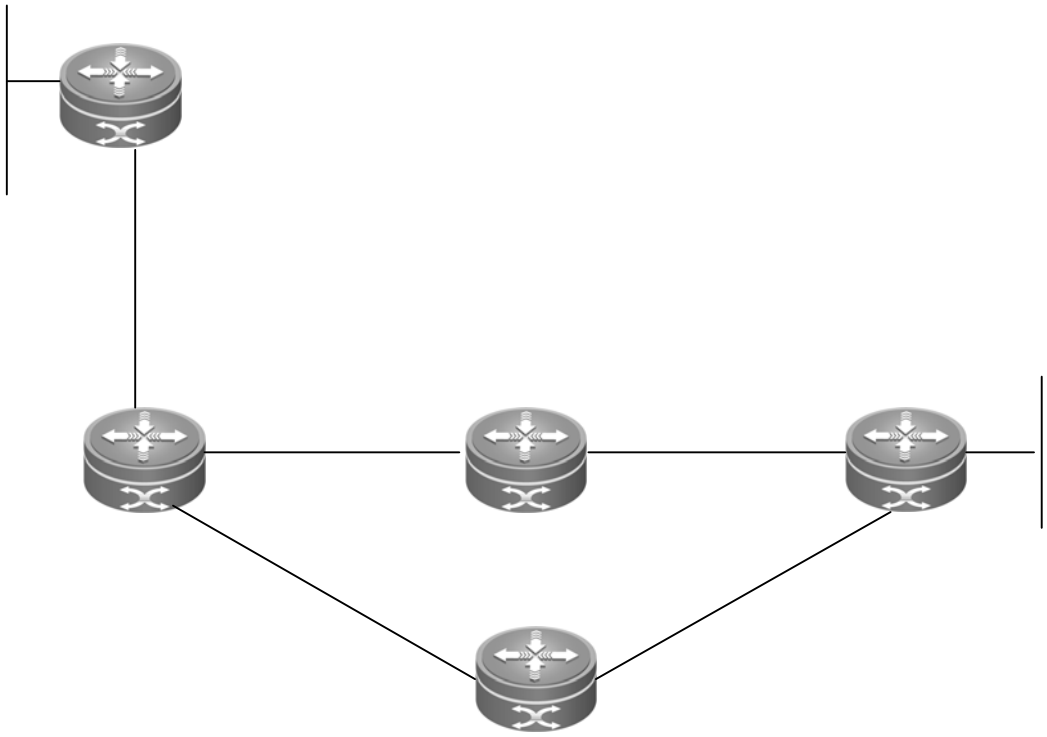


Fig 10 Network topology for MPLS TE fast reroute

1.1.1.54 Configuration tips

Configure interface IP address on respective routers and the Loopback address of LSR ID.

Configure OSPF on respective routers and enable OSPF TE.

Enable global TE on respective routers and enable TE on respective interfaces.

Enable MPLS forwarding on respective routers

Configure TE Tunnel on RA and apply partial protection

Establish Bypass Tunnel on RB and provide protection for Gi 0/2

Configure Hello detection

1.1.1.55 Configuration steps

1) Configure IP address on the interface of respective routers.

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface loopback 0
Ruijie(config-if)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/1
# "no switchport" command is used to switch the port mode to "Routed Port" mode on switch products, and is not applicable to the router. Therefore, you don't need to execute this command on router products.
Ruijie(config-if)# no switchport
# For router products, enable fast forwarding on the interface.
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 192.17.1.1 255.255.255.0
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
```

The configurations of RB, RC, RD and RE are the same as that of RA.

2) Configure OSPF on respective routers and enable OSPF-TE.

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 192.17.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

Configure RB

```
Ruijie# configure terminal
```

```
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 192.17.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.18.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.16.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

Configure RC

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# network 192.18.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.19.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

Configure RD

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 4.4.4.4 0.0.0.0 area 0
Ruijie(config-router)# network 192.19.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.20.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

Configure RE

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 5.5.5.5 0.0.0.0 area 0
Ruijie(config-router)# network 192.16.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.20.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

3) Configure respective routers to enable TE.

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
```

Configure RB

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/3
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
```

Configure RC

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
```

Configure RD

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# mpls te
```

```
Ruijie(config-if)# exit
```

Configure RE

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
```

4) Configure MPLS forwarding

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# label-switching
Ruijie(config-if)# exit
```

Configure RB

Same as the configurations of RA.

Configure RC

Same as the configurations of RA.

Configure RD

Same as the configurations of RA.

Configure RE

Same as the configurations of RA.

5) Establish primary LSP.

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
```

```
Ruijie(config)# ip explicit-path name t_1
Ruijie(cfg-ip-expl-path)# next-address 2.2.2.2
Ruijie(cfg-ip-expl-path)# next-address 3.3.3.3
Ruijie(cfg-ip-expl-path)# next-address 4.4.4.4
Ruijie(cfg-ip-expl-path)# exit
Ruijie(config)# interface tunnel 1
Ruijie(config-if)# label-switching
# For router products, enable fast forwarding on the interface.
Ruijie(config-if)# ip ref
Ruijie(config-if)# tunnel mode mpls te
Ruijie(config-if)# ip unnumbered looback 0
Ruijie(config-if)# tunnel destination 4.4.4.4
Ruijie(config-if)# tunnel mpls te fast-reroute
Ruijie(config-if)# tunnel mpls te path-option 10 explicit-path name t_1
Ruijie(config-if)# exit
```

6) Configure Bypass Tunnel.

Configure RB

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# ip explicit-path name t_10
Ruijie(cfg-ip-expl-path)# exclude-address 3.3.3.3
Ruijie(cfg-ip-expl-path)# exit
Ruijie(config)# interface tunnel 10
Ruijie(config-if)# label-switching
# For router products, enable fast forwarding on the interface.
Ruijie(config-if)# ip ref
Ruijie(config-if)# tunnel mode mpls te
Ruijie(config-if)# ip unnumbered loopback 0
Ruijie(config-if)# tunnel destination 4.4.4.4
Ruijie(config-if)# tunnel mpls te path-option 10 explicit-path name t_10
Ruijie(config-if)# exit
```

7) Configure to protect the interface

Configure RB

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# mpls te backup-path tunnel 1
Ruijie(config-if)# exit
```

8) Enable RSVP Hello

Configure RB

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# ip rsvp hello
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# ip rsvp hello
Ruijie(config-if)# exit
```

Configure RC

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# ip rsvp hello
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# ip rsvp hello
Ruijie(config-if)# exit
```

1.1.1.56 Verification

After configuration, execute "**show ip rsvp fast-reroute**" command on RB to verify the binding between Bypass Tunnel and primary LSP.

```
Ruijie# show ip rsvp fast-reroute
Primary     Protect  BW   Backup
Tunnel       I/F     BPS  Tunnel:Label  State  Level  Type
------      -------  ---- ------------  -----  -----  -----
Router_t1  Gi0/2    0K    Tu10:1024       Ready  Unlim   NNHOP
```

Example of configuring automatic fast reroute

1.1.1.57 Networking requirements

As shown in Fig 11:

RA shall use explicit path to create two TE tunnels along RA->RB->RC->RD and RA->RB->RC->RE respectively.

Use automatic FRR to create a link protection and node protection Bypass Tunnel on RA, and provide protection for RB and the link between RA and RB.

Use automatic FRR to create a Bypass Tunnel on RB, and provide protection for the link between RB and RC.

1.1.1.58 Network topology

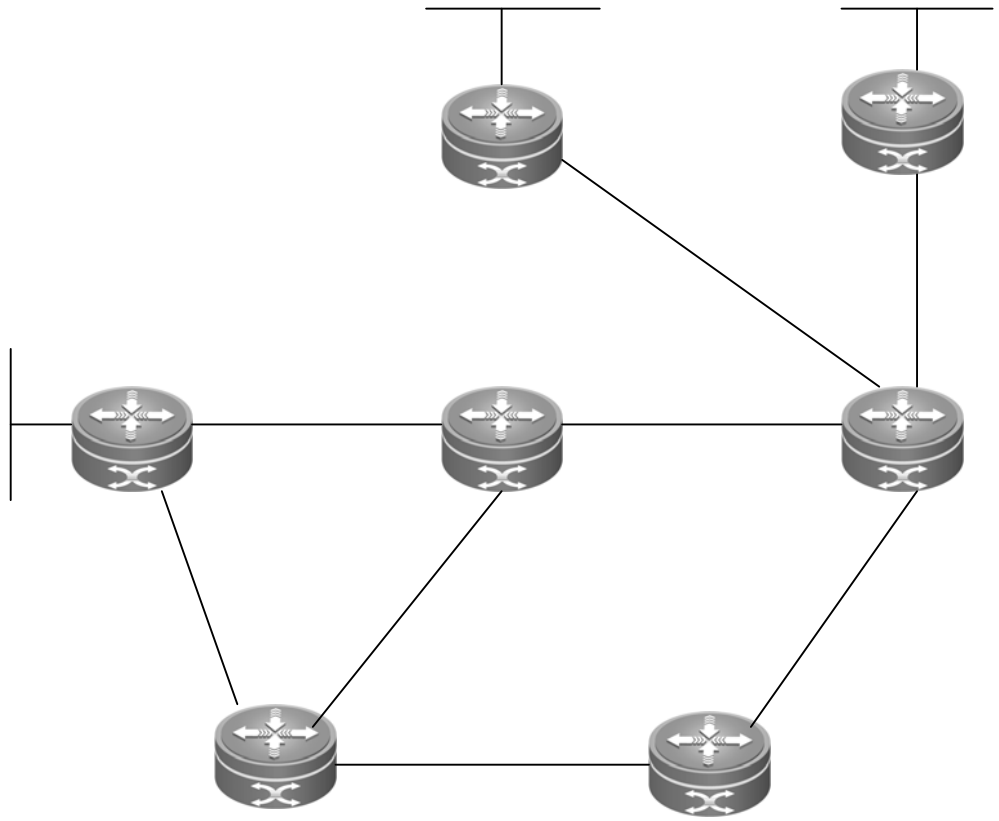


Fig 11 Network topology for automatic FRR

1.1.1.59 Configuration tips

Configure the IP address of respective nodes

Configure OSPF on respective nodes and enable OSPF-TE extension

Configure respective routers to enable MPLS TE

Enable MPLS forwarding on respective routers

Establish the primary TE LSP

Enable automatic fast reroute

Enable RSVP-TE Hello detection

1.1.1.60 Configuration steps

1) Configure the IP address of respective nodes.

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface loopback 0
Ruijie(config-if)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/1
# "no switchport" command is used to switch the port mode to "Routed Port" mode on switch products, and is not applicable to the router. Therefore, you don't need to execute this command on router products.
Ruijie(config-if)# no switchport
# For router products, enable fast forwarding on the interface.
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 192.17.1.1 255.255.255.0
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
# "no switchport" command is used to switch the port mode to "Routed Port" mode on switch products, and is not applicable to the router. Therefore, you don't need to execute this command on router products.
Ruijie(config-if)# no switchport
# For router products, enable fast forwarding on the interface.
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 192.21.1.1 255.255.255.0
Ruijie(config-if)# no shutdown
Ruijie(config-if)# exit
```

The configurations of RB, RC, RD, RE, RF and RG are the same as that of RA.

2) Configure respective nodes to enable OSPF.

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 192.17.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.21.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

Configure RB

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 192.17.1.0 0.0.0.255 area 0
```

```
Ruijie(config-router)# network 192.18.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.22.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

Configure RC

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# network 192.18.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.19.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.20.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.24.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

Configure RD

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 4.4.4.4 0.0.0.0 area 0
Ruijie(config-router)# network 192.19.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

Configure RE

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 5.5.5.5 0.0.0.0 area 0
Ruijie(config-router)# network 192.20.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

Configure RF

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 6.6.6.6 0.0.0.0 area 0
Ruijie(config-router)# network 192.21.1.0 0.0.0.255 area 0
```

```
Ruijie(config-router)# network 192.22.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.23.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

Configure RG

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 7.7.7.7 0.0.0.0 area 0
Ruijie(config-router)# network 192.23.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.24.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

3) Configure respective routers to enable TE.

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
```

Configure RB

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/3
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
```

Configure RC

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/3
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
```

Configure RD

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
```

Configure RE

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
```

Configure RF

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/3
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
```

Configure RG

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# mpls te
Ruijie(config-if)# exit
```

4) Configure MPLS forwarding on respective routers

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# label-switching
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# label-switching
Ruijie(config-if)# exit
```

Configure RB

Same as the configurations of RA.

Configure RC

Same as the configurations of RA.

Configure RD

Same as the configurations of RA.

Configure RE

Same as the configurations of RA.

Configure RF

Same as the configurations of RA.

Configure RG

Same as the configurations of RA.

5) Establish primary TE LSP.

Establish the TE LSP to RD on RA.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# ip explicit-path name t_1
Ruijie(cfg-ip-expl-path)# next-address 2.2.2.2
Ruijie(cfg-ip-expl-path)# next-address 3.3.3.3
Ruijie(cfg-ip-expl-path)# next-address 4.4.4.4
Ruijie(cfg-ip-expl-path)# exit
Ruijie(config)# interface tunnel 1
Ruijie(config-if)# tunnel mode mpls te
Ruijie(config-if)# label-switching
# For router products, enable fast forwarding on the interface.
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip unnumbered looback 0
Ruijie(config-if)# tunnel destination 4.4.4.4
Ruijie(config-if)# tunnel mpls te fast-reroute
Ruijie(config-if)# tunnel mpls te path-option 10 explicit-path name t_1
Ruijie(config-if)# exit
```

Establish the TE LSP to RE on RA.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# ip explicit-path name t_2
Ruijie(cfg-ip-expl-path)# next-address 2.2.2.2
Ruijie(cfg-ip-expl-path)# next-address 3.3.3.3
Ruijie(cfg-ip-expl-path)# next-address 5.5.5.5
Ruijie(cfg-ip-expl-path)# exit
Ruijie(config)# interface tunnel 2
Ruijie(config-if)# label-switching
# For router products, enable fast forwarding on the interface.
Ruijie(config-if)# ip ref
Ruijie(config-if)# tunnel mode mpls te
Ruijie(config-if)# ip unnumbered looback 0
Ruijie(config-if)# tunnel destination 5.5.5.5
Ruijie(config-if)# tunnel mpls te fast-reroute
Ruijie(config-if)# tunnel mpls te path-option 10 explicit-path name t_2
Ruijie(config-if)# exit
```

6) Enable automatic fast reroute

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# auto-tunnel backup
Ruijie(config-te)# exit
```

Configure RB

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# auto-tunnel backup nhop-only
Ruijie(config-te)# exit
```

7) Enable RSVP-TE Hello detection

Configure RA

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# ip rsvp hello
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# ip rsvp hello
Ruijie(config-if)# exit
```

Configure RB

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# ip rsvp hello
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# ip rsvp hello
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# ip rsvp hello
Ruijie(config-if)# exit
```

Configure RC

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# ip rsvp hello
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# ip rsvp hello
Ruijie(config-if)# exit
```

1.1.1.61 Verification

After configuration, execute "**show ip rsvp fast-reroute**" command on RB to verify the binding between Bypass Tunnel and primary LSP.

```
Ruijie# show ip rsvp fast-reroute
Primary     Protect  BW   Backup
Tunnel       I/F     BPS  Tunnel:Label  State  Level  Type
------      -------  ---- ------------  -----  -----  -----
Router_t1  Gi0/1    0K    Tu2049:1024     Ready  Unlim   NNHOP
```

Execute "**show ip rsvp fast-reroute**" command on RB to verify the binding between Bypass Tunnel and primary LSP.

```
Ruijie# show ip rsvp fast-reroute
Primary     Protect  BW   Backup
Tunnel       I/F     BPS  Tunnel:Label  State  Level  Type
------      -------  ---- ------------  -----  -----  -----
Router_t1  Gi0/2    0K    Tu2049:1024     Ready  Unlim   NHOP
```

Example of configuring MPLS-TE Over MPLS TE

Here we will take L3VPN as the example. The TE tunnel is established in the same way in the scenario of L2VPN.

1.1.1.62 Networking requirements

As shown in Fig 12:

1) CE-A and CE-B are two nodes of L3VPN vpna

2) PE-A, P and PE-B constitute MPLS core network

3) The maximum reservable bandwidth of each link is 5Mbps

4) Bidirectional TE tunnel is established between PE-A and PE-B, and the bandwidth needed is 1Mbps

5) EBGP is used for route exchange between PE and CE

6) The public network tunnel of VPN uses TE tunnel to forward traffic

1.1.1.63 Network topology

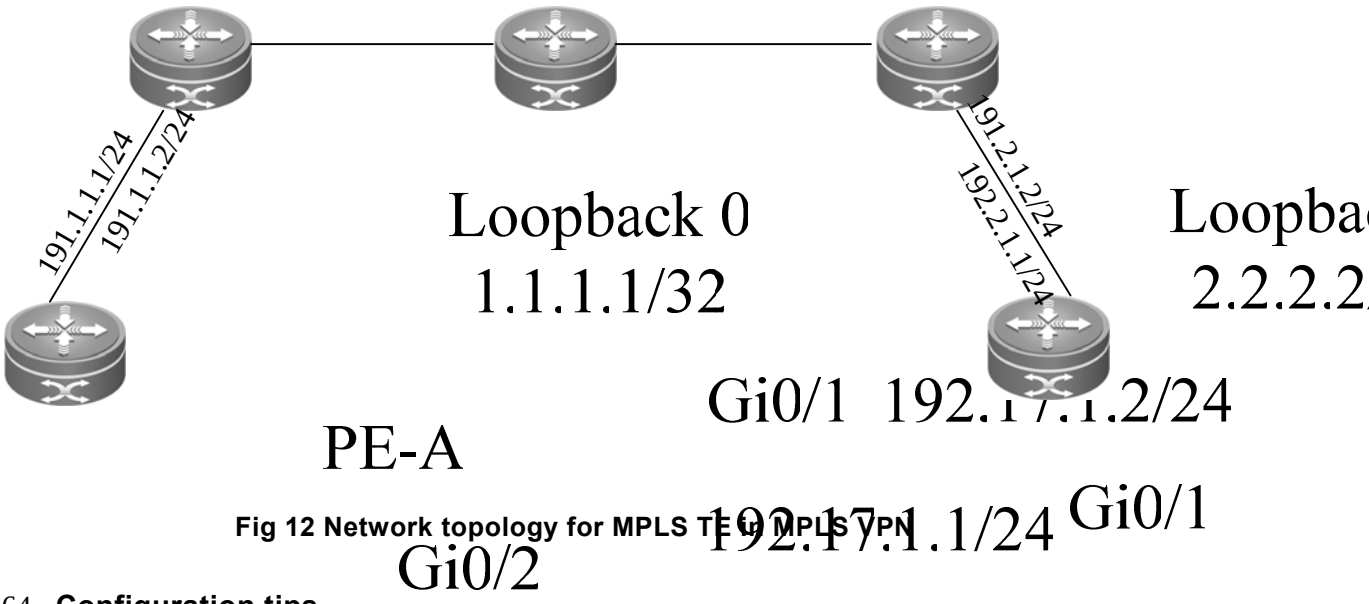


Fig 12 Network topology for MPLS TE in MPLS VPN

1.1.1.64 Configuration tips

Configure the IP address of respective devices

Configure OSPF on respective MPLS devices and enable OSPF-TE

Configure respective MPLS devices to enable MPLS TE

Configure respective MPLS devices to enable MPLS forwarding

Establish bidirectional TE tunnel

Enable TE tunnel forwarding

Configure L3 VPN

1.1.1.65 Configuration steps

1) Configure the IP address of respective devices

CE-A

Configure PE-A

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface loopback 0
Ruijie(config-if)# ip address 1.1.1.1 255.255.255.255
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/1
```

```
# "no switchport" command is used to switch the port mode to "Routed Port" mode on switch products, and is not applicable to the router. Therefore, you don't need to execute this command on router products.
Ruijie(config-if)# no switchport
# For router products, enable fast forwarding on the interface.
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 192.17.1.1 255.255.255.0
Ruijie(config-if)# exit
```

The configurations of other devices are the same as that of PE-A.

2) Configure OSPF on respective MPLS devices

Configure PE-A

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 192.17.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

Configure P

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 192.17.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.18.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

Configure PE-B

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# network 192.18.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

3) Enable MPLS-TE on respective MPLS devices

Configure PE-A

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# mpls te reservable-bandwidth 5000
Ruijie(config-if)# exit
```

Configure P

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# mpls te reservable-bandwidth 5000
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# mpls te
Ruijie(config-if)# mpls te reservable-bandwidth 5000
Ruijie(config-if)# exit
```

Configure PE-B

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# mpls te reservable-bandwidth 5000
Ruijie(config-if)# exit
```

4) Configure forwarding on respective MPLS devices

Configure PE-A

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# label-switching
Ruijie(config-if)# exit
```

Configure P

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls ip
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# label-switching
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# label-switching
Ruijie(config-if)# exit
```

Configure PE-B

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# label-switching
Ruijie(config-if)# exit
```

5) Configure TE tunnel

Configure PE-A

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface tunnel 1
Ruijie(config-if)# label-switching
# For router products, enable fast forwarding on the interface.
Ruijie(config-if)# ip ref
Ruijie(config-if)# tunnel mode mpls te
Ruijie(config-if)# tunnel destination 3.3.3.3
Ruijie(config-if)# ip unnumbered loopback 0
Ruijie(config-if)# tunnel mpls te bandwidth 1000
Ruijie(config-if)# tunnel mpls te path-option 10 dynamic
Ruijie(config-if)# exit
```

Configure PE-B

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface tunnel 1
Ruijie(config-if)# tunnel mode mpls te
Ruijie(config-if)# tunnel destination 1.1.1.1
Ruijie(config-if)# ip unnumbered loopback 0
```

```
Ruijie(config-if)# tunnel mpls te bandwidth 1000
Ruijie(config-if)# tunnel mpls te path-option 10 dynamic
Ruijie(config-if)# exit
```

6) Enable TE tunnel forwarding

Configure PE-A

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface tunnel 1
Ruijie(config-if)# tunnel mpls te autoroute announce
Ruijie(config-if)# exit
```

Configure PE-B

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface tunnel 1
Ruijie(config-if)# tunnel mpls te autoroute announce
Ruijie(config-if)# exit
```

7) Configure VPN sites

Configure PE-A

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# ip vrf vpna
Ruijie(config-vrf)# rd 100:1
Ruijie(config-vrf)# route-target both 100:1
Ruijie(config-vrf)# exit
Ruijie(config)# interface gigabitethernet 0/2
# "no switchport" command is used to switch the port mode to "Routed Port" mode on switch
products, and is not applicable to the router. Therefore, you don't need to execute this
command on router products.
Ruijie(config-if)# no switchport
# For router products, enable fast forwarding on the interface.
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip vrf forwarding vpna
Ruijie(config-if)# ip address 192.1.1.2 255.255.255.0
Ruijie(config-if)# exit
```

Configure PE-B

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# ip vrf vpna
Ruijie(config-vrf)# rd 100:1
Ruijie(config-vrf)# route-target both 100:1
```

```
Ruijie(config-vrf)# exit
Ruijie(config)# interface gigabitethernet 0/2
# "no switchport" command is used to switch the port mode to "Routed Port" mode on switch products, and is not applicable to the router. Therefore, you don't need to execute this command on router products.
Ruijie(config-if)# no switchport
# For router products, enable fast forwarding on the interface.
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip vrf forwarding vpna
Ruijie(config-if)# ip address 192.2.1.2 255.255.255.0
Ruijie(config-if)# exit
```

8) Configure route exchange between CE and PE

Configure PE-A

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf vpna
Ruijie(config-router)# neighbor 192.1.1.1 remote-as 65535
Ruijie(config-router)# exit
```

Configure CE-A

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router bgp 65535
Ruijie(config-router)# neighbor 192.1.1.2 remote-as 1
Ruijie(config-router)# exit
```

Configure PE-B

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf vpna
Ruijie(config-router)# neighbor 192.2.1.1 remote-as 65536
Ruijie(config-router)# exit
```

Configure CE-B

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router bgp 65536
Ruijie(config-router)# neighbor 192.2.1.2 remote-as 1
Ruijie(config-router)# exit
```

9) Configure MP-BGP between PEs

Configure PE-A

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 3.3.3.3 remote-as 1
Ruijie(config-router)# neighbor 3.3.3.3 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router)# neighbor 3.3.3.3 activate
Ruijie(config-router)# exit
```

Configure PE-B

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 1
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router)# neighbor 1.1.1.1 activate
Ruijie(config-router)# exit
```

1.1.1.66 Verification

After configuration, execute "**show mpls forwarding-table vrf** *vpna*" on PE-A to view VPNA forwarding table.

```
Ruijie# show mpls forwarding-table vrf vpna
Label Operation Code:
PH--PUSH label
PP--POP label
SW--SWAP label
SP—-SWAP topmost label and push new label
DP—-DROP packet
PC—-POP label and continue lookup by IP or Label
PI--POP label and do ip lookup forward
PN--POP label and forward to nexthop
PM--POP label and do MAC lookup forward
PV--POP label and output to VC attach interface
IP--IP lookup forward
Local Outgoing OP FEC        Outgoing      Next Hop
label label                   interface
——   1025    PH  192.2.1.0/24(v) Tu1   point2ponit
1024   --      PI  VRF(vpna)    --            --
```

Example of configuring LDP over TE

Here we will take L3VPN as the example. In the scenario of L2VPN, all configurations are the same except for the configuration between PE and CE.

1.1.1.67 Networking requirements

As shown in Fig 13, only P1, P2 and P3 support MPLS TE:

1) Establish bidirectional TE tunnel between P1 and P3

2) Run LDP between PE1 and P1 and between PE2 and P3

3) The traffic between P1, P2 and P3 shall be forwarded via TE tunnel, with guaranteed bandwidth reaching 1Mbps.

1.1.1.68 Network topology

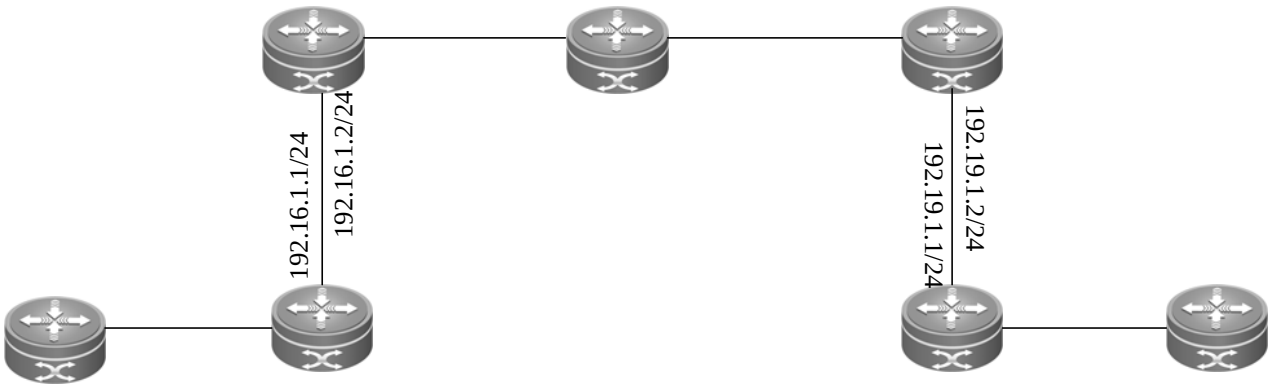


Fig 13 Network topology for LDP over TE

1.1.1.69 Configuration tips

Configure the IP address of respective devices

Configure OSPF intercommunication among MPLS devices

Configure MPLS devices to enable MPLS

Configure P devices to enable TE

Establish a TE tunnel between P devices

Enable TE tunnel forwarding

Configure TE tunnel to enable LDP

Configure L3VPN

Loopback 0
1.1.1.1/32
Loopba
2.2.2.2/
Gi0/1 192.17.1.2/24
P1
192.17.1.1/24 Gi0/1
Gi0/2
P2

1.1.1.70 Configuration steps

1) Configure the IP address of respective devices

Gi0/1
Gi0/2
Loopback 0
17.17.17.1/24
10.1.1.1/32
17.17.17.2/24

Configure PE1

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface loopback 0
Ruijie(config-if)# ip address 10.1.1.1 255.255.255.255
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/1
# "no switchport" command is used to switch the port mode to "Routed Port" mode on switch products, and is not applicable to the router. Therefore, you don't need to execute this command on router products.
Ruijie(config-if)# no switchport
# For router products, enable fast forwarding on the interface.
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip address 192.16.1.1 255.255.255.0
Ruijie(config-if)# exit
```

The configurations of other devices are the same as that of PE1.

2) Configure OSPF on MPLS devices

Configure PE1

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 10.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 192.16.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

Configure P1

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 1.1.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 192.16.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.17.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

Configure P2

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
```

```
Ruijie(config-router)# network 2.2.2.2 0.0.0.0 area 0
Ruijie(config-router)# network 192.17.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.18.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

Configure P3

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 3.3.3.3 0.0.0.0 area 0
Ruijie(config-router)# network 192.18.1.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.19.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

Configure PE2

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 1
Ruijie(config-router)# network 10.2.1.1 0.0.0.0 area 0
Ruijie(config-router)# network 192.19.1.0 0.0.0.255 area 0
Ruijie(config-router)# mpls te area 0
Ruijie(config-router)# mpls te router-id loopback 0
Ruijie(config-router)# exit
```

3) Configure MPLS on respective MPLS devices

Configure PE1

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# label-switching
Ruijie(config-if)# mpls ip
Ruijie(config-if)# exit
```

Configure P1

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls ip
```

```
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# label-switching
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# label-switching
Ruijie(config-if)# mpls ip
Ruijie(config-if)# exit
```

Configure P2

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls ip
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# label-switching
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# label-switching
Ruijie(config-if)# exit
```

Configure P3

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# label-switching
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/2
Ruijie(config-if)# label-switching
Ruijie(config-if)# mpls ip
Ruijie(config-if)# exit
```

Configure PE2

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls ip
Ruijie(config)# mpls router ldp
Ruijie(config-mpls-router)# ldp router-id loopback 0 force
Ruijie(config-mpls-router)# exit
Ruijie(config)# interface gigabitethernet 0/1
```

```
Ruijie(config-if)# label-switching
Ruijie(config-if)# mpls ip
Ruijie(config-if)# exit
```

4) Configure P devices to enable MPLS TE

Configure P1

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# mpls te reservable-bandwidth 5000
Ruijie(config-if)# exit
```

Configure P2

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# mpls te reservable-bandwidth 5000
Ruijie(config-if)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# mpls te reservable-bandwidth 5000
Ruijie(config-if)# exit
```

Configure P3

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mpls te
Ruijie(config-te)# exit
Ruijie(config)# interface gigabitethernet 0/1
Ruijie(config-if)# mpls te
Ruijie(config-if)# mpls te reservable-bandwidth 5000
Ruijie(config-if)# exit
```

5) Establish MPLS TE tunnel

Configure P1

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface tunnel 1
```

```
Ruijie(config-if)# label-switching
# For router products, enable fast forwarding on the interface.
Ruijie(config-if)# ip ref
Ruijie(config-if)# tunnel mode mpls te
Ruijie(config-if)# tunnel destination 3.3.3.3
Ruijie(config-if)# ip unnumbered loopback 0
Ruijie(config-if)# tunnel mpls te bandwidth 1000
Ruijie(config-if)# tunnel mpls te path-option 10 dynamic
Ruijie(config-if)# exit
```

Configure P3

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface tunnel 1
Ruijie(config-if)# label-switching
# For router products, enable fast forwarding on the interface.
Ruijie(config-if)# ip ref
Ruijie(config-if)# tunnel mode mpls te
Ruijie(config-if)# tunnel destination 1.1.1.1
Ruijie(config-if)# ip unnumbered loopback 0
Ruijie(config-if)# tunnel mpls te bandwidth 1000
Ruijie(config-if)# tunnel mpls te path-option 10 dynamic
Ruijie(config-if)# exit
```

6) Enable TE tunnel forwarding

Configure P1

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface tunnel 1
Ruijie(config-if)# tunnel mpls te autoroute announce
Ruijie(config-if)# exit
```

Configure P3

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface tunnel 1
Ruijie(config-if)# tunnel mpls te autoroute announce
Ruijie(config-if)# exit
```

7) Configure TE tunnel to enable LDP

Configure P1

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface tunnel 1
```

```
Ruijie(config-if)# mpls ip
Ruijie(config-if)# exit
```

Configure P3

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface tunnel 1
Ruijie(config-if)# mpls ip
Ruijie(config-if)# exit
```

8) Configure VPN sites

Configure PE1

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# ip vrf vpna
Ruijie(config-vrf)# rd 100:1
Ruijie(config-vrf)# route-target both 100:1
Ruijie(config-vrf)# exit
Ruijie(config)# interface gigabitethernet 0/2
# "no switchport" command is used to switch the port mode to "Routed Port" mode on switch products, and is not applicable to the router. Therefore, you don't need to execute this command on router products.
Ruijie(config-if)# no switchport
# For router products, enable fast forwarding on the interface.
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip vrf forwarding vpna
Ruijie(config-if)# ip address 17.17.17.1 255.255.255.0
Ruijie(config-if)# exit
```

Configure PE1

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# ip vrf vpna
Ruijie(config-vrf)# rd 100:1
Ruijie(config-vrf)# route-target both 100:1
Ruijie(config-vrf)# exit
Ruijie(config)# interface gigabitethernet 0/2
# "no switchport" command is used to switch the port mode to "Routed Port" mode on switch products, and is not applicable to the router. Therefore, you don't need to execute this command on router products.
Ruijie(config-if)# no switchport
# For router products, enable fast forwarding on the interface.
Ruijie(config-if)# ip ref
Ruijie(config-if)# ip vrf forwarding vpna
Ruijie(config-if)# ip address 17.17.18.1 255.255.255.0
```

```
Ruijie(config-if)# exit
```

9) Configure EBGP access between CE and PE

Configure PE1

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf vpna
Ruijie(config-router)# neighbor 17.17.17.2 remote-as 65535
Ruijie(config-router)# exit
```

Configure CE-1

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router bgp 65535
Ruijie(config-router)# neighbor 17.17.17.1 remote-as 1
Ruijie(config-router)# exit
```

Configure PE2

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router bgp 1
Ruijie(config-router)# address-family ipv4 vrf vpna
Ruijie(config-router)# neighbor 17.17.18.2 remote-as 65536
Ruijie(config-router)# exit
```

Configure CE-2

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router bgp 65536
Ruijie(config-router)# neighbor 17.17.18.1 remote-as 1
Ruijie(config-router)# exit
```

10) Configure MP-BGP between PE1 and PE2

Configure PE1

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 3.3.3.3 remote-as 1
Ruijie(config-router)# neighbor 3.3.3.3 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router)# neighbor 3.3.3.3 activate
Ruijie(config-router)# exit
```

Configure PE2

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router bgp 1
Ruijie(config-router)# neighbor 1.1.1.1 remote-as 1
Ruijie(config-router)# neighbor 1.1.1.1 update-source loopback 0
Ruijie(config-router)# address-family vpnv4
Ruijie(config-router)# neighbor 1.1.1.1 activate
Ruijie(config-router)# exit
```

1.1.1.71 Verification

After configuration, execute "**show mpls forwarding table** *10.2.1.1/32*" on P1 to view configurations.

```
Ruijie# show mpls forwarding table 10.2.1.1/32
Label Operation Code:
PH--PUSH label
PP--POP label
SW--SWAP label
SP—-SWAP topmost label and push new label
DP—-DROP packet
PC—-POP label and continue lookup by IP or Label
PI--POP label and do ip lookup forward
PN--POP label and forward to nexthop
PM--POP label and do MAC lookup forward
PV--POP label and output to VC attach interface
IP--IP lookup forward
Local Outgoing OP FEC        Outgoing      Next Hop
label label                   interface
--    1024     PH  10.2.1.1/32  Tu1          3.3.3.3
1534   1024     SW  10.2.1.1/32  Tu1          3.3.3.3
```

RGOS Series Switches Configuration Guide

V10.4(3b13)

Link layer protocol Configuration

1. HDLC Configutation
2. PPP and MP Protocol Configuration
3. Frame Relay Configutation
4. LAPB and X2.5 Configutation
5. DLDP Configutation
6. BFD Configutation

HDLC Configutation

Understanding HDLC

The RGOS supports the Cisco HDLC private protocol. Unlike the ISO HDLC, the Cisco HDLC protocol uses the SDLC frame format and supports synchronous and full-duplex operation, but does not support the traffic control like the ISO HDLC. It is an unreliable connection. After this protocol is encapsulated, the reliable connection is implemented at the upper layer. The HDLC features high efficiency and simple implementation and is a point-to-point (PTP) link protocol.

Note

Reliable connection refers to the message acknowledgement mechanism that is used during data communication. A lost packet will be retransmitted and the connection is interrupted if a packet times out. The PTP protocol means that communication parties are in one-to-one relationship. PPP and SLIP are also PTP protocols, whereas X.25 and Frame Relay are point-to-multipoint protocols.

The working principle of the HDLC is illustrated in the following phases:

- Negotiation and connection establishment: Two parties of the HDLC link send a link detection negotiation message to each other every 10 seconds. The messages are received or sent based on the sequence numbers of messages. Disorder of sequence numbers results in link disconnection. This kind of message that is used to detect whether a PTP link is active is called the keepalive message.
- Message transmission: The IP messages are encapsulated at the HDLC layer. During data transmission, the keepalive message negotiation is still working to detect whether the link is valid.
- Timeout disconnection: When the interface encapsulated with HDLC cannot receive the acknowledgement from the peer to increment the sequence number for 3 times continuous (or 6 times when the packet receiving speed is over 1000 packets/second), the link state changes from UP to Down. At this time, the link is in down state, and data communication fails.

Configuring HDLC

HDLC Configuration Task List

The HDLC configuration is rather simple and involves only the following tasks.

- Configuring the Interface Encapsulation Protocol
- Configuring the Keepalive Time

Configuring the Interface Encapsulation Protocol

The protocol encapsulated on the synchronous interface is HDLC by default.

Use the following command to change the protocol encapsulated on the interface to HDLC.

Command	Function

Command	Function
Ruijie(config-if)**#encapsulation hdlc**	Encapsulates the HDLC protocol.

Configuring the Keepalive Time

For the HDLC encapsulated on a synchronous interface, only two parameters are configurable: interval at which the keepalive message is sent and the maximum timeout time of the keepalive message. The interval is 10 seconds by default.

Use the following command to set the interval and maximum timeout time of the keepalive message based on the link traffic.

Command	Function
Ruijie(config-if)#**keepalive** *second*s	Sets the interval at which the keepalive message is sent and the maximum timeout time of the keepalive message. The maximum timeout time is optional. The range of the interval is from 1 to 32767. The range of the maximum timeout time is from 1 to 255.

Monitoring and Maintaining HDLC

Command	Function
Ruijie#**debug hdlc events**	Turns on the HDLC link status event debugging switch.
Ruijie#**debug hdlc packets**	Turns on the HDLC message receiving/transmitting debugging switch.

1) debug hdlc events

If an interface (for example, Serial1/0) is encapsulated with HDLC, the following information is printed during the keepalive message negotiation:

```
%Interface serial 1/0 : receive one HDLC keepalive packet.
%Interface serial 1/0 send one keepalive packet:
    my_seq = 21, my_seen = 20, your_seen = 16
    line protocol is UP, not in loopback state.
%Interface serial 1/0 : receive one HDLC keepalive packet.
%Interface serial 1/0 send one keepalive packet:
    my_seq = 22, my_seen = 21, your_seen = 17
    line protocol is UP, not in loopback state.
```

Where, my_seq is the sequence number of the message sent by the local router, my_seen is the sequence number of the HDLC keepalive message recognized by the peer router, and your_seen means the sequence number of the peer router recognized by the local router. The sequence numbers are incremental. See the following debug information:

```
%Interface serial 1/0 : receive one HDLC keepalive packet.
%Interface serial 1/0 send one keepalive packet:
    my_seq = 21, my_seen = 20, your_seen = 16
    line protocol is UP, not in loopback state.
```

```
%Interface serial 1/0 send one keepalive packet:
    my_seq = 22, my_seen = 20, your_seen = 16
    line protocol is UP, not in loopback state.
%Interface serial 1/0 send one keepalive packet:
    my_seq = 23, my_seen = 20, your_seen = 16
    line protocol is UP, not in loopback state.
```

The local sequence number my_seq increments according to the keepalive time, but the keepalive message of the peer router is not received. The my_seen is always 20. The local party has no way to know the acknowledgement for the increment of your_seen. This means that the message of the peer router cannot reach the local HDLC protocol layer during communication possibly because the peer router is shut down or a fault occurs during line transmission.

2) debug hdlc packets

Use this command to turn on the HDLC receiving/transmitting message debug switch to print the messages received or to be sent by the HDLC, including the message length and received message type. If the message is longer than 64 bytes, only the first 64 bytes are printed, as shown below:

```
Interface serial 1/0 HDLC input:
  packet->len = 22(0x16):
  8F 00 80 35 00 00 00 02 00 00 00 16 00 00 00 1A
  FF FF 00 5C E2 53
  packet->pkt_type = 3(PDD_RARP)
Interface serial 1/0 HDLC output:
  packet->len = 22(0x16):
  8F 00 80 35 00 00 00 02 00 00 00 1B 00 00 00 16
  FF FF 00 5F 8E D9
```

PPP and MP Protocol Configuration

PPP and MP Protocol Introduction

The PPP (Point-to-Point Protocol) is a kind of link layer protocol providing bearer for network data packets over point-to-point links. PPP defines a whole set of protocols, including LCP (Link Control Protocol), NCP (Network Control Protocol) and authentication protocols (PAP and CHAP). PPP is widely used for its ability of authentication, easy to expand and support of synchronization and asynchronization. For the PPP specifications, see RFC 1661.

PPP Working Process and Principle

- The PPP performs LCP negotiation before line setup, including operation mode (SP or MP), authentication method, and maximum transmission unit.
- The PPP enters the Line Establish phase after LCP negotiation. At this time, the LCP state is Opened, indicating that the link has been established.
- If authentication (the remote end authenticates the local end or vice versa) is enabled in the configuration, the PPP enters the Authenticate phase to start CHAP or PAP authentication.
- If authentication fails, it enters the Terminate phase to remove the link, and the LCP status turns to Closed; if the authentication succeeds, it enters the Network consultation phase (NCP), here, the LCP status is still Opened but that of IPCP and IPXCP turns from Closed to Opened.
- The support of NCP negotiation includes IPCP, IPXCP and BRIDGECP negotiation. IPCP negotiation mainly includes the IP addresses of both parties; IPXCP negotiation mainly includes network IDs and node numbers; BRIDGECP negotiation mainly includes the MAC addresses of both parties, MAC address type, spanning tree and Bridge ID. One or more network layer protocols are selected and configured through NCP negotiation. After the successful configuration of each selected network layer protocol, this network layer protocol can send messages through this link.
- This link will keep available for communication, until a definite LCP or NCP frame closes it, or some external events happen.

PPP Authentication Mode

The PPP supports two kinds of authentication modes: PAP and CHAP.

1. The PAP is a two-handshake authentication, and the password is in clear text.The PAP authentication process is as follows:
    1) The party to be authenticated sends the username and password to the authenticating party.
    2) The authenticating party checks whether this user name exists and whether the password is correct according to the user configuration, and then returns a response accordingly.

2. The CHAP refers to challenge handshake authentication protocol, and the password is in cipher text (key). The process of CHAP authentication is as follows:
   1) The authenticating party sends some random reports to the party to be authenticated.
   2) The authenticated party encrypts the random messages using its own password and MD5 algorithm, and sends the generated cipher text back to the authenticating party.
   3) The authenticating party encrypts the original random reports with the stored password of the authenticated party and the MD5 algorithm, compares the two cipher texts, and then returns the relevant response according to the comparison results.

MP Protocol Introduction

The Multi-Link PPP (MP) binds the PPP of multiple physical links to a single logical interface, aiming to increase link bandwidth. Any physical link that supports PPP can enable MP and be bound to the same logical interface Dialer port. The MP allows fragment of the messages on the network layers like IP. The fragments of the message are transmitted via multiple links and arrive at the same destination at the same time, resulting in summarization of the bandwidth of all links.
The operational process of the MP is as follows:
After the negotiation of general LCP parameters is completed, the PPP initiates the MP request again. If the peer link supports MP and responds properly, it is bound to the logical interface together with the other physical links for further NCP (such as IPCP) negotiation. If negotiation succeeds, all MP physical links use the network address of the same logical interface.

PPP Configuration

PPP Configuration Task List

This chapter describes how to configure PPP in the dedicated line mode (including synchronous interface and asynchronous interface). For the PPP configuration for the dialup connection available in the serial interface, additional configurations are needed in addition to the following ones. See Dialup Configuration Guide for details.

- Configure the interface encapsulation protocol
- Configure the PPP CHAP authenticated party
- Configure the PPP CHAP authenticating party
- Configure the PPP PAP authenticated party
- Configure the PPP PAP authenticating party
- Configure the PPP compression mode

Configuring the Encapsulation Protocol on the Interface

To configure the PPP, encapsulate the PPP on the interface. To encapsulate the PPP, run the following commands in the interface configuration mode:

Command	Function
D-Link(config-if)#**encapsulation ppp**	Encapsulate the PPP on the interface.
D-Link(config-if)#**no encapsulation ppp**	Remove the PPP encapsulation on the

Command	Function
	interface.

Configuring the PPP CHAP Authenticated Party

The CHAP authentication generally involves authenticating party and authenticated party. The CHAP negotiation is initiated by the authenticating party, and the authenticated party sends only the username and password for the use of the PPP authentication. By default, the authenticated party sends its own hostname as the PPP username.

To configure the PPP CHAP authenticated party, use the following command at interface configuration mode:

Command	Description
D-Link(config-if)# **ppp chap hostname** *hostnmae*	Specify the hostname for PPP CHAP authentication.
D-Link(config-if)# **ppp chap password** {**0|7**} *password*	Specify the password for PPP CHAP. authentication

If the hostname used by the authenticating party is known, the following configuration can be used:

Command	Description
D-Link(config-if)# **ppp chap hostname** *hostnmae*	Specify the hostname for PPP CHAP authentication.
D-Link(config)# **username** *username* password {0|7} *password*	Create user database records for the authenticating party hostname, with passwords consistent at both ends.

Note

There are clear text password and cipher text password, "0" for clear text password and 1-7 for cipher text password. The default input method is the clear text password. In this manual, all places involving password setting is suitable for the above rule. In the interconnection with other manufacturers, only the clear text password is accepted. For the configuration of bidirectional authentication, the configuration of authenticating party is also needed.

Configuring the PPP CHAP Authenticating Party

The PPP CHAP authenticating party initiates the authentication proactively. Since the username and password from the peer router shall be validated, the authenticating party shall create and maintain a local user database. To configure the PPP CHAP authenticating party, use the following command at interface configuration mode:

Command	Description
D-Link(config-if)# **ppp authentication chap [callin]**	Enable the PPP authentication and specify the PPP CHAP authentication method.

D-Link(config-if)# **no ppp authentication chap**	Disable the PPP CHAP authentication.
D-Link(config)# **username** *username* **password {0|7}** *password*	Create the user database record.

The authenticating party has the username and related password configured in the user database, where the username is the PPP hostname of the peer router (the authenticated party).

Note

The Callin is an optional command option. With it configured, the CHAP authentication is not initiated unless the peer router (authenticated party) dials to connect the network in dialup mode. For the PPP connection that is set up because the local router dials out, the CHAP authentication is not initiated. Therefore, this command does not affect the dedicated line PPP negotiation.

Configuring the PPP PAP Authenticated Party

The PAP authentication involves authenticating party and authenticated party. For the setting of PAP authenticated party for PPP, run the following commands:

Command	Function
D-Link(config-if)# **ppp pap sent-username** *username* **password {0|7}** *password*	Specify the username and password for PPP PAP authentication.
D-Link(config-if)# **no ppp pap sent-username**	Remove the PPP PAP authentication settings.

Configuring the PPP PAP Authenticating Party

The commands for setting the PPP PAP authenticating party are as follows:

Command	Description
D-Link(config-if)# **ppp authentication pap [callin]**	Configure the PPP PAP authenticating party
D-Link(config)# **username** *username* **password {0|7}** *password*	Create the user database record.

Note

The Callin is an optional command option. With it configured, the PAP authentication is not initiated unless the peer router (authenticated party) dials to connect the network via dialup mode. For the PPP connection that is set up because the local router dials out, the PAP authentication is not initiated. Therefore, this command does not affect the dedicated line PPP negotiation.

Configure the PPP Negotiation Parameters

During the PPP negotiation, both LCP and IPCP have timeout periods. Once the period expires, the LCP resends requests. This period can be set by using this command to coordinate the negotiation time in the interconnection with heterogeneous devices.

Command	Function
D-Link(config-if)#**ppp negotiation-timeout** *seconds*	Configure the PPP LCP negotiation time.
D-Link(config-if)#**no ppp negotiation-timeout**	Restore the PPP negotiation time to the default.

MP configuration

Configuring MP on the Dialer Interface

MP Configuration Task List

The MP can be implemented by configuring the rotary-group on the physical interface layer and binding the dialer logical interface. This chapter describes only the multilink PPP binding the dialer interface and the synchronous serial interface. For the configuration of the dialup multilink of asynchronous serial interface, see DDR Configuration Guide. The list of configuration tasks for the multilink of Dialer interface binding synchronous serial interface is as follows:

- Configuring the synchronous serial interface
- Encapsulating PPP link protocol
- Configuring dialer in-band
- Configuring rotary-group
- Creating the logical interface dialer
- Configuring the ppp multilink
- Configuring the dialup filtering rule

Configuring the synchronous serial interface

To configure the synchronous serial interface for multilink binding:

Command	Function
D-Link(config)# **interface serial** *interface-number*	Enter the configuration mode of the specified serial interface.

Encapsulating PPP link protocol

The multilink PPP is a PPP at first. So, it is required to encapsulate the PPP link protocol first no matter whether it is on a physical interface or a logical interface.

Command	Function
D-Link(config-if)#**encapsulation ppp**	Encapsulate the PPP link protocol.
D-Link(config-if)#**no encapsulation ppp**	Cancel the encapsulation of the PPP link protocol.

Configuring dialer in-band

To configure the multilink, it is required to configure the DDR on the serial interface configuration layer at first by using the following command, which is the prerequisite for configuring rotary-group:

Command	Function
D-Link(config-if)#**dialer in-band**	Set the DDR configuration.
D-Link(config-if)#**no dialer in-band**	Cancel the DDR configuration.

Configuring rotary-group

This command binds the physical interface to the rotary group of logical interface to enable the multilink binding.

Command	Function
D-Link(config-if)#**dialer rotary-group** *group-number*	Set the number of the rotary group.
D-Link(config-if)#**no dialer rotary-group** *group-number*	Delete the rotary group.

Note

The configuration of the rotary-group needs the DDR. So, if the **dialer in-band** has not been configured in advance, it will be automatically configured in configuring **dialer rotary-group**.

Creating the logical interface dialer

When the rotary group is set, it is necessary to create the logical interface dialer that individual physical interfaces are bound to. The interface number must be the same as the number of the rotary group. After the logical interface dialer is created, it enters into the dialer logical interface configuration layer. Accordingly, it is required to encapsulate the PPP link protocol, configure the PPP multilink, configure the dialup filtering rule, and so on.

Command	Function
D-Link(config)#**interface dialer** *group-number*	Create the logical interface dialer.
D-Link(config)#**no interface dialer** *group-number*	Delete the logical interface dialer.

Note

When you create the logical interface dialer, the physical interface with the rotary group configured must be existent, which maintains the binding by consistency of the rotary group number and the logical interface dialer number. If the logical interface is to be deleted, it is required to delete the rotary group on the physical interface first.

Configuring the ppp multilink

To set the multilink PPP, it is required to configure the **PPP multilink** command on the logical interface to specify the logical interface to use the multilink negotiation mode.

Command	Function
D-Link(config-if)#**ppp multilink**	Set the multilink negotiation mode.
D-Link(config-if)#**no ppp multilink**	Cancel the setting of the PPP multilink negotiation mode.

Configuring the dialup filtering rule

On the logical interface, it is required to configure the dialup filtering rule. This rule is powerful enough to use with the ACL. Here is the simplified description for the functions of the **dialer-list**.

Command	Function
D-Link(config-if)#**dialer-group** *group-number*	Set the dialer group.
D-Link(config)#**dialer-list** *group-number* **protocol ip permit**	Set the common dialer group list allowing the access to IP packets.

Configuring MP on the Multilink Interface

MP Configuration Task List

The MP can be implemented by configuring the multilink group on the physical interface layer and binding the multilink logical interface. This chapter describes only the multilink PPP of the multilink interface binding the synchronous serial interface. The list of configuration tasks of multilink interface binding synchronous serial interface is as follows:

- Creating the logical interface multilink
- Configuring the synchronous serial interface
- Encapsulating PPP link protocol
- Configuring the ppp multilink
- Configuring the ppp multilink group

Creating the logical interface multilink

To configure the MP binding of the multilink interface, create the logical interface multilink binding individual physical interfaces. After the logical interface multilink is created, it enters into the multilink logical interface configuration layer, where the PPP encapsulation and MP are enabled by default.

Command	Function
D-Link(config)#**interface multilink** *group-number*	Create the logical interface multilink.
D-Link(config)#**no interface multilink** *group-number*	Delete the logical interface multilink.

Caution

Up to 72 multilink interfaces are supported.

Configuring the synchronous serial interface

To configure the synchronous serial interface for multilink binding, execute the following command:

Command	Function
D-Link(config)# **interface serial** *interface-number*	Enter the specified serial interface configuration mode.

Encapsulating PPP link protocol

The multilink PPP is a PPP at first. So, it is required to encapsulate the PPP link protocol first on the synchronous serial interface.

Command	Function
D-Link(config-if)#**encapsulation ppp**	Encapsulate the PPP link protocol.
D-Link(config-if)#**no encapsulation ppp**	Remove the encapsulation of PPP link protocol.

Configuring the ppp multilink

To set the synchronous interface to use the multilink negotiation mode, execute the **PPP multilink** command on the synchronous serial interface.

Command	Function
D-Link(config-if)#**ppp multilink**	Set the multilink negotiation mode.
D-Link(config-if)#**no ppp multilink**	Remove the setting of the PPP multilink negotiation mode.

Configuring the ppp multilink group

To bind the synchronous serial interface to the group of logical interface for multilink binding, execute the following command.

Command	Function
D-Link(config-if)# **ppp multilink group** *group-number*	Set the number of the multilink group.
D-Link(config-if)#**no ppp multilink group** *group-number*	Remove the number of the multilink group.

Note

The parameter group-number configured here is the same as the multilink interface number in the creation of the multilink. When configuring the ppp multilink group, the multilink interface must exist accordingly. The physical interface uses the multilink group number and the logical interface number of multilink interface to maintain binding. If the logical interface is to be deleted, it is required to delete the multilink group on the physical interface first.

Configuring MP on the Virtual-Template Interface

MP Configuration Task List

The MP can be implemented by configuring the MP on the physical interface layer and binding the virtual template interface. This chapter describes only the multilink PPP of the virtual tempalte interface binding the synchronous serial interface. For details of the virtual template, see VPN Configuration Guide. The list of configuration tasks for the virtual tempalte interface binding synchronous serial interface is as follows:

- Creating the virtual template interface
- Creating the bounded virtual template interface
- Configuring the synchronous serial interface
- Encapsulating the PPP link protocol
- Configuring the ppp multilink

Creating the virtual template interface

To configure the MP in the Virtual-Template method, it is required to create the Virtual-Template interface. After the Virtual-Template interface is created, it enters into the virtual template interface configuration layer. Accordingly, it is required to encapsulate the PPP link protocol, configure the PPP multilink, configure the dialup filtering rule, and so on.

Command	Function
D-Link(config)#**interface virtual-template** *number*	Create/configure the specified virtual -template interface
D-Link(config)#**no interface virtual-template** *number*	Delete the specified virtual -template interface

Creating the bounded virtual template interface

After the virtual template interface is created, the **multilink virtual-template** command is used to specify which virtual template copy binds the interface parameters.

Command	Purpose
D-Link(config)# **multilink virtual-template** *number*	Specify the virtual template for the MP bundle interface to clone interface parameters
D-Link(config)# **no multilink virtual-template** *number*	Delete the virtual template for the MP bundle interface to clone interface parameters

Note

For the Virtual-Template multilink binding, in the setup of the binding, a virtual access interface Virtual-Access is created automatically as the binding interface. This command specifies which virtual template copy configuration acts as the settings of the virtual access interface during the creation of the virtual access interface.

Configuring the synchronous serial interface

To configure the synchronous serial interface for multilink binding:

Command	Function
D-Link(config)# **interface serial** *interface-number*	Enter the configuration mode of the specified serial interface

Encapsulating the PPP link protocol

The multilink PPP is a PPP at first. So, it is required to encapsulate the PPP link protocol first no matter whether it is on a synchronous serial interface or a virtual template interface.

Command	Function
D-Link(config-if)#**encapsulation ppp**	Encapsulate PPP link protocol
D-Link(config-if)#**no encapsulation ppp**	Cancel the encapsulation of PPP link protocol

Configuring the ppp multilink

To set the virtual template interface and physical interface to use the multilink negotiation mode, execute this command on the virtual template interface and synchronous interface.

Command	Function
D-Link(config-if)#**ppp multilink**	Set the multilink negotiation mode.
D-Link(config-if)#**no ppp multilink**	Remove the setting of the PPP multilink

Command	Function
	negotiation mode.

Note

It is not necessary to configure multilink group or rotary-group on the physical interface for virtual template-based binding. It only the **ppp multilink** command is configured on the physical interface but no configuration for which link group or dialup rotary group to belong to, the physical interface will belong to the multilink binding in virtual template mode.

PPP Monitoring and Maintenance

Showing the Protocol Interface Information

Run the following command to show the PPP protocol interface information, which is the first step to debug PPP:

Command	Function
D-Link#**show interface serial** *interface-number*	Show the information of the serial interface.

Take Serial1/0 as an example. The following information in printed after the command is entered:

```
serial 1/0 is UP  , line protocol is UP
Hardware is Infineon DSCC4 PEB20534 H-10 serial
Interface address is: 100.100.100.1/24
 MTU 1500 bytes, BW 2000 Kbit
 Encapsulation protocol is PPP, loopback not set
 Keepalive interval is 10 sec , set
 Carrier delay is 2 sec
 RXload is 1 ,Txload is 1
 LCP Open
 Open: ipcp
 Queueing strategy: WFQ
 5 minutes input rate 30 bits/sec, 0 packets/sec
 5 minutes output rate 30 bits/sec, 0 packets/sec
 49 packets input, 786 bytes, 0 no buffer
 Received 1 broadcasts, 0 runts, 0 giants
 0 input errors, 0 CRC, 0 frame, 0 overrun, 0 abort
 47 packets output, 768 bytes, 0 underruns
 0 output errors, 0 collisions, 1 interface resets
 1 carrier transitions
  V35 DTE cable
 DCD=up  DSR=up  DTR=up  RTS=up  CTS=up
```

First check the link status from the physical layer. The five signals (DCD, DSR, DTR, RTS, CTS) in the last row determine whether the serial is UP or not. This is the prerequisite for PPP Line Protocol UP.

Then, check whether the PPP negotiation is successful by checking whether the LCP status is UP and whether the IPCP status is UP. If yes for both, the line protocol is in the up status, and the link layer shall be available for communication.

Last, refer to the data receiving/transmitting conditions at the bottom layer. Packet Input and Output indicate the number of messages received and transmitted. If there is no interface reset, the message

transmission is successful. If there is no number of drops in the Input Queue, it means all messages are received successfully.

PPP Debugging Information

In case of problem with the PPP link layer negotiation, run the following command to debug the PPP:

Command	Function
D-Link# **debug ppp packet**	Print message debug information during PPP communication
D-Link# **debug ppp negotiation**	Print negotiation debug information during PPP communication
D-Link# **debug ppp authentication**	Print authorization debug information during PPP communication

Packet debugging

In the privileged command layer, enter the **PPP Packet** debug command:

```
D-Link#debug ppp packet
PPP: serial 1/0 [S] LCP CONFREQ id 3 len 10
   MAGICNUMBER (6) 0x0 0x2b 0x39 0x1b
%LINK CHANGED: Interface serial 1/0, changed state to up
PPP: serial 1/0 [R] LCP CONFREQ id 6 len 10
   MAGICNUMBER (6) 0x29 0xbd 0xea 0xeb
PPP: serial 1/0 [S] LCP CONFACK id 6 len 10
   MAGICNUMBER (6) 0x29 0xbd 0xea 0xeb
PPP: serial 1/0 [R] LCP CONFACK id 3 len 10
   MAGICNUMBER (6) 0x0 0x2b 0x39 0x1b
PPP: serial 1/0 LCP up
PPP: serial 1/0 PPP up.
PPP: serial 1/0 [S] IPCP CONFREQ(2) id 10 len 2
   Address (6) 0x64 0x64 0x64 0x1
PPP: serial 1/0 [R] IPCP CONFREQ(3) id 10 len 2
   Address (6) 0x64 0x64 0x64 0x2
PPP: serial 1/0 [S] IPCP CONFACK(3) id 10 len 2
   Address (6) 0x64 0x64 0x64 0x2
PPP: serial 1/0 [S] LCP PROTREJ id 4 len 10 protocol = 0x82070103
PPP: serial 1/0 [R] IPCP CONFACK(2) id 10 len 2
   Address (6) 0x64 0x64 0x64 0x1
%LINE PROTOCOL CHANGE: Interface serial 1/0, changed state to UP
D-Link#
PPP: serial 1/0 [S] LCP ECHOREQ id 1 len 12 magic 0x2b391b
```

The above debugging information is for all messages from the start of the PPP negotiation to the Line Protocol Up, without authentication. Pay attention to the bolded debug information: Both routers send the LCP CONFREQ to each other and then respond with the LCP CONFACK. Then it enters into the IPCP negotiation. Also pay attention to the bolded contents. Both routers send IPCP CONFREQ to each other and attach their own IP addresses, and then send the IPCP CONFACK response with the peer IP address attached after the IPCP CONFREQ request is received. Now the PPP negotiation of the interface succeeds.

PPP negotiation debugging information

The negotiation debugging information is used for the debugging trace purpose in negotiating the PPP parameters. For example, in the CHAP authentication of PPP, the **debug ppp negotiation** command can trace the following parameter negotiation information:

```
D-Link#
PPP: serial 1/0 reset lcp options
PPP: serial 1/0 sending OPCODE_CONFREQ, type = 5 (LCP_MAGICNUMBER), value = 0x10a5df
%LINK CHANGED: Interface serial 1/0, changed state to up
LCP: received config , type = 5 (MAGICNUMBER) value = 0x29cbca60 acked
PPP: serial 1/0 OPCODE_CONFACK received, type = 5 (LCP_MAGICNUMBER), value = 0x10a5df
PPP: serial 1/0 state = Acksent ppp_recv_confack(0xc021): rcvd id 5
PPP: serial 1/0 reset ipcp options
IPCP: serial 1/0 sending OPCODE_CONFREQ, type = 3 (IPCP_ADDRESS), Address = 100.100.100.1
IPCP: serial 1/0 received ADDR : her address 100.100.100.2 (ACK)
IPCP: ipcp_do_req_cb: returning OPCODE_CONFACK.
IPCP: serial 1/0 OPCODE_CONFACK received, type = 3 (IPCP_ADDRESS), Address = 100.100.100.1
PPP: serial 1/0 state = Acksent ppp_recv_confack(0x8021): rcvd id 3
IPCP: serial 1/0 install route to 100.100.100.2
%LINE PROTOCOL CHANGE: Interface serial 1/0, changed state to UP
```

Pay attention to the bolded contents, which are the options for the LCP and IPCP negotiation parameters.

PPP authentication debugging information

The debug of the authentication information is used to trace the PPP authentication. With PAP as an example, the PAP authenticating party prints the following debugging information:

```
PPP: serial 1/0 PAP authenticating peer DRO36
PPP: serial 1/0 Remote passed PAP authentication sending Auth-Ack to peer.
PPP: serial 1/0 lcp authentication OK#
```

The CHAP authentication party prints the following information when the sent CHAP password is wrong:

```
PPP: serial 1/0 recv CHAP challenge from Router
PPP: serial 1/0 remote router failed CHAP authentication
PPP: serial 1/0 Remote msg is: Authentication failure
```

Typical PPP Configuration Examples

PPP PAP Authentication Example

The example below shows a PAP configuration, username D-Link, password Router, authenticating party IP address 1.1.1.1/24, authenticated party IP address 1.1.1.2/24, username and password configured same as the authentication method.Router A is the authenticated party and Router B is the authenticating party.

Router A:

```
D-Link#config terminal
D-Link(config)#interface Serial1/0
```

Configure the IP address

```
D-Link(config-if)#ip address 1.1.1.2 255.255.255.0
```

Encapsulate PPP protocol

```
D-Link(config-if)#encapsulation ppp
```

Configure the username and password for PAP authentication.

```
D-Link(config-if)#ppp pap sent-username D-Link password 0 Router
```

Router B:

```
D-Link#config terminal
D-Link(config)#username D-Link password 0 Router
D-Link(config)#interface Serial1/0
```

Configure the IP address

```
D-Link(config-if)#ip address 1.1.1.1 255.255.255.0
```

Encapsulate PPP protocol

```
D-Link(config-if)#encapsulation ppp
```

Specify the PPP authentication mode

```
D-Link(config-if)#ppp authentication pap
```

PPP CHAP Authentication Example

The example below shows a PPP CHAP authentication configuration, where the Router A is the authenticating party, IP address is 1.1.1.1/24, hostname is RouterA, password is Router, and the user list contains the hostname RouterB; the Router B is the authenticating party, IP address is 1.1.1.2/24, hostname is RouterB and the password sent is Router.

Router A:

```
D-Link#config terminal
```

Set the hostname

```
D-Link(config)#hostname RouterA
```

Set the username and password list

```
RouterA(config)#username RouterB password 0 Router
RouterA(config)#username RouterC password 0 Router
RouterA(config)#interface serial1/0
```

Encapsulate protocol

```
RouterA(config-if)#encap ppp
```

Set IP address

```
RouterA(config-if)#ip address 1.1.1.1 255.255.255.0
```

Specify the PPP chap authentication mode

```
RouterA(config-if)#ppp authentication chap
```

Router B:

```
D-Link#config terminal
```

Set the hostname

```
D-Link(config)#hostname RouterB
```

Use the peer hostname as the username, and the password is the same as that configured on the peer router.

```
RouterB(config)#username RouterA password 0 Router
RouterB(config)#interface serial1/0
```

Encapsulate protocol

```
RouterB(config-if)#encap ppp
```

Set IP address

```
RouterB(config-if)#ip address 1.1.1.2 255.255.255.0
```

To keep the administration hostname, the hostname configured for the CHAP authentication can be configured by using the **chap hostname *hostname*** command. In the above example, the Router B as the authenticated party uses the default hostname, and the host for the CHAP authentication is RouterB.
Router B:

```
D-Link#config terminal
D-Link(config)#
```

Use the peer hostname as the username, and the password is the same as that configured on the peer router.

```
R(config)#username RouterA password 0 Router
D-Link(config)#interface serial1/0
```

Encapsulate protocol

```
D-Link(config-if)#encap ppp
```

Set IP address

```
D-Link(config-if)#ip address 1.1.1.2 255.255.255.0
```

Set the local CHAP authentication hostname

```
D-Link(config-if)#ppp chap hostname RouterB
```

MP Configuration Example

The example below shows a multilink configuration, where two synchronous interfaces serial1/0 and serial1/1 are bound to the logical interface dialer 1 to implement the Multilink PPP.

Create the loopback interface and use its IP address as the IP address of the dialer logical interface

```
interface Loopback0
ip address 192.168.20.2 255.255.255.0
```

Configure DDR on the physical interfaces serial1/0 and serial1/1, and specify the rotary group number (1 in this example)

```
interface Serial1/0
no ip address
encapsulation ppp
dialer in-band
dialer rotary-group 1
#
interface Serial1/1
no ip address
encapsulation ppp
dialer in-band
dialer rotary-group 1
```

Create the dialer 1 logical interface and borrow the IP address of loopback0, set the dialer group, and specify the multilink ppp negotiation method.

```
interface Dialer1
ip unnumbered Loopback0
encapsulation ppp
dialer-group 1
ppp multilink
#
dialer-list 1 protocol ip permit
```

The example below uses two synchronous interfaces serial1/0 and serial1/1 are bound to the logical interface multilink 1 to implement the Multilink PPP.

Create the loopback interface and use its IP address as the IP address of the multilink logical interface

```
interface Loopback0
```

```
  ip address 192.168.20.1 255.255.255.0
```

Configure ppp multilink on the physical interfaces serial1/0 and serial1/1, and specify the multilink group number 1.

```
interface Serial 1/0
  no ip address
  encapsulation ppp
  ppp multilink
  multilink-group 1
interface Serial 1/1
  no ip address
  encapsulation ppp
  ppp multilink
  multilink-group 1
```

Create the multilink 1 logical interface and borrow the IP address of loopback0.

```
interface multilink 1
  ip unnumbered Loopback0
  encapsulation ppp
  ppp multilink
```

The example below uses two synchronous interfaces serial1/0 and serial1/1 are bound to the virtual template interface to implement the Multilink PPP.

Create the loopback interface and use its IP address as the IP address of the virtual template interface

```
interface Loopback0
  ip address 192.168.20.1 255.255.255.0
```

Configure the PPP multilink on physical interfaces serial1/0 and serial1/1

```
interface Serial 1/0
  no ip address
  encapsulation ppp
  ppp multilink
interface Serial 1/1
  no ip address
  encapsulation ppp
  ppp multilink
```

Create the virtual-template 1 interface and borrow the IP address of loopback0.

```
interface virtual-template 1
  ip unnumbered Loopback0
  encapsulation ppp
  ppp multilink
multilink virtual-template 1
```

Specify copying parameters from virtual-template 1, to establish the binding from virtual-access interface to synchronous interface.

PPP Troubleshooting

First, use the **show interface serial** *slot-number/interface-number* command to check the interface status. A synchronous interface may have four statuses. Take the serial 1/0 as an example;

Status display	Fault description
serial 1/0 is administratively down, line protocol is down	The interface is shut down by someone.

Status display	Fault description
serial 1/0 is down, line protocol is down	The interface is not activated, or the physical interface has not turned Up
Serial 1/0 is up, line protocol is up	The interface is available for data transmission.
serial 1/0 is up, line protocol is down	The interface has been activated but the link negotiation fails.

Interface Cannot be Up

Firstly:Remove the fault of manual shutdown of the interface.
Secondly: Check the physical layer causes. Run the show interface serial1/0 command to check the interface status. All the physical layer parameters (DCD, DTR, DSR, CTS, RTS) shall be up. If some one is down, verify whether the related V.35 or V.24 cable has problem or not.
Finally: If the cable of the interface is DTE (the connector connected with the line device is a fame-end cable) but the DCD is down, verify whether the line handshake of the Modem connected with the cable is successfully. If so, the DCD or LINE indicator on the Modem shall be always on.

Link Protocol Cannot be Up

The interface is up is the prerequisite for Line Protocol Up. Therefore, first remove the interface down fault in troubleshooting the fault of the link protocol cannot be up. Then, verify the data receiving/transmitting of the link layer: Run the **show interface serial *slot-number/interface-number*** command to note the numbers of Packet Input and Packet Output. If there is no Input message, the peer router may be shut down or the transmission of the peer router has problem.
Run the **Clear Count serial *slot-number/interface-number*** command for a period and note the number of Interface reset. If any, it indicates the local router transmission has problem.
To prevent the loopback problem with the line: Run the **show interface serial *slot-number/interface-number*** command to check whether there is the prompt "Loopback is set". Use the **debug PPP packet** command to check whether the PPP negotiation matches the reply of the peer router Magic Number. If yes, the line may be in the loopback status, causing the link cannot be up. It may also possible that the link is up but the peer cannot be pinged through.
If the data transmission/receiving of the line is normal but the protocol settings of the line do not match, such as HDLC protocol set for the peer router, run the **debug PPP packet** command to view the prompt for protocol type. If so, the line protocol cannot be up.
The fault that the link protocol cannot be up is related with the negotiation parameters. If the line negotiation needs the CHAP or PAP authentication, it is necessary to ensure correct username and password, which can be verified by using the **debug ppp packet** or **debug ppp negotiation** command.

Link is Up but Ping Failed

The status of link up is based on the successful LCP negotiation. If the interface has been configured with an IP address, the Line protocol may also be up but there is no prompt "IPCP Open". As a result, if the IP address of the peer WAN interface cannot be pinged through, remove the fault of the IPCP negotiation failure. If the peer WAN interface can be pinged through but the IP addresses inside the peer LAN cannot be pinged through, troubleshoot from the routing table first. For the related routing configuration, see IP Routing Protocol Configuration Guide.

Frame Relay Configutation

Understanding Frame Relay

The Frame Relay is a fast-switching link layer protocol that is developed on the basis of the X.25. It is an unreliable connection and a PTP link layer protocol. The Frame Relay is widely used because it is simple, efficient, and can implement one-to-many connections.

Basic Concept

1) DTE/DCE

A frame relay connection is not a peer-to-peer connection. The data terminal device (DTE) is generally used at the user end, whereas the device that provides the frame relay network service is the data circuit termination device (DCE). Generally the frame relay network operator provides DCEs. On the user side, in a certain test environment, the DTE and DCE are interconnected to set up a frame relay connection, or a frame relay connection is set up by usingthe frame relay switching solution.

2) Frame relay address DLCI

The Frame Relay is a multi-path reuse service in the statistical way. It allows multiple logical connections (also called channels) to coexist on the same physical connection. In other words, it can provide multiple virtual circuits on a single physical transmission line. Each virtual circuit is identified by a Data Link Connection Identifier (DLCI). The DLCI is effective only between the DTE and the DCE but not between the DTE and the DTE. In a frame relay network, the same DLCI on different physical interfaces does not mean the same virtual connection. The user interface of the frame relay network supports up to 1024 virtual circuits, where the DLCIs available for users range from 16 to 991. Since the frame relay virtual circuit is connection-oriented, different local DLCIs are connected to different peer devices. Therefore, the DLCI can be treated as the frame relay address provided by the DCE.

3) Static address mapping

The frame relay address mapping means that the IP address of the peer device is associated with the local DLCI, so that the network layer protocol can address the peer device. The frame relay mainly bears IP packets, and the next-hop IP address of the message is known according to the routing table when the message is sent. Before a devices sends a message, it determines the related DLCI according to the next-hop IP address. The device completes this process by searching the frame relay address mapping table, because the address mapping table stores the mapping between the next-hop IP address and the next-hop DLCI. Each entry in the address mapping table can be configured manually.

4) Reverse ARP

The reverse ARP enables the frame relay to dynamically learn the network protocol IP address. The request message of the reverse ARP is used to request the next-hop protocol address. The IP address obtained from the response message of the reverse ARP is put into the DLCI-IP mapping table. By default, the router supports the reverse ARP to negotiate the DLCI and IP address. The dynamic address mapping is specially used for the point-to-multipoint frame relay configuration. In the PTP configuration, there is only one destination and therefore addressing is not required. When the PVC remote device does not support reverse ARP, disable this protocol or the reverse ARP of that DLCI.

5) Permanent virtual circuit (PVC) and switching virtual circuit (SVC)

Based on the virtual circuit setup mode, the virtual circuit falls into two types: permanent virtual circuit (PVC) and switching virtual circuit (SVC). The virtual circuit that is created manually is called the permanent virtual circuit. The one that is created through protocol negotiation is called the switching virtual circuit, which is created or deleted automatically. Currently, PVC is the most frequently used virtual circuit setup mode in the frame relay, that is, virtual circuits are configured manually.

6) Local management information

In PVC mode, the availability of the virtual circuit must be tested. The Local Management Information (LMI) protocol is used for such a purpose. Three local management information protocols can be used: ITU-T Q.933 appendix A, ANSI T1.617 appendix D, and CISCO format. Their basic working mode is as follows: The DTE sends a Status Enquiry message at a fixed interval to query the status of the virtual circuit. The DCE receives the Status Enquiry message and responds Status message immediately to notify the DTE of the current states of all virtual circuits on the current interface.

7) Commited information rate (CIR) technology

The frame relay is mostly used for data transfer during which the acknoweldgement mechanism and error correction function are disabled. However, it provides a set of reasonable bandwidth management and congestion prevention mechanisms, so that users can effectively make use of the predefined bandwidth (that is, the CIR). The frame relay also allows the burst data of users to occupy the undefined bandwidth.

Local Negotiation Process of Frame Relay

1) When the T391 timer expires, the DTE sends a Status Enquiry message and starts counting at the same time. When the count is smaller than N391, the Status Enquiry message sent by the DTE only queries the link integrity. When the count reaches N391, the Status Enquiry message sent by the DTE is a full status request message, querying not only the link integrity but also states of all PVCs.
2) After receiving the Status Enquiry message, the DCE sends a reply message to the DTE. At the same time, the T392 timer at the DCE side starts and waits for the next Status Enquiry message. If the T392 times out but the DCE does not receive the Status Enquiry message from the DTE, the DCE records this error and increases the error count in N393 by 1.
3) The DTE receives the status reply message and knows the link status and the PVC status. If the PVC status changes in the network, no matter whether the PVC is added or deleted, the DCE sends a message that contains the status of all PVCs to the DTE, so that the DTE knows in time the change of the frame relay network and updates the related records.
4) If the T391 expires but the DTE does not receive the reply message, the DTE records the event error and increases the error count in N393 by 1.
5) If the number of errors in the N393 exceeds N392, the DTE or DCE determines thta the virtual circuit is unavailable. N393 refers to the total number of monitored events, and the N392 refers to the error threshold.

Configuring Frame Relay

Frame Relay Configuration Task List

The frame relay configuration involves the following task:

- Configuring the Interface Encapsulation Protocol
- Configuring Address Mapping

- Configuring the LMI Type(optional)
- Configuring Frame Relay Switching (optional)
- Configuring the Frame Relay Sub-Interface(optional)

Configuring the Interface Encapsulation Protocol

Use the following commands to encapsulate the Frame Relay protocol on the synchronous interface.

Command	Function
Ruijie(config-if)# **encapsulation frame-relay [ietf]**	Encapsulates the Frame Relay protocol.
Ruijie(config-if)# **no encapsulation frame-relay**	Removes the Frame Relay encapsulation from a specified interface.

To ensure the compatibility with mainstream devices, the system use the default frame relay encapsulation format of the CISCO encapsulation. Unless the application scenario is special, use the **encapsulation frame-relay ietf** command.

Configuring the Frame Relay Interface Type

The frame relay interface type is DTE by default. The DCE type is used only when the device is used as the frame relay switch or to emulate the frame relay office device.

Use the following commands to configure the frame relay interface type.

Command	Function
Ruijie(config-if)# **frame-relay intf-type {dte|dce}**	Specified the type of interface on which the frame relay is encapsulated. The type is DTE or DCE.
Ruijie(config-if)# **no frame-relay intf-type**	Restores the default type of the interface

Configuring Address Mapping

Configuring Static Address Mapping

The static address mapping reflects the mapping between the IP addresses of remote devicees and the local DLCIs.

Use the following commands to manually configure the static address mapping.

Command	Function
Ruijie(config-if)# **frame-relay map ip** *ip-address dlci* [**broadcast|ietf|cisco**]	Creates a static address mapping table of frame relay manually.
Ruijie(config-if)# **no frame-relay map ip** *ip-address*	Deletes the IP address mapping entry of frame relay.

When the peer device does not support the reverse ARP (dynamic address mapping) protocol, the peer device can communicate with the local device only when the local device is configured with the static address mapping. When the static mapping is configured, the reverse ARP does not take effect automatically.

The optional keyword **ietf** indicates that the IETF Frame Relay encapsulation method defined in RFC 1490 is used. When the router is communicating with a device that is using the Cisco encapsulation in a frame relay network, the **cisco** keyword is used. The **cisco** or **ietf** keyword can overwrite the method specified by the interface configuration command **encapsulation frame-relay**. If the **cisco** or **ietf** keyword is not specified, the address mapping will inherit the attributes specified by the **encapsulation frame-relay** command.

The keyword **broadcast** is used when the network protocol needs the broadcast function. This keyword is especially important when the OSPF or RIP routing protocol is used on the IP network.

Configuring Dynamic Reverse ARP

The dynamic address mapping is enabled by default for network protocols.

Since the reverse ARP is enabled by default, you do not need to specify it specially for dynamic addressing, unless the reverse ARP is disabled.

Use the following command in interface configuration mode to disable the reverse ARP.

Command	Function
Ruijie(config-if)# **frame-relay inverse-arp** [*protocol*] [*dlci*]	Enables the specific protocol and DLCI of the frame relay to use the reverse ARP.
Ruijie(config-if)# **no frame-relay inverse-arp** [*protocol*] [*dlci*]	Disables the specific protocol and DLCI of the frame relay to use the reverse ARP.

The optional **protocol** variable allows the router administrator to disable the reverse ARP for a specific network protocol, while other supported protocols can still use the reverse ARP. Currently, the **protocol** variable can be set to **IP** only.

The value of the **dlci** variable is a valid interface number in the range from 16 to1007. You can specify both the **protocol** and **dlci** variables to determine a specific DLCI protocol. This allows another DLCI that runs the same protocol to continue the use of dynamic address mapping.

When only the **no frame-relay inverse-arp** command is used but no protocol and DLCI number are specified, all DLCIs of all protocols and interfaces will have the reverse ARP disabled.

Configuring the DLCI

Use the following command to configure the DLCI in interface configuration mode only when the interface type is DCE.

Command	Function
Ruijie(config-if)# **frame-relay local-dlc**i *dlci*	Specifies the DLCI of frame relay.
Ruijie(config-if)# **no frame-relay local** *dlci*	Deletes the DLCI of frame relay.

Configuring the LMI Type

RGOS series supports three types of local management interface for frame relays:

- ITU-T Q.933 appendix A (Q933A)
- ANSI T1.617 appendix D (ANSI)
- CISCO format

When you configure the LMI type, the LMI type must be consistent with that configured on the access device (DCE) of the frame relay network. The default LMT type is Q933A, and generally ANSI type is provided by operators. When RGOS series is interconnected with Cisco devices, you can use the same management interface type as Cisco.

Use the following command to configure the LMI type.

Command	Function
Ruijie(config-if)# **frame-relay lmi-type {q933a}ansi|cisco}**	Specifies the LMI type of frame relay.

Configuring the Other LMI-related Parameters

Use the following commands to configure all the LMI timers and counters of frame relay to optimize the operation of the DTE and DCE.

Command	Function
Ruijie(config-if)# **frame-relay** *lmi-n391dte*	Sets the PVC status counter N391 DTE.
Ruijie(config-if)# **no frame-relay** *lmi-n391dte*	Restores the default value of N391 DTE.
Ruijie(config-if)# **frame-relay** *lmi-n392dce*	Sets the LMI error threshold N392 DCE.
Ruijie(config-if)# **no frame-relay** lmi-n392dce	Restores the default value of N392 DCE.
Ruijie(config-if)# **frame-relay** *lmi-n392dte*	Sets the LMI error threshold N392 DTE.
Ruijie(config-if)# **no frame-relay** lmi-n392dte	Restores the default value of N392 DTE.
Ruijie(config-if)# **frame-relay** *lmi-n393dte*	Sets the LMI event counter N393 DTE.
Ruijie(config-if)# **no frame-relay** *lmi-n393dte*	Restores the default value of N393 DTE.
Ruijie(config-if)# **frame-relay** *lmi-n393dce*	Sets the LMI event counter N393 DCE.
Ruijie(config-if)# **no frame-relay** lmi-n393dce	Restores the default value of N393 DCE.
Ruijie(config-if)# **frame-relay lmi-t391dte**	Sets the user side link integrity polling timer T391 DTE.
Ruijie(config-if)# **no frame-relay** *lmi-t391dte*	Restores the default value of T391 DTE.
Ruijie(config-if)# **frame-relay** *lmi-t392dce*	Sets the network side polling timer T392 DCE.
Ruijie(config-if)# **no frame-relay** *lmi-t392dce*	Restores the default value of T392 DCE.

Configuring Frame Relay Switching

RGOS series supports the frame relay switching function. With this function, a router is used to emulate a switch on the network side. Precautions in configuring the frame relay switching function are as follows:

- The command that enables the frame relay switching function must be configured.
- The interface type (intf-type) must be set to DCE.
- For a frame relay switching router, the switching function takes effect only when this function is enabled on more than two interfaces.
- Frame relay switching routes must be configured.

Use the following commands to configure the frame relay switching function.

Command	Function
Ruijie(config-if)# **frame-relay route** *in-dlci* **interface serial** *number out-dlci*	Sets the frame relay switching function and enables DLCI switching between two synchronous interfaces.
Ruijie(config-if)# **no frame-relay route** *in-dlci*	Cancels the DLCI switching between the interface and the serial number.

Set *in-dlci* to the DLCI on the DCE of the local interface and *out-dlci* to the DLCI on the DCE of another synchronous interface. For more information, see the configuration example of frame relay switching.

Configuring the Frame Relay Sub-Interface

Sub-Interface Overview

With the sub-interface, a single physical interface can be treated as multiple virtual interfaces. Using sub-interface allows a router to apply the attributes of the physical interface to every virtual interface. All the DLCIs are allocated to the physical interfaces by default. You need to allocate DLCIs to specified virtual sub-interfaces of that physical interface. One physical interface can have multiple sub-interfaces. Although the logical structure of the sub-interface does not exist at all, the sub-interface and the master interface are the same for the network layer, both of which can be configured with PVCs to connect to remote devices.

There are two types of frame relay sub-interfaces: PTP sub-interface and point-to-multipoint sub-interface. The PTP sub-interface is used for PTP connections. Generally, one PTP sub-interface is allocated with a PVC. Attributes of this kind of sub-interface are similar to those of the physical interface that is used to connect the DDN line. The point-to-multipoint sub-interface is used to connect multiple (generally more than two) user devices in the same network segment.

For the PTP sub-interface, since there is only one remote DTE device, configuration of static address mapping is not necessary. The reverse ARP can be used to know the DLCI mapping the peer IP address. For the point-to-multipoint sub-interface, the reverse ARP can be enabled to dynamically learn the mapping relationship of each PVC and its connected DTE, or the mapping relationship can be manually configured.

The **frame-relay interface-dlci** command must be configured for all PTP interface and point-to-multipoint sub-interfaces that have the reverse ARP capability. For the point-to-multipoint sub-interface that uses static addressing, you do not need to configure the **frame-relay interface-dlci** command.

Sub-Interface Configuration Task List

The sub-interface configuration involves the following tasks:

- Create sub-interface
- Configure the DCLI number of the frame relay sub-interface
- Configure the frame relay sub-interface PVC and set up the address mapping

Creating a Sub-Interface

Use the following commands in sequence to create a sub-interface.

Command	Function
Ruijie(config)# **interface serial** *slot-numberlinterface-number*	Enters the configuration layer of the synchronous serial interface.
Ruijie(config-if)# **encapsulation frame-relay [ietf|cisco]**	Encapsulates the frame relay. The IETF format is recommended.
Ruijie(config)# **interface serial** *slot-number/interface-number.subinterface-number* [**multipoint**|**point-to-point**]	Exits the global configuration layer, creates the frame relay sub-interface, and specifies the interface type.

During encapsulation of the frame relay sub-interface, the point-to-multipoint sub-interface is encapsulated by default.

Configuring the DCLI of the Frame Relay Sub-Interface

If the reverse ARP is used, use the following command to configure the DLCI of the frame relay sub-interface. If the static mapping is used, skip this step.

Command	Function
Ruijie(config-subif)# **frame-relay interface-dlci** *dlci*	Configures the DCLI of the sub-interface.
Ruijie(config-subif)# **no frame-relay interface-dlci** *dlci*	Deletes the DCLI of the sub-interface.

Establishing the Frame Relay Sub-Interface Address Mapping

For the PTP sub-interface, since there is only one peer DTE, the peer network address is implicitly determined when the virtual circuit DLCI is configured for the sub-interface. For the point-to-multipoint sub-interface, the mapping relationship between the peer network address and the local DLCI is determined by the static address mapping or by using the reverse ARP.

1) Use the following commands to establish the static address mapping for the frame relay sub-interface.

Command	Function
Ruijie(config-subif)# **frame-relay map ip** *ip-address dlci* [*option*]	Establishes the static address mapping for the frame relay sub-interface.
Router(config-isubf)# **no frame-relay map ip** *ip-address dlci* [*option*]	Deletes the static address mapping for the frame relay sub-interface.

2) Use the following command to enable or disable reverse ARP on the frame relay sub-interface.

Command	Function
Ruijie(config-subif)# **frame-relay inverse-arp ip** [*dlci*]	Enables reverse ARP on the frame relay sub-interface.
Ruijie(config-subif)# **no frame-relay inverse-arp** *ip* [*dlci*]	Disables reverse ARP on the frame relay sub-interface.

The reverse ARP is enabled for the frame relay sub-interface by default. For more information about the configuration and examples, see the typical configuration example of frame relay.

Monitoring and Maintaining Frame Relay

Displaying Frame Relay Debugging Information

Use the following information to show the frame relay debugging information.

Command	Function
Ruijie# **debug frame-relay events**	Debugs the frame relay event information
Ruijie# **debug frame-relay lmi** [**interface serial** *slot-numberlinterface-number]*	Debugs the frame relay LMI message information
Ruijie# **debug frame-relay packet**	Debugs the frame relay message transmission information

The **debug frame-relay lmi** and **debug frame-relay packet** are the mostly used. The following is a configuration example of the **debug frame-relay packet** command.

```
serial 1/0(o): dlci 100, NLPID 0x800(IP), paklen 92
l2_start = 0x7e6f490, data=0x7e6f490, paklen = 92, fr encap = 0x18410800
45 00 00 58 00 11 00 00 3f 01 77 90 01 01 01 02
01 01 01 01 08 00 b8 0d 00 0c 91 19 61 62 63 64 65
66 67 68 69 6a 6b 6c 6d 6e 6f 70 71 72 73 74 75 76
77 78 79 7a 61 62 63 64 65 66 67 68 69 6a 6b 6c 6d
6e 6f 70 71 72 73 74 75 76 77 78 79 7a 61 62 63 64
65 66 67 68
serial 1/0(i): dlci 100, NLPID 0x800(IP), paklen 88
```

In the preceding example, serial1/0 indicates the interface serial1/0, (o) indicates the output message, (i) indicates the input message, dlci 100 indicates the messages on the virtual link with DLCI 100, the message network protocol is 0x800,IP and the message length datagram size is 92.

The following is a configuration example of the **debug frame-relay lmi** command.

```
serial 1/0(out): Send message, myseq 41, yourseq 51, DTE up
l2_start = 0x7f78410, data=0x7f78410, paklen = 13, fr encap = 0x00010308
00 75 51 01 01 53 02 29 33
serial 1/0(in): Status, myseq 41
```

In the preceding example, the frame relay is encapsulated in the serial1/0 interface, the local DTE transmitting sequence number (myseq) is 41, the sequence number confirmed by the DCE (yourseq) is 51, and DTE message length is 13 bytes. For the messages received in the serial1/0 interface, the peer DCE acknowledges the myseq 41 with the DTE.

Maintaining Frame Relay Links

Use the following commands to maintain frame relay links.

Command	Function
Ruijie# **clear frame-relay-inarp**	Clears the dynamic address mapping created with the reverse ARP.
Ruijie# **show interfaces serial** *slot-number/interface-number*	Shows the information about the synchronous interface.
Ruijie# **show frame-relay lmi**	Shows the local management information of frame relay
Ruijie# **show frame-relay map**	Shows the mapping table of frame relay.
Ruijie# **show frame-relay pvc**	Shows frame relay permanent virtual circuit PVC information
Ruijie# **show frame-relay traffic**	Shows the traffic information of frame relay

1) Clear the dynamic address mapping created by using the reverse ARP.

```
serial 1/0 (up): ip 1.1.1.1
dlci 100(0x1840), dynamic,
broadcast,CISCO, status: ACTIVE
```

The preceding output of the **show frame-relay map** command shows the frame relay mapping table created by using the reverse AR. "Dynamic" in the output indicates that the mapping relationship is not manually configured. If you use the **show frame-relay map** command after configuring the **clear frame-relay-inarp** command, no output is displayed. If you

use the **show frame-relay map** command after the frame relay protocol of the interface learns the mapping relationship again, the output is displayed normally.

2) Show the information about the synchronous interface.

```
serial 1/0 is UP  , line protocol is UP
Hardware is Infineon DSCC4 PEB20534 H-10 serial
Interface address is: 1.1.1.2/24
MTU 1500 bytes, BW 2000 Kbit
Encapsulation protocol is FRAME RELAY, loopback not set
Keepalive interval is 10 sec , set
Carrier delay is 2 sec
RXload is 1 ,Txload is 1
LMI enq sent  261, LMI status recvd 200, LMI update recvd 0, DTE LMI up
LMI enq recvd 8, LMI status sent  0, LMI update sent  0
LMI DLCI 0  LMI type is CCITT, frame relay DTE  interface broadcasts 0
Queueing strategy: WFQ
5 minutes input rate 15 bits/sec, 0 packets/sec
5 minutes output rate 14 bits/sec, 0 packets/sec
229 packets input, 4623 bytes, 0 no buffer
Received 0 broadcasts, 0 runts, 0 giants
0 input errors, 0 CRC, 0 frame, 0 overrun, 0 abort
1087 packets output, 22847 bytes, 0 underruns
0 output errors, 0 collisions, 807 interface resets
7 carrier transitions
V35 DCE cable
DCD=up  DSR=up  DTR=up  RTS=up  CTS=up
```

The preceding output is described as follows:

- The last line indicates that the physical signals are all up.
- The first line indicates that the serial interface is up and the line protocol is up.
- The interface encapsulation protocol is FRAME RELAY.
- "LMI enq sent 261" indicates the number of sent status enquiry messages, and "LMI status recvd 200" inicates the number of received status messages.
- "DTE LMI up" inicates whether the DTE on the interface is active.

3) Show the local management information of frame relay.

LMI Statistics for interface serial (Frame Relay DTE) LMI TYPE = CCITT

Invalid Unnumbered info 0 Invalid Prot Disc 0

Invalid dummy Call Ref 0 Invalid Msg Type 0

Invalid Status Message 0 Invalid Lock Shift 0

Invalid Information ID 0 Invalid Report ELE Len 0

Invalid Report Request 0 Invalid Keepalive ELE Len 0

Num Status Enq. Sent 294 Num Status msgs Rcvd 233

Num Update Status Rcvd 0 Num Status Timeouts 0

The preceding information indicates the numbers of the status enquiry message received and sent.

4) Shows the mapping table of frame relay.

```
serial 1/0 (up): ip 1.1.1.1
dlci 100(0x1840), dynamic,
broadcast,CISCO, status: ACTIVE
```

The preceding output is described as follows:

- "Serial1/0" indicates that interface that is encapsulated with the frame relay.
- "Ip 1.1.1.1" indicates the IP address of the peer DTE (DCE) device.
- "Dlci 100" indicates the DLCI.
- "dynamic" indicates the dynamically-generated mapping.
- "CISCO" indicates the message format of the frame relay encapsulation.
- "ACTIVE" indicates that the current PVC is in the active status.

5) Show frame relay permanent virtual circuit PVC information

```
PVC Statistics for interface serial 1/0 (Frame Relay DTE)
DLCI = 100, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE , INTERFACE = serial 1/0

input pkts 13    output pkts 13    in bytes 338
out bytes 390    RSRpped pkts 0    in FECN pkts 0
in BECN pkts 0   out FECN pkts 0   out BECN pkts 0
in DE pkts 0     out DE pkts 0
```

In the preceding output, the first two lines show the basic information about the local PVC, including the DLCI, interface, PVC status, DTE or DCE.

6) Show the traffic information of frame relay.

```
Frame Relay Inverse Arp statistics:
Inarp requests sent 14, Inarp replies recvd 14
ARP request recvd 0, ARP replies sent 0
```

The preceding output shows the number of received ARP requests and the number of sent ARP replies.

Configuration Examples

Configuring Frame Relay IETF DTE

Networking Requirements

LANs are interconnected through the public frame relay network. The router can only act as the user device and work in frame relay DTE mode. Assume that the DLCI of router R1 is 16, and that of router R2 is 17.

Networking Topology

Figure 1

Configuration Steps

1) Configure R1:

Configure the IP address of the interface.

```
Ruijie(config)#interface serial 1/0
Ruijie(config-if)#ip address 1.1.1.1 255.255.255.252
```

Set the frame relay encapsulation format of the interface to IETF.

```
Ruijie(config-if)#encapsulation frame-relay ietf
```

Configure the static address mapping.

```
Ruijie(config-if)#frame-relay map ip 1.1.1.2 16
```

2) Configure R2:

Configure the IP address of the interface.

```
Ruijie(config)#interface serial 1/0
Ruijie(config-if)#ip address 1.1.1.2 255.255.255.252
```

Set the frame relay encapsulation format of the sub-interface to IETF.

```
Ruijie(config-if)#encapsulation frame-relay ietf
```

Configure the static address mapping.

```
Ruijie(config-if)#frame-relay map ip 1.1.1.1 17
```

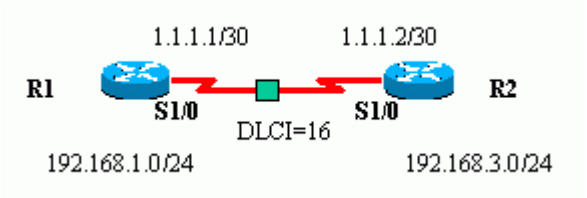
Configuring Frame Relay IETF DCE

Networking Requirements

Two routers are directly connected in the back-to-back manner by using cables. The physical layer and frame relay link layer of R1 work in DTE mode; those of R2 work in DCE mode.

Networking Topology

Figure 2



Configuration Steps

1) Configure R1.

Configure the IP address of the interface.

```
Ruijie(config)# interface serial 1/0
Ruijie(config-if)# ip address 1.1.1.1 255.255.255.252
```

Set the frame relay encapsulation format of the sub-interface to IETF.

```
Ruijie(config-if)# encapsulation frame-relay ietf
```

Configure the static address mapping.

```
Ruijie(config-if)# frame-relay map ip 1.1.1.2 16
```

2) Configure R2.

Configure the frame relay switching function.

```
Ruijie(config)# frame-relay switching
```

Configure the IP address of the interface.

```
Ruijie(config)# interface serial 1/0
Ruijie(config-if)# ip address 1.1.1.2 255.255.255.252
```

Set the frame relay encapsulation format of the sub-interface to IETF.

```
Ruijie(config-if)# encapsulation frame-relay ietf
```

Configure the interface type DCE.

```
Ruijie(config-if)# frame-relay intf-type dce
```

Configure the DLCI.

```
Ruijie(config-if)# frame-relay local-dlci 16
```

Configure the static address mapping.

```
Ruijie(config-if)# frame-relay map ip 1.1.1.1 16
```

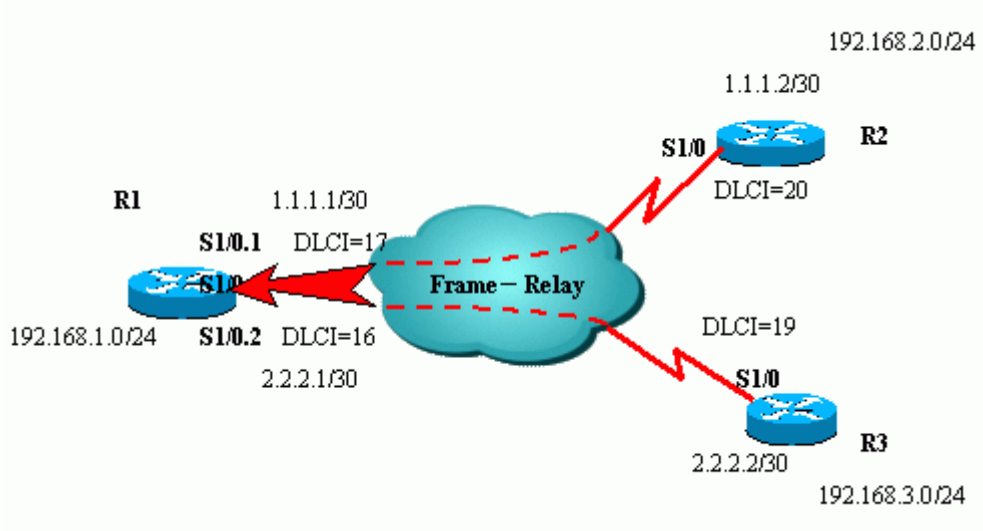
Configuring the PTP Frame Relay Sub-Interface

Networking Requirements

There are three routers: R1, R2, and R3. R1 is encapsulated with PTP frame relay sub-interface; R2 and R3 are encapsulated with frame relay in the physical layer interface and work in DTE mode. The DLCIs are 16 and 17 on R1, 20 on R2, and 19 on R3. The ANSI local management type is used.

Networking Topology

Figure 3



Configuration Steps

1) Configure R1.

Set the frame relay encapsulation format of the physical sub-interface to IETF, and the local management type to ANSI.

```
Ruijie(config)# interface serial1/0
Ruijie(config-if)# encapsulation frame-relay ietf
Ruijie(config-if)# frame-relay lmi-type ansi
```

Create the frame relay PTP sub-interface serial1/0.1, set the IP address, and specify the DLCI.

```
Ruijie(config)# interface serial1/0.1 point-to-point
Ruijie(config-subif)#ip address 1.1.1.1 255.255.255.252
Ruijie(config-subif)# frame-relay interface-dlci 16
```

Create the frame relay PTP sub-interface serial1/0.2, set the IP address, and specify the DLCI.

```
Ruijie(config)# interface serial1/0.2 point-to-point
Ruijie(config-subif)#ip address 2.2.2.1 255.255.255.252
Ruijie(config-subif)# frame-relay interface-dlci 17
```

2) Configure R2.

Set the frame relay encapsulation format of the interface serial1/0 to IETF, and the local management type to ANSI.

```
Ruijie(config)# interface serial1/0
Ruijie(config-if)# ip address 1.1.1.2 255.255.255.252
Ruijie(config-if)# encapsulation frame-relay ietf
```

```
Ruijie(config-if)# frame-relay lmi-type ansi
Ruijie(config-if)#frame-relay map ip 1.1.1.1 20  broadcast
```

3) Configure R3.

Set the frame relay encapsulation format of the interface serial1/0 to IETF, and the local management type to ANSI.

```
Ruijie(config)# interface serial1/0
Ruijie(config-if)# ip address 2.2.2.2 255.255.255.252
Ruijie(config-if)# encapsulation frame-relay ietf
Ruijie(config-if)# frame-relay lmi-type ansi
Ruijie(config-if)#frame-relay map ip 2.2.2.1 19 broadcast
```

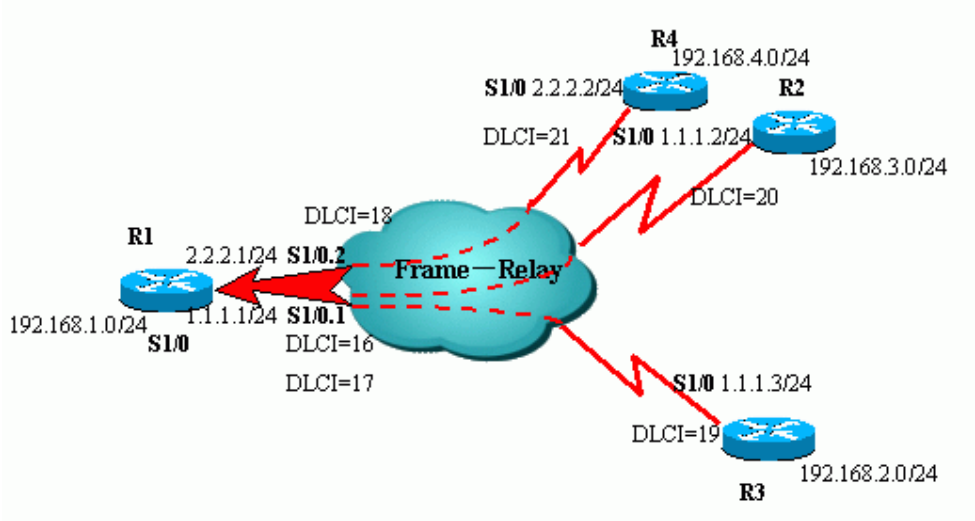
Configuring Point-to-Multipoint Frame Relay Sub-Interface

Networking Requirements

There are four routers: R1, R2, R3, and R4. The sub-interface serial0.1 of R1 encapsulates the frame relay point-to-multipoint sub-interface and is mapped to two physical interfaces of R2 and R3. The sub-interface serial0.2 of R1 encapsulates the frame relay PTP sub-interface and is mapped to the physical interface of R4. R2, R3 and R4 are encapsulated with frame relay on the physical layer interface and work in the DTE mode. The DLCIs are 16, 17 and 18 on R1, 20 on R2, 19 on R3, and 21 on R4. The default Q933A local management type is adopted. R1 uses the manually-specified frame relay address mapping table by using the static route mapping method. Serial0.2 is a PTP sub-interface.

Networking Topology

Figure 4



Configuration Steps

1) Configure R1.

Set the frame relay encapsulation format of the physical sub-interface to IETF.

```
Ruijie(config)# interface serial1/0
```

```
Ruijie(config-if)# encapsulation frame-relay ietf
```

Create the frame relay point-to-multipoint sub-interface serial1/0.1, set the IP address, and specify the DLCI.

```
Ruijie(config)# interface serial1/0.1 multipoint
Ruijie(config-subif)# ip address 1.1.1.1 255.255.255.0
Ruijie(config-subif)# frame-relay map ip 1.1.1.2 16
Ruijie(config-subif)# frame-relay map ip 1.1.1.3 17
```

2) Configure R2.

Set the frame relay encapsulation format of the interface serial1/0 to IETF.

```
Ruijie(config)# interface serial1/0
Ruijie(config-if)# ip address 1.1.1.2 255.255.255.0
Ruijie(config-if)# encapsulation frame-relay ietf
Ruijie(config-if)# frame-relay map ip 1.1.1.1 20
```

3) Configure R3.

Set the frame relay encapsulation format of the interface serial1/0 to IETF.

```
Route(config)# interface serial1/0
Ruijie(config-if)# ip address 1.1.1.3 255.255.255.0
Ruijie(config-if)# encapsulation frame-relay ietf
Ruijie(config-if)# frame-relay map ip 1.1.1.1 19
```

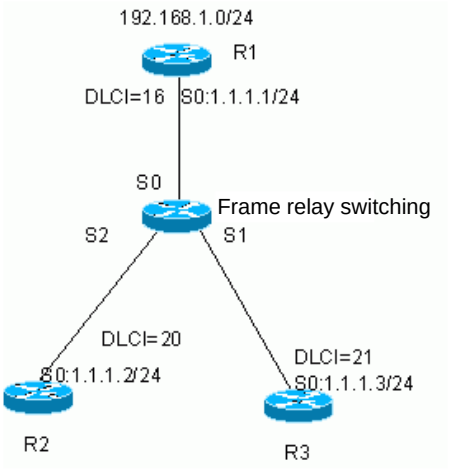
Configuring Frame Relay Switching

Networking Requirements

There are four routers: R1, R2, R3, and R4. One of them is used to emulate the frame relay switch and supports the frame relay switching function. R1 is encapsulated with frame relay and uses multiple IP address static mapping; R2 and R3 encapsulate frame relay in the physical layer interface and work in DTE mode. The DLCIs are 16 on R1, 20 on R2, and 21 on R3. R1 is used as a point-to-multipoint frame relay interface. R2 and R3 are mapped to the central router R1 respectively.

Networking Topology

Figure 5



Configuration Steps

1) Configure the frame relay switching router.

Enable the frame relay switching function.

```
Ruijie(config)#frame-relay switching
```

On the serial interface serial0/0, set the frame relay encapsulation format to DCE. Enable the DCLI 16 of serial 0/0 to switch with the DCLI 21 of serial0/1, and the DCLI 17 of serial0/0 to switch with the DCLI 20 of serial0/2.

```
Ruijie(config)# interface serial0/0
Ruijie(config-if)# encapsulation frame-relay
Ruijie(config-if)# frame-relay intf-type dce
Ruijie(config-if)# frame-relay route 16 interface Serial0/1 21
Ruijie(config-if)#frame-relay route 17 interface Serial0/2 20
```

On the interface seiral0/1, set the frame relay encapsulation format to DCE, and enable the DCLI 21 of serial 0/1 to switch with the DCLI 16 of serial 0/0.

```
Route(config)# interface Serial0/1
Ruijie(config-if)# encapsulation frame-relay
Ruijie(config-if)# frame-relay intf-type dce
Ruijie(config-if)# frame-relay route 21 interface Serial0/0 16
```

On the interface seiral0/2, set the frame relay encapsulation format to DCE, and enable the DCLI 20 of serial 0/2 to switch with the DCLI 17 of serial 0/0.

```
Ruijie(config)# interface Serial0/2
Ruijie(config-if)# encapsulation frame-relay
Ruijie(config-if)# frame-relay intf-type dce
Ruijie(config-if)# frame-relay route 20 interface Serial0/0 17
```

2) Configure R1.

```
Ruijie(config)# interface serial0/0
```

```
Ruijie(config-if)# encapsulation frame-relay ietf
Ruijie(config-if)# frame-relay map ip 1.1.1.2 16
Ruijie(config-if)# frame-relay map ip 1.1.1.3 17
```

3) Configure R2.

```
Ruijie(config)#interface serial0/0
Ruijie(config-if)#encapsulation frame-relay ietf
Ruijie(config-if)#frame-relay map ip 1.1.1.1 20
```

4) Configure R3.

```
Ruijie(config)# interface serial0/0
Ruijie(config-if)# encapsulation frame-relay ietf
Ruijie(config-if)# frame-relay map ip 1.1.1.1 21
```

Troubleshooting Frame Relay Faults

Interface Cannot Be Up

For more information about troubleshooting of the frame relay interface, see the "错误!未找到引用源。" section on page13.

Interface Is Up but Link Protocol Cannot Be Up

The interface is up, which indicates that no fault exists at the physical layer. Therefore, you need to rectify the fault as follows:

1) Check whether the peer DTE or the local DTE has been encapsulated with frame relay.
2) Check the encapsulation message formats of the local DTE and the office end (or the emulating office) are the same (IETF for both, for example). If the frame relay encapsulation formats are the same, ensure that the LMI types are the same at both ends.
3) If the preceding configurations are correct, view the frame relay debugging information to check whether the sequence numbers of the Status Enquiry and Status messages are in one-to-one relationship. If not, it indicates that data receiving/transmitting at the physical layer is faulty. In this case, locate the problem at the physical layer.

Link Protocol Is Up but the Ping Operation Fails at Either End

Rectify the fault as follows:

1) Check that the negotiation is successful between the local DTE and DCE. That is, check that the DTE and DCE link layer protocols are in Up state.
2) Use the **show frame-relay map** command to check that the DTEs at both ends generate correct address mapping. If one DTE does not support the reverse ARP, you need to manually configure the mapping between the static IP address and DLCI.
3) Check the routing table to see whether the routes to the peer have been generated. When setting the frame relay static route, you need to specify the frame relay next-hop IP address. When enabling the OSPF, EIGRP or other routing protocols that can be used to send broadcast messages, you need to add the **broadcast** option to the **frame map ip** command, so that the routing protocol can be learned through broadcast.

LAPB and X2.5 Configutation

Understanding LAPB and X2.5

The X.25 protocol is the interface specifications between the DTE and the DCE in the X.25 public packet switching network. The first draft of the X.25 was released by CCITT in 1974. The initial document was derived from the experiences and recommendations of the packet switching network by the Telenet and Tymnet in USA and the Datapac in Canada. It was revised in years 1976, 1978, 1980 and 1984, with many optional service functions and facilities added.

Based on the structure of the OSI reference model, the X.25 protocol defines three layers from the physical layer to the packet layer. The third layer (packet layer) specifications of the X.25 protocol describes the packet format used at layer 3 and the specifications for the packet switching between two layer-3 entities. The second layer (link layer) specifications of the X.25 protocol are also called the Link Access Procedure Balanced (LAPB). It defines the frame format and specifications in the interactions between the DTE and DCE. The first layer (physical layer) of the X.25 protocol defines the physical electrical characteristics for the connections between DTE and DCE.

The X.25 enables the communication through the X.25 public packet switching network between two DTEs. To implement a communication process, one end must first call the peer end, requesting the peer end to set up a connection between them. The peer end can accept or reject the connection request according to the actual conditions. Once the connection is set up, devices at both ends can transfer information in full duplex mode. Any end has the right to release this connection at any time. The X.25 is the PTP interaction specifications between the DTE and DCE (the connection is available for PVC without initiation of a call).

At the physical layer, the DTE is generally a host or terminal on the user side, the DCE is generally the synchronous modem. The DTE and DCE are directly connected. The DCE is connected to a port of the packet switch. Multiple connections are set up between packet switches. In this way, the path between the DTE and DCE is established.

This chapter describes how to configure the X.25 protocol on the WAN interface of a router. When the RGOS series routers are used to connect another X.25-encapsulated router through the X.25 public packet switching network, you need to configure the X.25 protocol and the LAPB protocol parameters on the WAN interface of the router.

Configuring LAPB

LAPB Configuration Task List

LAPB configuration involves the following tasks:

- Configuring the Interface Encapsulation Protocol
- Configure LAPB parameter N1
- Configure LAPB parameter N2
- Configure LAPB parameter K
- Configure LAPB parameter T1
- Configure LAPB parameter Modulo
- Configure LAPB parameter T4 (optional)

Configuring the Interface Encapsulation Protocol

The LAPB is a PTP protocol. Therefore, you need to configure two different encapsulation types (DTE and DCE).

Use the following commands to encapsulate the LAPB on the interface.

Command	Function
Ruijie(config-if)# **encapsulation lapb [DTE|DCE]**	Encapsulates the LAPB on the interface.
Ruijie(config-if)# **no encapsulation lapb [DTE|DCE]**	Removes the LAPB encapsulation from the interface.

Configuring LAPB Parameters

Use the following commands to configure LAPB parameters.

Command	Function	Default Value	Value Range
Ruijie(config-if)# **lapb N1** *bits*	Sets the maximum allowed frame length in bits. The length is a multiple of 8.	12032	1096 to 12104
Ruijie(config-if)# **lapb N2** *tries*	Sets the retransmission times.	20	1 to 255
Ruijie(config-if)# **lapb k** *window-size*	Sets the size of the slip window.	7	1 to Modulo - 1
Ruijie(config-if)# **lapb modulo** *modulu*	Sets the LAPB modulo.	8	Modulo 8 or Modulo 128
Ruijie(config-if)# **lapb T1** *milliseconds*	Sets the T1 duration of LAPB.	3000	1 to 64000
Ruijie(config-if)# **lapb T4** *seconds*	Sets the T4 duration of LAPB.	0	0 to 255

N1 is the maximum frame length in the LAPB protocol. The X.25 packet cannot be longer than it.

N2 is the maximum number of times the LAPB data is retransmitted. When N2 is exceeded, the state of the LAPB link protocol changes from UP to Down.

K is the size of the LAPB slip window. The slip window specifies the acceptable maximum number of messages that is not acknowledged by the peer device.

The modulo of the LAPB protocol determines the value range of the slip window. The maximum size of the LAPB slip window can only be equal to (modulo – 1). There are two numbering schemes for LAPB frames: Modulo 8 and Modulo 128. Every data frame (I frames) are numbered sequentially from 0 to (modulo – 1). The sequence number is recycled in the range of the modulo.

T1 is the timeout time for frame retransmission. The setting of T1 must match that on the peer device. You need to set T1 based on the link rate. If T1 expires before the message reaches the peer device, communication disorder may occur.

T4 is the LAPB link detection time. Once the LAPB receives a frame, T4 is reset. If T4 expires, the LAPB immediately sends an RR frame that contains the Poll tag. If the LAPB does not receive any response to the RR frame, the LAPB disconnects the link and initiates negotiation again. T4 must be greater than T1.

Configuring X.25

X.25 Configuration Task List

The X.25 configuration involves the following tasks:

- Configuring the Interface Encapsulation Protocol
- Configuring X.121 Address and Mapping of the X.25
- Configuring X.25 Virtual Circuit Channel Range
- Configuring X.25 Flow Control
- Configure X.25 Timeout Time (optional)
- Configuring X.25 PVC
- Configuring X.25 Advanced Functions

Configuring the Interface Encapsulation Protocol

To configure the X.25, you need to configure the encapsulation type on the interface. The X.25 has two different protocol encapsulation formats: DTE and DCE. The protocol encapsulation format is the X.25 DTE IETF by default. The IETF is compliant with RFC 1356.

Command	Function
Ruijie(config-if)# **encapsulation x25 [DTE|DCE|ietf]**	Encapsulates the X.25 on the interface.
Ruijie(config-if)#**no encapsulation X25 [DTE | DCE | ietf]**	Removes the X.25 encapsulation from the interface.

Configuring X.121 Address and Mapping of the X.25

The X.25 dedicated line has the network address of the X.25 itself, that is, the X.121 address. This address is also the local number identified by the switching virtual circuit (SVC). If a call-in request is just for the local X.121 address and the other responses suffice, the X.25 must respond correctly; otherwise, the release request is sent. The X.25 address setting is also the basis for sending a request from the local end to the remote end to obtain the address.

Use the following commands to configure the X.121 address.

Command	Function
Ruijie(config-if)# **x25 address** *X1.21*	Sets the X.25 address on the interface
Ruijie(config-if)# **no x25 address**	Removes the X.25 address on the interface

After the X.25 is encapsulated, it must bear the upper-layer network protocol before it can take effect. Therefore, you need to set the mapping between the x.121 address and the network protocol address. Use the following command to set the mapping between the X.25 address and IP address on the interface.

Command	Function
Ruijie(config-if)# **x25 map ip|** *ip-address X1.21* [option]	Sets the mapping between the X.25 address and IP address on the interface

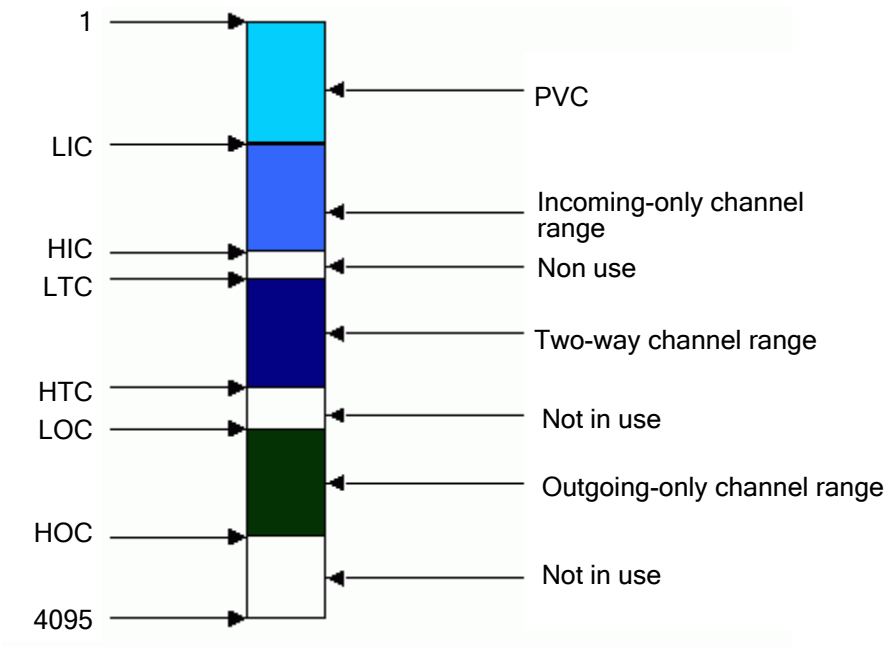
The commonly-used option is the **broadcast**. With the **broadcast** option, broadcast messages of the network protocol can be sent to the other DTEs of the X.25 packet switching network. This keyword is especially important when the OSPF or EIGRP routing protocol is used in the IP network.

Configuring X.25 Virtual Circuit Channel Range

The X.25 can be used to set up multiple connections between the DTE and DCE on the same physical link. These connections are called the virtual circuits or logical channels. The X.25 supports up to 4,095 virtual circuits, numbered from 1 to 4,095. The virtual circuits are identified by the logical channel identifier (LCI) or virtual circuit number (VCN).

In the ascending order, the X.25 logical channel numbers are divided into four ranges: permanent virtual circuit (PVC), incoming-only channel range, two-way channel range, and outgoing-only channel range, as shown in the following figure:

Figure 6 X.25 channel range



According to the ITU-X.25 recommendations, when initiating a call, the DTE starts from the highest virtual circuit number, whereas the DCE starts from the lowest virtual circuit number in the available change range. That is, the DTE starts from HOC (or HTC if the HOC is not defined), and the DCE starts from LIC (or LTC if the LIC is not defined) to initiate a call. By default, the channel range only includes the two-way channel range with LTC=1 and HTC=1024. The six parameters related to the channel range are explained below:

Logical Channel	Description
LIC	Lowest Incoming-only Channel
HIC	Highest Incoming-only Channel
LTC	Lowest Two-way Channel
HTC	Highest Two-way Channel
LOC	Lowest Outgoing-only Channel
HOC	Highest Outgoing-only Channel

Use the following commands to set the six parameters related to the channel range.

Command	Function
Ruijie(config-if)# **x25 lic** *circuit-number*	Sets the X.25 LIC.

Command	Function
Ruijie(config-if)# **x25 hic** *circuit-number*	Sets the X.25 HIC.
Ruijie(config-if)# **x25 ltc** *circuit-number*	Sets the X.25 LTC.
Ruijie(config-if)# **x25 htc** *circuit-number*	Sets the X.25 HTC.
Ruijie(config-if)# **x25 loc** *circuit-number*	Sets the X.25 LOC.
Ruijie(config-if)# **x25 hoc** *circuit-number*	Sets the X.25 HOC.
Ruijie(config-if)# **no x25 lic** *circuit-number*	Restores the default X.25 LIC.
Ruijie(config-if)# **no x25 hic** *circuit-number*	Restores the default X.25 HIC.
Ruijie(config-if)# **no x25 ltc** *circuit-number*	Restores the default X.25 LTC.
Ruijie(config-if)# **no x25 htc** *circuit-number*	Restores the default X.25 HTC.
Ruijie(config-if)# **no x25 loc** *circuit-number*	Restores the default X.25 LOC.
Ruijie(config-if)# **no x25 hoc** *circuit-number*	Restores the default X.25 HOC.

The settings of the logical channel range must be the same as those at the X.25 packet switching network side.

Note A changed logical channel does not take effect unless the router is restarted.

Configuring X.25 Flow Control

Configuring the Modulo

The X.25 protocol configured on the RGOS series supports the standard Modulo 8 and extended Modulo 128. Modulo 128 is set to satisfy the high-speed bandwidth services. The modulo must be opened at the packet switching network side (the office), so that the modulo can be used at the user side. Modulo 8 is often used.

Use the following commands to set the modulo.

Command	Function
Ruijie(config-if)# **x25 Module 8**	Sets X.25 Modulo 8.
Ruijie(config-if)# **x25 Module 128**	Sets X.25 Modulo 128.

Setting the Size of the Slip Window

The slip window specifies the acceptable maximum number of messages that is not acknowledged by the peer device. The X.25 slip window includes the input slip window (win) and output slip window (wout). You can set the slip window to control the traffic at the X.25 layer. If the size of the slip window slip increases on the DTE, the DTE can send more unacknowledged X.25 messages to the DCE, as long as the DCE acknowledges the last message sequence number. The settings of the slip window must be consistent with that configured by the operator. The maximum size of the slip window is (modulo – 1), and the default size is 2.

Use the following commands to set the slip window.

Command	Function
Ruijie(config-if)# **x25 win** *packet*	Sets the size of the X.25 input slip window.
Ruijie(config-if)# **x25 wout** *packets*	Sets the size of the X.25 output slip window.

Command	Function
Ruijie(config-if)# **no x25 win**	Restores the default size of the X.25 input slip window.
Ruijie(config-if)# **no x25 wout**	Restores the default size of the X.25 output slip window.

Setting the Maximum Size of Output Message

The output packet size (OPS) specifies the maximum length of the output X.25 packet. The maximum transmission unit (MTU) of a upper-layer network data message is generally greater than the OPS. Therefore, a packet message that is longer than the X.25 OPS will be divided into fragments when passing through the X.25 packet switching network. In addition, Mbit is used to identify the X.25 message fragments. When arriving at the destination X.25 terminal, fragments are reassembled into a complete message and sent to the upper-layer network. The OPS is generally set to the same value as the input packet size (IPS), and must be consistent with the setting of the connected packet switching network. The range of OPS is from 16 to 4096. The default value is 128.

Use the following commands to set the OPS and IPS.

Command	Function
Ruijie(config-if)#**x25 ops** *size*	Sets the X.25 OPS.
Ruijie(config-if)#**x25 ips** *size*	Sets the X.25 IPS.
Ruijie(config-if)#**no x25 ops**	Restores the default X.25 OPS.
Ruijie(config-if)#**no x25 ips**	Restores default X.25 IPS.

Configure X.25 Timeout Time

Configuring the DTE/DCE Packet Timeout Time

According to the ITU-T X.25 recommendations, specific timers start when a transmission restart request, call request, release request, or reset request is sent. When the timer expires, requests must be sent again if there is no reply for these packet messages.

Command	Function
Ruijie(config-if)# **x25 t20** *seconds*	Sets the timeout time of the X.25 DTE restart request.
Ruijie(config-if)# **x25 t10** *seconds*	Sets the timeout time of the X.25 DCE restart indication.
Ruijie(config-if)# **x25 t21** *seconds*	Sets the timeout time of the X.25 DTE outgoing call request.
Ruijie(config-if)# **x25 t11** *seconds*	Sets the timeout time of the X.25 DCE incoming call request.
Ruijie(config-if)# **x25 t22** *seconds*	Sets the timeout time of the X.25 DTE reset request.
Ruijie(config-if)# **x25 t23** *seconds*	Sets the timeout time of the X.25 DCE reset indication.
Ruijie(config-if)# **x25 t23** *seconds*	Sets the timeout time of the X.25 DTE release request.
Ruijie(config-if)# **x25 t13** *seconds*	Sets the timeout time of the X.25 DCE release indication.

Configuring X.25 PVC

A PVC is equivalent to an X.25 dedicated line. In other words, an MAP network address and an X121 address must be configured for the PVC to set up a connection. The PVC is always in connected state without the need of initiating a call. The mapping between the PVC and the network address is set up when the PVC is created.

Use the following commands to create an X.25 PVC.

Command	Function
Ruijie(config-if)# **x25 pvc** *circuit protocol address* [option]	Creates an X.25 PVC and maps the PVC to a network address.
Ruijie(config-if)# **no x25 pvc** *circuit*	Deletes an X.25 PVC.

Multiple PVCs can exist and be used at the same time. The number of the NVCs that is set by using the **X.25 MAP** command exceeds the number of the configured PVCs. The PVC can also coexist with the SVC. The maximum number of PVCs that can co-exist cannot be greater than 8. The range of the number of PVCs is from 1 to 4095. For more information about the PVC configuration, see the configuration examples of the PVC.

Configuring X.25 Advanced Functions

Configuring the X.25 Sub-Interface

The RGOS series supports the X.25 virtual sub-interface. The sub-interfaces fall into the following two types: PTP and point-to-multipoint. When a sub-interface is created, a point-to-multipoint interface is created by default and uses the same X.121 address as the physical interface. The sub-interface can be used to clearly specify the IP addresses of different network segments, so as to map to the peer LAN in different network segments. For the IP routing, the logic is clearer. For more information, see the sub-interface configuration examples.

The sub-interface can be applied in the following steps:

1) Create sub-interface
2) Configure the IP address of the interface
3) Establish the sub-interface address mapping

Use the following commands in sequence to create a sub-interface.

Command	Function
Ruijie(config)# **interface serial** *number*	Enters the physical layer interface of the synchronous serial interface
Ruijie(config-if)# **encapsulation x25 [dte|dce|ietf]**	Encapsulates the X.25. The IETF format is recommended.
Ruijie(config-if)# **X25 address** *address*	Sets the X.121 address.
Ruijie(config)# **interface serial** *number.subinterface-number* [**multipoint|point-to-point**]	Exits the global configuration layer, creates an X.25 sub-interface, and specifies the interface type.

Configuring an IP network address for the sub-interface is the same as configuring IP addresses for other physical interfaces. Creating the address mapping of sub-interface is the same as configuring the mapping between X.25 X.121 address and IP address on the physical interface.

Monitoring and Maintaining LAPB

Use the following command to show the LAPB debugging information.

Command	Function
Ruijie# **debug lapb**	Shows the LAPB debugging information.

```
serial 1/3: LAPB I CONNECT (7) IFRAME 1 2
serial 1/3: LAPB O CONNECT (93) IFRAME 2 2
serial 1/3: LAPB I CONNECT (2) RR (R) 3
serial 1/3: LAPB I CONNECT (93) IFRAME 2 3
serial 1/3: LAPB O CONNECT (2) RR (R) 3
serial 1/3: LAPB O CONNECT (93) IFRAME 3 3
```

The preceding output is described as follows:

- "serial 1/3" indicates the name of the interface
- "O" indicates the LAPB message output.
- "I" indicates the message input.

Monitoring and Maintaining X.25

Displaying the X.25 Debugging Information

Use the following command to show the X.25 debugging information, based on which you can trace X.25 running status.

Command	Function
Ruijie# **debug x25 packet**	Shows the X.25 debugging information.

```
serial 1/3: X25 O P3 CALL REQUEST (13) 8 lci 1
From(4):2222 To(4):3333
Facilities: (0)
Call User Data (4): 0xcc0 0 0  (ip)#
serial 1/3: X25 I P3 CALL CONNECTED (5) 8 lci 1
From(0): To(0):
Facilities: (0)
serial 1/3: X25 O P4 DATA (91) 8 lci 1 PS 0 PR 0
serial 1/3: X25 I P4 DATA (91) 8 lci 1 PS 0 PR 1
serial 1/3: X25 O D1 DATA (91) 8 lci 1 PS 1 PR 1#
serial 1/3: X25 I D1 DATA (91) 8 lci 1 PS 1 PR 2
```

The preceding output indicates that the X.25 local end first initiates a call request using the logical channel number 16. The call is from the local X.121 address 2222 to the remote X.121 address 1111. The call user data type is 0xCC(IP type). Then, the call acceptance acknowledgement is received, so the X.25 virtual circuit link is established. Then, packet data is sent, where "PS" is the X.25 send sequence number, "PR" is the receive sequence number, and all the packets before PR-1 (including the PR-1) have been acknowledged. In regard to the call user data type, 0x01 represents the PAD type, 0xd5 represents the bridge type, and 0xd3 represents the IPX type.

Showing the X.25 Interface Information

Use the following command to view the X.25 interface information.

Command	Function
Ruijie# **show interface serial number**	Shows the information about the X.25 interface.

```
Ruijie# show interface serial 1/3
serial 1/3 is UP  , line protocol is UP
Hardware is Infineon DSCC4 PEB20534 H-10 serial
Interface address is: 2.2.2.1/24
MTU 1500 bytes, BW 2000 Kbit
Encapsulation protocol is X.25, loopback not set
Keepalive interval is 0 sec , no set
Carrier delay is 2 sec
RXload is 1 ,Txload is 1
LAPB DCE, modulo 8, k 7, N1 12056, N2 20
T1 3000, interface outage (partial T3) 0, T4 0
State CONNECT, VS 7, VR 7, Remote VR 7, Retransmissions 0
Queues: U/S frames 0, I frames 0, unack. 0, reTx 0
IFRAMEs 57/55 RNRs 0/0 REJs 0/0 SABM/Es 3/40 FRMRs 0/0 DISCs 0/0
X25 DCE, address 2222, state R1, modulo 8
Defaults: DEF encapsulation, idle 0, nvc 3
input/output window sizes 2/2, packet sizes 128/128
Timers: T10 60, T11 180, T12 60, T13 60, TH 0
Channels: Incoming-only none, Two-way 1-1024, Outgoing-only none
RESTARTs 43/4 CALLs 6+3/1+0/0+0 DIAGs 0/0
Queueing strategy: FIFO
Output queue 0/40, 0 RSRps;
Input queue 0/75, 0 RSRps
5 minutes input rate 17 bits/sec, 0 packets/sec
5 minutes output rate 14 bits/sec, 0 packets/sec
181 packets input, 4401 bytes, 0 no buffer
Received 0 broadcasts, 0 runts, 0 giants
0 input errors, 0 CRC, 0 frame, 0 overrun, 0 abort
100 packets output, 3733 bytes, 0 underruns
0 output errors, 0 collisions, 3 interface resets
7 carrier transitions
DCD=up  DSR=up  DTR=up  RTS=up  CTS=up
```

You can learn the following information by checking the information about the X.25 interface:

- Whether the interface and the line protocol are up. The line protocol will be up as long as the LAPB (X.25 layer-2) negotiation succeeds.
- Layer-2 LAPB protocol parameters: modulo, slip window, maximum frame length, retransmission times, and timer
- Layer-2 data sending/receiving connection conditions: VS, VR, and Remote VR
- X.25 encapsulation protocol type, X.121 address, and current status

- X.25 flow control parameters: slip window size and maximum input/output packet size
- X.25 timers: T20, T21, T22 and T23
- X.25 channel range: incoming-only channel range, two-way channel range, and outgoing-only channel range
- Statistics of various types of X.25 packets: number of Restart input/output packets, number of call packets in each channel range, and number of diagnosis packets

X.25 Maintenance Commands

Use the **show X25** command to check the details about the X.25.

Command	Function
Ruijie# **show x25 map**	Shows the X.25 address mapping table.
Ruijie# **show x25 vc**	Shows the information about X.25 virtual circuits.

The following is an example of the **show x25 map** command:

```
show x25 map
serial 1/3: X.121 3333 <--> ip 2.2.2.2
PERMANENT, 1 VC: 1
```

This command shows the X.25 address mapping table. In the preceding example, the x.121 address 3333 is mapped to the remote address 2.2.2.2, the active SVC LCN is 1, and the broadcast type is used.

The following is an example of the **show x25 vc** command:

```
Show x25 vc
SVC 1,  State: D1,  Interface: serial 1/3
Connects 3333 <--> ip 2.2.2.2
no Tx data PID
Window size input: 2, output: 2
Packet size input: 128, output: 128
PS: 5  PR: 5  ACK: 4  Remote PR: 5  RCNT: 1  RNR: FALSE
Retransmits: 0  Reassembly (bytes): 0
Held Fragments/Packets: 0/0
Bytes 440/440 Packets 5/5 Resets 0/0 RNRs 0/0 REJs 0/0 INTs 0/0
```

This command shows information about all virtual circuits. In the preceding example, the switching virtual circuit SVC LCN is 1, the status is D1 (data transmission status), the local virtual circuit is located on the interface seiral0, and the address 1.1.1.2 is mapped to the x.121 address 2222. The PS is the sequence number of a data packet sent from the local device, the PR is the data packet sequence number that is expected from the peer device. Packets with the PS as 4 or smaller are acknowledged by the peer device.

Configuration Examples

Configuring LAPB Encapsulation

Networking Requirements

There are two routers: R1 and R2. R1 is encapsulated with LAPB DTE, and the IP address of R1 is 1.1.1.1/30. R2 is encapsulated with LAPB DCE, and the IP address of R2 is 1.1.1.2/30. IP messages are forwarded over PTP connections.

Networking Topology

Figure 7

Configuration Steps

1) Configure R1.

Configure the IP address of the interface and encapsulate the LAPB DTE.

```
Ruijie(config)# interface serial 0/0
Ruijie(config-if)# ip address 1.1.1.1 255.255.255.252
Ruijie(config-if)# encapsulation lapb dte
```

2) Configure R2.

Configure the IP address of the interface and encapsulate the LAPB DCE.

```
Ruijie(config)# interface serial 0/0
Ruijie(config-if)# ip address 1.1.1.2 255.255.255.252
Ruijie(config-if)# encapsulation lapb dce
```

APB D

R2

R1

S0/0 S0/0

LAN

LAN

Configuring X.25

Networking Requirements

There are two remote routers:

- R1: R1 is encapsulated with X.25 DTE IETF. The IP address is 1.1.1.1/30. The X.25 X121 address is 11111111. The channel range is LTC-HTC (1-16). The OPS/IPS is 512. Default values are used for other related parameters.
- R2 is encapsulated with X.25 DTE IETF. The IP address is 1.1.1.2/30. The X.25 X121 address is 22222222. The channel range is LTC-HTC (1-16). The OPS/IPS is 512. Default values are used for other related parameters.

IP messages are forwarded over PTP connections.

Networking Topology

Figure 8

Configuration Steps

1) Configure R1.

Configure the IP address of the interface and encapsulate the LAPB DTE.

```
Ruijie(config)# interface serial 0/0
Ruijie(config-if)# ip address 1.1.1.1 255.255.255.252
Ruijie(config-if)# encapsulation x.25 dte ietf
Ruijie(config-if)# x25 address 11111111
Ruijie(config-if)# x25 htc 16
Ruijie(config-if)# x25 ops 512
Ruijie(config-if)# x25 ips 512
Ruijie(config-if)# x25 map ip 1.1.1.2 22222222
```

2) Configure R2.

Configure the IP address of the interface and encapsulate the LAPB DCE.

```
Ruijie(config)# interface serial 0/0
Ruijie(config-if)# ip address 1.1.1.2 255.255.255.252
Ruijie(config-if)# encapsulation x.25 dte ietf
Ruijie(config-if)# x25 address 22222222
Ruijie(config-if)# x25 htc 16
Ruijie(config-if)# x25 ops 512
Ruijie(config-if)# x25 ips 512
Ruijie(config-if)# x25 map ip 1.1.1.1 11111111
```

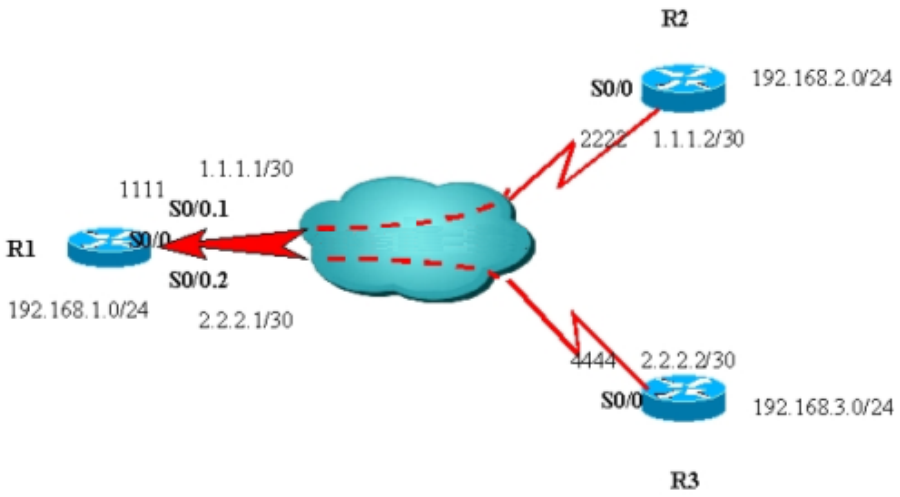
Configuring X.25 Sub-Interface

Networking Requirements

The router R1 acts as the central service router and is allocated with the IP addresses of two network segments. Therefore, the PTP sub-interface is used. R2 and R3 are two DTEs that only call or receive the X.121 address of router R1. Owing to horizontal split, R2 and R3 cannot communicate with each other. The network topology shows the related parameters. Default values are used for other related parameters.

Networking Topology

Figure 9



Configuration Steps

1) Configure R1.

Encapsulate the physical interface x.25 DTE, and configure the local X.121 address.

```
Ruijie(config)# interface Serial0/0
Ruijie(config-if)# no ip address
Ruijie(config-if)# encapsulation x25 ietf
Ruijie(config-if)# x25 address 1111
```

Create the PTP sub-interface serial0.1, and configure the sub-interface IP address and address mapping.

```
Ruijie(config)# interface Serial0/0.1 point-to-point
Ruijie(config-subif)#ip address 1.1.1.1 255.255.255.252
Ruijie(config-subif)# x25 map ip 1.1.1.2 2222 broadcast
```

Create the PTP sub-interface serial0.2, and configure the sub-interface IP address and address mapping.

```
Ruijie(config)# interface Serial0/0.2 point-to-point
Ruijie(config-subif)#ip address 2.2.2.1 255.255.255.252
Ruijie(config-subif)# x25 map ip 2.2.2.2 4444 broadcast
```

2) Configure R2.

```
Ruijie(config)# interface serial 0/0
Ruijie(config-if)# ip address 1.1.1.2 255.255.255.252
Ruijie(config-if)# encapsulation x25 dte ietf
Ruijie(config-if)# x25 address 2222
Ruijie(config-if)# x25 map ip 1.1.1.1 1111 broadcast
```

3) Configure R3.

```
Ruijie(config)# interface serial 0/0
```

```
Ruijie(config-if)# ip address 2.2.2.2 255.255.255.252
Ruijie(config-if)# encapsulation x25 dte ietf
Ruijie(config-if)# x25 address 4444
Ruijie(config-if)# x25 map ip 2.2.2.1 1111 broadcast
```

Troubleshooting LAPB and X.25 Faults

LAPB Link Layer Is Down

The **show interface serial** command shows "Line protocol Down ". Check the output of the **debug lapb** command as follows:

- If only "Serial0: LAPB O SABMSENT (2) SABM P" is displayed, and the number of input frames is zero, it indicates that the physical layer cannot receive the LAPB data frame. In this case, handle the fault as follows:

1) Ensure that the physical layer is not faulty. The physical layer is not faulty if the modem indicator is on, and "serial 0 is up " is displayed in the output of the **show interface serial** *0* command.

2) Ensure that Modem RD is on and flashes and the number of input packets is not zero in the output of the **Show interface serial** *0* command.

3) Ensue that the peer end is encapsulated with X.25. If another protocol is encapsulated, the LAPB cannot receive correct frames. As a result, the line protocol is down.

- If both "Serial0: LAPB O DMSENT (2) SABM P" and "Serial Lapb (S1) I: DM [2]" are displayed, it indicates that the DCE is encapsulated on both the user side and the office side. In this case, rectify the fault by changing the encapsulation mode on the user side to DTE.
- If both " Serial0: LAPB O SABMSENT (2) SABM P" and " Serial0: LAPB I: SABM (2) P " are displayed, it indicates that the DTE is encapsulated on both the user side and the office side. In this case, rectify the fault by changing the encapsulation mode on the office side to DCE.

Link Protocol Is Up but the IP Communication Is Abnormal

This fault is classified into the following types:

1) The link protocol is up but the local device fails to ping the IP address of the peer device.

"Line Protocol Up" simply indicates that the LAPB layer is active. To ping the peer IP address successfully, the following conditions must be met:

- The local X.121 address is correctly configured and then be acknowledged by the office.
- The remote user X.121 address is correctly configured to be acknowledged by the remote office.
- The mapping between the local X.25 IP address and the remote x.121 address is correct.
- The mapping between the remote user X.25 IP address and the local x.121 address is correct.

If this fault occurs, monitor and trace the X.25 debug information. If the debugging information indicates that the call initiated by the ping command is rejected by the packet switch, check whether the settings of the logical channel are consistent with the range given by the office. That is, you need to ensure that the logical channel range of the DTE interface is consistent with that of the DCE interface.

2) The local device can successfully ping the IP address of the peer device, but the packet size is limited. If the packet size is greater than OPS, the ping operation fails.

If the size of a packet is greater than OPS, the packet will be divided into several fragments. If the OPS/IPS settings are not consistent between the X.25 DTE and DCE interfaces, the fragments will be lost in the packet switching network. Therefore, a negotiation is required to ensure that the settings of OPS/IPS are consistent with those on the office side.

DLDP Configutation

Overview

Based on the SDH platform, the MSTP supports access, processing, and transmission of multiple services such as TDM, ATM, and Ethernet and provides multi-service nodes with a the unified network management system. The Ethernet access mode is commonly used at user access points. However, link keep-alive protocols are not available on Ethernet, causing exceptions where the link protocol status is normal whereas lines are disonnected when MSTP networks are accessed in Ethernet access mode. In this case, route convergence is slow and faults are more difficult to locate.

The major procedure for device link detection falls into the following stages:

3) Initialization

When DLDP is enabled on the interface, the status of DLDP changes to the initialization state, and then an ARP request is sent to obtain the MAC address of the peer device. If DLDP cannot obtain the MAC address of the peer device, DLDP remains in the initialization stage. In this case, if the DLDP function is disabled, the DLDP status changes to deleted. After the MAC address of the peer device is obtained, the DLDP status changes to link succeeded.

4) Link succeeded status

In this state, a DLDP link detection request can be sent to detect line connectivity. If a DLDP response is received, the corresponding interface is marked as UP. If no response is received, requests are sent until the number of requests exceeds the maximum allowed number of requests. In this case, the link is marked as failed and the DLDP status changes to initialization. If this function is deleted during this process, the DLDP status changes to deleted.

5) Deleted status

In the deleted state, the interface status is not analyzed by the link detection function and remains consistent with the physical channel status.

The devices on both sides detected by DLDP can work in active/passive mode through configuration. In passive mode, DLDP detection packets are not actively sent and only the DLDP detection packets from the peer end are detected and replied to for link detection. When multi-channel DLDP detection is configured on a convergence router, the passive mode can greatly reduce processing load of the convergence device and traffic load of lines.

In passive mode, the peer end must be set to the active mode so that the devices on both sides can normally work with each other.

Configuring Device Link Detection

Task List

Configuring the Ethernet Link Detection Function

This command can be configured on the Ethernet port only. By default, this function is disabled. To activate this function, run the following command:

Command	Function
Ruijie(config-if)#**dldp** *ip [nexthopip]*	Activates the link detection protocol.

Note

1. This function is implemented using ICMP ECHO packets. The ICMP response function needs to be enabled on the peer device.
2. The precondition for enabling this function is that the interface is in the UP state.
3. After this function is enabled, the IP address of the interface cannot be modified when the interface is in the down state .
4. In the case of detection across network segments, the next-hop IP address needs to be configured. For example, If the local interface IP address is 10.1.1.1 and 30.1.1.1 needs to be detected through the 20.1.1.2 gateway, the next-hop IP address 20.1.1.2 needs to be configured.

Configuring the Interval

Setting heartbeat intervals can change the frequency of handshake packet sending for link detection.

Command	Function
Ruijie(config-if)# **dldp** ip **interval** *val*	Sets the interval for device link detection.

Configuring Retry Times

Command	Function
Ruijie(config-if)# **dldp** ip **retry** *val*	Sets the threshold of error times during device link detection.

Configuring the Active/Passive Mode

Command	Function
Ruijie(config-if)# **dldp passive**	Sets the working mode of device link detection to the passive mode.

Configuring Resume Times

Command	Function
Ruijie(config-if)# **dldp** ip **resume** *val*	Sets the resumption threshold of the device link. The threshold indicates the times for receiving continuous DLDP detection packet responses before the link status changes from DOWN to UP. The resumption time is related to the interval for sending link detection packets set by running the **dldp ip interval** command. The line resumption time can be calculated using the following formula: Line resumption time = Resume times x Time configured by using the **dldp ip interval** command.

Note

This function is used to avoid oscillation of device links. For example, if link status changes between connnected and disonnected during the link status detection using the **ping** command, continuous oscillation occurs on the link (Link status changes continuously between UP and DOWN or ARP is continuously switched.). This problem can be avoided by setting a greater resume value. Link status changes from DOWN to UP only when the number of detection packet responses received by the link reached the threshold set by using the **resume** command.

Clearing the Records of the Times When DLDP Status Changes Between UP and DOWN

Command	Function
Ruijie(config-if)# **clear-dldp***[all] [ip [nexthopip]]*	Ruijie routers can record the times when DLDP protocol status changes between UP and DOWN. The **clear-dldp** command can be used to clear the recorded times and start the new recording.

Note

1. The **clear-dldp all** command can be used to clear the recorded times when DLDP status changes between UP and DOWN on an interface within a period of time and to start the new recording from 0.
2. The **clear-dldp ip [nexthopip]** command can be used to clear the recorded times when link status changes between UP and DOWN on a specified interface within a period of time and to start the new recording from 0.

Checking the Times When DLDP Status Changes Between UP and DOWN Within a Period of Time

Command	Function
Ruijie(config-if)# **show dldp** interface *[ ] [FastEthernet/GigabitEthernet number]*	Displays the times when DLDP status changes between UP and DOWN within a period of time.

Note

1. The **show dldp interface** command can be used to check the times when DLDP status changes between UP and DOWN on all interfaces and view the time when the recording starts.
2. The **show dldp interface FastEthernet/GigabitEthernet number** command can be used to check the recorded times when protocol status changes between UP and DOWN on an Ethernet interface and view the time when the recording starts.

BFD Configutation

Understanding BFD

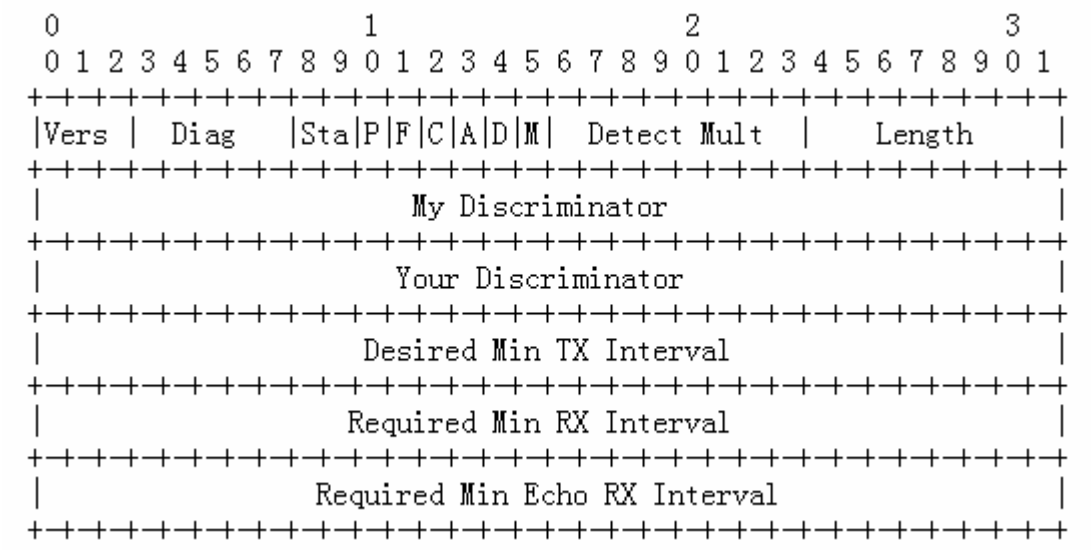
Overview

Bidirectional forwarding detection (BFD) provides low-overhead, short-duration detection of the connectivity in the forwarding path between adjacent routers. The fast detection of failures in the forwarding path speeds up enabling the backup forwarding path and improves the network performance.

BFD Packet Format

The two types of BFD packets are control packets and echo packets. The local end sends echo packets to the peer, which returns the received echo packets back without processing. Therefore, no BFD echo packet format is defined. Only BFD control packet format is defined. There are two versions for the BFD control packet: version 0 and version 1. By default, the BFD session establishment adopts the version 1. However, if one end receives the version 0 control packets from the peer, the default version 1 automatically switches to version 0 to establish the BFD session. You can use the **show bfd neighbors** command to view the version member. The format of the version 1 packet is shown as follows:

Figure 10 Format of BFD control packets (version 1)



Field	Description
Vers	BFD protocol version. Currently, the value is **1**.
Diag	The following are causes of the latest switchover from the UP state to other states: **0**: indicates no diagnosis. **1**: indicates the control timeout detection. **2**: indicates the echo function failure. **3**: indicates that the neighbor advertising session is down.

Field	Description
	4: indicates that the forwarding plane is reset. **5**: indicates that the channel is invalid. **6**: indicates that the connection channel is invalid. **7**: indicates that administration is down.
Sta	Local status of the BFD. Including: **0**: AdminDown **1**: agent down **2**: agent Init **3**: agent UP
P	When a parameter changes, the sender places this flag in a BFD packet. The receiver must immediately respond the packet.
F	The packet must have the F flag set for responding to the packet with the P flag set.
C	Forward/control separation flag. Once this flag is set, the change of the control plane does not affect the BFD. For example, if the control plane deploys OSPF, the BFD continues with link status detection when OSPF restarts or performs a graceful restart (GR).
A	Authentication flag. If this flag is set, sessions need to be authenticated.
D	Query demand flag. If this flag is set, the sender expects to detect links in the query mode.
M	Used in point-to-multipoint in the future. Currently, the value must be set to **0**.
Detect Mult	Detection timeout multiples. This flag is used by the detector to compute the timeout duration.
Length	Packet length
My Discriminator	Discriminator used by the BFD session to connect to the local end
Your Discriminator	Discriminator used by the BFD session to connect to the remote end
Desired Min Tx Interval	Minimum BFD packet sending interval supported by the local end
Required Min RX Interval	Minimum BFD packet receiving interval supported by the local end
Required Min Echo RX Interval	Minimum echo packet receiving interval supported by the local end. If the local end does not support the echo function, set the value to 0.
Auth Type	Authentication types (optical), including: Simple Password Keyed MD5 Meticulous Keyed MD5 Keyed SHA1 Meticulous Keyed SHA1
Auth Length	Authentication data length
Authentication Data	Authentication data area

Note

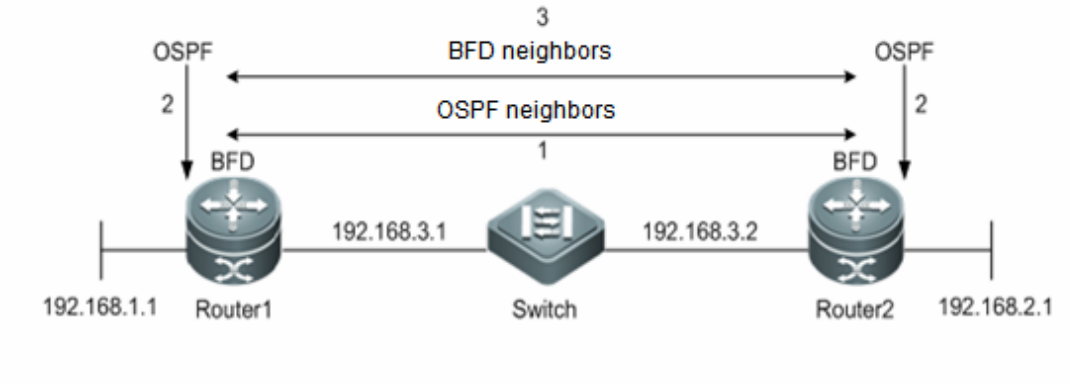
From version 10.3(4b3), the RGOS supports version 1 and version 0 packets. By default, session initiation packets adopt version 1. If one end receives version 0 control packets from the peer, the default version 1 automatically switches to version 0 to establish the session.

BFD Operation Mechanism

The BFD detection mechanism is independent from the applied interface media type, encapsulation format mad, associated upper-layer protocols such as OSPF, BGP, and RIP. The BFD establishes a session between adjacent routers enables the route protocols to re-calculate the route table by rapidly sending the detection fault to the running route protocols and decreases the network convergence time sharply. The BFD cannot discover the neighbors, so it needs the upper-layer protocols to notify the neighbors of which the session is established.

The following figure shows that two routers are connected through a L2 switch. The two routers runs OSPF and BFD.

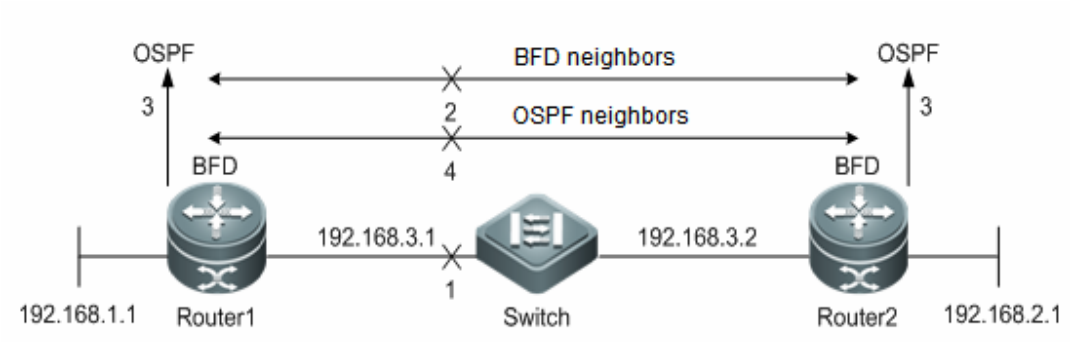
Figure 11 BFD session establishment



The BFD session establishment process is as follows:

6) OSPF discovers neighbors and establishes neighbor relationships.
7) OSPF notifies BFD of establishing the session with the neighbors.
8) BFD establishes the session with the neighbors.

Figure 12 BFD fault detection process



The BFD fault detection process is as follows:

1) Step 1: A link communication failure between Router1 and Router2 occurs.
2) Step 2: BFD session between the Router1 and Router2 detects the fault.
3) Step 3: BFD notifies the fault of the OSPF reachability to the forwarding path of the neighbor.
4) Step 4: OSPF deals with the process of the neighbor Down. If the backup forwarding path exists, and the protocol convergence is performed and the backup forwarding path is enabled.

Related Protocols and Regulations

The related BFD protocols and regulations are:

- draft-ietf-bfd-base-09: Bidirectional Forwarding Detection
- draft-ietf-bfd-generic-05: Generic Application of BFD
- draft-ietf-bfd-mib-06: Bidirectional Forwarding Detection Management Information Base
- draft-ietf-bfd-v4v6-1hop-09: BFD for IPv4 and IPv6 (Single Hop)
- draft-ietf-bfd-multihop-07: BFD for IPv4 and IPv6 (Multihop)
- draft-ietf-bfd-mpls-07: BFD For MPLS LSPs

☑ Currently, no version supports draft-ietf-bfd-mib-06.

BFD Features

This section describes the BFD features.

BFD Session Establishment Mode

The BFD session is established in the following modes:

- Active Mode: Before a session is established, BFD actively sends the BFD control packets regardless of whether any BFD control packet is received from the peer.
- Passive Mode: Before a session is established, no BFD control packet is sent until a BFD control packet is received from the peer.

☑ In all versions, the passive mode is not supported and cannot be configured.

BFD Detection Mode

Asynchronous Mode

In the asynchronous mode, the BFD control packets are sent periodically among the systems. If one system receives no BFD control packet from the peer within the BFD interval, the BFD session will be down.

Demand Mode

In the demand mode, suppose that every system has an independent method to confirm whether it has been connected to other systems, once a BFD session is established, the system stops sending the BFD control packets unless a system needs the connection verification. If the connection verification is necessary, the system will send a BFD control packet with the short sequence. If no returned packet is received within the detection interval, the BFD session will be down. If the echo packet is received from the peer, the forwarding path is normal.

Echo Mode

The local system sends the BFD echo packet periodically. The peer system loops back the echo packet via the forwarding channel. The BFD session will be down if the continuous echo packets are not received within the detection interval. The

echo mode can be co-used with the above-mentioned two detection modes. In the echo mode, the packets are forwarded back via the forwarding panel of the peer system rather than the control panel, reducing the delay and speeding up the fault detection in comparison to the control packet sending. In the asynchronous mode, the control packet sending will be decreased with the echo function enabled, for the echo function processes the detection. If the echo function is enabled in the demand mode, the control packet sending can be cancelled after the BFD session establishment. The echo function must be enabled in the BFD session; otherwise the echo function will be invalid.

☑ Currently, no version supports the query mode.
☑ Only BFD session version 1 supports the BFD echo function


Caution

The **no ip redirects** command must be executed to disable the redirect function of the IP packets and the **no ip deny land** command must be executed to disable the function of anti-attack of the Land-based DDOS before configuring the echo mode.

BFD Session parameters

- BFD session parameters (including Desired Min Tx Interval, Required Min RX Interval, and Detect Mult) must be configured on interfaces at both ends. Otherwise, BFD sessions cannot be created.
- During BFD session creation, interfaces at both ends will negotiate BFD session parameters and accordingly detect the session.
- If BFD session parameters are revised after BFD session creation, interfaces at both ends re-initiate the negotiation. During revision, the BFD session remains in the UP state.

BFD Authentication

The BFD authentication methods include:

- Simple Password
- Keyed MD5
- Meticulous Keyed MD5
- Keyed SHA1
- Meticulous Keyed SHA1

☑ Currently, no version supports the BFD authentication.

BFD for Dynamic Route Protocols

Configuring BFD for the route protocols improves the convergence performance of the protocol by taking advantages of the faster fault detection of the BFD in comparison to the HELLO mechanism of the protocol. Generally, the fault detection time can be decreased to less than 1s.

Make sure that the BFD for corresponding protocol is enabled on all BFD session neighbors, or the BFD session cannot be established. However, if the dynamic route protocol or other applications have already notify the BFD of establishing the session with the corresponding neighbor, the BFD for this protocol is established.

BFD for Static Route

Configuring BFD for static route prevents the static route from being the forwarding path when the router selects the routing under the circumstances that the configured static route is unreachable. It can rapidly switch to the backup forwarding path if the backup forwarding path exists.

Being different from the dynamic route protocol, the static route protocol has no mechanism of discovering the neighbor. Therefore, when configuring the BFD for static route, the reachability of the next-hop of the static route is dependent on the BFD session state. If the BFD session detects the fault, which means that next-hop of the static route is unreachable; the static route cannot be installed into the RIB. Make sure that the BFD for static route is enabled on all BFD session neighbors, or the BFD session cannot be established. However, if the dynamic route protocol or other applications have already notify the BFD of establishing the session with the corresponding neighbor, the BFD for static route is enabled..

If the BFD session is removed from the peer in the process of the BFD session establishment, the BFD session is down. Under this circumstance, the static route forwarding shall be ensured.

BFD for PBR

Configuring BFD for PBR prevents the PBR from being the forwarding path when the router selects the routing under the circumstances that the configured PBR is unreachable. It can rapidly switch to the backup forwarding path if the backup forwarding path exists.

The method of BFD for PBR is similar to the BFD for static route. If the BFD session detects the fault by following the forwarding path of the specified neighbor, the PBR will be notified of the unreachability to the corresponding next-hop. The PBR reaching the next-hop is ineffective.

Make sure that the BFD for PBR is enabled on all BFD session neighbors, or the BFD session cannot be established. However, if the dynamic route protocol or other applications have already notify the BFD of establishing the session with the corresponding neighbor, the BFD for PBR will be enabled automatically.

If the BFD session is removed from the peer in the process of the BFD session establishment, the BFD session will be down. And under this circumstance, the PBR forwarding shall be ensured.

BFD for VRRP

BFD for VRRP configuration can replace the HELLO mechanism of VRRP itself to realize the fast detection of running state of the master and backup routers and improve the network performance. Generally, the time of failure detection can be shortened to less than 1s.

Make sure that the BFD for VRRP is enabled on the router at both ends, or the BFD session cannot be established. However, if the dynamic route protocol or other applications have already notify the BFD of establishing the session with the corresponding neighbor, the BFD for VRRP will also be configured.

VRRP can also use BFD to follow the specified neighbor. If the BFD session detects the fault of the forwarding path to the neighbor, it will reduce the VRRP priority automatically and trigger the switchover between the master and backup routers.

The BFD can be established only when the dynamic route protocol or other applications notify BFD of establishing the session with corresponding neighbor.

BFD for VRRP+

BFD for VRRP+ can replace the BVF detection by BVG of VRRP+, allowing quick detection of BVF operating state and accelerating the switchover of forwarding entity during failure. Under general circumstances, the fault detection time can be shortened to less than 1 second.

Since VRRP+ is based on VRRP protocol, no extra configuration will be needed during its association with BFD. You only need to make sure VRRP has been enabled on the devices at both ends and BFD session has been correctly associated.

☑ BFD for VRRP+ is supported in release RGOS 10.4(3).

BFD Supports to Change the State of Layer3 Interfaces

The BFD supports the function of changing the L3 interface status. In the configuration mode, you can run the **bfd bind peer-ip** command to detect the direct connection address of a specified L3 interface. BFD session status established through this command will generate the corresponding interface BFD status, such as BFD-DOWN/BFD-UP. With this function commonly used in various FRRs, the BFD is used to detect the interface status and perform FRR.

BFD for MPLS-LSP

The BFD for MPLS indicates that the Label Switched Path (LSP) performs fast detection for neighbors through the BFD. The following detection modes are supported:

- Configuring the BFD for static LSP
- Configuring the BFD for LSPs generated by LDP
- Configuring the BFD for LSP reverse links by using IP addresses

BFD for VRF

The BFD supports VPN Routing and Forwarding (VRF) and detects the connectivity of the forwarding path between the Provider Edge (PE) and the Customer Edge (CE).

BFD for Interfaces

Switches: BFD configuration is allowed only on Routed Port and SVI, not on a L3 AP. If the SVI member interface is a L2 AP, BFD session creation fails on the member interface.

Routers: BFD configuration is allowed on synchronous interfaces, asynchronous interfaces, ATM, serial interfaces, frame relay, POS, CPOS, Ethernet interfaces and child interfaces, E1, channelized ATM, and channelized CPOS.

Configuring BFD

Default configurations for the BFD

Function	Defaults

Function	Defaults
BFD session creation mode	Active mode. It cannot be set.
BFD detection mode	Asynchronous mode. The echo function is enabled by default.
BFD session parameter	No default value. It must be set.
BFD authentication method	Disabled. It cannot be set.
BFD for dynamic route protocol	Disabled
BFD for the static route	Disabled
BFD for PBR	Disabled
BFD for VRRP	Disabled
BFD for VRRP+	Disabled
BFD for VRF	Disabled
BFD for MPLS-LSP	Disabled

Configuring BFD Session Parameters

The BFD session parameter has no default value and must be configured. To configure BFD session parameters, run the following command in turn.

Command	Function
Ruijie>**enable**	Enters privileged mode.
Ruijie# **configure terminal**	Enters global mode.
Ruijie(config)# **interface** *type number*	Enters interface configuration mode.
Ruijie(config-if)# **bfd interval** *milliseconds* **min_rx** *milliseconds* **multiplier** *interval-multiplier*	Configures BFD session parameters for a specified interface. **interval** *milliseconds*: indicates the minimum sending interval. The unit is millisecond. **min_rx** *milliseconds*: indicates the minimum receiving interval. The unit is millisecond. **multiplier** *interval-multiplier*: indicates the detection timeout multiples.
Ruijie(config-if)# **end**	Exits interface configuration mode and restores privileged mode.

To delete BFD session parameter configurations, run the **no bfd interval** command in interface configuration mode.

The following example shows how to configure BFD session parameters on the Routed Port FastEthernet 0/2.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface fastEthernet 0/2
Ruijie(config-if)# bfd interval 100 min_rx 100 multiplier 3
```

Caution The difference of the bandwidth transmitted on different interfaces must be considered when configuring the parameters. If the minimum sending and receiving intervals are too low, it may result in the oversized bandwidth of the BFD and affect data transmission.
Switches cannot be configured on the L3 AP interface.

Configuring the BFD Echo Function

The session status is not affected if the echo function is enabled after the BFD session is created. After the echo function is disabled, no echo packet is sent and the forwarding plane ceases to receive echo packets. To configure the BFD echo function, run the following commands in turn.

Command	Function
Ruijie>**enable**	Enters privileged mode.
Ruijie# **configure terminal**	Enters global mode.
Ruijie(config)# **interface** *type number*	Enters interface configuration mode.
Ruijie(config-if)# **bfd echo**	Enables the BFD echo function.
Ruijie(config-if)# **end**	Exits interface mode and returns to privileged mode.

To disable the BFD echo function, run the **no bfd echo** command in interface mode.

The following example shows how to configure the BFD echo function on the Routed Port FastEthernet 0/2:

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface fastEthernet 0/2
Ruijie(config-if)# bfd echo
```

To enable the BFD control packet to be sent in a slower frequency after the echo function is enabled in the BFD asynchronous mode, run the following commands in turn.

Command	Function
Ruijie>**enable**	Enters privileged mode.
Ruijie# **configure terminal**	Enters global mode.
Ruijie(config)# **bfd slow-timer** milliseconds	Configures the slow-timer. The default value is 1 second. The value range is from 1000 to 30000 and the unit is millisecond.
Ruijie(config)# **end**	Enters global configuration mode.

To restore the default value of the slow-timer, run the **no bfd slow-time** mode in global mode.

The following example shows how to configure the time of the slow-timer to 1400 milliseconds:

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# bfd slow-timer 1400
```

Caution The local end sends the BFD echo packet to the peer, which returns the received packets with processing on the forwarding panel. In this process, the BFD session detection may fail for the peer has been congested resulting in the loss of the echo packets. Under these circumstances, the corresponding QoS policy is necessary to be configured to make sure that the echo packets take the precedence to be processed or the echo function is disabled.

Configuring the BFD UP-Dampening Time

The BFD up-dampening time configuration solves the problem that the BFD session status frequent switches between DOWN and UP due to the line instability, which results in the frequent forwarding path switchover of the associated application (for example, the static route) and the abnormal operation. This feature allows you to configure the required up-dampening time before advertising the session UP state to a related application. To configure the BFD UP-Dampening function, run the following commands in turn.

Command	Function
Ruijie>**enable**	Enters privileged mode.
Ruijie# **configure terminal**	Enters global mode.
Ruijie(config)# **interface** *type number*	Enters interface configuration mode.
Ruijie(config)# **bfd up-dampening** *milliseconds*	Configures the up-dampening time.
Ruijie(config)#**end**	Exits global mode

To restore the default value, run the **no bfd up-dampening** command in interface configuration mode.

The following example shows how to configure the BFD up-dampening time as 60,000ms:

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface fastEthernet 0/2
Ruijie(config-if)# bfd up-dampening 60000
```

Caution In the configuration process, the parameter configurations for two ends of the BFD session must be consistent. This ensures that applications and protocols associated with the BFD take effect simultaneously, and avoid that unidirectional communication occurs on the forwarding path due to different up-dampening time on the two ends.
The dampening function does not take effect in the BFD for OSPFv3.

Configuring the BFD CPP

The BFD protocol is a sensitive protocol. When the device with BFD function enabled suffers from attack (for example, a large amount of Ping packets attack the device), which lead to the BFD session turbulence, the device can be protected by enabling the BFD protection policy. However, if the BFD function and the BFD protection policy are enabled at the same time, the loss of BFD packets on the attacked device occurs when the packets sent from the last-hop device go

through this device, influencing the BFD session establishment between the last-hop device and other devices. This function takes effect only for the switches.

To configure the BFD CPP, run the following commands in turn.

Command	Function
Ruijie>**enable**	Enters privileged mode.
Ruijie# **configure terminal**	Enters global mode.
Ruijie(config)# **bfd cpp**	Enables the BFD CPP.
Ruijie(config)# **end**	Exits global configuration mode.

By default, the BFD CPP is enabled. To disable the BFD CPP, run the **no bfd cpp** command in global mode.

The following example shows how to enable the BFD CPP.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# bfd cpp
```

Configuring the BFD for RIP

RIP sends the route updating information periodically. A route is invalid and RIP cannot rapidly respond to the link failure when no route updating information is received within the specified time.

After enabling the BFD for RIP, the BFD session will be established for the RIP route information source (the source address for RIP route updating packet). Once BFD detects that a neighbor is invalid, RIP route information will directly be in the invalid state and not join in the route forwarding no longer. The convergence time can be decreased from 180s (the default RIP timer) to less than 1s.

Run the **bfd all-interfaces** command to enable BFD for RIP applications on all interfaces. Or run the **ip rip bfd** [**disable**] command in interface configuration mode to enable or disable to allow BFD for RIP applications on specified interfaces.

Command	Function
Ruijie>**enable**	Enters privileged mode.
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router rip**	Enters router configuration mode.
Ruijie(config-router)# **bfd all-interfaces**	Allows the BFD for RIP on all interfaces.
Ruijie(config-router)# **exit**	Exits router configuration mode and returns to global configuration mode. (Optional)
Ruijie(config)# **interface** *type number*	Enters interface configuration mode. (Optional)
Ruijie(config-if)#**ip rip bfd** [**disable**]	Allows or prohibits the BFD for RIP on specified interfaces. (Optional)
Ruijie(config-if)#**end**	Exits interface configuration mode. (Optional)
Ruijie#**show bfd neighbors** [**details**]	Displays the BFD session establishment information and whether RIP is for the specified session. (Optional)

To disable to allow the BFD for RIP applications, run the **no bfd all-interfaces** in Router mode.

The following example shows how to enable the BFD for RIP on all interfaces excluding the FastEthernet 0/2:

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router rip
Ruijie(config-router)# bfd all-interfaces
Ruijie(config-router)# exit
Ruijie(config)# interface FastEthernet 0/2
Ruijie(config-if)# ip rip bfd disable
Ruijie(config-if)#end
```

Caution

The route information sources (source address for RIP route updating packet) of two devices with RIP enabled must be in the same network segment to establish the BFD session between adjacent routers.

BFD session parameters must have been configured. Otherwise, BFD session creation fails.

For the non-unnumbered interface, if the neighbor end and the local end are not connected directly, the BFD for IPv4 PBR fails to be enabled.

BFD session creation fails if an interface specified during BFD session creation is different from the actual BFD packet egress or ingress interface due to IP routing.

BFD session creation fails if an interface specified during BFD session creation is different from the actual BFD packet egress or ingress interface.

Configuring the BFD for OSPF

The OSPF protocol dynamically discovers the neighbors by the Hello packets. With BFD for OSPF configured, the BFD session for the neighbors in FULL relationship will be established and the neighbor state will be detected by the BFD mechanism. Once BFD neighbor is invalid, OSPF processes the network convergence. The convergence time could be from 120s(by default, the sending interval of the OSPF Hello packet in non-broadcast network is 30s, which is a quarter of the invalid time for the adjacency router, namely, 120s) to less than 1s.

Run the **bfd all-interfaces** command to enable BFD for RIP applications on all interfaces. Or run the **ip ospf bfd** [**disable**] command in interface configuration mode to enable or disable to allow the BFD for RIP applications on specified interfaces.

Command	Function
Ruijie>**enable**	Enters privileged mode.
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router ospf** *process-id*	Enters router configuration mode.
Ruijie(config-router)# **bfd all-interfaces**	Allows the BFD for RIP on all interfaces. Prohibits the BFD for RIP on all interfaces by running the **no** command.
Ruijie(config-router)# **exit**	Exits router configuration mode and returns to global configuration mode. (Optional)
Ruijie(config)# **interface** *type number*	Enters interface configuration mode. (Optional)
Ruijie(config-if)#**ip ospf bfd** [**disable**]	Allows or prohibits the BFD for RIP on specified interfaces. (Optional)

Ruijie(config-if)#**end**	Exits interface configuration mode. (Optional)
Ruijie#**show bfd neighbors** [**details**]	Displays the BFD session establishment information and whether OSPF is for the specified session. (Optional)
Ruijie#**show ip ospf**	Displays whether OSPF is for the specified session. (Optional)

To disable to allow the BFD for RIP applications, run the **no bfd all-interfaces** in Router mode.

The following example shows how to enable the BFD for OSPF on all interfaces excluding the FastEthernet 0/2:

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# router ospf 123
Ruijie(config-router)# bfd all-interfaces
Ruijie(config-router)# exit
Ruijie(config)# interface FastEthernet 0/2
Ruijie(config-if)# ip rip bfd disable
Ruijie(config-if)#end
```

☑ 10.3(4b3) or 10.3(5) do not support the BFD for OSPFv3.

Caution

BFD session parameters must have been configured. Otherwise, BFD session creation fails.

BFD session creation fails if an interface specified during BFD session creation is different from the actual BFD packet egress or ingress interface due to IP routing.

BFD session creation fails if an interface specified during BFD session creation is different from the actual BFD packet egress or ingress interface.

The OSPFv2/OSPFv3 virtual link does not support the BFD monitoring.

Configuring the BFD for BGP

Being similar to OSPF, by configuring the BFD for BGP, the BGP protocol rapidly detects the faults, realizes the rapid detection of the neighbor relationship and fastens the protocol convergence. By default, the BGP keepalive interval is 60s and the holdtime is 180s. The minimum value of the keepalive interval and holdtime are 1s and 3s respectively. It is slow to detect the neighbor relationship.

A large amount of the packets will be lost on the interface that receives and sends the packets at the fast speed. With the BFD enabled, the holdtime can decrease to less than 1 second.

Run the **neighbor** *ip-address* **fall-over bfd** command to enable the BFD for BGP.

Command	Function
Ruijie>**enable**	Enters privileged mode.
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **router bgp** *as-tag*	Enters router configuration mode.
Ruijie(config-router)#**neighbor** *ip-address* **fall-over bfd**	Selects BFD keywords to indicate the BFD for

	BGP to detect the faults of specified neighbors.
Ruijie(config-router)#**end**	Exits router configuration mode. (Optional)
Ruijie#**show bfd neighbors** [**details**]	Displays the BFD session establishment information and whether the BGP is associated to the specified session. (Optional)
Ruijie#**show ip bgp neighbors**	Displays whether the BGP is associated to the specified session. (Optional)

To disable the BFD for BGP applications, run the **no neighbor** *ip-address* **fall-over bfd** in Router mode.

The following example shows how to enable the BFD for BGP, and detect the forwarding path with the neighbor 172.16.0.2:

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface FastEthernet 0/1
Ruijie(config-if)# no switchport
Ruijie(config-if)# ip address 172.16.0.1 255.255.255.0
Ruijie(config-if)# bfd interval 50 min_rx 50 multiplier 3
Ruijie(config-if)# exit
Ruijie(config)# router bgp 44000
Ruijie(config-router)# bgp log-neighbors-changes
Ruijie(config-router)# neighbor 172.16.0.2 remote-as 45000
Ruijie(config-router)# neighbor 172.16.0.2 fall-over bfd
Ruijie(config-router)# end
```

☑ 10.3(4b3) and 10.3(5) support the BFD for BGP only when BGP works in IPv4 address families.


Caution

If BGP establishes the session using the loopback address and enables BFD to detect the neighbors, the outbound interface for the BFD packets will be specified according to the result of IP routing. In this situation, before configuring the BFD for BGP, the **bfd interval** command is necessary to be used to configure the BFD session parameter on the possible outbound interface. Otherwise, it may fail to establish the session. The BFD session cannot be established if the specified interface and the actual incoming interface for the BFD packets are inconsistent.

Configuring the BFD for Static Route

To configure the BFD for Static Route, run the following commands in turn.

Command	Function
Ruijie>**enable**	Enters privileged mode.
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **ip route static bfd** [**vrf** *vrf-name*] *interface-type interface-number gateway* [**souce** *ip-addess*]	Configures the BFD for the static route. The parameters *interface-type*, *interface-number* and

	gateway indicate the interface and IP address of a neighbor. For multi-hops, **souce** *ip-addess* needs to be configured as the session source IP address. BFD session parameters must be configured before the configuration.
Ruijie(config)#{ **ip route** *prefix mask* {*ip-address* | *interface-type interface-number [ip-address*]}	Ensures the parameters *interface-type*, *interface-number* and *gateway* are consistent with that configured in Step 3 before configuring the BFD for the static route.
Ruijie(config)# **end**	Exits global configuration mode.
Ruijie#**show bfd neighbors** [**details**]	Displays the BFD session establishment information and whether the static route is associated to the specified session. (Optional).

To disable the BFD for the static route, run the **no ip route static bfd** [**vrf** *vrf-name*] *interface-type interface-number gateway* command in interface mode.

The following example shows how to enable the BFD for static route, and detect the forwarding path with the neighbor 172.16.0.2:

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface FastEthernet 0/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)# ip address 172.16.0.1 255.255.255.0
Ruijie(config-if)# bfd interval 50 min_rx 50 multiplier 3
Ruijie(config-if)# ip route static bfd FastEthernet 0/1 172.16.0.2
Ruijie(config-if)# ip route 10.0.0.0 255.0.0.0 FastEthernet 0/1 172.16.0.2
Ruijie(config-if)# end
```

Configuring the BFD for PBR

To configure the BFD for PBR, run the following commands in turn.

Command	Function
Ruijie>**enable**	Enters privileged mode.
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **route-map** *route-map-name* [**permit** | **deny**] *sequence*	Configures the defined route map to enter route map configuration mode.
Ruijie(config-route-map)#**match ip address** *access-list-number*	Configures the matching access list.
Ruijie(config-route-map)#**set ip next-hop verify-availability** *next-hop-address* { **track** *number* **| bfd** [**vrf** *vrf-name*] *interface-type interface-number gateway* }	Configure the BFD for PBR. The parameters *interface-type*, *interface-number* and *gateway* indicate the interface and IP address of a neighbor. BFD session parameters must be configured before the configuration.

	The next hop specified by the parameter *next-hop-address* is unreachable if the BFD session detects faults. Run the **no** command to cancel the configuration.
Ruijie(config-route-map)#**exit**	Exits route map configuration mode.
Ruijie(config)# **interface** *type number*	Enters interface configuration mode.
Ruijie(config-if)#**ip policy route-map** *route-map*	Enables the PBR on interfaces.
Ruijie(config-if)#**end**	Exits interface configuration mode.
Ruijie#**show bfd neighbors** [**details**]	Displays the BFD session establishment information and whether the PBR is associated with the specified session. (Optional)
Ruijie#**show route-map**	Displays whether the PBR is associated with the specified session. (Optional)

To disable the BFD for PBR applications, run the **no set ip next-hop verify-availability** [*next-hop-address* [**track** *number*|**bfd** [**vrf** *vrf-name*] *interface-type interface-number gateway*]] command in router-map mode.

The following example shows how to enable the BFD for PBR, and detect the forwarding path with the neighbor 172.16.0.2:

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# route-map Example1 permit 10
Ruijie(config-route-map)# match ip address 1
Ruijie(config-route-map)#set ip next-hop verify-availability 172.16.0.2 bfd FastEthernet 0/1
172.16.0.2
Ruijie(config-route-map)#end
Ruijie(config)#interface FastEthernet 0/1
Ruijie(config-if)#no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)#ip address 172.16.0.1 255.255.255.0
Ruijie(config-if)#bfd interval 50 min_rx 50 multiplier 3
Ruijie(config-if)#ip policy route-map Example1
Ruijie(config-if)#exit
```

☑ The BFD for PBRv6 is not supported in v10.3(4b3) and v10.3(5).

Configuring the BFD for VRRP

To enable the BFD for VRRP groups to detect the master and backup routers, run the following commands in turn.

Command	Function
Ruijie>**enable**	Enters privileged mode.
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type number*	Enters interface mode.
Ruijie(config-if)#**vrrp** *group-number* **ip** [*ip-address*[**secondary**]]	Creates VRRP groups and virtual IP addresses. *ip-address* indicates the IP address of the specified neighbor.

Ruijie(config-if)# **vrrp** *group-number* **bfd** *ip-address*	Configures the BFD for all VRRP groups. *ip-addess* indicates the neighbor IP address.
Ruijie(config-if)# **end**	Exits interface configuration mode.
Ruijie#**show bfd neighbors** [**details**]	Displays the BFD session establishment information and whether the VRRP is associated with the specified session. (Optional).
Ruijie#**show vrrp**	Displays whether the VRRP is associated with the specified session. (Optional)

To disable the BFD for VRRP groups to detect the master and backup routers, run the **no vrrp** *group-number* **bfd** command in interface mode.

The following example shows how to enable the BFD for VRRP, and detect the forwarding path between the master and slave routers:

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface FastEthernet 0/1
Ruijie(config-if)#no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)#ip address 192.168.201.11 255.255.255.0
Ruijie(config-if)#bfd interval 50 min_rx 50 multiplier 3
Ruijie(config-if)#vrrp 1 priority 120
Ruijie(config-if)#vrrp 1 ip 192.168.201.1
Ruijie(config-if)#vrrp 1 bfd 192.168.201.12
Ruijie(config-if)#end
```

To enable the specified VRRP group to track the IP address of the specified neighbor through the BFD, run the following commands in turn.

Command	**Function**
Ruijie>**enable**	Enters privileged mode.
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type number*	Enters interface configuration mode.
Ruijie(config-if)#**vrrp** *group-number* **ip** [*ip-address*[**secondary**]]	Creates VRRP groups and virtual IP addresses on specified interfaces.
Ruijie(config-if)# **vrrp** *group-number* **track bfd** *interface-type interface-number ip-addess* [*priority*]	Configures the specified VRRP group to track the IP address of the specified neighbor through the BFD. Run the **no** command to cancel the configuration.
Ruijie(config-if)# **end**	Exits interface configuration mode.
Ruijie#**show bfd neighbors** [**details**]	Displays the BFD session establishment information and whether the VRRP is associated with the specified session. (Optional).
Ruijie#**show vrrp**	Displays whether the BFD is for VRRP is enabled to track the IP address of the specified neighbor. (Optional).

To disable the specified VRRP group to track the IP address of the specified neighbor through the BFD, run the no **vrrp** *group-number* **track bfd** *interface-type interface-number ip-addess* command in interface mode.

The following example shows how to specify the VRRP to track the specified neighbor 192.168.1.3:.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface FastEthernet 0/1
Ruijie(config-if)#no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)#ip address 192.168.1.1 255.255.255.0
Ruijie(config-if)#bfd interval 50 min_rx 50 multiplier 3
Ruijie(config)#interface FastEthernet 0/2
Ruijie(config-if)#no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)#ip address 192.168.201.17 255.255.255.0
Ruijie(config-if)#vrrp 1 priority 120
Ruijie(config-if)#vrrp 1 ip 192.168.201.1
Ruijie(config-if)#vrrp 1 track bfd FastEthernet 0/1 192.168.1.3 30
Ruijie(config-if)#end
```

Configuring the BFD for VRRP+

The VRRP+ protocol relies on the VRRP protocol, and therefore the BFD for VRRP+ is automatically configured after the BFD for VRRP is configured.

Configuring BFD for Changing the State of Layer 3 Interfaces

Generally, it takes a long time for link communication failure or link failure to change the interface state. For various FRRs relying on interface state, high-performance switchover cannot be achieved. Therefore, BFD is generally associated with the layer-3 interface state to realize fast detection of interface state. Execute the following configurations to associate BFD and layer 3 interface states.

Command	Function
Ruijie>**enable**	Enters privileged mode.
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface** *type number*	Enters an L3 interface.
Ruijie(config-if)# **bfd bind peer-ip** *ip-address* [**source-ip** *ip-adress*] **process-pst**	Configure the BFD for L3 interfaces. Source-ip specifies the source IP address of a BFD packet for avoiding that the packet is discarded due to uRPF check failure when the uRPF is also used. Process-pst indicates the BFD status of the BFD session generation interface.
Ruijie(config-if)#**end**	Exits interface configuration mode. (Optional).
Ruijie#**show bfd neighbors** [**details**]	Displays the BFD session establishment information and whether the interface is associated with the specified session. (Optional).

To disable the BFD for interfaces, run the **no bfd bind peer-ip** *ip-address* in configuration mode.

The following example shows how to enable the BFD for FastEthernet 0/2.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface FastEthernet 0/2
Ruijie(config-if)#no sw (This configuration is unnecessary for routers)
Ruijie(config-if)#ip address 1.1.1.1 255.255.255.0
Ruijie(config-if)#bfd bind peer-ip 1.1.1.2 source-ip 1.1.1.1 process-pst
Ruijie(config-if)#end
```

Configuring the BFD for MPLS

The BFD for MPLS indicates that the BFD performs rapid detection on the LSP on the MPLS network to improve MPLS network reliability.

Configuring the BFD Detection for the Static LSP

Command	Function
Ruijie>**enable**	Enters privileged mode.
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **bfd bind static-lsp peer-ip** *ip-address* **source-ip** *ip-address* [**local-discriminator** *discr-value* **remote-discriminator** *discr-value*] [**process-state**]	Configures the BFD for static LSP. You can configure the homing address, next-hop address, and egress interface of the LSP. If no local discriminator is configured, the system automatically elects the local discriminator. If no remote discriminator is configured, the system learns of the remote discriminator in automatic configuration mode.

Configuring the BFD detection for the Dynamic LSP

Command	Function
Ruijie>**enable**	Enters privileged mode.
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie#**mpls router ldp**	Enters LDP configuration mode.
Ruijie(config-mpls-router)# **bfd bind ldp-lsp peer-ip** *ip-address* **nexthop** *ip-address* [**interface** *interface-type interface-number*] **source-ip** *ip-address* [**local-discriminator** *discr-value* **remote-discriminator** *discr-value*] [**process-state**]	Configures the BFD for dynamic LSP. You can configure the homing address, next-hop address, and egress interface of the LSP. If no local discriminator is configured, the system automatically elects the local discriminator. If no remote discriminator is configured, the system learns of the remote discriminator in automatic configuration mode.

Configuring the IP Address Mode for Reverse Link Detection in BFD for the LSP

Command	Function
Ruijie>**enable**	Enters privileged mode.

Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **bfd bind backward-lsp-with-ip peer-ip** *ip-address* [**vrf** *vrf-name*] **interface** *interface-type interface-number* [**source-ip** *ip-address*] {**local-discriminator** *discr-value* **remote-discriminator** *discr-value*}	Configures the IP address mode for reverse link detection in BFD for the LSP. You can configure the source addresses, homing address, and egress interface of the LSP. Both the local and remote discriminators must be manually configured.

For details about enabling the BFD for MPLS-LSP, see the documents *MPLS-CREF* and *MPLS-SCG*.

Displaying BFD Configuration and Status

BFD provides following display commands for checking various configuration and running information. The following table describes functions of commands.

Command	Function
show bfd neighbors [**vrf** *vrf-name*] [**ipv4** *ip-addess* [**details**]| **ipv6** *ipv6-addess* [**details**] |**client** {**bgp**|**ospf**|**rip**|**vrrp**|**vrrp-balance** |**ldp-lsp**|**static-lsp**|**backward-lsp-with-ip**|**static-route**| **pbr**|**pst**} **[ipv4** *ip-addess* [**details**]	**ipv6** *ipv6-addess* [**details**]| **details**]]	Displays the BFD session information. For details, see the description about session display fields in Figure 4.
show vrrp	Displays information about enabling the BFD for VRRP.
show vrrp balance	Displays information about enabling the BFD for VRRP+.
show route-map	Displays information about enabling the BFD for PBR.
show ip route static bfd	Displays information about enabling the BFD for static route.
show ip bgp neighbors	Displays information about enabling the BFD for BGP.
show ip ospf neighbor	Displays information about enabling the BFD for OSPF.
show ip rip peer	Displays information about enabling the BFD for RIP.

Note The preceding display commands can be configured in any mode except for user mode.

☑ 10.3(4b3), 10.4(1), and later versions support the preceding configurations.

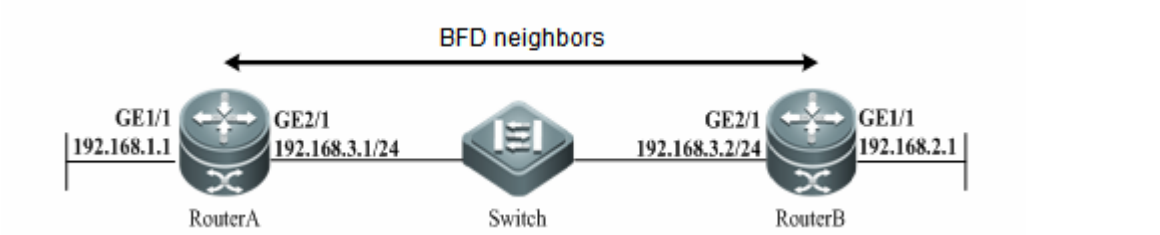
Example of Configuring BFD for RIP

Networking Requirement

Router A and Router B are interconnected through a L2 switch. Both routers run the RIP protocol and enable the BFD for RIP on the interface. After a link failure between Router B and L2 switch occurs, BFD detects the failure and notifies the RIP of the failure, triggering the rapid convergence.

Networking Topology

Figure 13 Topology of configuring BFD for RIP



Configuration Tips

- Router A Configuration

Configure the Routed Port GE 2/1, the IP address, and the BFD session parameter for Router A.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface GigabitEthernet2/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)# ip address 192.168.3.1 255.255.255.0
Ruijie(config-if)# bfd interval 200 min_rx 200 multiplier 5
```

Configure the Routed Port GE1/1.

```
Ruijie(config-if)# exit
Ruijie(config)# interface GigabitEthernet1/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config)# ip address 192.168.1.1 255.255.255.0
```

Enable RIP and configure the BFD for RIP to detect the neighbor 192.168.3.2.

```
Ruijie(config-if)# exit
Ruijie(config)# router rip
Ruijie(config-router)# version 2
Ruijie(config-router)# network 192.168.3.0
Ruijie(config-router)# network 192.168.1.0
Ruijie(config-router)# passive-interface GigabitEthernet 2/1
Ruijie(config-router)# bfd all-interfaces
```

- Router B Configuration

Configure the Routed Port, the IP address, and the BFD session parameter for Router B.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface GigabitEthernet 2/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)# ip address 192.168.3.2 255.255.255.0
Ruijie(config-if)# bfd interval 50 min_rx 50 multiplier 3
```

Configure the Routed Port GE 1/1.

```
Ruijie(config-if)# exit
Ruijie(config)# interface GigabitEthernet1/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)# ip address 192.168.2.1 255.255.255.0
```

Enable RIP and configure the BFD for RIP to detect the neighbor 192.168.3.1.

```
Ruijie(config-if)# exit
Ruijie(config-router)# router rip
Ruijie(config-router)# version 2
Ruijie(config-router)# network 192.168.3.0
Ruijie(config-router)# network 192.168.2.0
Ruijie(config-router)# passive-interface GigabitEthernet 2/1
Ruijie(config-router)# bfd all-interfaces
Ruijie(config-router)# end
Ruijie#
```

Verification

- View the BFD session of Router A

```
Ruijie# show bfd neighbors details
OurAddr         NeighAddr       LD/RD   RH  Holdown(mult)   State   Int
192.168.3.1     192.168.3.2     1/2     1       532 (3 )        Up      Ge2/1
Local Diag: 0, Demand mode: 0, Poll bit: 0
MinTxInt: 200000, MinRxInt: 200000, Multiplier: 5
Received MinRxInt: 50000, Received Multiplier: 3
Holdown (hits): 600(22), Hello (hits): 200(84453)
Rx Count: 49824, Rx Interval (ms) min/max/avg: 208/440/332
Tx Count: 84488, Tx Interval (ms) min/max/avg: 152/248/196
Registered protocols: RIP
Uptime: 02:18:49
Last packet:    Version: 1              - Diagnostic: 0
I Hear You bit: 1       - Demand bit: 0
Poll bit: 0             - Final bit: 0
Multiplier: 3               - Length: 24
My Discr.: 2            - Your Discr.: 1
Min tx interval: 50000  - Min rx interval: 50000
Min Echo interval: 0
```

Field	Description
OurAddr	IP address for the session on the local end
NeighAddr	IP address for the adjacent session
LD/RD	Session ID on the local and remote end

Field	Description
RH/RS	Current status of the session peer end
Holdown(mult)	Time of not receiving the Hello packets on the local end of the session
State	Current session status
Int	Interface number for the session
Session state is UP and using echo function with 50 ms interval	Whether the session is in echo mode and the interval of sending frames. This information is shown only in echo mode.
Local Diag	Diagnosis information of the session
Demand mode	Whether the demand mode is enabled.
Poll bit	Whether the session configuration is modified.
MinTxInt	Minimum sending interval of the session on the local end
MinRxInt	Minimum receiving interval of the session on the local end
Multiplier	Timeout times detected on the local end
Received MinRxInt	Minimum sending interval of the session on the remote end
Received Multiplier	Timeout times detected on the remote end
Holdown (hits)	Session detection time and the detected timeout times
Hello (hits)	Minimum interval of receiving the Hello packet after the session negotiation
Rx Count	Number of BFD packets received on the local end
Rx Interval (ms) min/max/avg	Minimum/maximum/average interval of receiving the session on the local end
Tx Count	Number of BFD packets sent from the local end
Tx Interval (ms) min/max/avg	Minimum/maximum/average interval of sending the session from the local end
Registered protocols	Type of protocol registered to the session
Uptime	Time of keeping the session UP
Last packet	Last BFD packet received by the local end

- View the BFD session of Router B

```
Ruijie# show bfd neighbors details
OurAddr         NeighAddr       LD/RD   RH  Holdown (mult)  State   Int
192.168.3.2     192.168.3.1     2/1     1       532 (5 )        Up      Ge2/1
Local Diag: 0, Demand mode: 0, Poll bit: 0
MinTxInt: 50000, MinRxInt: 50000, Multiplier: 3
Received MinRxInt: 200000, Received Multiplier: 5
Holdown (hits): 600(22), Hello (hits): 200(84453)
Rx Count: 49824, Rx Interval (ms) min/max/avg: 209/440/332
```

```
Tx Count: 84488, Tx Interval (ms) min/max/avg: 153/249/197
Registered protocols: RIP
Uptime: 02:18:49
Last packet:    Version: 1              - Diagnostic: 0
I Hear You bit: 1       - Demand bit: 0
Poll bit: 0             - Final bit: 0
Multiplier: 5               - Length: 24
My Discr.: 1            - Your Discr.: 2
Min tx interval: 200000     - Min rx interval: 200000
Min Echo interval: 0
```

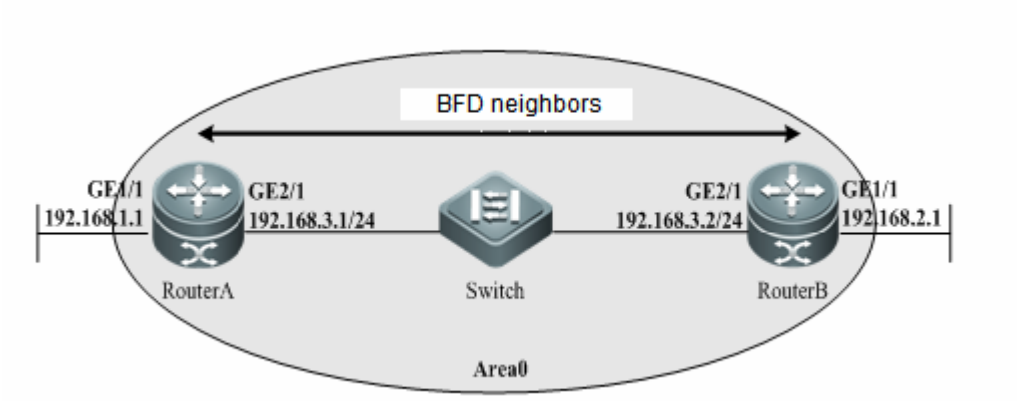
Example of Configuring BFD for OSPF

Networking Requirement

Router A and Router B are interconnected through a L2 switch. Both routers run the OSPF protocol and enable the BFD for OSPF on the interface. After a link failure between Router B and L2 switch occurs, BFD detects the failure and notifies the OSPF of the failure, triggering the rapid convergence.

Networking Topology

Figure 14 Topology of Configuring BFD for OSPF



Configuration Steps

- Router A Configuration

Configure the Routed Port, the IP address, and the BFD session parameter for Router A.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface GigabitEthernet2/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)# ip address 192.168.3.1 255.255.255.0
Ruijie(config-if)# bfd interval 200 min_rx 200 multiplier 5
```

Configure the Routed Port GE 1/1.

```
Ruijie(config-if)# exit
Ruijie(config)# interface GigabitEthernet1/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config)# ip address 192.168.1.1 255.255.255.0
```

Enable OSPF and configure the BFD for OSPF to detect the neighbor 192.168.3.2.

```
Ruijie(config-if)# exit
Ruijie(config-router)# router ospf 123
Ruijie(config-router)# log-adj-changes detail
Ruijie(config-router)# network 192.168.3.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.168.1.0 0.0.0.255 area 0
Ruijie(config-router)# bfd all-interfaces
Ruijie(config-router)# end
Ruijie#
```

- Router B Configuration

Configure the Routed Port, the IP address, and the BFD session parameter for Router B.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface GigabitEthernet 2/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)# ip address 192.168.3.2 255.255.255.0
Ruijie(config-if)# bfd interval 50 min_rx 50 multiplier 3
```

Configure the Routed Port GE 1/1.

```
Ruijie(config-if)# exit
Ruijie(config)# interface GigabitEthernet1/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)# ip address 192.168.2.1 255.255.255.0
```

Enable OSPF and configure the BFD for OSPF to detect the neighbor 192.168.3.1.

```
Ruijie(config-if)# exit
Ruijie(config-router)# router ospf 123
Ruijie(config-router)# log-adj-changes detail
Ruijie(config-router)# network 192.168.3.0 0.0.0.255 area 0
Ruijie(config-router)# network 192.168.2.0 0.0.0.255 area 0
Ruijie(config-router)# bfd all-interfaces
Ruijie(config-router)# end
Ruijie#
```

Verification

- View the BFD session of Router A

```
Ruijie# show bfd neighbors details
OurAddr         NeighAddr       LD/RD   RH  Holdown(mult)   State   Int
192.168.3.1     192.168.3.2     1/2     1       532 (3 )        Up      Ge2/1
Local Diag: 0, Demand mode: 0, Poll bit: 0
MinTxInt: 200000, MinRxInt: 200000, Multiplier: 5
Received MinRxInt: 50000, Received Multiplier: 3
Holdown (hits): 600(22), Hello (hits): 200(84453)
Rx Count: 49824, Rx Interval (ms) min/max/avg: 208/440/332
Tx Count: 84488, Tx Interval (ms) min/max/avg: 152/248/196
Registered protocols: OSPF
Uptime: 02:18:49
Last packet:    Version: 1              - Diagnostic: 0
I Hear You bit: 1       - Demand bit: 0
Poll bit: 0             - Final bit: 0
Multiplier: 3               - Length: 24
My Discr.: 2            - Your Discr.: 1
Min tx interval: 50000  - Min rx interval: 50000
Min Echo interval: 0
```

- View the BFD session of Router B

```
Ruijie# show bfd neighbors details
OurAddr         NeighAddr       LD/RD   RH  Holdown(mult)   State   Int
192.168.3.2     192.168.3.1     2/1     1       532 (5 )        Up      Ge2/1
Local Diag: 0, Demand mode: 0, Poll bit: 0
MinTxInt: 50000, MinRxInt: 50000, Multiplier: 3
Received MinRxInt: 200000, Received Multiplier: 5
Holdown (hits): 600(22), Hello (hits): 200(84453)
Rx Count: 49824, Rx Interval (ms) min/max/avg: 209/440/332 last: 66 ms ago
Tx Count: 84488, Tx Interval (ms) min/max/avg: 153/249/197 last: 190 ms ago
Registered protocols: OSPF
Uptime: 02:18:49
Last packet:    Version: 1              - Diagnostic: 0
I Hear You bit: 1       - Demand bit: 0
Poll bit: 0             - Final bit: 0
Multiplier: 5               - Length: 24
My Discr.: 1            - Your Discr.: 2
Min tx interval: 200000     - Min rx interval: 200000
Min Echo interval: 0
```

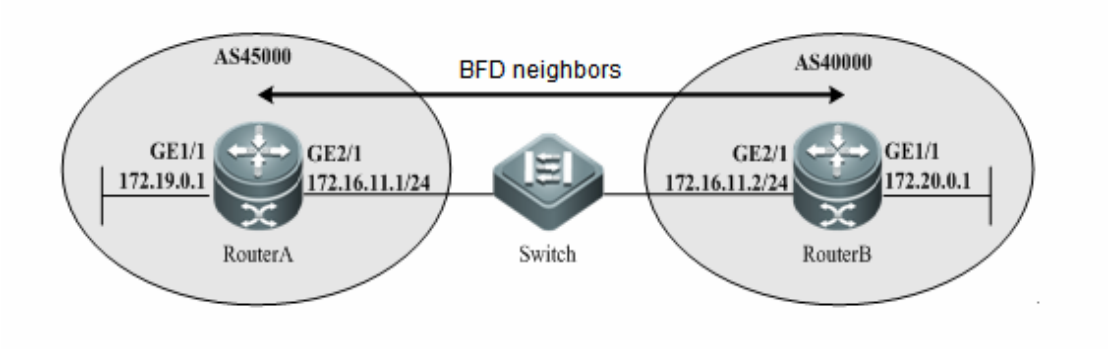
Example of Configuring BFD for BGP

Networking Requirement

Router A and Router B are interconnected through a L2 switch. Both routers run the BGP protocol and enable the BFD for BGP on the interface. After a link failure between Router B and L2 switch occurs, BFD detects the failure and notifies the BGP of the failure, triggering the rapid convergence.

Networking Topology

Figure 15 Topology of configuring BFD for BGP



Configuration Tips

- Router A Configuration

Configure the Routed Port, the IP address, and the BFD session parameter for Router A.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface GigabitEthernet2/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)# ip address 172.16.11.1 255.255.255.0
Ruijie(config-if)# bfd interval 200 min_rx 200 multiplier 5
```

Configure the Routed Port GE 1/1.

```
Ruijie(config-if)# exit
Ruijie(config)# interface GigabitEthernet1/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config)# ip address 172.19.0.1 255.255.255.0
```

Enable BGP and configure the BFD for BGP to detect the neighbor 172.16.11.2.

```
Ruijie(config-if)# exit
Ruijie(config)# router bgp 45000
Ruijie(config-router)# bgp log-neighbor-changes
Ruijie(config-router)# neighbor 172.16.11.2 remote-as 40000
Ruijie(config-router)# neighbor 172.16.11.2 fall-over bfd
```

```
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 172.16.11.2 activate
Ruijie(config-router-af)# no auto-summary
Ruijie(config-router-af)# no synchronization
Ruijie(config-router-af)# network 172.19.0.0 mask 255.255.255.0
Ruijie(config-router-af)# exit-address-family
Ruijie(config-router)# end
Ruijie#
```

- Router B Configuration

Configure the Routed Port, the IP address, and the BFD session parameter for Router B.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface GigabitEthernet2/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)# ip address 172.16.11.2 255.255.255.0
Ruijie(config-if)# bfd interval 50 min_rx 50 multiplier 3
```

Configure the Routed Port GE 1/1.

```
Ruijie(config-if)# exit
Ruijie(config)# interface GigabitEthernet1/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config)# ip address 172.20.0.1 255.255.255.0
```

Enable BGP and configure the BFD for BGP to detect the neighbor 172.16.11.1.

```
Ruijie(config-if)# exit
Ruijie(config-router)# router bgp 40000
Ruijie(config-router)# bgp log-neighbor-changes
Ruijie(config-router)# neighbor 172.16.11.1 remote-as 45000
Ruijie(config-router)# neighbor 172.16.11.1 fall-over bfd
Ruijie(config-router)# address-family ipv4
Ruijie(config-router-af)# neighbor 172.16.11.1 activate
Ruijie(config-router-af)# no auto-summary
Ruijie(config-router-af)# no synchronization
Ruijie(config-router-af)# network 172.20.0.0 mask 255.255.255.0
Ruijie(config-router-af)# exit-address-family
Ruijie(config-router)# end
Ruijie#
```

Verification

- View the BFD session of Router A.

```
Ruijie# show bfd neighbors details
OurAddr         NeighAddr   LD/RD   RH/RS   Holdown(mult)   State   Int
172.16.11.1     172.16.11.2     1/2     Up      532 (3 )            Up      Ge2/1
Local Diag: 0, Demand mode: 0, Poll bit: 0
MinTxInt: 200000, MinRxInt: 200000, Multiplier: 5
Received MinRxInt: 50000, Received Multiplier: 3
Holdown (hits): 600(22), Hello (hits): 200(84453)
Rx Count: 49824, Rx Interval (ms) min/max/avg: 208/440/332
Tx Count: 84488, Tx Interval (ms) min/max/avg: 152/248/196
Registered protocols: BGP
Uptime: 02:18:49
Last packet: Version: 1     - Diagnostic: 0
I Hear You bit: 1           - Demand bit: 0
Poll bit: 0             - Final bit: 0
Multiplier: 3           - Length: 24
My Discr.: 2                - Your Discr.: 1
Min tx interval: 50000      - Min rx interval: 50000
Min Echo interval: 0
```

- View the BFD session of Router B.

```
Ruijie# show bfd neighbors details
OurAddr         NeighAddr   LD/RD   RH/RS   Holdown(mult)   State   Int
172.16.11.2     172.16.11.1     2/1     Up      532 (5 )            Up      Ge2/1
Local Diag: 0, Demand mode: 0, Poll bit: 0
MinTxInt: 50000, MinRxInt: 50000, Multiplier: 3
Received MinRxInt: 200000, Received Multiplier: 5
Holdown (hits): 600(22), Hello (hits): 200(84453)
Rx Count: 49824, Rx Interval (ms) min/max/avg: 209/440/332 last: 66 ms ago
Tx Count: 84488, Tx Interval (ms) min/max/avg: 153/249/197 last: 190 ms ago
Registered protocols: BGP
Uptime: 02:18:49
Last packet: Version: 1     - Diagnostic: 0
I Hear You bit: 1           - Demand bit: 0
Poll bit: 0             - Final bit: 0
Multiplier: 5           - Length: 24
My Discr.: 1                - Your Discr.: 2
Min tx interval: 200000     - Min rx interval: 200000
Min Echo interval: 0
```

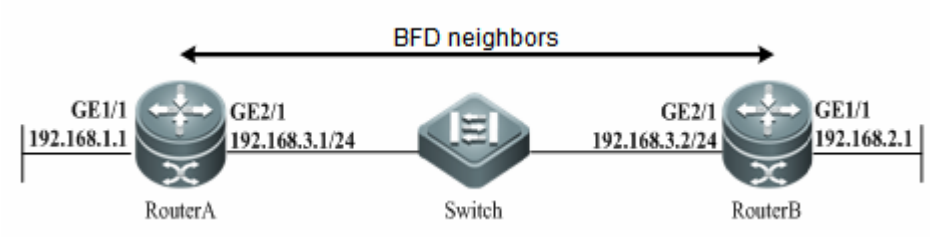
Example of Configuring BFD for Static Route

Networking Requirement

Router A and Router B are interconnected through a L2 switch. Both routers run the static route protocol and enable the BFD for static route on the interface. After a link failure between Router B and L2 switch occurs, BFD detects the failure and notifies the static route of the failure, triggering the static route removal from RIB and preventing the routing error.

Networking Topology

Figure 16 Topology of configuring BFD for Static Route



Configuration Tips

- Router A Configuration

Configure the Routed Port, the IP address, and the BFD session parameter for Router A.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface GigabitEthernet2/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)# ip address 192.168.3.1 255.255.255.0
Ruijie(config-if)# bfd interval 200 min_rx 200 multiplier 5
```

Configure the Routed Port GE 1/1.

```
Ruijie(config-if)# exit
Ruijie(config)# interface GigabitEthernet1/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config)# ip address 192.168.1.1 255.255.255.0
```

Configure the BFD for static route to detect the neighbor 192.168.3.2.

```
Ruijie(config-if)# exit
Ruijie(config)# ip route static bfd GigabitEthernet 2/1 192.168.3.2
Ruijie(config)# ip route 192.168.2.0 255.255.255.0 GigabitEthernet 2/1 192.168.3.2
Ruijie(config)# end
Ruijie#
```

- Router B Configuration

Configure the Routed Port, the IP address, and the BFD session parameter for Router B.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface GigabitEthernet 2/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)# ip address 192.168.3.2 255.255.255.0
Ruijie(config-if)# bfd interval 50 min_rx 50 multiplier 3
```

Configure the Routed Port GE 1/1.

```
Ruijie(config-if)# exit
Ruijie(config)# interface GigabitEthernet1/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)# ip address 192.168.2.1 255.255.255.0
```

Configure the BFD for static route to detect the neighbor 192.168.3.1.

```
Ruijie(config-if)# exit
Ruijie(config)# ip route static bfd GigabitEthernet 2/1 192.168.3.1
Ruijie(config)# ip route 192.168.1.0 255.255.255.0 GigabitEthernet 2/1 192.168.3.1
Ruijie(config)# end
Ruijie#
```

Verification

- View the BFD session of Router A.

```
Ruijie# show bfd neighbors details
OurAddr         NeighAddr       LD/RD   RH  Holdown(mult)   State   Int
192.168.3.1     192.168.3.2     1/2     1       532 (3 )        Up      Ge2/1
Local Diag: 0, Demand mode: 0, Poll bit: 0
MinTxInt: 200000, MinRxInt: 200000, Multiplier: 5
Received MinRxInt: 50000, Received Multiplier: 3
Holdown (hits): 600(22), Hello (hits): 200(84453)
Rx Count: 49824, Rx Interval (ms) min/max/avg: 208/440/332
Tx Count: 84488, Tx Interval (ms) min/max/avg: 152/248/196
Registered protocols: STATIC ROUTE
Uptime: 02:18:49
Last packet:    Version: 1              - Diagnostic: 0
I Hear You bit: 1       - Demand bit: 0
Poll bit: 0             - Final bit: 0
Multiplier: 3               - Length: 24
My Discr.: 2            - Your Discr.: 1
Min tx interval: 50000  - Min rx interval: 50000
Min Echo interval: 0
```

- View the BFD session of Router B.

```
Ruijie# show bfd neighbors details
OurAddr         NeighAddr       LD/RD   RH  Holdown(mult)   State   Int
192.168.3.2     192.168.3.1     2/1     1       532 (5 )        Up      Ge2/1
```

```
Local Diag: 0, Demand mode: 0, Poll bit: 0
MinTxInt: 50000, MinRxInt: 50000, Multiplier: 3
Received MinRxInt: 200000, Received Multiplier: 5
Holdown (hits): 600(22), Hello (hits): 200(84453)
Rx Count: 49824, Rx Interval (ms) min/max/avg: 209/440/332 last: 66 ms ago
Tx Count: 84488, Tx Interval (ms) min/max/avg: 153/249/197 last: 190 ms ago
Registered protocols: STATIC ROUTE
Uptime: 02:18:49
Last packet:    Version: 1              - Diagnostic: 0
I Hear You bit: 1       - Demand bit: 0
Poll bit: 0             - Final bit: 0
Multiplier: 5               - Length: 24
My Discr.: 1            - Your Discr.: 2
Min tx interval: 200000     - Min rx interval: 200000
Min Echo interval: 0
```

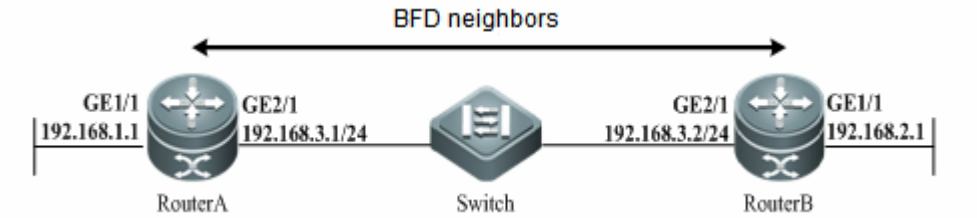
Example of Configuring BFD for PBR

Networking Requirement

Router A and Router B are interconnected through a L2 switch. Both routers run the PBR protocol and enable the BFD for PBR on the interface. After a link failure between Router B and L2 switch occurs, BFD detects the failure and notifies the PBR of the failure, triggering the PBR removal and preventing the routing error.

Networking Topology

Figure 17 Topology of configuring BFD for PBR



Configuration Tips

- Router A Configuration

Configure the Routed Port GE2/1, the interface IP address, and the BFD session parameter of the interface for Router A.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface GigabitEthernet2/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)# ip address 192.168.3.1 255.255.255.0
```

```
Ruijie(config-if)# bfd interval 200 min_rx 200 multiplier 5
```

Configure the Routed Port GE 1/1.

```
Ruijie(config-if)# exit
Ruijie(config)# interface GigabitEthernet1/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config)# ip address 192.168.1.1 255.255.255.0
```

Configure the BFD for PBR to detect the neighbor 192.168.3.2.

```
Ruijie(config)# ip access-list extended 100
Ruijie(config-ext-nacl)# permit ip any 192.168.2.0 0.0.0.255
Ruijie(config-ext-nacl)# deny ip any any
Ruijie(config-ext-nacl)# exit
Ruijie(config)# route-map Example1 permit 10
Ruijie(config-route-map)# match ip address 100
Ruijie(config-route-map)# set ip precedence priority
Ruijie(config-route-map)#set ip next-hop verify-availability 192.168.3.2 bfd GigabitEthernet
0/1 192.168.3.2
Ruijie(config)# end
Ruijie#
```

- Router B Configuration

Configure the Routed Port, the IP address, and the BFD session parameter for Router B.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface GigabitEthernet 2/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)# ip address 192.168.3.2 255.255.255.0
Ruijie(config-if)# bfd interval 50 min_rx 50 multiplier 3
```

Configure the Routed Port GE 1/1.

```
Ruijie(config-if)# exit
Ruijie(config)# interface GigabitEthernet1/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)# ip address 192.168.2.1 255.255.255.0
```

Configure the BFD for PBR to detect the neighbor 192.168.3.1.

```
Ruijie(config)# ip access-list extended 100
Ruijie(config-ext-nacl)# permit ip any 192.168.1.0 0.0.0.255
Ruijie(config-ext-nacl)# deny ip any any
Ruijie(config-ext-nacl)# exit
Ruijie(config)# route-map Example1 permit 10
Ruijie(config-route-map)# match ip address 100
Ruijie(config-route-map)# set ip precedence priority
```

```
Ruijie(config-route-map)#set ip next-hop verify-availability 192.168.3.1 bfd GigabitEthernet
2/1 192.168.3.1
Ruijie(config)# end
Ruijie#
```

Verification

- View the BFD session of Router A.

```
Ruijie# show bfd neighbors details
OurAddr         NeighAddr       LD/RD   RH  Holdown(mult)   State   Int
192.168.3.1     192.168.3.2     1/2     1       532 (3 )        Up      Ge2/1
Local Diag: 0, Demand mode: 0, Poll bit: 0
MinTxInt: 200000, MinRxInt: 200000, Multiplier: 5
Received MinRxInt: 50000, Received Multiplier: 3
Holdown (hits): 600(22), Hello (hits): 200(84453)
Rx Count: 49824, Rx Interval (ms) min/max/avg: 208/440/332
Tx Count: 84488, Tx Interval (ms) min/max/avg: 152/248/196
Registered protocols: PBR
Uptime: 02:18:49
Last packet:    Version: 1              - Diagnostic: 0
I Hear You bit: 1       - Demand bit: 0
Poll bit: 0             - Final bit: 0
Multiplier: 3               - Length: 24
My Discr.: 2            - Your Discr.: 1
Min tx interval: 50000  - Min rx interval: 50000
Min Echo interval: 0
```

- View the BFD session of Router B.

```
Ruijie# show bfd neighbors details
OurAddr         NeighAddr       LD/RD   RH  Holdown(mult)   State   Int
192.168.3.2     192.168.3.1     2/1     1       532 (5 )        Up      Ge2/1
Local Diag: 0, Demand mode: 0, Poll bit: 0
MinTxInt: 50000, MinRxInt: 50000, Multiplier: 3
Received MinRxInt: 200000, Received Multiplier: 5
Holdown (hits): 600(22), Hello (hits): 200(84453)
Rx Count: 49824, Rx Interval (ms) min/max/avg: 209/440/332 last: 66 ms ago
Tx Count: 84488, Tx Interval (ms) min/max/avg: 153/249/197 last: 190 ms ago
Registered protocols: PBR
Uptime: 02:18:49
Last packet:    Version: 1              - Diagnostic: 0
I Hear You bit: 1       - Demand bit: 0
Poll bit: 0             - Final bit: 0
Multiplier: 5               - Length: 24
My Discr.: 1            - Your Discr.: 2
Min tx interval: 200000     - Min rx interval: 200000
```

```
Min Echo interval: 0
```

Example of Configuring BFD for VRRP

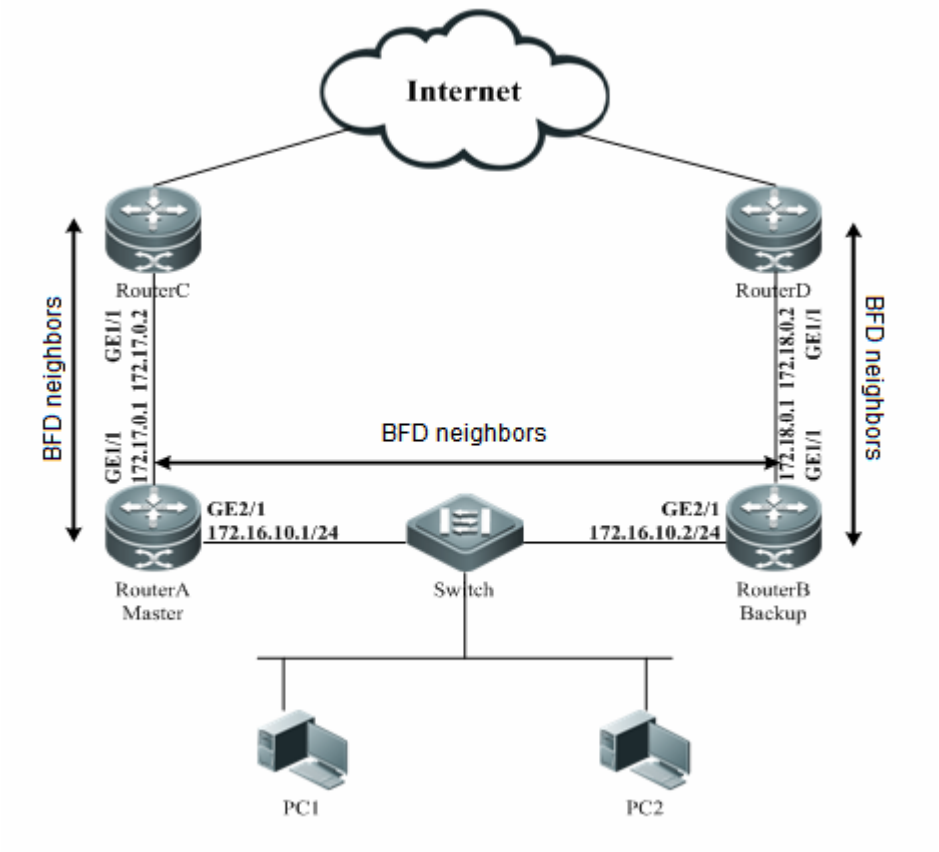
Networking Requirement

Router A and Router B are interconnected through a L2 switch. Both routers run the VRRP protocol and enable the BFD for PBR on the interface to detect the master and backup routers. After a link failure between Router A and L2 switch occurs, BFD detects the failure, notifies VRRP of the failure, and triggers the decrease of the priority of the VRRP master router. As a result, the switchover between the master and backup routers, which enables the backup router rapidly.

Router A and Router B access the Internet through Router C and Router D respectively. Configure the static routes to establish the forwarding path between Router A and Router C, Router B and Router D and enable the BFD to detect the neighbor. At the same time, Router A and Router B are configured the BFD for VRRP to detect the forwarding path between the Router A and Router C, Router B and Router D. The detection failure triggers the decrease of the priority for VRRP master router and switchover between the master and backup routers, which enables the backup router rapidly.

Networking Topology

Figure 18 Topology of configuring BFD for VRRP



Configuration Tips

- Router A Configuration

Configure the Routed Port, the IP address, and the BFD session parameter for Router A.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface GigabitEthernet2/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)# ip address 172.16.10.1 255.255.255.0
Ruijie(config-if)# bfd interval 200 min_rx 200 multiplier 5
```

Configure the Routed Port GE 1/1.

```
Ruijie(config-if)# exit
Ruijie(config)# interface GigabitEthernet1/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)# ip address 172.17.0.1 255.255.255.0
Ruijie(config-if)# bfd interval 200 min_rx 200 multiplier 5
```

Enable VRRP and configure the BFD for VRRP to detect the neighbor 172.16.10.2 and 172.17.0.2 at the same time.

```
Ruijie(config-if)# interface GigabitEthernet2/1
Ruijie(config-if)# vrrp 1 timers advertise 3
Ruijie(config-if)# vrrp 1 ip 172.16.10.3
Ruijie(config-if)# vrrp 1 priority 120
Ruijie(config-if)# vrrp 1 bfd 172.16.10.2
Ruijie(config-if)# vrrp 1 track bfd GigabitEthernet 1/1 172.17.0.2 30
```

Configure the static route and associate the BFD to detect the neighbor 172.17.0.2:

```
Ruijie(config-if)# exit
Ruijie(config)# ip route static bfd GigabitEthernet 1/1 172.17.0.2
Ruijie(config)# ip route 0.0.0.0 0.0.0.0 GigabitEthernet 1/1 172.17.0.2
Ruijie(config)# end
Ruijie#
```

- Router B Configuration

Configure the Routed Port, the IP address, and the BFD session parameter for Router B.

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface GigabitEthernet2/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)# ip address 172.16.10.2 255.255.255.0
Ruijie(config-if)# bfd interval 50 min_rx 50 multiplier 3
```

Configure the Routed Port GE 1/1.

```
Ruijie(config-if)# exit
Ruijie(config)# interface GigabitEthernet1/1
Ruijie(config-if)# no switchport (This configuration is unnecessary for routers)
Ruijie(config-if)# ip address 172.18.0.1 255.255.255.0
Ruijie(config-if)# bfd interval 200 min_rx 200 multiplier 5
```

Enable VRRP and configure the BFD for VRRP to detect the neighbor 172.16.10.1 and 172.18.0.2 at the same time.

```
Ruijie(config-if)# interface GigabitEthernet2/1
Ruijie(config-if)# vrrp 1 timers advertise 3
Ruijie(config-if)# vrrp 1 ip 172.16.10.3
Ruijie(config-if)# vrrp 1 priority 120
Ruijie(config-if)# vrrp 1 bfd 172.16.10.1
Ruijie(config-if)# vrrp 1 track bfd GigabitEthernet 1/1 172.18.0.2 30
```

Configure the static route and associate the BFD to detect the neighbor 172.18.0.2.

```
Ruijie(config-if)# exit
Ruijie(config)# ip route static bfd GigabitEthernet 1/1 172.18.0.2
Ruijie(config)# ip route 0.0.0.0 0.0.0.0 GigabitEthernet 1/1 172.18.0.2
Ruijie(config)# end
Ruijie#
```

Verification

- View the BFD session of Router A.

```
Ruijie# show bfd neighbors details
OurAddr         NeighAddr       LD/RD   RH  Holdown(mult)   State   Int
172.16.10.1     172.16.10.2     1/2     1       532 (3 )        Up      Ge2/1
Local Diag: 0, Demand mode: 0, Poll bit: 0
MinTxInt: 200000, MinRxInt: 200000, Multiplier: 5
Received MinRxInt: 50000, Received Multiplier: 3
Holdown (hits): 600(22), Hello (hits): 200(84453)
Rx Count: 49824, Rx Interval (ms) min/max/avg: 208/440/332
Tx Count: 84488, Tx Interval (ms) min/max/avg: 152/248/196
Registered protocols: VRRP
Uptime: 02:18:49
Last packet:    Version: 1              - Diagnostic: 0
I Hear You bit: 1       - Demand bit: 0
Poll bit: 0             - Final bit: 0
Multiplier: 3               - Length: 24
My Discr.: 2            - Your Discr.: 1
Min tx interval: 50000  - Min rx interval: 50000
Min Echo interval: 0
```

```
OurAddr         NeighAddr       LD/RD   RH  Holdown(mult)   State   Int
172.17.0.1  172.17.0.2          2/3     1       532 (3 )        Up      Ge2/1
Local Diag: 0, Demand mode: 0, Poll bit: 0
MinTxInt: 200000, MinRxInt: 200000, Multiplier: 5
Received MinRxInt: 50000, Received Multiplier: 3
Holdown (hits): 600(22), Hello (hits): 200(84453)
Rx Count: 49824, Rx Interval (ms) min/max/avg: 208/440/332 last: 68 ms ago
Tx Count: 84488, Tx Interval (ms) min/max/avg: 152/248/196 last: 192 ms ago
Registered protocols: VRRP,STATIC ROUTE
Uptime: 02:18:49
Last packet:    Version: 1              - Diagnostic: 0
I Hear You bit: 1       - Demand bit: 0
Poll bit: 0             - Final bit: 0
Multiplier: 3               - Length: 24
My Discr.: 2            - Your Discr.: 1
Min tx interval: 50000  - Min rx interval: 50000
Min Echo interval: 0
```

View the BFD session of Router B.

```
Ruijie# show bfd neighbors details
OurAddr         NeighAddr       LD/RD   RH  Holdown(mult)   State   Int
172.16.10.2     172.16.10.1     2/1     1       532 (3 )        Up      Ge2/1
Local Diag: 0, Demand mode: 0, Poll bit: 0
MinTxInt: 50000, MinRxInt: 50000, Multiplier: 3
Received MinRxInt: 200000, Received Multiplier: 5
Holdown (hits): 600(22), Hello (hits): 200(84453)
Rx Count: 49824, Rx Interval (ms) min/max/avg: 208/440/332 last: 68 ms ago
Tx Count: 84488, Tx Interval (ms) min/max/avg: 152/248/196 last: 192 ms ago
Registered protocols: VRRP
Uptime: 02:18:49
Last packet:    Version: 1              - Diagnostic: 0
I Hear You bit: 1       - Demand bit: 0
Poll bit: 0             - Final bit: 0
Multiplier: 3               - Length: 24
My Discr.: 1            - Your Discr.: 2
Min tx interval: 200000     - Min rx interval: 200000
Min Echo interval: 0

OurAddr         NeighAddr       LD/RD   RH  Holdown(mult)   State   Int
172.18.0.1      172.18.0.2      1/3     1       532 (3 )        Up      Ge2/1
Local Diag: 0, Demand mode: 0, Poll bit: 0
MinTxInt: 200000, MinRxInt: 200000, Multiplier: 5
Received MinRxInt: 50000, Received Multiplier: 3
Holdown (hits): 600(22), Hello (hits): 200(84453)
Rx Count: 49824, Rx Interval (ms) min/max/avg: 208/440/332 last: 68 ms ago
```

```
Tx Count: 84488, Tx Interval (ms) min/max/avg: 152/248/196 last: 192 ms ago
Registered protocols: VRRP,STATIC ROUTE
Uptime: 02:18:49
Last packet:    Version: 1             - Diagnostic: 0
I Hear You bit: 1       - Demand bit: 0
Poll bit: 0             - Final bit: 0
Multiplier: 3               - Length: 24
My Discr.: 2            - Your Discr.: 1
Min tx interval: 50000  - Min rx interval: 50000
Min Echo interval: 0
```

Example of Configuring BFD for the L3 Interface

Because the configuration of BFD for the L3 interface is usually used in FRR application and independent usage is not recommended. For details, see description in *MPLS-SCG.doc*.

Example of Configuring BFD for MPLS

For details, see description in *MPLS-SCG.doc*.

Example of Configuring BFD for VRRP

For details, see description in *VRRP-PLUS-SCG.doc*.

RGOS Switches Configuration Guide

V10.4(3b13)

Dialing Configuration

1. Dialup Configuration
2. WAN-3G Configuration

Dialup Configutation

Understanding Asynchronous Interface Dialup

Asynchronous Dialup Overview

Ruijie device supports the dialup with asynchronous interface or asynchronous interface group, and also support Dial-on-Demand Routing (DDR), including the legacy DDR and profile DDR. Different dialup modes can be selected according to the actual network conditions.

The dialup function of asynchronous interface just implements the basic dialup function of the asynchronous serial interface, including the negotiation and authentication of link protocol and the bearing function of network protocol. The DDR functions will be detailed in the "Dial-on-Demand Routing (DDR)" section.

Asynchronous interface and asynchronous dialup group

The asynchronous interface of RSR series can be configured with the following functions:

- Network protocols (such as IP)
- Encapsulation (such as PPP and SLIP)
- IP address (default/dynamic)
- PPP authentication (including CHAP and PAP)

See the example below:

```
interface Async1
ip address negotiate
encapsulation ppp
 async mode dedicated
 dialer in-band
 dialer string 163
 dialer-group 1
 ppp authentication pap
!
```

To configure multiple asynchronous interfaces with the same parameters, add every interface into an asynchronous interface group and then configure that interface group. The following example adds asynchronous interfaces 1 through 16 into asynchronous interface group 1:

```
interface Group-Async1
 ip unnumbered FastEthernet0/0
 encapsulation ppp
 async mode dedicated
 peer default ip address pool default
 dialer in-band
 dialer-group 1
```

```
ppp authentication pap
group-range 1 16
!
```

Note

Once an asynchronous interface is added into an asynchronous interface group, it cannot be configured independently. To configure different attributes for different asynchronous interfaces, do not add them into the same asynchronous interface group, or add them into different asynchronous interface groups.

Caution

The backup interface can only be used independently and cannot be added into any asynchronous interface group as a member.

Asynchronous interface and line (tty) number

The following table shows the relations between the asynchronous interface and line tty number:

Asynchronous interface number	Line (tty) number	Description
Backup interface	Aux 0	The backup interface has the biggest asynchronous interface number, and is numbered with the asynchronous cards inserted. If a card with 8 asynchronous interfaces is inserted, the backup asynchronous interface is numbered 9 (interface 9), and asynchronous interfaces are numbered from 1 to 8 (interfaces 1-8).
Async n	Line tty n	The numbers of the interfaces on the asynchronous card are the same as the line numbers, that is, async 1, 2, 3… correspond to line tty number 1, 2, 3…

For the detailed relations between the asynchronous interfaces and lines (VTY), run the **show line** command in the privileged EXEC configuration mode.

The relationship between the asynchronous interface and line layer is described below.

The number on an asynchronous interface card starts from the interfaces of the asynchronous card in the slot of the smallest number and increases by degree (starting from 1). If there is no asynchronous card in a slot, it does not increase. For example, for a device with 16 asynchronous cards inserted in slot 0, the numbers of the asynchronous interfaces are as follows:

16 asynchronous cards in slot 0: interface async 1-16, line tty 1-16

Backup interface: interface async 17, line aux 0

The following table shows the relations among the console interface, auxiliary interface, asynchronous interface and vty line layer.

line 0	line console 0	Console interface
line 1 16	line tty 1 16	async interface 1-16
line 17	line aux 0	Auxiliary interface

line 18 22	line vty 0 4	vty

Preparations for Dialup

RSR series uses external modem. The following tasks must be completed before the dialup is configured.

- Install and connect the modem and related network module correctly by referring to the attached installation manual.
- Initialize the modem.
- Verify the related parameters required for the dialup, including the IP address, telephone number, username and password.
- Perform some necessary global configurations.

Caution If Ruijie's device and Cisco device dial to connect each other, make sure the modem connector used to connect the Cisco device is the dedicated Cisco connector (RJ45 to DB25; the DB25 end has 7 rather than 8 pins).
Without a dedicated Cisco connector, dialup may fail and the Cisco device may prompt "line is in use".

Initializing the modem

RSR series supports up to 115200 bit/s line. The maximum rate is recommended in general cases to maximize the use of the line. Before dialup, it is required to use the line rate to initialize the modem to ensure the line rate consistent with the modem rate.

There are two ways to initialize the modem:

- Script: Use a configured script to issue the **at** instruction from the device to the modem so as to initialize the modem.
- Manual initialization: On HyperTerminal, use the **at** instruction to initialize the modem. This is the simplest method.

Note It is recommended to initialize the modem manually, unless you are very familiar with configuration.

Initializing the modem by using a script

There are two ways to initialize the modem by using a script:

- Run the script manually on the device.
- Run the script automatically when an event occurs on the device.

For details, see the related chapters of the script configurations.

The following example runs the script manually on the device to initialize the modem.

```
chat-script factory "" "AT&f" OK "ATs0=1" OK "AT&W" OK
Ruijie# start-chat factory 1       //the line number of aux 0 interface is 1
```

Explanation of the initialization string:

- Lock the rate of the serial interface.
- Configure the auto-reply of the modem.
- Save the modem configurations.

Global configuration

Complete the following global configurations before configuring the asynchronous interface dialup:

- Define the ACL which defines the packets to activate dialup.
- Define the rule to dialup.
- Define the dialup script.

The fist one is optional while the other two are required.

Command	Function
Ruijie(config)# **access-list** *access-list-number* **{deny** | **permi**t} *source [source-mas*k] or Ruijie(config)# **access-list** *access-list-number* **{deny** | **permit**} *protocol source source-mask destination destination-mask [operator operand*]	Defines the access list: standard or extended access list.
Ruijie(config)#**dialer-list** *number dialer-group* **protocol** *protocol-name* {**permit** | **deny** | **list** *access-list-number* | *access-grou*p}	Defines the rule to stimulating dialup.
Ruijie(config)# **chat-script** *script-name expect send …*	Defines the dialup script.

A typical example:

```
chat-script dialout ABORT BUSY ABORT ERROR "" "ATDT \T" TIMEOUT 60 CONNECT \c
dialer-list 1 protocol ip permit
```

Caution The current version of RUIJIE DEVICE must use a script for outgoing calls.

Configuration Tasks for Asynchronous Interface

After the preparations are completed, the following two configurations must be completed in order to enable dialup of the asynchronous interface:

- Configuring the line parameters
- Configuring the asynchronous interface

Configuring the line parameters

There are a lot of line parameters for the dialup of asynchronous interface, some required while most optional, as detailed below.

There are four required line parameters for asynchronous dialup:

- Line rate
- Allow the connected line to use all protocols
- Associate the script of dialup event
- Dialup direction

Use the following command to configure the line rate,in line configuration mode.

Command	Function
Ruijie(config-line)# **speed** *speed*	Configures the line rate.

Use the following command to associate the script of dialup event in line configuration mode.

Command	Function
Ruijie(config-line)# **script dialer** *script-name*	Associates the script of dialup event.

Use the following command to configure the dialup direction in line configuration mode.

Command	Function
Ruijie(config-line)# **modem** {**InOut**|**Dialin**}	Configures the direction of asynchronous dialup. **InOut** allows both incoming and outgoing calls on the asynchronous interface, and **Dialin** allows only incoming calls.

Configuring the asynchronous interface

Ruijie device supports dialup in the automaic mode (dedicate). In this mode, all protocol negotiations are completed automatically.

Dialup in automatic mode

The configurations for the dialup on a single asynchronous interface and on an asynchronous interface group are basically the same. To make the use easier, they are described in the following two sections.

Configuring dialup on a single asynchronous interface

Use the following commands to configure dialup on a single asynchronous interface in global configuration mode.

Command	Function
Ruijie(config)# **interface async** *number*	Turns on the asynchronous interface and enter the asynchronous interface configuration mode.
Ruijie(config-if)# **ip address** *address mask* or Ruijie(config-if)# **ip address negotiate** or Ruijie(config-if)# **ip unnumbered** *interface-type interface-number*	Configures the asynchronous interface IP address: set it directly, or obtain from the peer, or share the IP address of another interface.
Ruijie(config-if)# **encapsulation ppp**	Encapsulates the PPP protocol.
Ruijie(config-if)# **dialer in-band**	Enables dialup.
Ruijie(config-if)# **async mode dedicated**	Configures the dedication mode.
Ruijie(config-if)# **dialer-group** *group*	Associates a rule to activate dialup.
Ruijie(config-if)#**dialer string** *number*	Configures the telephone number for dialup.
Ruijie(config-if)# **ppp authentication** {**chap**| **pap**}	(Optional) Configures the ppp authentication mode. The

Command	Function
[*list-name*]	keyword **list-name** indicates the name of the AAA authentication method list. See the related chapters of security configuration for details.
Router(config-pmap)# **exit**	Exits to the global configuration mode.

In addition to the preceding required steps, see Configuring More PPP Negotiation Options below for more details.

Configuring dialup on a asynchronous interface group

Use the following commands to configure dialup on a asynchronous interface group in global configuration mode.

Command	Function
Ruijie(config)# **interface Group-Async** *number*	Enters the asynchronous interface group configuration mode.
Ruijie(config-if)# **ip address** *address mask* or Ruijie(config-if)# **ip address negotiate** or Ruijie(config-if)# **ip unnumbered** *interface-type interface-number*	Configures the asynchronous interface group IP address: set it directly, or obtain from the peer, or share the IP address of another interface.
Ruijie(config-if)# **encapsulation ppp**	Encapsulates the PPP protocol.
Ruijie(config-if)# **peer default ip address** { **pool** *pool-name* | **dhcp**}	Selects the policy to allocate IP address for dial-in users. For more details on the pool and DHCP, see the chapters below.
Ruijie(config-if)# **async mode dedicated**	Configures the dedication mode.
Ruijie(config-if)# **group-range** *low-end-of-range high-end-of-range*	Specifies the range of the interfaces in the group.
Ruijie(config-if)# **ppp authentication** {**chap| pap**} [*list-name*]	(Optional) Configures the PPP authentication mode. The keyword **list-name** indicates the name of the AAA authentication method list. See the related chapters of security configuration for details.
Router(config-pmap)# **exit**	Exits to the global configuration mode.

In addition to the precding required steps, see the “Configuring More PPP Negotiation Options” section below for more details.

Note Generally, for IP address configuration in step 2, the asynchronous interface group shares the address of a loopback interface.

Caution The asynchronous interface group accepts the dial-in of multiple users, not used for outgoing calls.

Note

Ruijie device supports the dialup with not only PPP but also SLIP. The dialup configuration with SLIP is the same as the PPP configuration except for the PPP authentication configuration, no more details provided here. The configuration examples below will exemplify the dialup with SLIP.

Configuring More PPP Negotiation Parameters

Customizing interface settings

You can customize dialup according to actual requirements.

- Timers on the interface
- Hold queue on the interface

The tasks for the timers on the interface are as follows:

- Idle time of the line
- Fast idle time of the line
- Line invalid time
- Carrier waiting time

Setting the idle time of the line

The idle time of the line means the duration in which the line will be disconnected in case of no data communication in the dialup line. Use the following command to configure the idle time in interface configuration mode.

Command	Function
Ruijie(config-if)# **dialer idle-timeout** *seconds*	Sets the idle time of the line.

Setting the fast idle time of the line

If a dialup line has been activated and is in communication, but the device receives the data that needs to dial on that line to another destination address, line contention occurs. Now the device activates the line fast idle time. If the fast idle time is specified on the current idle line, the device disconnects the current line and dials to connect another destination address.

Within the fast idle time, if the device receives the messages to be sent to the currently-connected destination and match the rule of activating dialup, , it resets the fast idle time of the line.

Use the following command to configure the fast idle time of the line in interface configuration mode.

Command	Function
Ruijie(config-if)# **dialer fast-idle** *seconds*	Sets the fast idle time of the line.

Caution

The fast idle time of the line must be shorter than the idle time of the line.

The data that match the dialup activation rule are called the interested data.

Setting the line invalid time

The line invalid time is the waiting time before it is ready to dial after a line disconnection or dialup failure. Use the following command to configure the line invalid time in interface configuration mode.

Command	Function
Ruijie(config-if)# **dialer enable-timeout** *seconds*	Sets the line invalid time.

Hold queue on the interface

A period of negotiation is needed when the device works with MODEM to dial, during which messages may be RSRpped. If the hold queue is configured, it is possible to hold the messages of dialup activation rule on the device and send after the connection is set up.

Use the following command to configure a hold queue in interface configuration mode.

Command	Function
Ruijie(config-if)# **dialer hold-queue** *packets*	Configures the hold queue on the interface.

The device can store up to 100 message packets.

Address option related configurations

As the dialup server, when the device accepts the incoming dialup from the user, it may need to allocate the IP address to the dial-in user. The device can allocate IP address for the user in any of the following two ways:

- Address pool
- Direct allocation by using the **peer default** *ip address* command

The device allocates IP addresses for users by priority in the descending order:

- IP address allocated through the local address pool
- IP address specified by using the **peer default** *ip address* command

Address pool configuration

Use the following commands to allocate IP address for the dialup users through address pool in global configuration mode.

Command	Function
Ruijie(config)# **ip address-pool local**	(Optional) Sets the local address pool as the default global address pool.
Ruijie(config)# **ip local pool** {*named-address-pool* | **default**} {*first-IP-address* [*last-IP-address*]}	Defines a local address pool.
Ruijie(config)# **interface** *type number*	Selects the asynchronous interface and enters the interface configuration mode.
Ruijie(config-if)# **peer default ip address pool** *named-address-pool*	Applies the defined address pool on the interface.
Router(config-pmap)# **exit**	Exits to the global configuration mode.

Monitoring and Debugging Asynchronous Connections

You can perform the following monitoring and maintaining tasks on the asynchronous interface:

- Monitor the activities on asynchronous interface
- Debug asynchronous interface
- Debug PPP

Use the following commands to monitor the activities of an asynchronous interface in privileged EXEC mode.

Command	Function
Ruijie# **clear line** *line-number*	Disconnects the asynchronous interface connection and returns to the idle status.
Ruijie# **show line** [*line-number*]	Shows the line status of the asynchronous interface.

Use the following command to debug the asynchronous interface in privileged EXEC mode.

Command	Function
Ruijie**# debug async {framing | state | packets}**	Turns on the switch of the asynchronous interface.

Use the following commands to debug PPP in privileged EXEC mode.

Command	Function
Ruijie# **debug ppp negotiation**	Turns on the PPP negotiation process debug switch.
Ruijie# **debug ppp error**	Turns on the PPP negotiation error debug switch.
Ruijie# **debug ppp packet**	Turns on the PPP packet debug switch.
Ruijie# **debug ppp authentication**	Turns on the PPP authentication debug switch.
Ruijie# **debug ppp event**	Turns on the PPP event debug switch.

Example of Configuring Asynchronous Interface

The following configuration examples are provided in this chapter:

- Example of configuring the dialup of a single asynchronous interface
- Example of configuring the dialup on an asynchronous interface group

Example of configuring the dialup of a single asynchronous interface

Configuration requirements

Configure the device to dial to connect the remote server by using the asynchronous interface.

Router configuration

Configure the router as follows:

```
!
hostname "Ruijie"
```

Configure the script used for dialup (Dialout)

```
chat-script Dialout ABORT ERROR ABORT BUSY "" "ATDT\T" TIMEOUT 45 CONNECT \c
```

Configure the asynchronous interface, and the IP address of the interface is allocated by the remote server. The authentication username/password is 163/163, in automatic negotiation mode, line idle time 60 seconds, fast idle time 40 seconds, line invalid time 50 seconds, hold queue size 50 messages, and telephone number 163.

```
interface Async1
 ip address negotiated
 encapsulation ppp
 ppp pap sent-username 163 password 0 163
 async mode dedicated
 dialer in-band
 dialer idle-timeout 60
 dialer fast-idle 40
 dialer enable-timeout 10
 dialer string 163
 dialer hold-queue 50
 dialer-group 1
```

Default route

```
ip route 0.0.0.0 0.0.0.0 Async1
```

Define the dialup activation rule: All IP messages can stimulate the dialup

```
dialer-list 1 protocol ip permit
```

Configure the line parameters of the asynchronous interface: Associate the dialup script, dialup direction incoming/outgoing, allowing all protocol in the incoming direction, and more

```
line 1
 script dialer Dialout
 modem InOut
speed 115200
!
end
```

For dialup with encapsulation of SLIP, the configurations of the router are as follows:

Configure the asynchronous interface: Configure the IP address, in automatic negotiation mode, line idle time 60 seconds, fast idle time 40 seconds, line invalid time 50 seconds, hold queue size 50 messages, and telephone number 163.

```
interface Async1
 ip address 1.1.65.2 255.255.255.0
 encapsulation slip
async mode dedicated
 dialer in-band
 dialer idle-timeout 60
 dialer fast-idle 40
 dialer enable-timeout 10
```

```
dialer string 163
dialer hold-queue 50
dialer-group 1
```

The other configurations are same as the PPP encapsulation configurations.

Note

PPP and SLIP have different implementation mechanisms, with the following key differences:

1. PPP can be configured with authentication parameters but SLIP has no authentication.
2. PPP allows the negotiation of IP address, but SLIP cannot. SLIP specifies the address forcibly.

Example of configuring the dialup on an asynchronous interface group

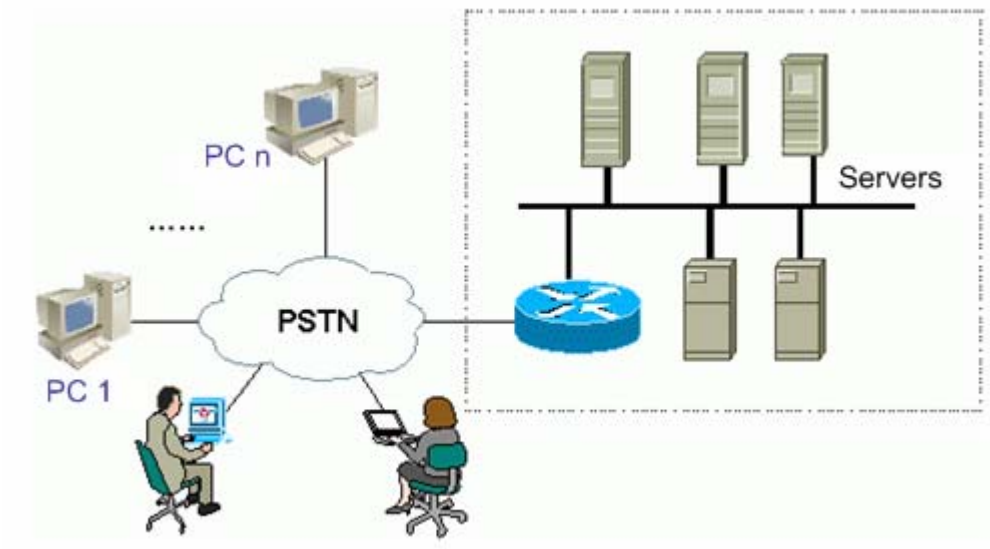
Configuration requirements

This example configures the device as the dialup access server to accept the users' dial-in calls and implement the following dialup requirements:

- Perform PAP authentication for the dialup users
- Allocate IP addresses for the dialup users
- Use the asynchronous interface group
- Use the IP address allocated by the local address pool

The specific network topology is shown in Figure 1:

Figure 1 Example of the dialup on an asynchronous interface group



Router configuration

Configure the router as follows:

```
hostname "Ruijie"
```

Create the username/password for authenticating the dialup

```
username aaa password 0 aaa
```

```
username bbb password 0 bbb
username ccc password 0 ccc
!
interface Loopback0
 ip address 1.1.65.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 192.168.12.1 255.255.255.0
```

Configure the asynchronous interface group; add asynchronous interfaces 1-16 into that group; share the address of the loopback interface; automatic mode; use the local address pool to allocate IP addresses for the dialup users; use PAP to authenticate dialup users.

```
interface Group-Async1
 ip unnumbered Loopback0
 encapsulation ppp
 async mode dedicated
 peer default ip address pool mypool
 ppp authentication pap
 group-range 1 16
```

Define a local address poop mypool to allocate addresses for the dialup users

```
ip local pool mypool 1.1.65.10 1.1.65.100
```

Configure the line parameters of asynchronous interfaces 1-16

```
line 1 16
 modem dialin
 speed 115200
!
End
```

Dialup Script

Script Overview

The chat scripts is the command text strings that are used to control the asynchronous interface dialup, remote login and initializing asynchronous line. The script is generally used to control the asynchronous interface for dialup, or can be configure on the asynchronous line and automatically executed when certain events occur on the line to implement some initialization tasks. The events include:

- Line activation
- Incoming connection initiation
- Asynchronous dial-on-demand routing
- Line reset
- System startup

The script can be executed manually.

Note

If the asynchronous interface is configured to allow only incoming calls (that is, **modem dialin** is configured on the line configuration layer), the scripts for dial-out operations cannot be executed any more.

Script syntax

The common format of the modem scripts is as follows:

```
receive-string1 send-string1 receive-string2 send-string2......
```

Caution

All strings and keywords in the script are case sensitive.

Where:

- receive-string means the receiving string.
- send-string means the sending string.
- The receive-string and send-string often appear in pair, and the script must start with a receive-string, for example, **receive-string1 send-string1 ...** indicating to receive the string receive-string1. If the received string matches receive-string1 before timeout (as long as the received string includes receive-string1), the device sends send-string1 to the modem; otherwise, it stops the execution of the script. Then, the device waits for receive-string2 and continues execution the following scripts, till end of the script.
- If the last string is a send-string, it indicates the end of the script execution after the string is sent and it is not necessary to wait for receiving string any more.
- If the start of the script does not need to wait for the string and directly sends a string, it is possible to set the first send-string as "", whose meaning will be detailed below.
- For the send-string, in addition to the end with \c, a carriage return will be added automatically at the end of the string.
- For matching the receive-string, the location-unrelated match method is used. In other words, the match succeeds as long as the received contents contain the excepted receive-string.
- There may be multiple expected receiving-string for the match of the receive-string, which are connected with "-". If the string before "-" is not received before timeout, it sends the string after the "-" and waits for the next string after the "-". For example, if "pass-\r-PASS" has not received the "pass" upon timeout, it sends a carriage return and continues to wait for "PASS".
- The default timeout time for waiting for receive-string is 5 seconds. It is possible to insert **TIMEOUT seconds** to adjust that time before the receive-string in the script, which keep valid till the next timeout setting.
- The strings or keywords are separated with spaces. If a string contains spaces, it shall be quoted with double-quotation marks (" "). If there is no content within the double-quotation marks, the string may have two different meanings. If the "" is at the start of the script, it indicates not sending any string but just waiting for receive-string. in case of other locations, it is considered that the string contents are "".
- Insert **ABORT receive-string** anywhere in the script to change the execution flow of the script. That is, stop the execution of the script if the received string matches the receive-string. In a script the **ABORT receive-string** may appear for many times, which function together to stop the execution of the script as long as one occurring matches. No matter where the **ABORT receive-string** appears, it will take effect in the process of the script execution. For example, if the modem reports BUSY in case of busy line at dialup, use

the **ABORT BUSY** in the dialup script to indicate the stop. Esc can be inserted in the script to make it better to control the script and increase flexibility. All Esc characters are also the separators of the string at the same time.

List of the script keywords

Keyword	Description
ABORT receive-string	Specifies a string to indicate the failure if it appears in the received string. It is valid during the whole execution process of the script.
TIMEOUT seconds	Sets the time (seconds) to wait for the receive-string, 5 seconds by default.

List of the script Esc characters

ESC characters	Description
“”	Wait for the blank string.
\c	Do not send the added carriage return in sending string. It appears only at the end of the script.
\d	Pause for 2 seconds.
\n	Send a line feed.
\p	Pause for 1/4 seconds.
\r	Send a carriage return.
\s	Send a space.
\t	Send a tab character.
\\	Send a backslash.
\T	Use for the replacement of telephone number. The place with \T will be replaced with a telephone number.

When a connection is set up and the Return key is pressed, prompts often appear only after pressing Return once again. For example:

```
password:-/r-password
```

This command means showing the password after the connection is set up. If not, it is required to press the Return key once again after timeout.

Script naming rules

Ruijie suggests the following naming conventions:

Manufacturer-modem type-model

According to the above rule, the **chat-script** command syntax is as follows:

chat-scripts *Manufacturer-modem type-model* expect-send

For example, if the star 5600DB modem is using the v90 protocol, the script can be named as follows:

```
star-5600db-v90
```

Script configuration tasks

Creating a script

Use the following command to create a script in global configuration mode.

Command	Function
Ruijie(config)# **chat-script** *script-name expect send …*	Creates a script that is used to stimulate the modem or remote login system.

Associating the script with specific event of the asynchronous interface

Associating the script with an event means automatically executing the related script on the device in case the specific event occurs. Ruijie device supports the following script event types:

DDR dialup: Start the dialup script in case of DDR dialup.

Use the following command to associate the script with specific event in line configuration mode.

Command	Function
Ruijie(config-line)# **script dialer** *script-name*	Specifies the modem script to be executed in DDR dialup. At most one **script dialer** command can be configured on a line.

Running the script manually

You can run the script manually on inactive line to control or debug the modem.

Use the following command to run the script manually in privileged EXEC mode.

Command	Function
Ruijie# **debug chat**	Turns on the debugging switch.
Ruijie# **start-chat** *script-name* [*line-number* [*dialer-strin*g]]	Runs the script on the specific line.

Example of Script Configuration

Example of managing modem by using script

Run the script manually on the device to initialize the modem.

```
chat-script factory "" "ATs0=1"
Ruijie#start-chat factory 1           // Run the script on the tty 1 line
```

Explanation of the initialization string:

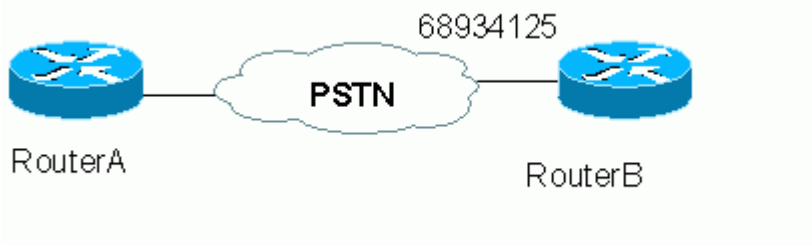
- Lock the rate of the serial interface
- DCD ON detection
- DTR ON disconnection function
- Configure the auto-reply of the Modem

Example of using script to dial and log in

Configuration requirements

RouterA is configured with a script to dial to connect RouterB and log in. See Figure 2.

Figure 2 Example of using script to dial and log in



Router configuration

Configure the router RouterA as follows:

Define a dialup script.

```
chat-script Dialout ABORT ERROR ABORT BUSY  "" "ATDT\T" TIMEOUT 60 CONNECT \c
```

Configure the asynchronous interface, in asynchronous mode.

```
interface async 3
 ip address 1.1.65.2 255.255.255.0
 encapsulation ppp
 async mode dedicated
 dialer in-band
 dialer map ip 1.1.65.1 modem-script Dialout 68934125
 dialer-group 1
```

Configure the line parameter of the asynchronous interface.

```
line 3
 modem InOut
speed 115200
```

Dialup script Dialout explanation:

Wait and send pair	Executing actions
ABORT ERROR ABORT BUSY	Stop the execution of script when text ERROR or BUSY is received
“” "ATDT\T"	Send "ATDT 68934125" directly without waiting any information.
TIMEOUT 60	Wait for only 60 seconds before the next waiting message is received; exit the script upon timeout.
CONNECT \c	Wait for "connect" and send nothing

When the modem dialup script is executed successfully, the device will execute the login script in succession.

Configure the router RouterB as follows:

Define the username/password to authenticate the remote dialup user.

```
username myname password 0 mypassword
```

Configure the asynchronous interface, in interactive mode.

```
interface Async65
 ip address 1.1.65.1 255.255.255.0
 encapsulation ppp
 dialer idle-timeout 60
 dialer enable-timeout 10
 async mode interactive
```

Configure the line parameters of the asynchronous interface; use the local database for authentication.

```
line aux 0
 login
 modem InOut
 speed 115200
!
end
```

The dialing end RouterA must be configured as the automatic negotiation mode, and the accepting end RouterB must be configured as the interactive mode.

Precautions in configuring router RouterA:

If the remote device does not require login authentication, it is not necessary to use **dialer map**. Just configure dialer string, and associate the script with the dialer event of the line, as shown below:

```
!
 interface async 3
 ip address 1.1.65.2 255.255.255.0
 encapsulation ppp
 async mode dedicated
 dialer in-band
 dialer string 68934125
 dialer-group 1
```

Configure the line parameter of the asynchronous interface.

```
line 3
script dialer Dialout
  modem InOut
speed 115200
```

Note

If there is no special requirement, use the following dialup script:

chat-script Dialout ABORT ERROR ABORT BUSY "" "ATDT\T" TIMEOUT 45 CONNECT \c

DDR

Preparation for DDR

The dialer in-band is configured on the interface to let the interface dial out, which is called DDR.

Generally the DDR is configured on the logical interface (dialer), compatible with Cisco and divided into the legacy DDR and Dialer Profiles DDR. The dialup of the asynchronous interface allows DDR. The context can help judge whether the dialup is on the logical interface or asynchronous interface.

Which DDR to select

Dialer Profiles

The implementation of Dialer Profiles is based on the logical and physical interfaces separately. It allows each dialup to invoke the physical interface to dynamically associate with the logical interface.

The Dialer Profiles are generally used in the following cases:

- Sharing one physical asynchronous interface for dial-in/out
- Different configurations for each user

Since the IP address negotiation is not required in the dialup with Dialer Profiles, the IP address configured with the **dialer map** command is used as the peer IP address. So, if you decide to use **Dialer Profiles**, it is required to disable the source address authentication for the supported routing protocol.

Legacy DDR

The legacy DDR is based on the static association between destination address and physical interface and binds the physical interface to a destination address. It features no expandability or flexibility.

It is mostly used on physical interfaces, and in the case when the destination address is bound with physical interface to make management easier.

You may select Dialer Profiles or Legacy DDR by the actual network requirements.

Configuration Preparations for DDR

The following tasks must be completed before the DDR is configured:

- Access list, used to define the dialup activation rule
- Define the dialup activation rule dialer-list
- Define the dialup script

Defining an access list

Use the following command to define the access list in global configuration mode.

Command	Function
Ruijie(config)# **access-list** *access-list-number* {**deny** | **permit**} *source [source-mas*k] or	Defines the standard access list: or extended access list.

Command	Function
Ruijie(config)# **access-list** *access-list-number* {**deny** | **permit**} *protocol source source-mask destination destination-mask [operator operan*d]	

Defining the dialup activation rule

Use the following command to define the dialup activation rule in global configuration mode.

Command	Function
Ruijie(config)#**dialer-list** number dialer-group **protocol** protocol-name {**permit** | **deny** | **list** access-list-number | access-group}	Defines the dialup activation rule.

Defining the dialup script

Use the following command to define the script in global configuration mode.

Command	Function
Ruijie(config)# **chat-script** *script-name expect send …*	Creates a script that is used to stimulate the modem or remote login system.

Legacy DDR Configuration

Legacy DDR configuration tasks

Before configuring the legacy DDR, make sure the preceding preparations are completed. To configure the legacy DDR on the interface, complete the following configuration tasks:

- Specify the interface (mandatory)
- Enable the DDR on the interface (mandatory)
- Configure the dialup direction of the interface: incoming only, outgoing only or both (mandatory)
- Configure the authentication information (optional)
- Associate the dialup activation rule (optional)
- Customize the Interface parameters (optional)

To monitor the legacy DDR, see the contents in the next section.

Specifing an interface

Use the following command to specify the interface in global configuration mode.

Command	Function
Ruijie(config)# **interface async** *number* or Ruijie(config)# **interface dialer** *number*	Specifies the DDR interface or asynchronous interface, which can be a logical interface.

Note No matter the physical interface or logical interface, the DDR interface is finally implemented on the physical interfaces.

This chapter emphasizes the DDR dialup on logical interface. For the DDR dialup on physical interfaces, see the above Asynchronous Interface Dialup.

Enabling the DDR on the interface

Use the following command to enable the DDR on the interface in interface configuration mode.

Command	Function
Ruijie(config-if)# **dialer in-band**	Enables the DDR on the interface.

Note If the DDR is enabled on the interface, the interface accepts both dial-in and dial-out.

Configuring the dialup direction

For the DDR dialup, the configuration of dialup direction involves the difference between center and remote branch. Both the physical interface and the logical interface can be a center or remote branch. In general cases, however, the center uses the logical interface for dialup while the remote branch uses the physical interfaces for dialup. The configuration tasks below deal with the center and remote branch respectively.

1) Configuring the interface as dial-out only

- **Remote branch**

Use the following command to configure dial-out only on the remote branch interface in interface configuration mode.

Command	Function
Ruijie(config-if)# **dialer string** *dial-strin*g or Ruijie(config-if)# **dialer map** *protocol next-hop-address* [**modem-script** *script-name*] [**system-script** *script-name*] *dial-string*	Specifies the telephone number of the destination.

To authenticate dial-in, use the **dialer map** to specify the destination.

Caution Since the current version of Ruijie device has not defined a default script for dialup, it is required to specify the dialup script. So, if the destination telephone number is specified with **dialer string**, it is required to use **script dialer** to associate the dialup script in the line configuration layer.

- **Center**

Use the following command to configure dial-out only on the center interface in interface configuration mode.

Command	Function
Ruijie(config-if)# **dialer map** *protocol next-hop-address* [**modem-script** *script-name*] [**system-script** *script-name*] *dial-string*	Specifies the telephone number of the destination.

Since the center needs to dial to connect the remote branch, only **dialer map** can be used to specify the telephone number. For the configuration for dialup to different remote branches, just repeat the above steps.

In general cases, the center uses the logical interface for dialup, so it is required to bind the physical interface to the logical interface. Use the following commands to bind the physical interface to the logical interface in global configuration mode.

Command	Function
Ruijie(config)# **interface async** *number*	Specifies the physical interface to be used.
Ruijie(config-if)# **dialer rotary-group** *number*	Binds the physical interface to the specific logical interface.

For each physical interface used by the logical interface (dialer), repeat the preceding two steps.

2) Configuring the interface as dial-in only

- **Remote branch**

If the DDR is enabled on the interface by using the **dialer in-band** command, the interface will allow dial-in only. The remote branches accept only dial-in and do not need any other configurations. No parity is required. If it is required to enhance security, configure the authentication by referring to the sections of configuring authentication information in this chapter.

- **Center**

If the DDR is enabled on the interface by using the **dialer in-band** command, the interface will accept the dial-in from multiple remote branches.

If the interface is configured to accept the dial-in from multiple remote branches, it is required to perform authentication for the remote branches. For details, see the section of configuring authentication information in this chapter.

If the center uses the logical interface (dialer) for dial-in, it is required to bind the physical interface.

Use the following commands to bind the physical interface to the logical interface in global configuration mode.

Command	Function
Ruijie(config)# **interface async** *number*	Specifies the physical interface to be used.
Ruijie(config-if)# **dialer rotary-group** *number*	Binds the physical interface to the specific logical interface

For each physical interface used by the logical interface (dialer), repeat the preceding two steps.

3) Configuriing the interface as both dial-in and dial-out

- **Remote branch**

If **dialer in-band** has been configured, the interface accepts dial-in. To allow dial-out of the interface, it is required to define the dialup destination.

Use the following command to configure the dialup destination in interface configuration mode.

Command	Function
Ruijie(config-if)# **dialer string** *dial-strin*g or	Specifies the telephone number of the destination.

Command	Function
Ruijie(config-if)# **dialer map** *protocol next-hop-address* [**modem-script** *script-name*] [**system-script** *script-name*] *dial-string*	

To authentication the dial-in, use the **dialer map** command to specify the dialup destination.

Note Since the current version of Ruijie device has not defined a default script for dialup, it is required to specify the dialup script. So, if the destination telephone number is specified with **dialer string**, it is required to use **script dialer** to associate the dialup script in the line configuration layer.

- **Center**

Similar to the remote branches, if **dialer in-band** has been configured, the interface accepts dial-in. To allow dial-out of the interface, it is required to define the dialup destination.

Use the following command to configure the dialup destination in the interface configuration mode.

Command	Function
Ruijie(config-if)# **dialer string** *dial-strin*g or Ruijie(config-if)# **dialer map** *protocol next-hop-address* [**modem-script** *script-name*] [**system-script** *script-name*] *dial-string*	Specifies the telephone number of the destination

To define the general dialup destination or authentication the dial-in, use the **dialer map** command to specify the dialup destination.

If the center uses the logical interface (dialer) for dial-in, it is required to bind the physical interface.

Use the following commands to bind the physical interface to the logical interface in global configuration mode.

Command	Function
Ruijie(config)# **interface async** *number*	Specifies the physical interface to be used.
Ruijie(config-if)# **dialer rotary-group** *number*	Binds the physical interface to the specific logical interface.

For each physical interface used by the logical interface (dialer), repeat the preceding two steps.

Note Since the current version of Ruijie device has not defined a default script for dialup, it is required to specify the dialup script. So, if the destination telephone number is specified with **dialer string**, it is required to use **script dialer** to associate the dialup script in the line configuration layer.

Configuring the authentication information

The authentication can be implemented through CHAP or PAP. In addition, the interface must be configured to map the host protocol address to the hostname for authenticating the remote host.

Use the following commands to configure the interface authentication in interface configuration mode.

Command	Function
Ruijie(config-if)# **encapsulation ppp**	Encapsulates PPP. This is required because only PPP supports the authentication.
Ruijie(config-if)# **ppp authentication chap** or Ruijie(config-if)# **ppp authentication pap**	Configures the authentication method (PAP or CHAP).
Ruijie(config-if)# **dialer map** *protocol next-hop-address* **name** *hostname* [**modem-script** *script-name*] [**system-script** *script-name*] *dial-string*	Maps the host address to hostname
Router(config-pmap)# **exit**	Returns to the global configuration mode.
Ruijie(config)# **username** *name* **password** *secret*	Defines the username/password for local authentication.

Note Generally the DDR dialup works with the local authentication. Only when the asynchronous interface group accepts dial-in, AAA is used to authenticate the dial-in user.

Associating the dialup activation rule

For the dialup on the interface, it is required to associate one and only one dialup activation rule. Use the following command to associate the dialup activation rule in global configuration mode.

Command	**Function**
Ruijie(config-if)# **dialer-group** *group-number*	Associates the dialup activation rule.

Customizing the Interface parameters

In the network, it is possible to customize the dialup as required according to the actual requirements.

- Timers on the interface
- Hold queue on the interface
- Dialup interface priority
- Load bandwidth

The tasks for the timers on the interface are as follows:

- Idle time of the line
- Fast idle time of the line
- Line invalid time
- Carrier waiting time

Setting the idle time of the line

The idle time of the line means the duration in which the line will be disconnected in case of no data communication in the dialup line. Use the following command to configure the line idle time in interface configuration mode.

Command	Function
Ruijie(config-if)# **dialer idle-timeout** *seconds*	Sets the idle time of the line.

Setting the fast idle time of the line

If a dialup line has been activated and is in communication, but the device receives the data that needs to dial on that line to another destination address, line contention occurs. Now the device activates the line fast idle time.

If the fast idle time is specified on the current idle line, the device disconnects the current line and dials to connect another destination address.

Within the fast idle time, if the device receives messages that are to be sent to the currently-connected destination and match the stimulation dialing rule, it resets the fast idle time of the line.

Use the following command to configure the fast idle time of the line in interface configuration mode.

Command	Function
Ruijie(config-if)# **dialer fast-idle** *seconds*	Sets the fast idle time of the line.

Caution The fast idle time of the line must be shorter than the idle time of the line.
The data that matches the dialup activation rule is called the interested data.

Setting the line invalid time

The line invalid time is the waiting time before it is ready to dial after a line disconnection or dialup failure. Use the following command to configure the line invalid time in interface configuration mode.

Command	Function
Ruijie(config-if)# **dialer enable-timeout** *seconds*	Sets the line invalid time.

Setting the carrier waiting time

The carrier waiting time means the time to wait for the modem handshake to generate the carrier. Use the following command to configure the carrier waiting time in interface configuration mode.

Command	Function
Ruijie(config-if)**# dialer wait-for-carrier-time** *seconds*	Sets the carrier waiting time.

Hold queue on the interface

A period of negotiation is needed when the device works with MODEM to dial, during which messages may be dropped. If the hold queue is configured, it is possible to configure the dialup activation rule messages to hold on the device and will be sent once the connection is set up.

Use the following command to configure a hold queue in interface configuration mode.

Command	Function
Ruijie(config-if)# **dialer hold-queue** *[packets]*	Configures the hold queue on the interface.

The device can store up to 100 packets.

Configuring the interface priority

Configuring the priority of the physical interface bound by a logical interface (dialer) makes a higher priority be assigned to the interface that is connected to a faster and more reliable modem, so that the use of the interface with higher priority can be maximized.

Use the following command to configure the interface priority in interface configuration mode.

Command	Function
Ruijie(config-if)# **dialer priority** *number*	Configures the interface priority.

The range of *number* is 0-255, 0 by default for the lowest priority, 255 for the highest priority. It is applicable to dial-out only.

Setting the load bandwidth

If there are multiple connections to the same destination, it is possible configure the load bandwidth. When the load of the active connections exceeds the configured bandwidth, it enables another connection that can dial to the same destination. This helps ensure the communication quality.

Use the following command to configure the load bandwidth in interface configuration mode.

Command	Function
Ruijie(config-if)# **dialer load-threshold** *load*	Sets the load bandwidth.

Once multiple connections are set up, there is still legacy bandwidth. If the total loads of all lines are below the preset value, the idle connections will be disconnected.

Monitoring legacy DDR

Use the following commands to monitor the legacy DDR in privileged EXEC mode.

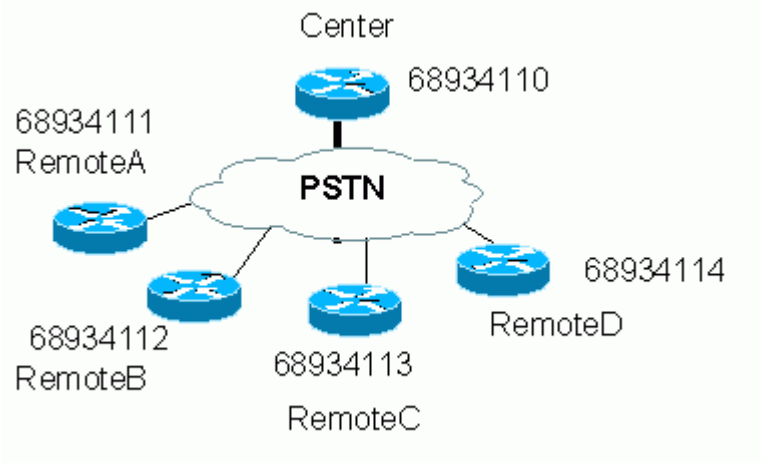
Command	Function
Ruijie# **show dialer** [**interface** *interface-type numbe*r]	Shows the general diagnosis information of the interface.
Ruijie# **show dialer maps**	Shows the dialup mapping information on the device.
Ruijie# **clear dialer** [**interface** *interface-type numbe*r]	Clears the diagnosis statistics.
Ruijie# **debug dialer packet**	Turns on the debugging switch of the logical interface.

Example of the legacy DDR configuration

Configuration requirements

This configuration requires that the center can dial to connect multiple remote branches and also accept the dial-in from them, and perform authentication for the dial-in users. The remote branches can dial to connect the center and also accept the dial-in from the center, and perform authentication for the center. See the figure below.

Figure 3



Router configuration

Configure the central router as follows:

Hostname

```
hostname "Center"
```

Define the username/password to authenticate the remote branches.

```
username RemoteA password 0 RemoteAword
username RemoteB password 0 RemoteBword
username RemoteC password 0 RemoteCword
username RemoteD password 0 RemoteDword
```

Define the dialup script.

```
chat-script Dialout ABORT ERROR ABORT BUSY "" "ATDT\T" TIMEOUT 45 CONNECT \c
```

Asynchronous interface 1, bound to the logical dialup interface (dialer 1)

```
interface Async1
 no ip address
 encapsulation ppp
 async mode dedicated
 dialer in-band
 dialer rotary-group 1
```

Asynchronous interface 2, bound to the logical dialup interface (dialer 1), priority 100

```
interface Async2
 no ip address
 encapsulation ppp
 async mode dedicated
 dialer in-band
 dialer rotary-group 1
 dialer priority 100
```

Asynchronous interface 3, bound to the logical dialup interface (dialer 1)

```
interface Async3
 no ip address
 encapsulation ppp
 dialer in-band
 dialer rotary-group 1
```

Define the logical interface.

```
interface Dialer1
 ip address 1.1.65.1 255.255.255.0
 encapsulation ppp
 dialer in-band
 dialer map ip 1.1.65.2 name RemoteA modem-script Dialout 68934111
 dialer map ip 1.1.65.3 name RemoteB modem-script Dialout 68934112
 dialer map ip 1.1.65.4 name RemoteC modem-script Dialout 68934113
 dialer map ip 1.1.65.5 name RemoteD modem-script Dialout 68934114
 dialer-group 1
 ppp authentication chap
```

Define the dialup activation rule.

```
dialer-list 1 protocol ip permit
```

Define the line parameters.

```
line 1 16
 modem InOut
 speed 115200
!
end
```

Configurations for the four remote branches are similar. The following shows the configurations for RemoteA:

Hostname

```
hostname RemoteA
```

Username/password pair

```
username Center password 0 RemoteAword
```

Configure the asynchronous interface.

```
interface Async1
 ip address 1.1.65.2 255.255.255.0
 encapsulation ppp
 dialer in-band
 dialer string 68934110
 dialer-group 1
 async mode dedicated
 ppp authentication chap
```

Configure the line parameters.

```
line 1
 script dialer Dialout
 modem InOut
speed 115200
```

Define the dialup activation rule.

```
dialer-list 1 protocol ip permit
```

If the remote branches do not perform authentication for the center, just delete the **ppp authentication chap** configuration on the interface.

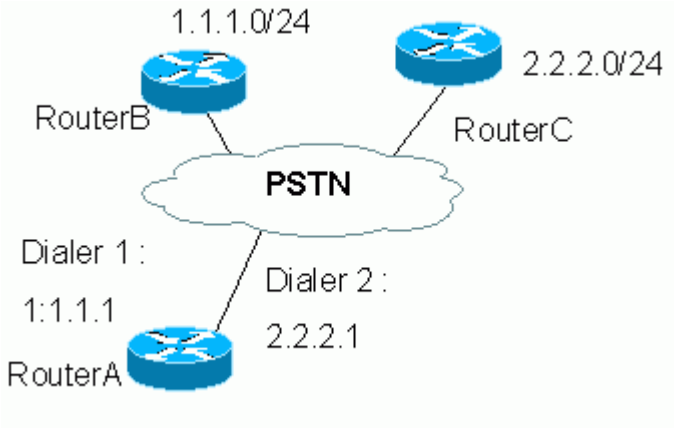
Dialer Profiles DDR

Dialer Profiles DDR Overview

The Dialer Profiles DDR separate the physical interface configurations from the logical interface configurations for the dialup, so that the logical configurations and physical configurations are dynamically associated in the invoking. The implementations are described as follows: The physical interface is bound to one or more dialer pool(s), the logical interface is used to define the dialup invoking parameters and associated with a defined dialer pool, and the dialup is implemented via the physical interface in the dialer pool.

With Dialer Profiles DDR, all invokes for the same destination use the same logical interface. To access different destination address, it is required to configure different logical interfaces. See the following figure.

Figure 4



The center router RouterA has to access the network 1.1.1.0/24 via dialer 1, or the network 2.2.2.0/24 via dialer 2. Dialer 1 cannot access the network 2.2.2.0/24, and dialer 2 cannot access the network 1.1.1.0/24.

Using the Dialer Profiles DDR, the physical interface does not need any configurations except for the encapsulation type and dialer pool. The authentication command must be configured on the physical interface since the logical interface cannot copy the authentication command to the physical interface.

With Dialer Profiles DDR, one logical interface can only use one dialer pool but one physical interface can belong to one or more dialer pool(s). If interface contention occurs, different priorities can be configured for the physical interface and the logical interface. The one with higher priority will be used first.

Configuration tasks for Dialer Profiles DDR

Before configuring the Dialer Profiles DDR, make sure the preceding preparations are completed. The Dialer Profiles DDR configuration involves the following tasks:

- Configure the logical interface
- Configure the physical interface

Configuring the logical interface

One device can have multiple logical interfaces created, each of which implements all the configurations for the access to one destination network.

Use the following commands to configure the logical interface in global configuration mode.

Command	Function
Ruijie(config)# **interface dialer** *number*	Creates a logical interface and enters the logical interface configuration mode.
Ruijie(config-if)# **ip address** *address mask*	Configures the IP address of the logical interface, which must be in the same network segment as the destination network to be accessed.
Ruijie(config-if)# **encapsulation ppp**	Encapsulates PPP.
Ruijie(config-if)# **dialer string** *dial-string*	Specifies the telephone number of the destination.
Ruijie(config-if)# **dialer pool** *number*	Associates the specific dialer pool.
Ruijie(config-if)# **dialer-group** *group-number*	Associates the dialup activation rule.
Ruijie(config-if)# **dialer remote-name** *name*	Specifies the remote host user name.

Configuring the physical interface

Use the following commands to configure the physical interface in global configuration mode.

Command	Function
Ruijie(config)# **interface** *type number*	Selects the physical interface and enters the interface configuration mode.
Ruijie(config-if)# **encapsulation ppp**	Encapsulates PPP.
Ruijie(config-if)# **ppp authentication chap**	Specifies the CHAP authentication to accept dial-in only.
Ruijie(config-if)# **dialer pool-member** *number* [**priority** *priority*]	Binds the physical interface to the specific dialer pool.
Ruijie(config-if)# **dialer pool-member** *number* [**priority** *priority*]	(Optional) Binds the physical interface to another dialer pool.

For the physical interface prepared for the profile DDR, repeat the preceding steps.

Monitoring Dialer Profiles DDR

Use the following commands to monitor the Dialer Profiles DDR in privileged EXEC mode.

Command	Function
Ruijie# **show dialer** [**interface** *interface-type number*]	Shows the general diagnosis information of the interface.
Ruijie# **show dialer maps**	Shows the dialup mapping information on the device.
Ruijie# **clear dialer** [**interface** *interface-type number*]	Clears the diagnosis statistics.
Ruijie#**debug dialer packet**	Turns on the debug switch of the logical interface.

Example of the Dialer Profiles DDR configuration

Configuration requirements

Use the dialer profiles DDR, dial out from the center interface, accept the dial-in from multiple branches, and perform authentication for the dial-in users. The topology is shown in Figure 4.

Router configuration

Configure the center router RouterA as follows:

Hostname

```
hostname "RouterA"
```

Username/password pair

```
username RouterB password 0 RouterBword
username RouterC password 0 RouterCword
```

Configure the dialup script.

```
chat-script Dialout ABORT ERROR ABORT BUSY "" "ATDT\T" TIMEOUT 45 CONNECT \c
```

Configure asynchronous interface 1 and bind to dialer pool 1.

```
interface Async1
 no ip address
 encapsulation ppp
 async mode dedicated
 dialer in-band
 dialer pool-member 1
 ppp authentication chap
```

Configure asynchronous interface 2 and bind to dialer pool 1.

```
interface Async2
 no ip address
 encapsulation ppp
 async mode dedicated
 dialer in-band
 dialer pool-member 1
 ppp authentication chap
```

Configure asynchronous interface 3 and bind to dialer pool 1.

```
interface Async3
 no ip address
 encapsulation ppp
 dialer in-band
 dialer pool-member 1
 ppp authentication chap
```

Configure logical interface 1, with IP address within network segment 1.1.1.0/24.

```
interface Dialer1
 ip address 1.1.1.1 255.255.255.0
 encapsulation ppp
ppp authentication chap
 dialer enable-timeout 10
 dialer pool 1
 dialer remote-name RouterB
 dialer string 68934111
 dialer-group 1
```

Configure logical interface 2, with IP address within network segment 2.2.2.0/24.

```
interface Dialer2
 ip address 2.2.2.1 255.255.255.0
 encapsulation ppp
 ppp authentication chap
 dialer pool 1
 dialer remote-name RouterC
 dialer string 68934112
 dialer-group 1
```

Define the rule to trigger dialup.

```
dialer-list 1 protocol ip permit
```

Configure the line parameters and associate the dialup script.

```
line 1 16
 script dialer Dialout
 modem InOut
 speed 115200
!
end
```

Configurations for RouterB and RouterC are similar. The following shows the configurations for RouterB:

Hostname

```
hostname RouterB
```

Username/password pair

```
username RouterA password 0 RouterBword
```

Configure the asynchronous interface.

```
interface Async1
 ip address 1.1.1.2 255.255.255.0
 encapsulation ppp
 dialer in-band
 dialer string 68934110
 dialer-group 1
 async mode dedicated
 ppp authentication chap
```

Configure the line parameters.

```
line 1
 script dialer Dialout
 modem InOut
 speed 115200
```

Define the dialup activation rule.

```
dialer-list 1 protocol ip permit
```

If the remote branches do not perform authentication for the center, just delete the **ppp authentication chap** configuration on the interface.

PPPoE Dialup

PPPoE Overview

Ruijie Device supports PPP running on the Ethernet (PPPoE, PPP over Ethernet) interface for DDR. Its characteristics are like the DDR: stimulating dialup if there is data communication and automatically disconnecting the line when it is idle for the specified period.

The PPPoE implementation on Ruijie devices is similar to DDR Profiles, which binds the Ethernet interface to the logical interface and performs the negotiations on the logical interface.

PPPoE Configuration Tasks

From the implementation of PPPoE, the PPPoE configuration tasks include:

- Configuring the Ethernet interface
- Configuring the logical interface
- Configuring the necessary global parameters

Configuring the Ethernet interface

The configuration of the Ethernet interface includes:

- Enable the PPPoE on the interface

- Bind the Ethernet interface to the specified dialer pool

Some basic configurations of the Ethernet interface are also required, such as the interface activation (**no shutdown**).

Use the following command to enable PPPoE on the Ethernet interface in interface configuration mode.

Command	Function
Ruijie(config-if)# **pppoe enable**	Enables PPPoE.

Since PPPoE is implemented via DDR Profiles, it is required to bind the Ethernet interface to the specified dialer pool available for the use of the logical interface in DDR Profiles. Use the following commands to bind the Ethernet interface to the specified dialer pool in interface configuration mode.

Command	Function
Ruijie(config-if)# **pppoe-client dial-pool-number** *pool-number* **dial-on-demand**	Binds the Ethernet interface to the specified logical dialer pool (to enable the DDR function. The dialup to the PPPoE server is activated only when there is some message).
Ruijie(config-if)# **pppoe-client dial-pool-number** *pool-number* **no-ddr**	Binds the Ethernet interface to the specified logical dialer pool (to enable automatic dialup to the PPPoE server).

Note One of **dial-on-demand** and **no-ddr** must be selected. **dial-on-demand** enables the PPPoE DDR function to disconnect the line when the specified idle period expires; **no-ddr** enables the PPPoE auto-dialup function to dial to the PPPoE server automatically.

Configuring the logical interface

All PPP negotiations of the PPPoE dialup are based on the logical interface, so it is required to configure the PPPoE dialup related parameters on the logical interfaces.

Use the following commands to configure the logical interface in global configuration mode.

Command	Function
Ruijie(config)# **interface dialer** *dialer-number*	Enters the specified logical interface.
Ruijie(config-if)# **ip address negotiate**	Obtains address from negotiation .
Ruijie(config-if)# **dialer pool** *pool-number*	Associates the dialer pool, with the one in the Ethernet interface one-by-one.
Ruijie(config-if)# **dialer idle-timeout** *seconds*	(Optional) Configures the timeout time to disconnect the line when the specified idle time times out.
Ruijie(config-if)# **encapsulation ppp**	Encapsulates PPP because PPPoE is based on PPP.
Ruijie(config-if)# **mtu 1488**	Configures the maximum transmission unit as 1488.
Ruijie(config-if)# **dialer-group** *dialer-group-number*	Sets the dialer group associated with the dialup

Command	Function
	activation rule.
Ruijie(config-if)# **ppp pap sent-username** *username* **password** *password*	Configures the username and password for authentication.

Note

Except for the command in step 4, all other commands are required. Especially in step 6, the MTU value must be 1488 for normal communication.

If the IP address of the logical interface is modified after a PPPoE connection has been set up, run the **clear pppoe tunnel** command to trigger PPPoE re-negotiation for the modification to take effect in privileged mode.

Configuring the necessary global parameters

The necessary PPPoE global parameters include:

- Define the dialup activation rule
- Configure the dialup route

To use PPPoE with other functions, such as NAT, it is required to configure other global parameters. The global parameters must be configured according to the actual conditions.

Use the following command to define the dialup activation rule in global configuration mode.

Command	Function
Ruijie(config)# **dialer-list** *dialer-group- number* **protocol** *protocol-name* {**permit** | **deny** | **list** *access-list-number* }	Defines the dialup activation rule.

Since the IP address of the interface is generally obtained from the negotiation and there is no directly-connected route of the logical interface, it is required to configure a dialup route to the destination for the logical interface with the PPPoE dialup, so that the data can be forwarded via the PPPoE interface.

Use the following command to configure the dialup route in global configuration mode.

Command	Function
Ruijie(config)# **ip route 0.0.0.0 0.0.0.0 dialer** *dialer-number* [**permanent**]	Sets the default route. The **permanent** option enables the route always valid, even when the logical interface is in the line invalid period (enable-timeout) (here, the logical interface is in the down status).

Note

It is also possible that the dialup route is not configured as the default route, and the specified route is configured as required. In whatever conditions, a dialup route must be configured to make dialup possible.

Monitoring PPPoE

Use the following commands to monitor the PPPoE in privileged EXEC mode.

Command	Function
Ruijie# **show pppoe** {**tunnel** | **session**}	Shows the PPPoE configuration.
Ruijie# **show interfaces dialer** *dialer-number*	Shows the logical interface configuration.
Ruijie# **debug pppoe** {**datas**|**errors**|**events**|**packets** }	Turns on the PPPoE debug switch.

PPPoE Configuration Examples

Configuration requirements

The WAN interface of RSR series is used to dial via PPPoE to the broadband network of China Telecom.

Configuration requirements:

1) The timeout time is 5 minutes, that is, the line is disconnected automatically if there is no data communication in 5 minutes.
2) The username and password are pppoe and pppoe.
3) The NAT function is used, and the internal network segment is 192.168.0.0/24.

Router configuration

The following shows configurations of the router:

```
!
hostname "Ruijie"
!
ip subnet-zero
```

Enable PPPoE, and bind the Ethernet interface to dialer pool 10.

```
interface FastEthernet0/0
 no ip address
 duplex auto
 pppoe enable
 pppoe-client dial-pool-number 10 dial-on-demand
```

Connect the Ethernet interface of the internal LAN.

```
interface FastEthernet0/1
 ip address 192.168.0.1 255.255.255.0
 ip nat inside
 ip mtu 1488
 duplex auto
 speed auto
```

Configure the logical interface.

```
interface Dialer1
 ip address negotiate
```

```
 mtu 1488
 encapsulation ppp
 ip nat outside
 dialer pool 10                    /Associate dialer pool 10
 dialer-group 1
 dialer idle-timeout 300               //5 minutes
 ppp pap sent-username pppoe password 0 pppoe
!
ip nat inside source list 1 interface Dialer1
access-list 1 permit any
ip route 0.0.0.0 0.0.0.0 Dialer1
!
dialer-list 1 protocol ip permit
!
line con 0
line aux 0
line vty 0 4
 login
!
end
```

ISDN Dialup

ISDN Overview

The remote connection technology was based on the analog system before but now it is evolving to the digital system. Digital technologies have been a choice of high speed and cost effective for the telecom. The integrated service digital network (ISDN) is an advanced digital technology that is used to provide the temporary remote access for the network of enterprises.

The following two application cases are possible: a station needs to communicate with another one at a very small time interval. For example, a station may need to send a large file at specific time in a week, or use the dialup connection as the backup of the dedicated line. The temporary remote connection can also be used as the remote office or support technology for enterprise networks. In similar cases, the ISDN dialup connection provides a solution. It eliminates any analog signal conversion during the communication. The "call" is a kind of end-to-end digital communication.

There are two types of ISDN service (BRI, PRI):

- The BRI service provides two ISDN Bearer (B) channels and one ISDN data (D) channel. The B channel is used for the transmission of data, voice, video or fax. The D channel transmits out-of-band signals that are used to set up or release the call.
- The PRI service provides 23 B channels and one D channel. The transmission rate of each B channel is 56 kbit/s or 64 kbit/s. The transmission rate depends on the ISDN type of the office end.

Ruijie device supports the BRI service. The following functions are provided by the BRI interface:

- The ISDN BRI supports all general dialup network access functions. It can implement the uni-/bi-channel data communication of one interface and the data communication of 4-channel bundle of two interfaces.

- The ISDN BRI supports the general backup function as the backup interface, and the backup bandwidth and dynamic routing backup functions.
- The ISDN BRI supports most dialer interfaces, multilink communication and legacy DDR and callback. It does not support the profile DDR function.
- For the bi-channel control, the ISDN BRI has the following methods: Design the upper threshold via the BIR interface, and enable the second channel when the threshold is exceeded.
- The ISDN BIR supports two interface modes: U interface and S/T interface.
- The encapsulation protocol of the ISDN B channel is PPP.

ISDN BRI Configuration Tasks

The ISDN BRI configuration tasks involve:

- Configuring the BRI interface uni-channel
- Configuring the BRI interface bi-channel
- Customizing the BRI parameters

Configuring the BRI interface uni-channel

The default BRI working mode is the uni-channel. Use the following commands to configure the BRI dialup in the uni-channel mode in global configuration mode.

Command	Function
Ruijie(config)# **interface bri** *number*	Specifies the physical interface and enters the BRI interface configuration mode.
Ruijie(config-if)# **ip address** *address mask* or Ruijie(config-if)# **ip address negotiate**	Configures the IP address of the BRI interface: Specify it directly or obtain from the negotiation
Ruijie(config-if)# **encapsulation ppp**	Encapsulates PPP.
Ruijie(config-if)# **dialer-group** *group*	Associates a rule to stimulate dialup.
Ruijie(config-if)# **dialer string** *number* or Ruijie(config-if)# **dialer map** *protocol next-hop-address dial-string* [**broadcast**]	Configures the telephone number for dialup.
Ruijie(config-if)# **ppp authentication** {**chap**| **pap**}	(Optional) Configures the PPP authentication mode.
Router(config-pmap)# **exit**	Returns to the global configuration mode.

The BRI interface attributes are similar to the logical interface. It is in the spoof (up) status without the necessity of configuring **dialer in-band**. There is no corresponding line configuration layer.

Note For the ISDN dialup, it is just required to specify the telephone number and not required to configure the dialup script.

Caution If the dynamic routing protocol is configured on the BRI interface and **dialer map** is used to specify the destination telephone number, the **broadcast** option must be used; otherwise, the routing information cannot be transferred on the BRI interface. For example:

```
dialer map ip 20.20.20.2 name router1 broadcast 3708414
```

Configuring the BRI interface bi-channel

The BRI interface bi-channel differs from the uni-channel in the following aspects:

- The rate of a bi-channel is twice that of a uni-channel.
- Some functions (such as the multilink) can be used only in the bi-channel working mode.

The configurations for the bi-channel and uni-channel are the same except for the working mode. To configure the BRI interface dialup in the bi-channel working mode, just specify the working mode in addition to the above configurations.

Use the following commands to configure the bi-channel working mode of the BRI interface in BRI interface configuration mode.

Command	Purpose
Ruijie(config-if)# **dialer load-threshold** *load*	Enables the second BRI channel according to the bandwidth.
Ruijie(config-if)# **ppp multilink**	Configures the multilink bundle of the bi-channel of the BRI interface.

When the line load exceeds the specified threshold, the second channel will be enabled. When the traffic is less than the specified threshold, the second channel will be disconnected.

Note additionally that the use of the BRI bi-channel is actually the process of a multilink bundle. So, it is necessary to configure the PPP multilink.

Note The bi-channel threshold is not a percentage but the line load value, 255 for full load. In other words, **dialer load-threshold** x means when the line load exceeds x/255, Ruijie device uses the second channel for dialup.

Customizing the BRI parameters

The use of the ISDN BRI is like an asynchronous interface at high rate has the same functions or services as the asynchronous interface:

- Backup function: the ISDN BRI interface can act as a backup interface of the main line and performs dialup when the main line is faulty.
- Callback function: Similar to the common asynchronous interface, the ISDN BRI also supports callback.
- DDR dialup function: Similar to the common asynchronous interface, ISDN BRI interface supports the physical interface to be bound to a rotary-group for the implementation of legacy DDR.

The backup, callback and DDR configurations of the ISDN BRI are the same as those for the asynchronous interface. To customize the ISDN BRI parameters for backup, callback and DDR dialup, see the related contents or the configuration example for the asynchronous interface.

Configuring ISDN PRI

Configuring the PRI interface

Ruijie routers support E1-based PRI operating mode. E1-based PRI uses HDB3 encoding and CRC-4 to create frames.

To configure dial-up connection over B-channel for ISDN PRI interface, you need to first configure the time-slot for PRI on the corresponding EI controller to form a logical synchronization interface. By default, all 30 B channels and 1 D channel will be used. The range of B-channel is 1-31, while time-slot 16 is exclusively used by D channel. On the synchronization interface formed, since its range is 0-30, the corresponding D-channel is identified as "interface serial controller-number: 15", for example, "interface serial 0:15". When this logical synchronization interface is created, the time-slot corresponding to the D-channel on this interface must be configured. The configuration thereon will apply to all B channels thereof.

CE1/PRI interface can only be bound and generate one pri-group, with the same logic behavior as ISDN BRI interface. It supports PPP link layer protocol, IP network protocol and DDR parameter.

See E1/CE1 configuration manual for relevant configurations in E1 and CE1 operating mode.

The following table lists configuration tasks:

Command	Function
Ruijie(config)#**controller e1 slot/port**	Enters the configuration mode of the specified CE1 interface.
Ruijie(config-controller)# **framing crc4**	Configures the frame check format of the line.
Ruijie(config-controller)#**linecode hdb3**	Configures the coding/encoding format of the line.
Ruijie(config-controller)#**pri-group timeslots** [*range*]	Configures as ISDN PRI.
Ruijie(config)#**interface serial slot/port:***15*	Specifies the D channel and sets relevant parameters on the logical synchronization interface formed.
Ruijie(config-if)#**ip address** *ip-address*	Configures the IP address.

The configurations on other interfaces are the same as those on BRI interface.

Monitoring the ISDN Interface

Use the following commands to monitor the ISDN interface in privileged EXEC mode.

Command	Function
Ruijie# **debug isdn**	Turns on transmit-receive debug switch of ISDN.
Ruijie# **show inter bri** *number*	Monitors the state of BRI interface.
Ruijie# **show ppp multilink**	Displays multilink PPP binding.
Ruijie# **debug dialer mlp**	Turns on multilink PPP debug switch.
Ruijie# **show dialer interface** *type number*	Displays dialer information of each interfaces.

Command	Function
Ruijie# **debug dialer packet**	Turns on logical interface debug switch.
Ruijie# **debug ppp negotiation**	Turns on PPP negotiation debug switch.
Ruijie# **debug ppp packet**	Turns on PPP packet debug switch.
Ruijie# **show isdn parameters**	Displays ISDN parameters.
Ruijie# **show isdn active-channel**	Displays the state of active channel.
Ruijie# **show isdn call-info**	Displays ISDN call related information.

Configuration Examples

Example of configuring the uni-channel dialup

Configuration requirements

Use the BRI 0/1 interface for dialup in the uni-channel working mode.

Router configuration

The configurations of the router are as follows:

```
!
hostname "Ruijie"
!
interface FastEthernet0/0
 ip address 192.168.1.1 255.255.255.0
!
interface BRI0/1
 ip address negotiate
 encapsulation ppp
dialer string 8163
 dialer-group 1
 ppp pap sent-username 8163 password 0 8163
!
ip route 0.0.0.0 0.0.0.0 BRI0/1
access-list 1 permit any
dialer-list 1 protocol ip permit
!
end
```

Example of configuring the bi-channel dialup

Configuration requirements

Use the BRI 0/1 interface to dial the 8163. The working mode is the threshold-controlled bi-channel. The second channel is enabled when the line load is over 100/255.

Router configuration

The following shows the specific configurations for the device to work in the threshold-controlled bi-channel mode.

```
!
hostname "Ruijie"
!
interface FastEthernet0/1
 ip address 192.168.1.1 255.255.255.0
!
interface BRI0/1
 ip address negotiate
 encapsulation ppp
 dialer string 8163
 dialer-group 1
 dialer load-threshold 100 either              //Threshold 100/255
 ppp multilink                      //Configure the multilink bundle
 ppp pap sent-username 8163 password 0 8163
!
ip route 0.0.0.0 0.0.0.0 BRI0/1
access-list 1 permit any
dialer-list 1 protocol ip permit
!
end
```

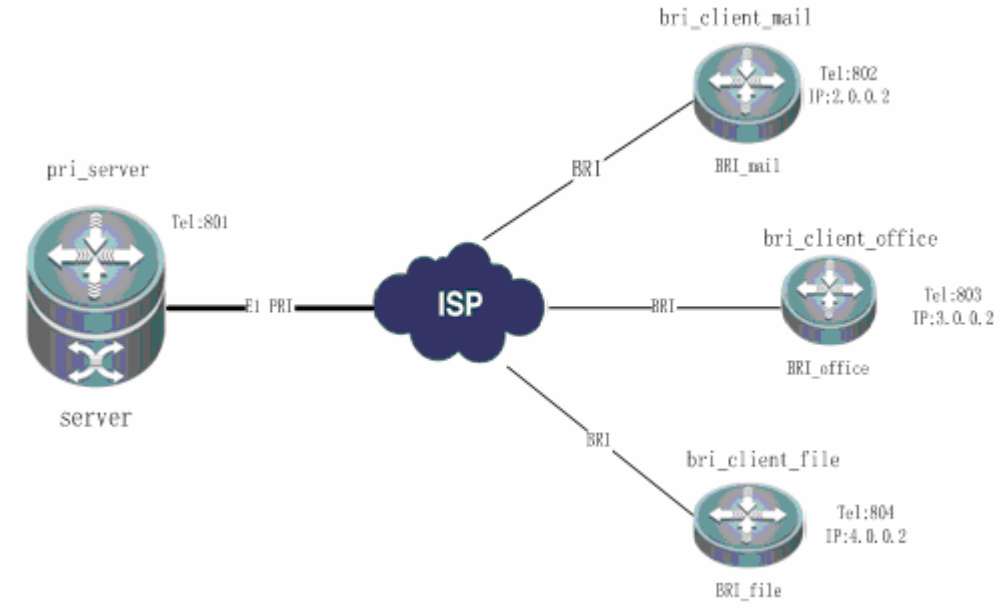
Example of configuring the ISDN PRI interface

Interconnection between ISDN PRI interface and ISDN BRI interface

Configuration requirements:

Interconnect ISDN PRI interface and BRI interface, with PRI end being the central and BRI interface being the client.

Figure 5



Router configuration:

Configure "server":

1) Define the dialer rule.

```
 dialer-list 1 protocol ip permit
```

2) Configure the user names for authentication.

```
 username bri_client_file password 123
 username bri_client_mail password 123
 username bri_client_office password 123
```

3) Configure to ISDN PRI interface.

```
Controller e1 0/0
linecode hdb3
pri-group timeslots 1-31
```

4) Configure physical interface.

```
interface serial 0/0:15
 no ip address
 encapsulation ppp
 ppp authentication chap
dialer in-band
 dialer pool-member 1
 dialer pool-member 2
dialer pool-member 3
```

5) Configure logical interface 1.

```
interface dialer 1
 ip addr 2.0.0.1 255.255.255.0
 encapsulation ppp
 ppp authentication chap
dialer pool 1
 dialer string 802
 dialer remote-name bri_client_mail
 dialer-group 1
```

6) Configure logical interface 2.

```
interface dialer 2
 ip addr 3.0.0.1 255.255.255.0
 encapsulation ppp
ppp authentication chap
dialer pool 2
dialer remote-name bri_client_file
 dialer string 803
 dialer-group 1
```

7) Configure logical interface 3.

```
interface dialer 3
 ip addr 4.0.0.1 255.255.255.0
 encapsulation ppp
 ppp authentication chap
 dialer pool 3
```

```
dialer remote-name bri_client_office
 dialer string 804
 dialer-group 1
```

Configure "BRI_mail":

```
dialer-list 1 protocol ip permit
!
Controller e1 0/0
linecode hdb3
pri-group timeslots 1-31
!
 interface bri 1/0
  ip address 2.0.0.1 255.255.255.0
   encapsulation ppp
   ppp chap hostname bri_client_mail
   ppp chap password 123
   dialer in-band
   dialer string 801
   dialer-group 1
```

Configure "BRI_file":

```
dialer-list 1 protocol ip permit
!
 interface bri 1/0
  ip address 3.0.0.1 255.255.255.0
  encapsulation ppp
  ppp chap hostname bri_client_file
  ppp chap password 123
  dialer in-band
  dialer string 801
  dialer-group 1
```

Configure "BRI_office":

```
dialer-list 1 protocol ip permit
!
interface bri 1/0
   ip address 4.0.0.1 255.255.255.0
   encapsulation ppp
   ppp chap hostname bri_client_office
   ppp chap password 123
   dialer in-band
   dialer string 801
   dialer-group 1
```

Callback configuration examples

Configuration requirements

Two Ruijie's devices are used for callback: one callback client and one callback server. The configuration requirements are as follows:

The working mode is the uni-channel working mode.

The CHAP authentication is configured.

The topology is as follows:

Figure 6

Router configuration

The callback client is configured as follows:

```
!
hostname "client"
username server password 0 1234
!
interface BRI0/1
ip address 3.3.3.2 255.255.255.0
encapsulation ppp
dialer map ip 3.3.3.1 name server 3794074
dialer-group 1
ppp callback request       //Configure the callback request
ppp authentication chap
!
dialer-list 1 protocol ip permit
!
end
```

The callback server is configured as follows:

```
hostname "server"
username client password 0 1234
!
interface BRI0/1
ip address 3.3.3.1 255.255.255.0
encapsulation ppp
dialer map ip 3.3.3.2 name client class dial 3708414
dialer-group 1
ppp callback accept            //Configure the callback receiving request
ppp authentication chap
!
```

```
map-class dialer dial  //Configure the callback authentication policy
 dialer callback-server username
ip classless
dialer-list 1 protocol ip permit
!
end
```

When the callback client stimulates the dialup, once the LCP callback negotiation succeeds, the server disconnects the link, and then starts callback after **enable time** (15 seconds by default) elapses.

Example of the DDR dialup configuration

Configuration requirements

The Ruijie device provides two-interface ISDN U card to bind BRI 0/1 and BRI 0/2 to logical interface 0 for the dialup to 8163.

Router configuration

Configure the router as follows:

```
hostname "Ruijie"
!
interface FastEthernet0/0
 ip address 192.168.12.1 255.255.255.0
!
interface BRI0/1
 ip address negotiate
 encapsulation ppp
 dialer rotary-group 0
 dialer priority 30    // Configure the priority of the BRI physical interface
 dialer-group 1
 dialer load-threshold 1
!
interface BRI0/2
 ip address negotiate
 encapsulation ppp
 dialer rotary-group 0
 dialer priority 10    // Configure the priority of the BRI physical interface
 dialer-group 1
dialer load-threshold 1
 !
interface Dialer0
 ip address negotiate
 encapsulation ppp
 dialer in-band
 dialer idle-timeout 4000
 dialer string 8163
 dialer load-threshold 30  //Configure the traffic threshold of the dialer interface
```

```
 dialer-group 1
 ppp multilink
 ppp pap sent-username 8163 password 0 8163
!
ip route 0.0.0.0 0.0.0.0 Dialer0
access-list 1 permit any
dialer-list 1 protocol ip permit
!
end
```

When several physical interfaces are bound to a logical interface or legacy DDR (two BRI interfaces bounded here), not all the physical interfaces are used at the same time in the dialup. The configured traffic threshold determines whether the next physical interface is used or not.

Which interface is selected first by the logical interface for dialup is controlled by **dialer priority**. The interface with the highest priority is selected first.

Note that the physical interface selected first is the master physical interface, and the others are the secondary physical interfaces. If the master interface is shutdown, the secondary ones will be shut down accordingly. Shutdown of the secondary interfaces does not affect the master physical interface.

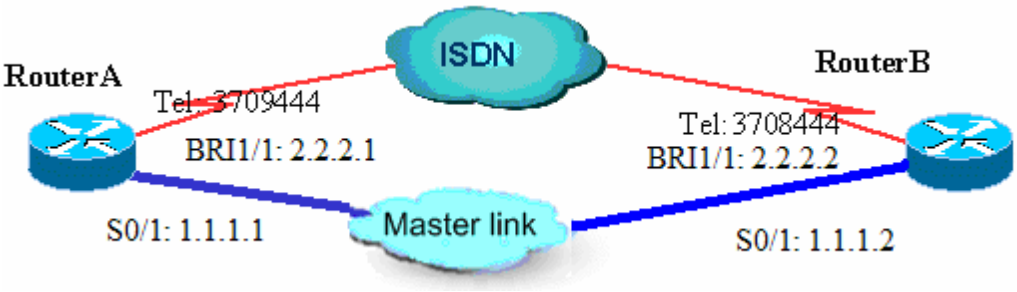
When the data traffic in the line exceeds the threshold specified by **dialer load-threshold**, the physical interface with lower priority will be enabled. When the data traffic of the line is lower than the threshold, the physical interface with lower priority will be disconnected first.

Example of the ISDN backup configuration

Configuration requirements

Figure 7 shows the network topology.

Figure 7



As shown in the preceding figure, the ISDN is the backup line and the DDN is the master line. RouterA is configured with the explicit backup mode. Both the master and backup lines run the OSPF routing protocol.

Router configuration

Configure RouterA as follows:

```
hostname "RouterA"
username RouterB password 0 1234
!
```

```
interface FastEthernet0/0
  ip address 192.168.12.1 255.255.255.0
!
interface Serial0/1
 backup delay 0 120
 backup interface BRI1/1                    //BRI interface as the backup interface
 ip address 1.1.1.1 255.255.255.0
 encapsulation ppp
 no fair-queue
!
interface BRI1/1
 ip address 2.2.2.1 255.255.255.0
 encapsulation ppp
 dialer map ip 2.2.2.2 name RouterB broadcast 3708444
 dialer-group 1
 no fair-queue
 dialer load-threshold 1
 ppp multilink
 ppp authentication chap
!
router ospf 100
 network 2.2.2.0 0.0.0.255 area 0
 network 1.1.1.0 0.0.0.255 area 0
 network 192.168.12.0 0.0.0.255 area 0
!
dialer-list 1 protocol ip permit
!
end
```

Configure RouterB as follows:

```
hostname "RouterB"
username RouterA password 0 1234
!
interface FastEthernet0
  ip address 192.168.100.1 255.255.255.0
!
interface Serial0/1
ip address 1.1.1.2 255.255.255.0
 encapsulation ppp
 no fair-queue
!
interface BRI1/1
 ip address 2.2.2.2 255.255.255.0
 encapsulation ppp
 dialer-group 1
 no fair-queue
```

```
 dialer load-threshold 1
 ppp multilink
 ppp authentication chap
!
router ospf 100
 network 2.2.2.0 0.0.0.255 area 0
 network 1.1.1.0 0.0.0.255 area 0
 network 192.168.100.0 0.0.0.255 area 0
!
dialer-list 1 protocol ip permit
!
End
```

PPP Asynchronous Multilink Configuration

Asynchronous PPP Multilink Overview

Ruijie device not only supports the synchronous interface to use multilink and ensures communication quality, but also support the asynchronous interface to use multilink and can ensure the communication quality on the asynchronous interface.

The implementation of Ruijie device asynchronous multilink is based on the legacy DDR: binding multiple physical interfaces to a logical interface and performing multilink dialup by the logical interface.

PPP Asynchronous Multilink Configuration Tasks

The configuration of the asynchronous multilink includes:

- Configuring the asynchronous interface
- Configuring the logical interface

First, configure the asynchronous interface to support the legacy DDR and PPP encapsulation; then configure the logical interface to support the PPP encapsulation, load bandwidth and multilink PPP.

Configuring the asynchronous interface

Use the following commands to configure the asynchronous interface in global configuration mode.

Command	Function
Ruijie(config)# **interface async** *number*	Specifies the asynchronous interface and enters the asynchronous interface configuration mode.
Ruijie(config-if)# **no ip address**	Specifies the interface with no IP address.
Ruijie(config-if)# **encapsulation ppp**	Encapsulates PPP.
Ruijie(config-if)# **dialer in-band**	Enables the DDR on the interface.
Ruijie(config-if)# **dialer rotary-group** *number*	Binds the current asynchronous interface to the specific logical interface.

For the other asynchronous interface to be added into the multilink, repeat the preceding steps.

Note

Sometimes adding too many asynchronous interfaces cannot improve the communication quality and performance at all. For the default MTU length (1500), the best performance of the multilink PPP can be achieved by using three channels of asynchronous connections.

In using asynchronous multilink, if the MTU is very small or burst of short frames occurs, the packets may be lost.

Configuring the logical interface

Use the following commands to configure the logical interface to support PPP multilink in global configuration mode.

Command	Function
Ruijie(config)# **interface dialer** *number*	Specifies the logical interface and enters the interface configuration mode.
Ruijie(config-if)# **ip address** *address mask*	Specifies the IP address of the logical interface.
Ruijie(config-if)# **encapsulation ppp**	Encapsulates PPP.
Ruijie(config-if)# **dialer in-band**	Enables the DDR on the interface.
Ruijie(config-if)# **dialer load-threshold** *load* [**inbound | outbound | either**]	Sets the multilink load bandwidth.
Ruijie(config-if)# **ppp multilink**	Enables the multilink PPP.
Ruijie(config-if)# **dialer string** *number*	Specifies the telephone number. Repeat this command to specify more telephone numbers.

Monitoring the Asynchronous PPP Multilink

Use the following commands to monitor the activities of a PPP multilink in privileged EXEC mode.

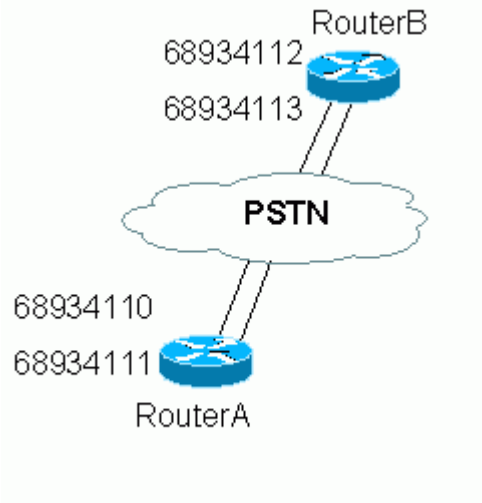
Command	Function
Ruijie# **show ppp multilink**	Shows the multilink PPP bundle information.
Ruijie# **debug dialer mlp**	Turns on the multilink PPP debug switch.

PPP Asynchronous Multilink Configuration Examples

Configuration requirements

Bind two asynchronous interfaces for multiple PPP, load bandwidth 50%. The second asynchronous interface is enabled for dialup as long as the communication traffic reaches 50%. Figure 8.

Figure 8 Multilink configuration examples



Router configuration

RouterA configurations:

Configure the hostname.

```
hostname "RouterA"
```

Configure the dialup script.

```
chat-script Dialout ABORT ERROR ABORT BUSY "" "ATDT\T" TIMEOUT 45 CONNECT \c
```

Bind asynchronous interface 1 to logical interface 0.

```
interface Async1
 no ip address
 encapsulation ppp
 async mode dedicated
 dialer in-band
 dialer rotary-group 0
 dialer-group 1
 no fair-queue
```

Bind asynchronous interface 2 to logical interface 0.

```
interface Async2
 no ip address
 encapsulation ppp
 async mode dedicated
 dialer in-band
 dialer rotary-group 0
 dialer-group 1
 no fair-queue
```

Configure the logical interface.

```
interface Dialer0
 ip unnumbered Loopback0
```

```
 encapsulation ppp
 dialer in-band
 dialer string 68934112
 dialer string 68934113
 dialer load-threshold 50
 dialer-group 1
 no fair-queue
 ppp multilink
```

Configure the default route.

```
ip route 0.0.0.0 0.0.0.0 Dialer0
```

Configure the dialup activation rule.

```
dialer-list 1 protocol ip permit
```

Configure the line parameters.

```
line 1 16
 script dialer Dialout
 modem InOut
 speed 115200
!
end
```

The telephone number can be configured only in the logical interface. One multiple bundle can have multiple telephone numbers, and the multilink uses the telephone numbers configured for dialup in the rotary manner:

- If there is data to be sent to the destination via the logical interface and the dialup activation rule has been configured, the logical interface attempts dialup with the configured telephone number. If the first telephone number fails, it will attempt the second one after the line invalid time (enable-timeout) expires, and so on.
- If the current line load reaches the configured load threshold, the logical interface uses the current available interface to start dialing from the first telephone number. If it fails, it will attempt the second one after the line invalid time (enable-timeout) expires, and so on.

The configurations for RouterB are similar to RouterA.

Callback

Callback Overview

Introduction

The callback needs the client/server relation between the two parties of the dialup. One remote callback client dials to connect the callback server, and the callback server performs authentication for the dial-in user. If the authentication passes, the callback server uses the related information of the remote host for callback.


Note

If the callback fails due to busy line, no reply, or other reasons, no redialing is done. If the callback server has no available interface for callback, no retry will be done.

Callback client: remote device or host that requests the callback

Callback server: the device that accepts the callback request, and if the authentication passes, disconnects the current connection and locally initiates the dialing to the remote client.

Purposes

The callback is generally used in the following three scenarios:

- Save cost: The call charge may be different for different areas. For example, the dialing from village to city may be more expensive than the reverse direction, so it is possible to save cost by calling back from the city to village.
- Unified call charge: An organization may have quite a lot of branches. It is possible to call back from the center to the branches so that the calls are all paid by the center to facilitate the financial management and statistics.
- Security considerations: The callback numbers set for the callback server are the reliable and valid numbers that have been configured. This helps ensure the location of the callback client is valid, forbidding the invalid dialing from the range out of control.

Callback configuration tasks

Before configuring the callback, make sure the global DDR configuration preparations are completed. The callback configuration tasks involve:

- Configure the callback client
- Configure the callback server

Configuring the callback client

Use the following commands to configure the callback client for the device in global configuration mode.

Command	Function
Ruijie(config)# **interface** *type number*	Specifies the interface and enters the interface configuration mode.
Ruijie(config-if)# **dialer in-band**	Enables DDR.
Ruijie(config-if)# **encapsulation ppp**	Encapsulates PPP.
Ruijie(config-if)# **ppp authentication** {**chap** | **pap**}	Configures the PPP authentication.
Ruijie(config-if)# **dialer map** *protocol next-hop-address* **name** *hostname dial-string*	Maps the callback server hostname, address and telephone number.
Ruijie(config-if)# **ppp callback request**	Configures the current interface as the callback client.
Ruijie(config-if)# **dialer hold-queue** *[packets* [**timeout** *seconds*]]	(Optional) Configures the hold queue on the interface.
Ruijie(config-if)# **dialer-group** *group*	Associates the dialup activation rule.
Ruijie(config-if)# **async mode dedicated**	Enables automatic negotiation of the dialup mode.

Configuring the callback server

Use the following commands to configure the callback server for the device in global configuration mode.

Command	Function
Ruijie(config)# **interface** *type number*	Specifies the interface and enters the interface configuration mode.
Ruijie(config-if)# **dialer in-band**	Enables DDR.
Ruijie(config-if)# **encapsulation ppp**	Encapsulates PPP.
Ruijie(config-if)# **ppp authentication** {**chap** | **pap**}	Configures the PPP authentication.
Ruijie(config-if)# **dialer map** *protocol next-hop-address* **name** *hostname* **class** *classname dial-string*	Maps the callback client hostname, address and telephone number.
Ruijie(config-if)# **dialer hold-queue** *[packets]* [**timeout** *seconds*]]	(Optional) Defines the hold queue on the interface.
Ruijie(config-if)# **dialer enable-timeout** *seconds*	(Optional) Configures the line invalid waiting time (i.e. waiting time before the callback).
Ruijie(config-if)# **ppp callback accept**	Accepts the callback request.
Ruijie(config-if)# **dialer-group** *group*	Associates the dialup activation rule.
Ruijie(config-if)# **async mode dedicated**	Enables automatic negotiation of the dialup mode.
Router(config-pmap)# **exit**	Returns to the global configuration mode.
Ruijie(config)# **map-class dialer** *classname*	Defines the dialup mapping class and enters the mapping class configuration mode.
Ruijie(config-map-class)# **dialer callback-server** [**username**] [**dial-string**]	Configures the dialup mapping class as the callback server.

Note

On the callback server, **dialer enable-timeout** controls the callback start time. If not configured, the default time is used, namely 15 seconds.

Monitoring Callback

Use the following command to monitor the callback in privileged EXEC mode.

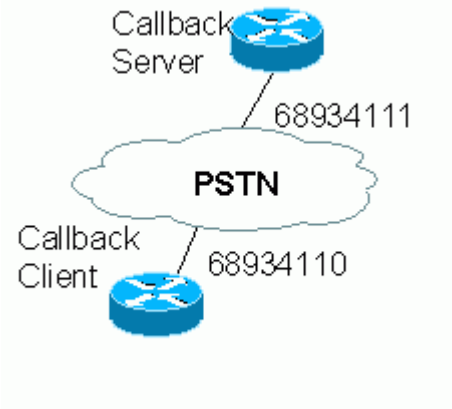
Command	Function
Ruijie # **debug dialer packet**	Turns on the DDR debug switch.

Callback Configuration Examples

Configuration requirements

The callback client dials to connect the callback server. The callback server uses the CHAP authentication for the callback client, and starts callback in 10 seconds since the disconnection of the line. The topology is shown in Figure 9:

Figure 9 Callback configuration examples



Router configuration

Configure the callback client as follows:

Configure the hostname.

```
hostname "Client"
```

Configure the username/password pair.

```
username Server password 0 aaa
```

Configure the dialup script.

```
chat-script Dialout ABORT ERROR ABORT BUSY "" "ATDT\T" TIMEOUT 45 CONNECT \c
```

Configure the asynchronous interface.

```
interface Async1
 ip address 3.3.3.2 255.255.255.0
 encapsulation ppp
 async mode dedicated
 dialer in-band
 dialer map ip 3.3.3.1 name Server 68934111
 dialer hold-queue 30
 dialer-group 1
 ppp callback request
 ppp authentication chap
```

Configure the line status of the asynchronous interface.

```
line 1
 script dialer Dialout
 modem InOut
 speed 115200
! Dialup activation rule
dialer-list 1 protocol ip permit
!
end
```

```
Configure the callback server:
```

Configure the hostname.

```
hostname "Server"
```

Configure the username/password pair.

```
username Client password 0 aaa
```

Configure the dialup script.

```
chat-script Dialout ABORT ERROR ABORT BUSY "" "ATDT\T" TIMEOUT 45 CONNECT \c
```

Configure the asynchronous interface.

```
interface Async1
 ip address 3.3.3.1 255.255.255.0
 encapsulation ppp
 async mode dedicated
 dialer in-band
 dialer enable-timeout 10
 dialer map ip 3.3.3.2 name Client class dial 68934110
 dialer hold-queue 30 timeout 100
 dialer-group 1
 ppp callback accept
 ppp authentication chap
```

Configure a mapping class.

```
map-class dialer dial
 dialer callback-server username
```

Configure the dialup activation rule.

```
dialer-list 1 protocol ip permit
```

Configure the line parameter of the asynchronous interface.

```
line 1
 script dialer Dialout
 modem InOut
 speed 115200
!
end
```

Configuring Level-2 Dialer Backup

Configuration Examples

Configuration requirements

Configure the ISDN BRI interface as the backup of the Ethernet interface, and the asynchronous interface as the backup of the BRI interface for Level-2 backup of Ethernet interface.

Router configuration

Configure the dialer stimulation rule.

```
dialer-list 1 protocol ip permit
```

Configure the dialer script.

```
chat-script Dialout ABORT ERROR ABORT BUSY "" "ATDT\T" TIMEOUT 45 CONNECT \c
```

Configure the Ethernet interface and set the IDSN BRI interface as its backup interface.

```
interface FastEthernet 1/0
ip address 6.0.0.1 255.255.255.0
backup interface Bri 2/0
backup delay 0 10
duplex auto
```

Configure the ISDN BRI interface and set the asynchronous interface as its sub backup interface, namely level-2 backup interface of Ethernet interface.

```
interface Bri 2/0
encapsulation PPP
ip address 2.0.0.1 255.255.255.0
backup interface Async 1
backup delay 0 10
dialer string 5551000
dialer load-threshold 1
dialer-group 1
```

Configure the asynchronous interface.

```
interface Async 1
encapsulation PPP
async mode dedicated
ip address 1.0.0.1 255.255.255.0
dialer in-band
dialer string 801
dialer-group 1
```

Configure the line parameters.

```
line aux 0
script dialer Dialout
modem InOut
speed 115200
```

Dialer Watch

Dialer Watch Overview

Introduction

The principle of the Dialer Watch is that the local route in the device is detected, and the backup dialup interface is triggered to dial if the specified route monitored does not exist in the routing table. If the specified route monitored appears in the routing table, the backup dialup interface will be triggered to disconnect the dialup line.

Purposes

For the general dialup backup, when the master line is disconnected, the backup link just turns from the standby status to the spoof up status but this does not indeed trigger the dialup. The dialup is triggered only when there is some traffic stimulation.

The purpose of the Dialer Watch is that it triggers the dialup as long as the monitored route disappears, freeing away the dependence of the traffic stimulation.

Dialer Watch Configuration Tasks

Before configuring the dialer watch, make sure the global DDR configuration preparations are completed. The dialer watch configuration tasks involve:

- Configure the backup interface for the DDR dialup
- Configure the monitored route for the dialup
- Configure how long to trigger dialup after the monitored route disappears
- Configure how long to disconnect the dialup after the monitored route appears

Configuring dialer watch

Use the following commands to configure the dialer watch in global configuration mode.

Command	Function
Ruijie(config)# **interface** *type number*	Specifies the interface and enters the interface configuration mode.
Ruijie(config-if)# **dialer watch-group** *group-number*	Enables dialer watch on the backup line.
Ruijie(config)# **dialer watch-list** group-number **ip** *ip-address address-mask*	Defines all the routes to be monitored. The dialer watch function can monitor multiple routes.
Ruijie(config)# **dialer watch-list** group-number **delay** {**connect** *connect-time* }	Configures how long to trigger dialup on the backup interface after the monitored route disappears. If not configured, the dialup is triggered immediately by default.
Ruijie(config)# **dialer watch-list** group-number **delay** {**disconnect** *disconnect-time* }	Configures how long to disconnect the dialup on the backup interface after the monitored route appears. By default, it is disconnected immediately.

Dialer Watch Configuration Example

Configuration requirements

The dialup of the asynchronous backup interface is triggered in 10 seconds after the Ethernet interface FastEthernet 0/0 route or the synchronous interface serial 2/0 route disappears.

The dialup disconnection of the asynchronous backup interface is triggered in 20 seconds after the Ethernet interface FastEthernet 0/0 route or the synchronous interface serial 2/0 route appears.

Router configuration

Configure dialer watch as follows:

```
!
```

Define the Ethernet interface FastEthernet 0/0 route for dialer watch to trigger the dialup on asynchronous interface 1 after the Ethernet interface route disappears.

```
dialer watch-list 1 ip 192.168.200.0 255.255.255.0
```

Define the synchronous interface serial 2/0 route for dialer watch to trigger the dialup on synchronous interface 1 after the synchronous interface route disappears.

```
dialer watch-list 1 ip 5.5.5.0 255.255.255.0
```

Trigger dialup in 10 seconds after the route disappears.

```
dialer watch-list 1 delay connect 10
```

Trigger disconnection in 20 seconds after the route appears.

```
dialer watch-list 1 delay disconnect 20
dialer-list 1 protocol ip permit
!
no service timestamps debug
no service timestamps log
!
interface Async 1
 encapsulation PPP
 ip address 6.6.6.1 255.255.255.0
 dialer in-band
 dialer string 8000
```

Define the backup interface for dialer watch and associate the related dialer watch policy.

```
 dialer watch-group 1
 dialer-group 1
 async mode dedicated
!
interface serial 2/0
 encapsulation PPP
 ip address 5.5.5.1 255.255.255.0
 clock rate 64000
```

```
!
interface FastEthernet 0/0
 ip address 192.168.200.147 255.255.255.0
 duplex auto
 speed auto
!
line con 0
line aux 0
line tty 1 8
 modem InOut
 speed 57600
line vty 0 4
 login
!
```

WAN-3G Configuration

Understanding 3G

3G Overview

3G: The 3rd-generation mobile communication technology refers to the cellular mobile communication technology supporting high-speed data transmission. 3G supports voice and high-speed data transmission services. Compared with the 1st generation analog mobile phones (1G) and 2nd generation GSM and CDMA digital mobile phones (2G), the 3rd generation (3G) mobile phones is a new-generation mobile communication system integrating wireless communication and Internet-based multimedia communication.

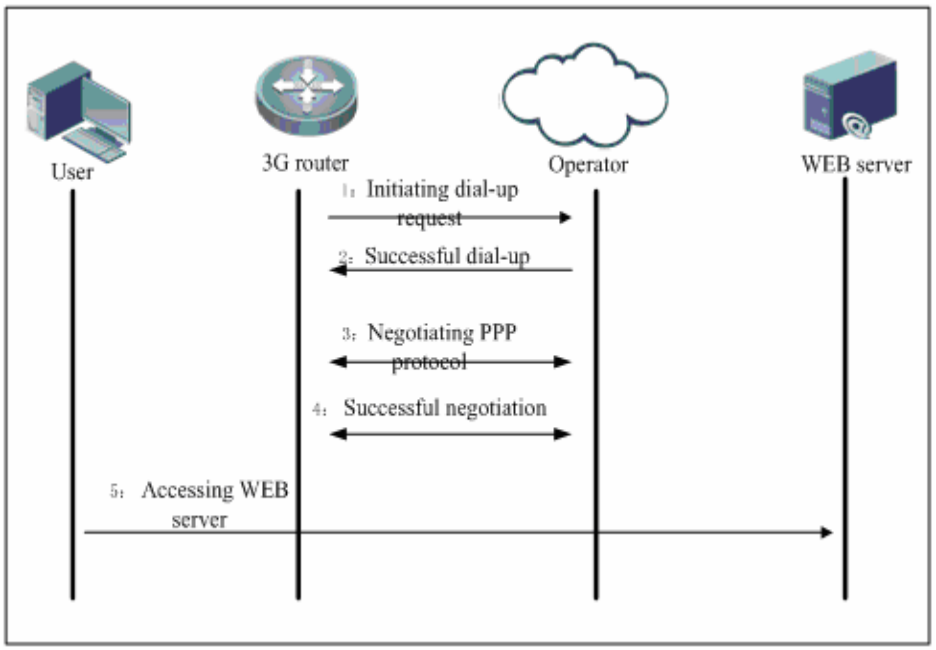
Compared with 2G, 3G is enhanced in terms of the data rate of voice and data transfer. It is capable of realizing better worldwide roaming, processing multiple media formats such as image, music, and video streams, and providing information services including webpage browsing, telephone conference and e-business, while maintaining a good compatibility with the existing 2G systems.

Working Principle

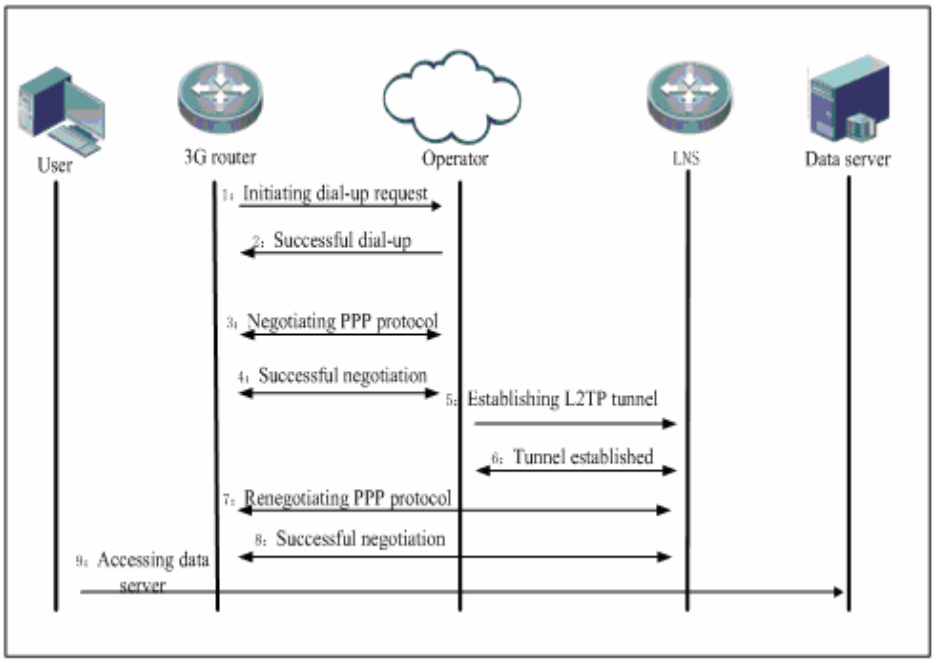
Insert an SIC-3G card onto the router (or use a 3G router directly). This router will then be able to access public network or private network through the 3G wireless network provided by the carrier.

The following figures demonstrate how the router accesses public network or private network through the 3G link.

1) Procedures for the router to access public network through 3G:



2) Procedures for the router to access private network through 3G:



Protocol Specification

NA

Default Configuration

The following table describes the default configuration of 3G.

Feature	Default Setting
Interface dialup	Not configured
Line parameters	Not configured
APN	Not configured
Automatic dialup	Not configured; dialup is triggered by data
3G link always online	Not configured; the default idle timeout timer is 120s
PPP Keepalive	Not configured
plmn pin-protection command	Not enabled
dialer enable-timeout command	Not configured; the default enable timeout duration is 15s
Multi-AP backup for single card and BFD association	Not enabled
Multi-AP backup for single card and Track association	Not enabled
Dual-card backup and BFD association	Not enabled
Dual-card backup and Track association	Not enabled
Dual-card backup and RSSI association	Not enabled
Associating single 3G interface with BFD	Not enabled
Associating single 3G interface with Track	Not enabled
Associating single 3G interface with RSSI	Not enabled
Searching and selecting the current access mode	Not enabled
Directly configuring the current access mode	Not enabled; the access mode is selected automatically

Configuring 3G Dialup

Configuring Interface Dialup

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **dialer-list 1 protocol ip permit**	Configures the dialer rule.
Ruijie(config)# **username** *UMTS_CHAP_SRVR* **password** ""	Configures username for PPP authentication. Usernames vary with carriers or user types.
Ruijie(config)# **interface async** *1*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **ip address negotiate**	Configures IP address negotiation.
Ruijie(config-if-Async 1)# **encapsulation PPP**	Configures the link protocol as PPP.
Ruijie(config-if-Async 1)# **ip ref**	Joins the interface into express forwarding. (Skip this command if the interface is added to express forwarding by default after system startup.)
Ruijie(config-if-Async 1)# **async mode dedicated**	Configures automatic asynchronous dial mode
Ruijie(config-if-Async 1)# **dialer in-band**	Enables DDR dialup.
Ruijie(config-if-Async 1)# **dialer string *99#**	Configures the dialed number. Dialed numbers vary with carriers.
Ruijie(config-if-Async 1)# **dialer-group** *1*	Associates with dialer rule.

Configure interface dialup:

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#dialer-list 1 protocol ip permit
Ruijie(config)#username UMTS_CHAP_SRVR password ""
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)#ip address negotiate
Ruijie(config-if-Async 1)#encapsulation ppp
Ruijie(config-if-Async 1)#ip ref
Ruijie(config-if-Async 1)#async mode dedicated
Ruijie(config-if-Async 1)#dialer in-band
Ruijie(config-if-Async 1)#dialer string *99#
Ruijie(config-if-Async 1)#dialer-group 1
Ruijie(config-if-Async 1)#show run interface async 1

Building configuration...
Current configuration : 141 bytes
!
interface Async 1
 encapsulation PPP
 async mode dedicated
 ip ref
 ip address negotiate
```

```
 dialer in-band
 dialer string *99#
 dialer-group 1
Ruijie(config-if-Async 1)#
```

Caution

1: The configuration of username and password is different for different carriers:

WCDMA: **username** UMTS_CHAP_SRVR **password** ""

CDMA2000: By default, the configuration must be done in interface mode.

ppp chap hostname ctnet@mycdma.cn

ppp chap password vnet.mobi

or

ppp chap hostname card

ppp chap password card

The command will take effect only after the **shut** or **no shut** command is executed on the interface.

TD-SCDMA: **username** PPPS **password** ""

The aforementioned configurations of hostname and password are for users accessing public network; for users accessing a dedicated network, the hostname and password provided by such dedicated network must be configured.

2: Different carriers will result in different dialed numbers, as shown below:

TD-SCDMA:*99***1#

WCDMA:*99#

CDMA2000:#777

3: For other dialing related configurations, seethe dialup session in the configuration commands..

4: The **ip ref** command must be configured after the **encapsulation PPP** command, as the SLIP protocol does not support express forwarding. If **ip ref** is configured before **encapsulation PPP**, the interface cannot join express forwarding. For the detailed configuration method, see the "Configuration Example of 3G Dialing for Accessing Public Network" section.

5:The ip ref command must be configured in the 10.4.3b12 or later version.

6:The first time of changing the user name and password in the SIC-3G card of CDMA2000 may lead to the dial up failure.

Configuring Line Parameters

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **line tty** *1*	Enters line configuration mode. The ID is the corresponding tty ID at initialization.
Ruijie(config-line)# **modem inout**	Configures the 3G modem dialup mode.
Ruijie(config)# **show running-config**	Displays line parameters configured.

Configure line parameters.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
```

```
Ruijie(config)#line tty 1
Ruijie(config-line)#script dialer Dialout
Ruijie(config-line)#modem inOut
Ruijie(config-line)#speed 115200
Ruijie(config-line)#exit
Ruijie(config)#show running-config
!
line tty 1
script dialer Dialout
 modem InOut
speed 115200
```

Configuring APN

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface async** *1*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **dialer apn** *3gnet*	Configures the specified APN. In this example, the APN is set to 3gnet. (No APN setting is available for CDMA2000. The APN setting varies with carriers or user types.)
Ruijie(config)# **show running-config**	Displays APN parameters configured.

#Configure APN:

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)#dialer apn 3gnet
Ruijie(config-if-Async 1)#show run interface async 1

Building configuration...
Current configuration : 141 bytes
!
interface Async 1
 encapsulation PPP
 async mode dedicated
 ip address negotiate
 dialer in-band
 dialer string *99#
 dialer apn 3gnet
 dialer-group 1
Ruijie(config-if-Async 1)#
```

Caution

1. Different carriers may use different APNs. The default APN used by 3G Internet cards of China Unicom is "3GNET", while the default APN used by those of China Mobile is "CMNET".
2. Dedicated line users must use the APN provided by the carrier.
3. An APN contains up to 39 characters.
4. No APN setting is available for CDMA2000.

Configuring Auto-dial

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface async** *1*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **dialer auto-dial**	Configures auto-dial.
Ruijie(config)# **show running-config**	Displays the parameters configured.

Configure auto-dial:

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)#dialer auto-dial
Ruijie(config-if-Async 1)#show run interface async 1

Building configuration...
Current configuration : 141 bytes
!
interface Async 1
 encapsulation PPP
 async mode dedicated
 ip address negotiate
 dialer in-band
 dialer string *99#
 dialer apn 3gnet
 dialer auto-dial
 dialer-group 1
Ruijie(config-if-Async 1)#
```

Caution

On 3G link, if auto-dial is configured, the connection is not terminated when idle timer runs out. Instead, the idle timer will be restarted.

Configuring No Timeout

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface async** *1*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **dialer idle-timeout** *0*	Configures no timeout.
Ruijie(config)# **show running-config**	Displays the parameters configured.

Configure no timeout:

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)#dialer idle-timeout 0
Ruijie(config-if-Async 1)#show run interface async 1

Building configuration...
Current configuration : 141 bytes
!
interface Async 1
 encapsulation PPP
 async mode dedicated
 ip address negotiate
 dialer in-band
 dialer string *99#
 dialer apn 3gnet
 dialer auto-dial
 dialer idle-timeout 0
 dialer-group 1
Ruijie(config-if-Async 1)#
```

Configuring PPP Keepailve

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface async** *1*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **keepailve** *5 3*	Sets keepailve interval to 10s and timeout times to 3. In consideration of 3G network instability and delay, if keepalive is enabled on lines, you are advised to set the keepalive interval to 5s and timeout times to 3.
Ruijie(config)# **show running-config**	Displays the parameters configured.

#Configure PPP keepailve:

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
```

```
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)#keepailve 5 3
Ruijie(config-if-Async 1)#show run interface async 1

Building configuration...
Current configuration : 141 bytes
!
interface Async 1
 encapsulation PPP
 async mode dedicated
 ip address negotiate
 dialer in-band
 dialer string *99#
 dialer apn 3gnet
 dialer auto-dial
 dialer idle-timeout 0
 dialer-group 1
 keepailve 5 3
Ruijie(config-if-Async 1)#
```

Caution On the 3G link, the keepalive feature is by default disabled as keepalive packets will compromise traffic. If it is needed to monitor link state, the keepalive feature can be enabled manually.

Configuring Single 3G interface and RSSI Correlation

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface async** *1*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **plmn status rssi-detect** *-150* **interval** *15* **ntimes** *3* **percent** *100*	In consideration of 3G network instability and delay, it is recommended to configure these parameters when there is one single 3G card.
Ruijie(config)# **show running-config**	Displays the parameters configured.

#Configure single 3G interface and RSSI correlation:

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)#plmn status rssi-detect -150 interval 15 ntimes 3 percent 100
Ruijie(config-if-Async 1)#show run interface async 1

Building configuration...
Current configuration : 141 bytes
```

```
!
interface Async 1
 encapsulation PPP
 async mode dedicated
 ip address negotiate
 dialer in-band
 dialer string *99#
 dialer apn 3gnet
 dialer auto-dial
 dialer idle-timeout 0
 dialer-group 1
 plmn status rssi-detect -150 interval 15 ntimes 3 percent 100
```

Configuring the dialer enable-timeout Command

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface async** *1*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **dialer enable-timeout** *30*	Sets the timeout duration. In consideration of 3G link instability, a short timeout duration may cause re-dialing failure after the dialup connection is disconnected. Therefore, you are advised to set the timeout duration to 30s (15s by default).
Ruijie(config)# **show running-config**	Displays the parameters configured.

Configure PPP Keepailve:

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)#dialer enable-timeout 30
Ruijie(config-if-Async 1)#show run interface async 1

Building configuration...
Current configuration : 141 bytes
!
interface Async 1
 encapsulation PPP
 async mode dedicated
 ip address negotiate
 dialer in-band
 dialer string *99#
 dialer apn 3gnet
 dialer auto-dial
 dialer idle-timeout 0
 dialer enable-timeout 30
```

```
dialer-group 1
 keepalive 5 3
Ruijie(config-if-Async 1)#
```

Configuring Inner/Outer Antenna Switchover (Only supported by 10-01G-E)

RSR1001G-E has two inner antennas (a primary antenna and a secondary antenna). And it can connect two outer antennas(a primary antenna and a secondary antenna). Users can select the inner/outer antennas at any time through the CLI command.

Command	Function
Ruijie(config)# **interface async** *1*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)#plmn **antenna outer**	Selects the outer antenna manully.

Caution

1. This command is applied only to the 10-01G-E, and by default the device uses the inner antennas.
2. The command takes effect immediately after the configuration.
3. It is recommended to use the outer antennas, if possible.

Displaying Configurations

Command	Function
show running-config	Displays configurations.
show interface async *async_number*	Displays the state of asynchronous interface and packet statistics.
show line tty *tty_number*	Displays line state.
show cellular info	Displays information about 3G interfaces.
show plmn backup	Displays 3G backup information.

Configuring PIN Code Protection Function

The first time of enabling the PIN code protection function

The PIN code protection function is to prevent the unauthorized user from using the SIM card by setting a password for the SIM card. By default, the PIN code of the SIM card is 1234. There are three PIN code protection mode, as shown in the following table:

Command	Function
show running-config	Displays configurations.
show interface async *async_number*	Displays the state of asynchronous interface and packet statistics.
show line tty *tty_number*	Displays line state.
show cellular info	Displays information about 3G interfaces.
show plmn backup	Displays 3G backup information.

Command	Function	Difference	Scenario
simple	Simple PIN code protection mode: The user needs to enter the PIN code of current SIM card through CLI commands. If the PIN code is correct, simple PIN code protection function will be enabled. If the PIN code is incorrect, the SIM card will be locked. The PUK code is required to unlock the SIM card. (See PUK unlocking for details). Use the **no** form of this command to disable the simple PIN code protection function	The number the user entered is the PIN code of the SIM card. The administrator can see the PIN code configured in this mode. Simple PIN code protection function enjoys less security.	The SIM card can be used on the routers or mobile terminals where the PIN code entering is supported.
strict-pin	Strict PIN code protection mode: The user needs to enter the PIN code of current SIM card and a HASH string through CLI commands. If the PIN code is correct, the HASH string replaces the current PIN code and strict PIN code function will be enabled, If the PIN code is incorrect, the SIM card will be locked. The PUK code is required to unlock the SIM card. (See PUK unlocking for details).	After entering HASH string, the user can get a new PIN code, which is invisible to the administrator. Strict PIN code protection function enjoys high security.	The SIM card is used only on the Ruijie router.
bind-router	Router binding PIN code protection mode: The user needs to enter the PIN code of current SIM card through CLI command. If the PIN code is correct, router binding PIN code protection function is enabled and the PIN code will be replaced by the HASH sting calculated with the router serial number. If the PIN code is incorrect, the SIM card will be locked. The PUK code is required to unlock the SIM card. (See PUK unlocking for details).	The PIN code will be replaced by the HASH sting calculated with the router serial number. The PIN code is bound to the router. Therefore, router binding PIN code protection function enjoys the highest security.	The SIM card can be used only on one Ruijie router.

Take the following configuration as a reference:

Simple PIN code protection mode

Command	Function
Ruijie(config)# **interface async** *1*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **plmn pin-protection simple 0 1234**	Enables simple PIN code protection. The PIN code is the number string in the command.
Ruijie(config)# **show running-config**	Displays the parameters configured.

Strict PIN code protection mode

Command	Function
Ruijie(config)# **interface async** *1*	Enters interface configuration. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **plmn pin-protection strict-pin 12345678 0 1234**	Enables strict PIN code protection function. The PIN code is the last number string in the command. The first number string is HASH string.
Ruijie(config-if-Async 1)# **profile create slave** Ruijie(config)# **show running-config**	Displays the parameters configured.

Router binding PIN code protection mode

Command	Function
Ruijie(config)# **interface async** *1*	Enters interface configuration function. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **plmn pin-protection bind-router 0 1234**	Enables routing binding PIN code protection. The PIN code is the number string in the command.
Ruijie(config)# **show running-config**	Displays the parameters configured.

PIN Code Protection Configuration (Router binding mode, the other modes are similar):

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)# plmn pin-protection bind-router 0 1234
Ruijie(config-if-Async 1)#show run interface async 1

Building configuration...
Current configuration : 141 bytes
!
interface Async 1
encapsulation PPP
plmn pin-protection bind-router 0 1234
async mode dedicated
ip address negotiate
dialer in-band
dialer string *99#
dialer auto-dial
dialer idle-timeout 0
dialer-group 1
Ruijie(config-if-Async 1)#
```

Caution 1. The user knows the default PIN code of a new SIM card or a new 3G card.

2. The administrator can enable the PIN code protection function through CLI command. During the

operation, the PIN code is required. The SIM card will be locked once an incorrect PIN code is entered. The user needs to obtain PUK code to unlock the SIM card. (See PUK unlocking for details)
plmn pin-protection simple 0 1234
OR: plmn pin-protection bind-router 0 1234
OR: plmn pin-protection strct-pin 12345678 0 1234
3. When strict PIN code protection function or router binding PIN code protection function are enabled, the PIN code is encrypted and no longer be the default value:1234. User cannot disable them by entering the command no plmn pin-protection on other devices (like mobile phone) but router.
4. The PIN codes in strict PIN code protection mode and router binding PIN code protection mode are invisible to the administrator.
5. Whenever the 3G card dials up to access the 3G network, the router will use the new PIN code to unlock the SIM card. If the PIN code is correct, the router allows the 3G card to dial up to access the 3G network.
6. The command to disable the PIN code protection to these three mode is the same. The command is: no plmn pin-protection. This command takes effect only after the PIN code protection function is enabled.

Replacing SIM card

When user wants to take out the SIM card from a router and use it in another router, please pay attention to the following cautions. The following cautions works in all three PIN code protection modes.

Caution If a SIM card is took out from router A and used in router B where PIN code protection is enabled and new PIN code is generated. There are two consequences:
1. If the PIN code of the SIM card is the same as that in the CLI command of router B. The SIM card can be used directly. The router will use the default PIN code to enable the PIN code protection and generate new PIN code according to the algorithm of router binding PIN code protection or the algorithm of strict PIN code protection. Afterwards whenever the 3G card dials up to access the 3G network, the router will use the new PIN code to unlock the SIM card. If the PIN code is correct, the router allows the 3G card to dial up to access the 3G network.
2. If the PIN code of the SIM card is different from that in the CLI command of router B. Using the 3G card directly on router B may lock the SIM card. In this case, the user may need an administrator to unlock the SIM card with PUK code and re-set the PIN code as default value.

About the second sequence, there are three methods to deal with it:
1.Before plugging the SIM card in router B, use other devices (like mobile phone) to set the PIN code of the SIM card as the default value in the CLI command of the router B.
2. Remove all router configurations before plugging in the SIM card. And then re-set the PIN code protection function.
3. Use the SIM card on the router B. And consequently, the SIM card is locked. Then, use the PUK code to unlock the SIM card. (See PUK unlocking for details).

PUK unlocking

The SIM card will be locked when an entered PIN code is incorrect. In this case, the PUK code is required to unlock the SIM card and re-set the PIN code. When the SIM card is locked, the router system will send a warning as a system log to the user. Or, user can check the SIM card status through the command sh cell info. The following scenario are where the PUK code might be needed.

1.After the PIN code protection is enabled, the SIM card will be locked if the PIN code of SIM card is different from that in the entered CLI command

2. After router binding PIN code protection is enabled, when the SIM card is took out from this device and is used on another device with the same configuration, the SIM card will be locked.

3. After strict PIN code protection is enabled, when the SIM card of this device is used in another device with different configuration, the SIM card will be locked.

4.During the SIM card replacement, if the default PIN code of the SIM card is different from that in the CLI command of router configuration, the SIM card will be locked.

Command	Function
Ruijie(config)# **interface async** *1*	Enters interface configuration function. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **plmn puk-unlock 12345678 1234**	PUK unlocking. The first character string is PUK code, the second character string is new PIN code.

Caution Use the PIM code to unlock the SIM card. Be careful, the SIM card will break after 10 attempts of entering an incorrect PUK code. So, it is recommended to PUK code of the SIM card from the ISP. User can perform the PUK unlocking on mobile phone or other terminals.

Changing PIN code

Use the following commands to change the PIN code.

Command	Function
Ruijie(config)# **interface async** *1*	Enters interface configuration function. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **plmn pin-protection simple 0 1234**	Enables simple PIN code protection function.
Ruijie(config-if-Async 1)# **plmn modify 2345**	Changes PIN code.

Caution

1. The PIN code change command takes effect only in simple PIN code protection mode.
2. Check the modem status before running this command. The change of the PIN code might fail when the modem status is abnormal. The failure will be send as a system log. User can try it later. Or user can change the PIN code with mobile phone or other devices.
3. The PIN code change may fail when the ISP network is busy.
4.Pay attention to this command. It is recommended to save all the configuration on the router before running this command.

Configuring Multi-AP Backup for Single 3G Card

Configuring Multi-AP Backup for Single Card and BFD Association

With respect to multi-AP backup for single card, you can apply to the carrier for 2 or more APs. When the master AP is unreachable, the system will switch to the slave AP and reestablish a connection, thus ensuring the reliability of the system.

Command	Function
Ruijie(config)# **interface async** *1*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **profile create master authentication pap apn** *a.apn* **username** *UserA* **password 0** *123* **bfd**	Configures the master AP and associates it with BFD.
Ruijie(config-if-Async 1)# **profile create slave authentication pap apn** *b.apn* **username** *UserB* **password 0** *123* **priority** *1*	Configures the slave AP. Determine whether to associate the slave AP with BFD as required.
Ruijie(config-if-Async 1)# **profile switch timer** *20* **max-fail-times** *3*	Configures the switch timer and the maximum times of failure.
Ruijie(config)# **show running-config**	Displays the parameters configured.

Configure multi-AP backup for single card and BFD association:

```
Ruijie# configure terminal
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)# profile create master authentication pap apn  a.apn username UserA
password 0 123 bfd
Ruijie(config-if-Async 1)# profile create slave authentication pap apn b.apn username UserB
password 0 123 priority 1
Ruijie(config-if-Async 1)# profile switch timer 20 max-fail-times 3
Ruijie(config-if-Async 1)#show run interface async 1

Building configuration...
Current configuration : 141 bytes
!
```

```
interface Async 1
 encapsulation PPP
profile create master authentication pap apn a.apn username UserA password 0 123 bfd
profile create slave authentication pap apn b.apn username UserB password 0 123 priority 1
profile switch timer 20 max-fail-times 3
async mode dedicated
 ip address negotiate
 dialer in-band
 dialer string *99#
dialer auto-dial
 dialer idle-timeout 0
 dialer-group 1
Ruijie(config-if-Async 1)#
```

Caution

While using multi-AP backup for single card, you need to apply to the carrier for two or more APs.

Here we will not describe how to associate BFD with the routing protocol. For details, see *BFD-SCG.doc*.

The additional feature of BFD association provided herein will not compromise the former association between BFD and routing protocol. There is no need for BFD protocol to add any unnecessary configuration.

To enable multi-AP backup for single card and BFD association, you must enable BFD on LNS side, or else the configuration does not function.

BFD must also be enabled on the LNS device corresponding to the master AP, while the configuration for slave AP can be determined according to the fact that whether or not BFD is enabled on the corresponding LNS side.

Configuring Multi-AP Backup for Single Card and Track Association

With respect to multi-AP backup for single card, you can apply to the carrier for 2 APs. When the master AP is unreachable, the system will switch to the slave AP and reestablish connection, thus ensuring the reliability of the system.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **ip rns** *1*	Enters IP RNS configuration mode.
Ruijie(config-ip-rns)# **icmp-echo** *10.1.1.1*	Configures an IP RNS object to send ICMP packets. The detection destination address can be set to the IP address of the LNS device.
Ruijie(config-ip-rns)# **frequency** *1000*	Configures the interval for RNS to send packets, in milliseconds. This interval must be greater than or equal to the timeout duration. The default value is 60 seconds. The range is from 10 to 604800000.

Command	Function
Ruijie(config-ip-rns)# **timeout** *1000*	Configures the timeout duration of a packet sent by the RNS, in milliseconds. Default value: 5 seconds for icmp echo packet, and 9 seconds for DNS packet. Configurable range: 10 to 604800000 ms for icmp echo detection, and 1000 to 604800000 ms for DNS detection.
Ruijie(config)# **track** *2* **rns** *1*	Traces the state of an IP RNS object and enters track mode.
Ruijie(config-track)# **delay up** *30*	(Optional) Specifies a delay time after which the state of a track object will change when its state changes. There is no delay by default.
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **ip rns** *2*	Enters IP RNS configuration mode.
Ruijie(config-ip-rns)# **icmp-echo** *20.1.1.1*	Configures an IP RNS object to send ICMP packets. The detection destination address can be set to the IP address of the LNS device.
Ruijie(config-ip-rns)# **frequency** *1000*	Configures the interval for RNS to send packets, in milliseconds. This interval must be greater than or equal to the timeout duration. The default value is 60 seconds. The range is from 10 to 604800000.
Ruijie(config-ip-rns)# **timeout** *1000*	Configures the timeout duration of a packet sent by the RNS, in milliseconds. Default value: 5 seconds for icmp echo packet, and 9 seconds for DNS packet. Configurable range: 10 to 604800000 ms for icmp echo detection, and 1000 to 604800000 ms for DNS detection.
Ruijie(config)# **track** *20* **rns** *2*	Traces the state of an IP RNS object and enters track mode.
Ruijie(config-track)# **delay up** *30*	(Optional) Specifies a delay time after which the state of a track object will change when its state changes. There is no delay by default.
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface async** *1*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **profile create master authentication pap apn** *a.apn* **username** *UserA* **password 0** *123* **track** *20*	Configures the master AP.
Ruijie(config-if-Async 1)# **profile create slave authentication pap apn** *b.apn* **username** *UserB* **password 0** *123* **track** *10* **priority** *1*	Configures the slave AP.
Ruijie(config-if-Async 1)# **profile switch timer** *20* **max-fail-times** *3*	Configures the switch timer and the maximum times of failure. The switch timer duration is in the range from 1 to 60 seconds, 10 seconds by default. The maximum times of failure is in the range of 1 to 10, 3 by default.
Ruijie(config)# **show running-config**	Displays the parameters configured.

Configure multi-AP backup for single card and Track association:

```
Ruijie# configure terminal
Ruijie(config)# ip rns 1
Ruijie(config-ip-rns)# icmp-echo 10.1.1.1
Ruijie(config-ip-rns)# frequency 1000
Ruijie(config-ip-rns)# timeout 1000
Ruijie(config)# track 2 rns 1
Ruijie(config-track)# delay up 30
Ruijie(config-track)# exit
Ruijie(config)#
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)# profile create master authentication pap apn a.apn username UserA
password 0 123 track 20
Ruijie(config-if-Async 1)# profile create slave authentication pap apn b.apn username UserB
password 0 123 track 10 priority 1
Ruijie(config-if-Async 1)# profile switch timer 20 max-fail-times 3
Ruijie(config-if-Async 1)#show run interface async 1

Building configuration...
Current configuration : 141 bytes
!
interface Async 1
 encapsulation PPP
profile create master authentication pap apn a.apn username UserA password 123 track 20
profile create slave authentication pap apn b.apn username UserB password 123 track 10 priority
1
profile switch timer 20 max-fail-times 3
async mode dedicated
 ip address negotiate
 dialer in-band
 dialer string *99#
dialer auto-dial
 dialer idle-timeout 0
 dialer-group 1
Ruijie(config-if-Async 1)#
```

Caution While using multi-AP backup for single card, you need to apply to the carrier for two or more APs.

Configuring 3G Dual-card Backup

Configuring Dual-card Backup and BFD Association

Ruijie's 3G routers support the association between dual-card backup and TRACK object state. When the TRACK object is down, the active link will become down, and the standby link will be activated to take up the role of active link.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface async** *1*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **plmn backup slave-interface Async** *2* **bfd**	Specifies the slave interface on master interface and associates with BFD.
Ruijie(config)# **interface async** *2*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 2)# **plmn backup master-interface Async** *1* **bfd**	Specifies the master interface on slave interface and associates with BFD.
Ruijie(config)# **show running-config**	Displays the parameters configured.

Configure dual-card backup and BFD association:

```
Ruijie# configure terminal
Ruijie(config)# ip rns 1
Ruijie(config-ip-rns)# icmp-echo 10.1.1.1
Ruijie(config-ip-rns)# frequency 1000
Ruijie(config-ip-rns)# timeout 1000
Ruijie(config)# track 2 rns 1
Ruijie(config-track)# delay up 30
Ruijie# configure terminal
Ruijie(config)# interface async 1
Ruijie(config-if-Async 1)# plmn backup slave-interface Async 2 bfd
Ruijie(config)# interface async 2
Ruijie(config-if-Async 2)# plmn backup master-interface Async 1 bfd
Ruijie# show run interface async 1
Building configuration...
Current configuration : 141 bytes
!
interface Async 1
 encapsulation PPP
 async mode dedicated
 ip address negotiate
 dialer in-band
 dialer string *99#
 dialer apn 3gnet
 dialer auto-dial
 plmn backup slave-interface Async 2 bfd
```

```
 dialer idle-timeout 0
 dialer-group 1
Ruijie# show run interface async 2
interface Async 2
 encapsulation PPP
 async mode dedicated
 ip address negotiate
 dialer in-band
 dialer string *99#
 dialer apn 3gnet
 dialer auto-dial
 plmn backup master-interface Async 1 bfd
 dialer idle-timeout 0
dialer-group 1
```

Caution

Here we will not describe how to associate BFD with the routing protocol. For details, see *BFD-SCG.doc*. The additional feature of BFD association provided herein will not compromise the former association between BFD and routing protocol. There is no need for BFD protocol to add any unnecessary configuration. BFD must be enabled on the LNSs connecting to the two 3G cards.

Configuring Dual-card Backup and Track Association

Ruijie's 3G routers support the association between dual-card backup and TRACK object state. When the TRACK object is down, the active link will become down, and the standby link will be activated to take up the role of active link.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **ip rns** *1*	Enters IP RNS configuration mode.
Ruijie(config-ip-rns)# **icmp-echo** *10.1.1.1*	Configures an IP RNS object to send ICMP packets. The detection destination address can be set to the IP address of the LNS device.
Ruijie(config-ip-rns)# **frequency** *1000*	Configures the interval for RNS to send packets, in milliseconds. This interval must be greater than or equal to the timeout time. The default value is 60 seconds. The range is from 10 to 604800000.
Ruijie(config-ip-rns)# **timeout** *1000*	Configures the timeout duration of a packet sent by the RNS, in milliseconds. Default value: 5 seconds for icmp echo packet, and 9 seconds for DNS packet. Configurable range: 10 to 604800000 ms for icmp echo detection, and 1000 to 604800000 ms for DNS detection.
Ruijie(config)# **track** *10* **rns** *1*	Traces the state of an IP RNS object and enters track mode.

Command	Function
Ruijie(config-track)# **delay up** *30*	(Optional) Specifies a delay time after which the state of track object will change when its state changes. There is no delay by default.
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **ip rns** *2*	Enters IP RNS configuration mode.
Ruijie(config-ip-rns)# **icmp-echo** *20.1.1.1*	Configures an IP RNS object to send ICMP packets. The detection destination address can be set to the IP address of the LNS device.
Ruijie(config-ip-rns)# **frequency** *1000*	Configures the interval for RNS to send packets, in milliseconds. This interval must be greater than or equal to the timeout time. The default value is 60 seconds. The range is from 10 to 604800000.
Ruijie(config-ip-rns)# **timeout** *1000*	Configures the timeout duration of a packet sent by the RNS, in milliseconds. Default value: 5 seconds for icmp echo packet, and 9 seconds for DNS packet. Configurable range: 10 to 604800000 ms for icmp echo detection, and 1000 to 604800000 ms for DNS detection.
Ruijie(config)# **track** *20* **rns** *2*	Traces the state of an IP RNS object and enters track mode.
Ruijie(config-track)# **delay up** *30*	(Optional) Specifies a delay time after which the state of track object will change when its state changes. There is no delay by default.
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface async** *1*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **plmn backup slave-interface Async** *2* **track** *10* **switch-delay** *10*	On the master interface, configures slave interface, ID of the associated track object and switch delay time.
Ruijie(config)# **interface async** *2*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 2)# **plmn backup master-interface Async** *1* **track** *20* **switch-delay** *10*	On the slave interface, configures master interface, ID of the associated track object and switch delay time.
Ruijie(config)# **show running-config**	Displays the parameters configured.
Ruijie# **show track** *10*	(Optional) Displays information about track object. Use this command to verify the configuration.
Ruijie# **show track** *20*	(Optional) Display information about track object. Use this command to verify the configuration.

Configure dual-card backup and Track association:

```
Ruijie# configure terminal
Ruijie(config)# ip rns 1
Ruijie(config-ip-rns)# icmp-echo 10.1.1.1
Ruijie(config-ip-rns)# frequency 1000
Ruijie(config-ip-rns)# timeout 1000
Ruijie(config)# track 2 rns 1
```

```
Ruijie(config-track)# delay up 30
Ruijie(config-track)# exit
Ruijie# configure terminal
Ruijie(config)# interface async 1
Ruijie(config-if-Async 1)#plmn backup slave-interface Async 2 track 10 switch-delay 10
Ruijie(config)# interface async 2
Ruijie(config-if-Async 2)#plmn backup master-interface Async 1 track 20 switch-delay 10
Ruijie# show run interface async 1
Building configuration...
Current configuration : 141 bytes
!
interface Async 1
 encapsulation PPP
 async mode dedicated
 ip address negotiate
 dialer in-band
 dialer string *99#
 dialer apn 3gnet
 dialer auto-dial
 plmn backup slave-interface Async 2 track 10 switch-delay 10
 dialer idle-timeout 0
 dialer-group 1
Ruijie# show run interface async 2
interface Async 2
 encapsulation PPP
 async mode dedicated
 ip address negotiate
 dialer in-band
 dialer string *99#
 dialer apn 3gnet
 dialer auto-dial
 plmn backup master-interface Async 1 track 20 switch-delay 10
 dialer idle-timeout 0
 dialer-group 1
```

Configuring Dual-card Backup and RSSI Association

Ruijie's 3G routers support the association between dual-card backup and RSSI signal strength. When the active link detects that RSSI falls below the preconfigured threshold, the active link will become down, and the standby link will be activated to take up the role of active link.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface async** *1*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.

Ruijie(config-if-Async 1)# **plmn backup slave-interface Async** *2* **rssi -***100* **interval** *15* **ntimes** *3* **percent** *100*	On the master interface, configures slave interface and RSSI signal detection conditions.
Ruijie(config)# **interface async** *2*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 2)# **plmn backup master-interface Async** *1* **rssi -***100* **interval** *15* **ntimes** *3* **percent** *100*	On the slave interface, configures the associated master interface and RSSI signal detection conditions.
Ruijie(config)# **show running-config**	Displays the parameters configured.

Configure dual-card backup and RSSI association:

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)# plmn backup slave-interface Async 2 rssi -100 interval 15 ntimes
3 percent 100
Ruijie(config)#interface async 2
Ruijie(config-if-Async 2) plmn backup master-interface Async 1 rssi -100 interval 15 ntimes
3 percent 100
Ruijie(config-if-Async 2)#show run interface async 1

Building configuration...
Current configuration : 141 bytes
!
interface Async 1
 encapsulation PPP
 async mode dedicated
 ip address negotiate
 dialer in-band
 dialer string *99#
 dialer apn 3gnet
 dialer auto-dial
 dialer idle-timeout 0
plmn backup slave-interface Async 2 rssi -100 interval 15 ntimes 3 percent 100
 dialer-group 1
Ruijie(config-if-Async 2)#show run interface async 2
interface Async 2
 encapsulation PPP
 async mode dedicated
 ip address negotiate
 dialer in-band
 dialer string *99#
 dialer apn 3gnet
 dialer auto-dial
 dialer idle-timeout 0
plmn backup master-interface Async 1 rssi -100 interval 15 ntimes 3 percent 100
 dialer-group 1
```

Configuring Single 3G Card and Single-AP Connectivity Detection

Associating Single 3G Interface with BFD

Ruijie's 3G routers can associate a single 3G card with BFD. When the state of BFD becomes down, the 3G link will reset the dialup connection.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface async** *1*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **plmn status bfd**	Associates the state of 3G interface with BFD.
Ruijie(config)# **show running-config**	Displays the parameters configured.

Associate a single 3G card with BFD:

```
Ruijie# configure terminal
Ruijie(config)# interface async 1
Ruijie(config-if-Async 1)# plmn status bfd
Ruijie(config-if-Async 1)#show run interface async 1

Building configuration...
Current configuration : 141 bytes
!
interface Async 1
 encapsulation PPP
 async mode dedicated
 ip address negotiate
 dialer in-band
 dialer string *99#
 dialer apn 3gnet
 dialer auto-dial
 dialer idle-timeout 0
 dialer-group 1
plmn status bfd
Ruijie(config-if-Async 1)#
```

Associating Single 3G Interface with Track

Ruijie's 3G routers can associate a single 3G card with Track. When the state of Track object becomes down, the 3G link will reset the dialup connection.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **ip rns** *1*	Enters IP RNS configuration mode.
Ruijie(config-ip-rns)# **icmp-echo** *10.1.1.1*	Configures an IP RNS object to send ICMP packets.

Command	Function
Ruijie(config-ip-rns)# **frequency** *1000*	Configures the interval for RNS to send packets, in milliseconds. This interval must be greater than or equal to the timeout time. The default value is 60 seconds. The range is from 10 to 604800000.
Ruijie(config-ip-rns)# **timeout** *1000*	Configures the timeout duration of a packet sent by the RNS, in milliseconds. Default value: 5 seconds for icmp echo packet, and 9 seconds for DNS packet. Configurable range: 10 to 604800000 ms for icmp echo detection, and 1000 to 604800000 ms for DNS detection.
Ruijie(config)# **track** *2* **rns** *1*	Traces the state of an IP RNS object and enters track mode.
Ruijie(config-track)# **delay up** *30*	(Optional) Specifies a delay time after which the state of track object will change when its state changes. There is no delay by default.
Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface async** *1*	Enter interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **plmn status track** *2*	Configures the ID of the track object associated with the state of 3G interface.
Ruijie(config)# **show running-config**	Displays the parameters configured.

Associate a single 3G card with Track:

```
Ruijie# configure terminal
Ruijie(config)# ip rns 1
Ruijie(config-ip-rns)# icmp-echo 10.1.1.1
Ruijie(config-ip-rns)# frequency 1000
Ruijie(config-ip-rns)# timeout 1000
Ruijie(config)# track 2 rns 1
Ruijie(config-track)# delay up 30
Ruijie# configure terminal
Ruijie(config)# interface async 1
Ruijie(config-if-Async 1)# plmn status track 2
Ruijie(config-if-Async 1)#show run interface async 1

Building configuration...
Current configuration : 141 bytes
!
interface Async 1
 encapsulation PPP
 async mode dedicated
 ip address negotiate
 dialer in-band
 dialer string *99#
 dialer apn 3gnet
```

```
 dialer auto-dial
 dialer idle-timeout 0
 dialer-group 1
plmn status track 2
Ruijie(config-if-Async 1)#
```

Associating Single 3G Interface with RSSI

Ruijie's 3G routers can associate a single 3G card with RSSI. When the signal strength of RSSI falls below the preconfigured value, the 3G link will reset the dialup connection.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface async** *1*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **plmn status rssi-detect rssi** *-90* **interval** *15* **ntimes** *3* **percent** *100*	Associates the state of 3G interface with RSSI.
Ruijie(config)# **show running-config**	Displays the parameters configured.

Associate a single 3G card with RNS for connectivity detection:

```
Ruijie# configure terminal
Ruijie(config)# ip rns 1
Ruijie(config-ip-rns)# icmp-echo 10.1.1.1
Ruijie(config-ip-rns)# frequency 1000
Ruijie(config-ip-rns)# timeout 1000
Ruijie(config)# track 2 rns 1
Ruijie(config-track)# delay up 30
Ruijie# configure terminal
Ruijie(config)# interface async 1
Ruijie(config-if-Async 1)# plmn status rssi-detect rssi -90 interval 15 ntimes 3 percent 100
Ruijie(config-if-Async 1)#show run interface async 1

Building configuration...
Current configuration : 141 bytes
!
interface Async 1
 encapsulation PPP
 async mode dedicated
 ip address negotiate
 dialer in-band
 dialer string *99#
 dialer apn 3gnet
 dialer auto-dial
 dialer idle-timeout 0
 dialer-group 1
plmn status rssi-detect rssi -90 interval 15 ntimes 3 percent 100
```

```
Ruijie(config-if-Async 1)#
```

Selecting 3G Network Access Mode

Searching and Selecting the Current Access Mode (2.5G/3G Manual Switchover)

While using a 3G card or a 3G router, if the poor 3G signal has compromised basic data communication and yet the carrier cannot automatically switch the network to 2.5G, you can manually switch the access mode to 2.5G to ensure basic data communication. If the current access mode is 2.5G but the carrier cannot automatically upgrade the access mode to 3G when the 3G signal restores, you can also manually switch the access mode to get higher transmission rate.

On Ruijie's router, you can configure on the 3G interface to select the current access mode. By default, the router will automatically select the access mode with higher transmission rate.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface async** *1*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **plmn search**	Configures the search command for selecting network mode.
Ruijie(config)# **show cellular info network**	Displays the list of networks found.
Ruijie(config)# **plmn select** *network-list-number*	Selects the ID of network mode to be used. You must run the **plmn search** command before running this command.
Ruijie(config)# **show cellular info network**	Verifies the result.

Steps to select the access mode (using TD-SCDMA as an example; the steps are the same for other standards)

Step 1: Run the plmn search command in interface mode:

```
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)#plmn search
Ruijie(config-if-Async 1)#00:00:14:02: %7: Searching for available PLMNS...Please wait...
```

Step 2: Verify whether the network search command has been completed:

The following prompting message indicates the completion of network search:

```
Ruijie(config-if-Async 1)#00:00:14:38: %7: PLMN search done. Please use "show cellular info"
to see available PLMNS
```

Step 3: Display the list of networks found:

```
Run the show cellular info network command to get the following result:
Ruijie(config-if-Async 1)#show cellular info
==========================================
Tty no: 1
Interface: Async 1
3G Type: TD_SCDMA
RSSI: -66 dBm
Sys mode:TDSCDMA(15)
```

```
Available PLMN's:
 list 1: Status = Available ,SP name = China Mobile , Network = GSM/GPRS(2G)
 list 2: Status = Registered,SP name = China Mobile , Network = UTRAN(3G)
```

If the software version is upgraded to Release 10.3 (5b5) or later, you only need to run the **show cellular info network** command:

```
Ruijie(config-if-Async 1)#show cellular info network
Interface Async1:
Network Information:
3G Type        = TD_SCDMA
Sys mode       = TDSCDMA(15)
Service status  = Valid service(2)
Roming status   = Non roaming state(0)
Service domain  = PS+CS service(3)
Available PLMN’s:
 list 1: Status = Available ,SP name = China Mobile , Network = GSM/GPRS(2G)
 list 2: Status = Registered,SP name = China Mobile , Network = UTRAN(3G)
```

Step 4: Select the network mode to be used:

The parameter carried by the **plmn select** command is the network list obtained after execution of the **plmn search** command. This list corresponds to the PLMN list displayed after execution of the **show cellular info** command.

```
Ruijie(config-if-Async 1)#plmn select 1
Ruijie(config-if-Async 1)#00:00:17:30: %7: Selecting PLMN mode…Please wait…
```

//This message indicates that the system is executing the command to select access mode.

Step 5: Verify results:

The following message indicates that selection was successful.

```
Ruijie(config-if-Async 1)#00:00:17:37: %7: PLMN selection successful
```

`00:00:17:37: %7: Deleted search results` //This message indicates that the network list searched previously is deleted.

The following message indicates that selection failed.

```
Ruijie(config-if-Async 1)#00:00:17:37: %7: PLMN selection unsuccessful
```

`00:00:17:37: %7: Deleted search results` //This message indicates that the network list searched previously is deleted.

Run the **show cellular info** command to view the current access mode

```
Ruijie(config-if-Async 1)#show cellular info
==========================================
Tty no: 1
Interface: Async 1
3G Type: TD_SCDMA
RSSI: -69 dBm
```

```
Sys mode: GSM/GPRS(3)
```

If the software version is upgraded to Release 10.3 (5b5) or later, you only need to run the **show cellular info network** command:

```
Ruijie(config-if-Async 1)#show cellular info network
Interface Async1:
Network Information:
====================
3G Type        = TD_SCDMA
Sys mode       = GSM/GPRS(3)
Service status  = Valid service(2)
Roming status   = Non roaming state(0)
Service domain  = PS+CS service(3)
```

Caution

1: It takes longer time (about 50s) to search for WCDMA and TD-SCDMA.
2: It takes shorter search time (about 5s) in case of CDMA2000.
3: During network search, do not perform dail-up; likewise, do not search for networks after successful dialup.
4: The network search may fail due to network-related factors
5: For WCDMA and CDMA2000, if the network type selected is registered, the system does not automatically restore to the higher-level access mode. Run the **plmn select auto** command to restore.
6: Generally, do not run the command for network access mode selection. Running this command will compromise network access bandwidth, thus affecting the data rate of connection.
7: After 2G network is selected, TD-SCDMA may automatically switch to the 3G network.

Directly Configuring the Current Access Mode (2.5G/3G Manual Switchover)

On Ruijie's router, you can configure on the 3G interface to select the current access mode. By default, the router will automatically select the access mode with higher transmission rate.
Directly selecting the current access mode is faster than the "search and then select" approach described in the "Searching and Selecting the Current Access Mode (2.5G/3G Manual Switchover)" section. However, the network mode selected may not be supported by the carrier.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface async** *1*	Enters interface configuration mode. Interface ID is the tty ID corresponding to modem.
Ruijie(config-if-Async 1)# **plmn mode manual gsm/gprs**	Configures to select gsm/gprs as the current access mode (using TD-SCDMA as an example).
Ruijie(config)# **show cellular info network**	Verifies the result.

Steps to select the access mode (using TD-SCDMA as an example; the steps are the same for other standards)

```
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)# plmn mode manual gsm/gprs
```

Run the **show cellular info** command to view the current access mode.

```
Ruijie(config-if-Async 1)#show cellular info
```

```
==========================================
Tty no: 1
Interface: Async 1
3G Type: TD_SCDMA
RSSI: -69 dBm
Sys mode: GSM/GPRS(3)
```

If the software version is upgraded to Release 10.3 (5b5) or later, you only need to run the **show cellular info network** command:

```
Ruijie(config-if-Async 1)#show cellular info network
Interface Async1:
Network Information:
====================
3G Type        = TD_SCDMA
Sys mode       = GSM/GPRS(3)
Service status  = Valid service(2)
Roming status   = Non roaming state(0)
Service domain  = PS+CS service(3)
```


Caution

1: After you directly select the desired network access mode, the dialup may fail depending on the carrier.
2: During network search, do not perform dialup; likewise, do not search for networks after successful dialup.

Typical Examples of 3G Dial Configuration


Caution

All examples given in this chapter focus only on the 3G part. Such configurations as routing and ACL are not iterated herein.

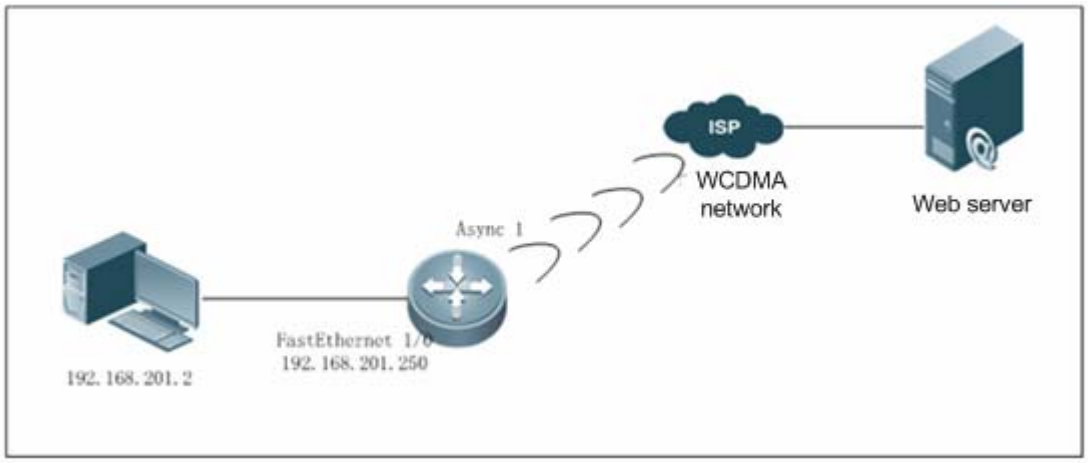
Configuration example of 3G access to public network

Networking Requirements

A PC accesses WCDMA 3G network and web servers in the public network through the router.

Networking Topology

Figure 10 Networking topology for 3G DIAL



Configuration Steps

#1) Configure interface dialing.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#dialer-list 1 protocol ip permit
Ruijie(config)#username UMTS_CHAP_SRVR password ""
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)#ip address negotiate
Ruijie(config-if-Async 1)#encapsulation ppp
Ruijie(config-if-Async 1)#ip ref
Ruijie(config-if-Async 1)#async mode dedicated
Ruijie(config-if-Async 1)#dialer in-band
Ruijie(config-if-Async 1)#dialer string *99#
Ruijie(config-if-Async 1)#dialer-group 1
```

#2) Configure line parameters.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#line tty 1
Ruijie(config-line)#modem inOut
```

#3) Configure NAT.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)#ip nat outside
Ruijie(config-if-Async 1)#exit
Ruijie(config)#interface FastEthernet 0/0
Ruijie(config-if-FastEthernet0/0)#ip nat inside
```

```
Ruijie(config-if-FastEthernet0/0)#ip address  192.168.201.250 255.255.255.0
Ruijie(config-if-FastEthernet0/0)#ip ref
Ruijie(config-if-FastEthernet0/0)#exit
Ruijie(config)# ip nat inside source list 1 interface Async 1
```

#4) Configure routes.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# ip route 0.0.0.0 0.0.0.0 Async 1
Ruijie(config)# ip route 192.168.0.0 255.255.0.0 FastEthernet 0/0
```

Example of configuring IPSec support for 3G

Networking Requirements

As the access router, Ruijie routers use 3G wireless network to access the carrier, which, as the LNS of LAC access user's headquarters, establishes L2TP tunnel with the headquarters which uses MSTP to access the carrier. The IPSec tunnel is established between the access router and headquarters through the L2TP tunnel of the carrier.

GGSN acts as the LAC. The domain name is verified on LAC, while the hostname and password are verified on LNS. The dialing port of the router uses fixed address (LAN address).

Assume that:

APN of the dedicated line provided by the carrier: ruijie.apn

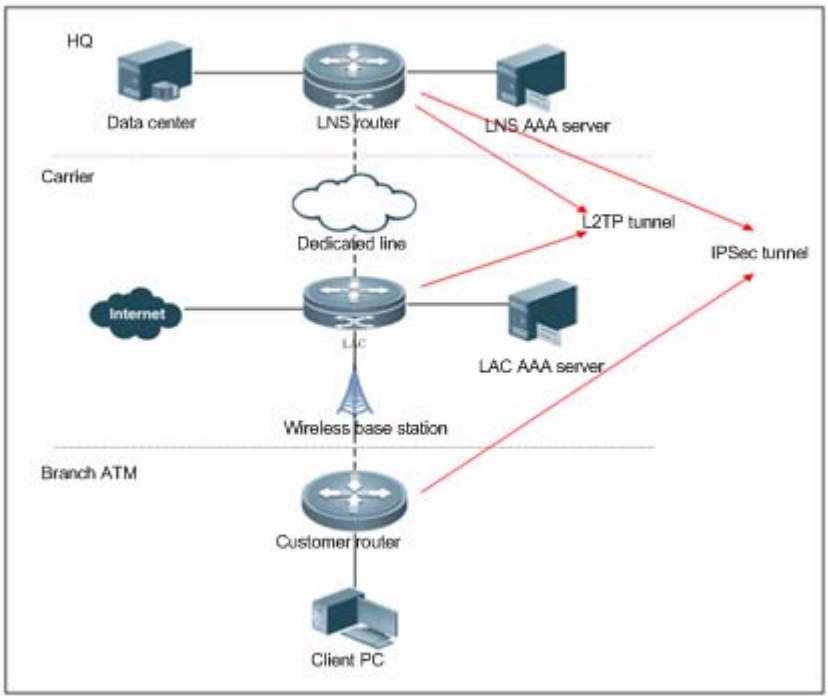
Hostname provided by LNS: ruijie; password: pass; authentication method: chap

AAA server address of LNS: 192.168.52.134

```
Address of LNS L2TP server connecting to carrier network: 10.0.0.1
Address of LNS server: 192.168.1.1
Address pool defined by LNS for client side: 192.168.1.10-192.168.1.254
IP address of data center: 192.168.3.1
The interface on LNS router for connecting the data center is an Ethernet port, with IP address being 192.168.3.2
LAC is carrier's device. No configuration related to this device is involved in this example
```

Network Topology

Figure 11 Networking topology for IPSec support for 3G



Configuration Steps

Configuration of client-side router

#1) Configure interface dialing.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#dialer-list 1 protocol ip permit
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)#ip address negotiate
Ruijie(config-if-Async 1)#encapsulation ppp
Ruijie(config-if-Async 1)#ppp chap hostname ruijie
Ruijie(config-if-Async 1)#ppp chap password pass
Ruijie(config-if-Async 1)#ip ref
Ruijie(config-if-Async 1)#async mode dedicated
Ruijie(config-if-Async 1)#dialer in-band
Ruijie(config-if-Async 1)#dialer string *99#
Ruijie(config-if-Async 1)#dialer-group 1
Ruijie(config-if-Async 1)#dialer apn ruijie.apn
```

#2) Configure line parameters.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#line tty 1
```

```
Ruijie(config-line)#modem inOut
```

#3) Configure the route.

```
Ruijie (config)#ip route 0.0.0.0 0.0.0.0 Async 1
```

#4) Enable IKE.

```
Ruijie (config)#crypto isakmp enable
```

#5) Configure PSK and transform set.

```
Ruijie (config)#crypto isakmp policy 1
Ruijie (isakmp-policy)#encryption 3des
Ruijie (isakmp-policy)#authentication pre-share
Ruijie (config)#crypto isakmp key 7 06162c0662061a261717 address 10.0.0.1
Ruijie (config)#crypto ipsec transform-set myset  esp-aes-192
```

#6) Define a crypto map.

```
Ruijie(config)#crypto map mymap 5 ipsec-isakmp
Ruijie(config-crypto-map)# set peer 10.0.0.1
Ruijie(config-crypto-map)# set transform-set myset
Ruijie(config-crypto-map)# match address 100
```

#7) Apply crypto map to the interface.

```
Ruijie (config)#int async 1
Ruijie (config-if-Async 1)#crypto map mymap
```

#8) Define the access list.

```
Ruijie (config)#ip access-list extended 100
Ruijie (config-ext-nacl)#10 permit ip 192.168.0.0 255.255.255.0  192.168.1.0 255.255.255.0
```

#9) Configure the IP address of the Ethernet interface connecting PC.

```
Ruijie(config)#interface FastEthernet 0/0
Ruijie (config-if-FastEthernet 0/0)#ip  ref
Ruijie (config-if-FastEthernet 0/0)# ip address 192.168.0.1 255.255.255.0
```

Configuration of LNS router

#1) Enable VPDN.

```
Ruijie#configure
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#vpdn enable
```

#2) Configure VPDN-GROUP.

```
Ruijie(config)#vpdn-group 1
Ruijie(config-vpdn)#accept-dialin
Ruijie(config-vpdn-acc-in)#protocol l2tp
Ruijie(config-vpdn-acc-in)#virtual-template 1
```

#3) Configure hostname and password.

```
Ruijie(config)#username ruijie password 0 pass
```

#4) Configure the address of dialing interface and address pool. The address of dialing interface is the IP address of the interface upon successful dialup; the address pool contains the IP addresses allocated to the peer device.

```
Ruijie(config)#interface loopback 1
Ruijie(config-Loopback 1)#ip address 192.168.1.1 255.255.255.0
Ruijie(config-Loopback 1)#exit
Ruijie(config)#ip local pool vpdn 192.168.1.10 192.168.1.254
```

#5) Configure virtual-template for receiving incoming calls.

```
Ruijie(config)#interface virtual-template 1
Ruijie(config-Virtual-Template 1)#ip ref
Ruijie(config-Virtual-Template 1)#ip unnumbered loopback 1
Ruijie(config-Virtual-Template 1)#ppp authentication pap chap ruijie_auth
Ruijie(config-Virtual-Template 1)#peer default ip address pool vpdn
Ruijie(config-Virtual-Template 1)#end
```

#6) Enable AAA.

```
Ruijie(config)#aaa new-model
```

#7) Configure radius authentication.

```
Ruijie(config)#aaa authentication ppp ruijie_auth group radius
```

#8) Configure radius server.

```
Ruijie(config)#radius-server host 192.168.52.134
Ruijie(config)#radius-server retransmit 5
Ruijie(config)#radius-server key 0 pass
```

#9) Enable IKE.

```
Ruijie (config)#crypto isakmp enable
```

#10) Configure PSK and transform set.

```
Ruijie (config)#crypto isakmp policy 1
Ruijie (isakmp-policy)#encryption 3des
Ruijie (isakmp-policy)#authentication pre-share
Ruijie (config)#crypto isakmp key 7 06162c0662061a261717 address 0.0.0.0 0.0.0.0
Ruijie (config)#crypto ipsec transform-set myset  esp-aes-192
```

#11) Define a crypto map.

```
Ruijie(config)#crypto dynamic-map dymap 1
Ruijie(config-crypto-map)#set transform-set myset
Ruijie(config-crypto-map)#exit
Ruijie(config)#crypto map mymap 1 ipsec-isakmp dynamic dymap
```

#12) Apply crypto map to the interface.

```
Ruijie(config)#interface FastEthernet 0/0
Ruijie (config-if-FastEthernet 0/0)#crypto map mymap
```

#13) Configure the IP address of the Ethernet interface of LNS server for connecting the carrier network.

```
Ruijie(config)#interface FastEthernet 0/0
Ruijie (config-if-FastEthernet 0/0)#ip  ref
Ruijie (config-if-FastEthernet 0/0)# ip address 10.0.0.1 255.255.255.0
```

#14) Configure the Ethernet interface for connecting to the data server.

```
Ruijie(config)#interface FastEthernet 0/1
Ruijie (config-if-FastEthernet 0/1)#ip  ref
Ruijie (config-if-FastEthernet 0/1)#ip address 192.168.3.2 255.255.255.0
```

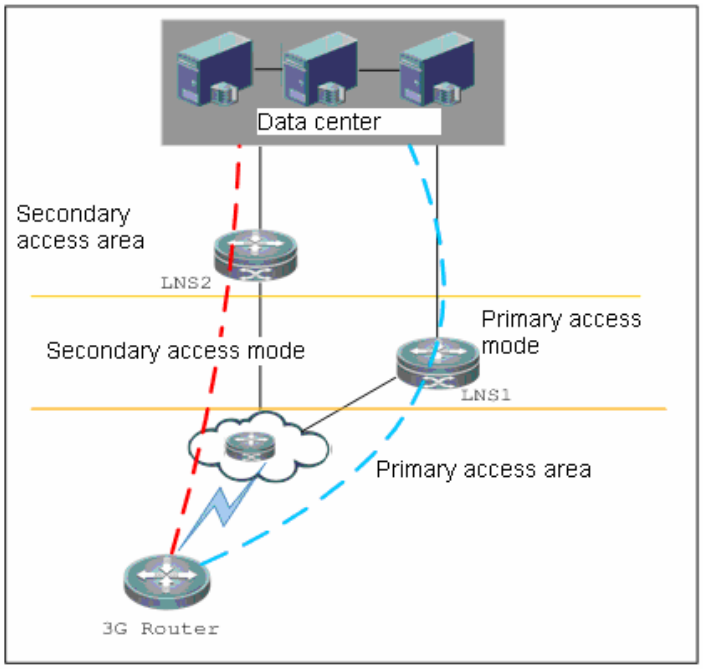
Example of 3G Supporting Multi-AP Backup for Single Card and BFD Association

Networking Requirements

The customer applies to the carrier for two APs. The master AP and slave AP can access different LNS devices. When the 3G router cannot reach the primary LNS, it will switch to the secondary LNS.

Network Topology

Figure 12 Networking topology for 3G supporting multi-AP backup for single card



Configuration Steps

Configurations on the customer router

This example only lists the required configurations for automatic switchover between two 3G cards. For other configurations, see the steps to configure IPSec support for 3G.

1) Perform dialup configuration of the 3G interface for China Telecom, and configure multiple APs.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#dialer-list 1 protocol ip permit
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)#ip address negotiate
Ruijie(config-if-Async 1)#encapsulation ppp
Ruijie(config-if-Async 1)#ip ref
Ruijie(config-if-Async 1)# profile create master authentication chap  apn  3gnet1 username
UserA password 0 123 bfd
Ruijie(config-if-Async 1)# profile create slave authentication pap apn  3gnet username UserB
password 0 123 priority 1
Ruijie(config-if-Async 1)# profile switch timer 20 max-fail-times 3
Ruijie(config-if-Async 1)#async mode dedicated
Ruijie(config-if-Async 1)#dialer in-band
Ruijie(config-if-Async 1)#dialer string #777
Ruijie(config-if-Async 1)#dialer-group 1
```

2) Configure line parameters.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config-line)#modem inOut
Ruijie(config-line)#speed 115200
```

3) Configure the route.

```
! This step is optional. Add or delete this command according to the actual situation.
! Dynamic and static routes may be involved in actual deployment. Add related commands
as required.
Ruijie (config)#ip route 0.0.0.0 0.0.0.0 Async 1
```

#4) Configure BFD.

! The configurations of BFD are the same as the configurations to associate BFD with the routing protocol. For details, see BFD-SCG.doc.

Configurations on LNS router

! As for the configurations on the LNS router, see SEC-VPDN-SCG.doc for the L2TP part and BFD-SCG.doc for the BFD part.

Example of 3G Supporting Multi-AP Backup for Single Card and Track Association

Networking Requirements

See the networking requirements in the "Example of 3G Supporting Multi-AP Backup for Single Card and Track Association" section.

Network Topology

See the network topology in the "Example of 3G Supporting Multi-AP Backup for Single Card and Track Association" section.

Configuration Steps

Configurations on the customer router

This example only lists the required configurations for automatic switchover between two 3G cards. For other configurations, see the steps to configure IPSec support for 3G.

1) Perform dialup configuration of the 3G interface for China Telecom.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#dialer-list 1 protocol ip permit
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)#ip address negotiate
Ruijie(config-if-Async 1)#encapsulation ppp
Ruijie(config-if-Async 1)#ip ref
Ruijie(config-if-Async 1)#async mode dedicated
Ruijie(config-if-Async 1)#dialer in-band
Ruijie(config-if-Async 1)#dialer string #777
Ruijie(config-if-Async 1)#dialer-group 1
```

2) Configure line parameters.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config-line)#modem inOut
Ruijie(config-line)#speed 115200
```

3) Configure the route.

```
! This step is optional. Add or delete this command according to the actual situation.
! Dynamic and static routes may be involved in actual deployment. Add related commands as required.
Ruijie (config)#ip route 0.0.0.0 0.0.0.0 Async 1
```

4) Configure RNS and Track.

```
Ruijie# configure terminal
Ruijie(config)# ip rns 1
! Assume that 10.1.1.1 is the IP address of the LNS device corresponding to slave AP.
Ruijie(config-ip-rns)# icmp-echo 10.1.1.1
Ruijie(config-ip-rns)# frequency 1000
Ruijie(config-ip-rns)# timeout 1000
Ruijie(config)# track 10 rns 1
Ruijie(config-track)# delay up 30
```

```
Ruijie(config-track)# exit
Ruijie(config)# ip rns 2
! Assume that 11.1.1.1 is the IP address of the LNS device corresponding to master AP.
Ruijie(config-ip-rns)# icmp-echo 11.1.1.1
Ruijie(config-ip-rns)# frequency 1000
Ruijie(config-ip-rns)# timeout 1000
Ruijie(config)# track 20 rns 2
Ruijie(config-track)# delay up 30
# 5) Associate multi-AP backup with track.
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)# profile create master authentication pap  apn  a.apn username UserA password 0 123 track 20
Ruijie(config-if-Async 1)# profile create slave authentication pap apn  b.apn username UserB password 0 123 track 10 priority 1
Ruijie(config-if-Async 1)# profile switch timer 20 max-fail-times 3
```

Configurations on LNS router

! As for the configurations on LNS router, see *SEC-VPDN-SCG.doc* for the L2TP part.

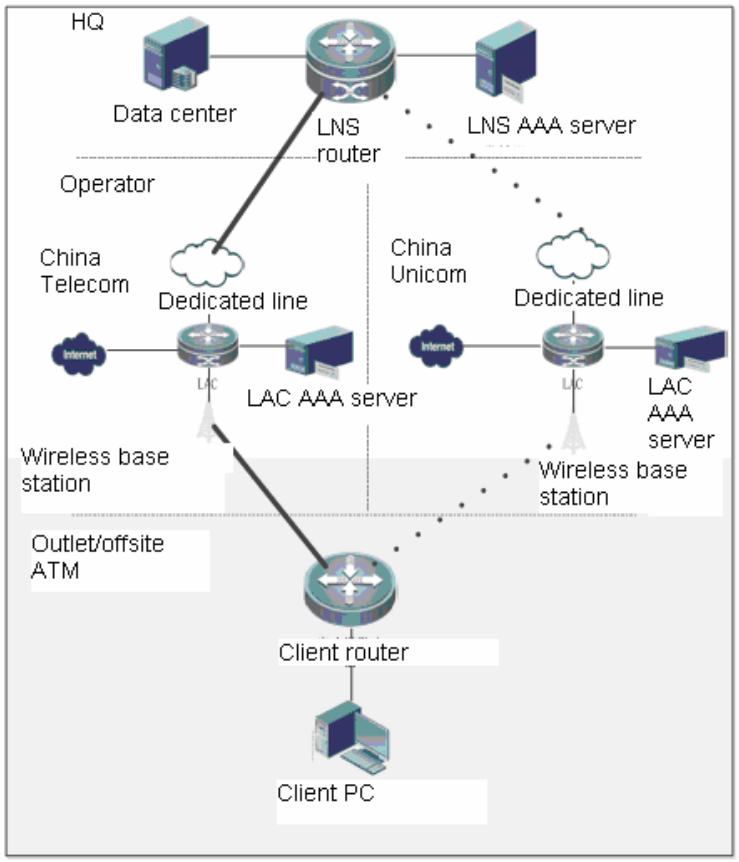
Example of 3G Supporting Dual-card Backup and BFD Association

Networking Requirements

Ruijie's router products support the automatic switchover between two 3G line cards, as well as the connectivity detection of the existing active 3G link. If the destination address cannot be detected through the preconfigured route, the destination address is unreachable through this link. In such a case, the router will automatically switch to the secondary 3G link. This is similar to the networking scenario of previous example: Ruijie's router serves as the access router and uses 3G wireless network to access the carrier. As the LNS through which LAC reaches user's HQ, the carrier establishes L2TP tunnel with the HQ, which uses MSTP to access the carrier. An IPSec tunnel is established between the access router and HQ through the L2TP tunnel of the carrier. The only difference is that the access router has two 3G cards, both configured with dual-card automatic switchover. Two cards can be configured for the same carrier or for different carriers (as in this example). As shown below, link 1 uses the 3G network of China Telecom, while link 2 uses the 3G network of China Unicom. Dual-card automatic switchover has been configured on both 3G links to enhance reliability.

Network Topology

Figure 13 Networking topology for 3G supporting dual-card automatic switchover



Configuration Steps

Configurations on the customer router

This example only lists the required configurations for automatic switchover between two 3G cards. For other configurations, see the steps to configure IPSec support for 3G.

1) Perform dialup configuration of the 3G interface for China Telecom.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#dialer-list 1 protocol ip permit
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)#ip address negotiate
Ruijie(config-if-Async 1)#encapsulation ppp
Ruijie(config-if-Async 1)#ppp chap hostname ruijie
Ruijie(config-if-Async 1)#ppp chap password pass
Ruijie(config-if-Async 1)#ip ref
Ruijie(config-if-Async 1)#async mode dedicated
Ruijie(config-if-Async 1)#dialer in-band
Ruijie(config-if-Async 1)#dialer string #777
Ruijie(config-if-Async 1)#dialer-group 1
```

2) Perform dialup configuration of the 3G interface for China Unicom.

```
Ruijie(config)#interface async 2
Ruijie(config-if-Async 2)#ip address negotiate
```

```
Ruijie(config-if-Async 2)#encapsulation ppp
Ruijie(config-if-Async 2)#ppp chap hostname ruijie
Ruijie(config-if-Async 2)#ppp chap password pass
Ruijie(config-if-Async 2)#ip ref
Ruijie(config-if-Async 2)#async mode dedicated
Ruijie(config-if-Async 2)#dialer in-band
Ruijie(config-if-Async 2)#dialer string *99#
Ruijie(config-if-Async 2)#dialer-group 1
Ruijie(config-if-Async 2)#dialer apn ruijie.apn
```

#3) Configure line parameters.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#line tty 1
Ruijie(config-line)#modem inOut
Ruijie(config-line)#speed 115200
Ruijie(config)#line tty 2
Ruijie(config-line)#modem inOut
Ruijie(config-line)#speed 115200
```

#4) Configure the routes.

! This step is optional. Add or delete this command according to the actual situation.

! Dynamic and static routes may be involved in actual deployment. Add related commands as required.

```
Ruijie (config)#ip route 0.0.0.0 0.0.0.0 Async 1
Ruijie (config)#ip route 0.0.0.0 0.0.0.0 Async 2
```

#5) Configure BFD.

! The configurations of BFD are the same as the configurations to associate BFD with the routing protocol. For details, see *BFD-SCG.doc*.

#6) Associate with BFD.

```
Ruijie#configure terminal
Ruijie(config)#interface async 1
Ruijie(config)#plmn backup slave-interface Async 2 bfd
Ruijie(config)#interface async 2
Ruijie(config)# plmn backup master-interface Async 1 bfd
```

Configurations on LNS router

! As for the configurations on LNS router, see *SEC-VPDN-SCG.doc* for the L2TP part and *BFD-SCG.doc* for the BFD part.

Example of 3G Supporting Dual-card Backup and Track Association

Networking Requirements

See the networking requirements in the "Example of 3G Supporting Dual-card Backup and BFD Association" section.

Network Topology

See the network topology in the "Example of 3G Supporting Dual-card Backup and BFD Association" section.

Configuration Steps

Configurations on the customer router

This example only lists the required configurations for automatic switchover between two 3G cards. For other configurations, see the steps to configure IPSec support for 3G.

1) Perform dialup configuration of the 3G interface for China Telecom.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#dialer-list 1 protocol ip permit
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)#ip address negotiate
Ruijie(config-if-Async 1)#encapsulation ppp
Ruijie(config-if-Async 1)#ppp chap hostname ruijie
Ruijie(config-if-Async 1)#ppp chap password pass
Ruijie(config-if-Async 1)#ip ref
Ruijie(config-if-Async 1)#async mode dedicated
Ruijie(config-if-Async 1)#dialer in-band
Ruijie(config-if-Async 1)#dialer string #777
Ruijie(config-if-Async 1)#dialer-group 1
```

2) Perform dialup configuration of the 3G interface for China Unicom.

```
Ruijie(config)#interface async 2
Ruijie(config-if-Async 2)#ip address negotiate
Ruijie(config-if-Async 2)#encapsulation ppp
Ruijie(config-if-Async 2)#ppp chap hostname ruijie
Ruijie(config-if-Async 2)#ppp chap password pass
Ruijie(config-if-Async 2)#ip ref
Ruijie(config-if-Async 2)#async mode dedicated
Ruijie(config-if-Async 2)#dialer in-band
Ruijie(config-if-Async 2)#dialer string *99#
Ruijie(config-if-Async 2)#dialer-group 1
Ruijie(config-if-Async 2)#dialer apn ruijie.apn
```

3) Configure line parameters.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#line tty 1
Ruijie(config-line)#modem inOut
Ruijie(config-line)#speed 115200
Ruijie(config)#line tty 2
Ruijie(config-line)#modem inOut
```

```
Ruijie(config-line)#speed 115200
```

4) Configure the routes.

! This step is optional. Add or delete this command according to the actual situation.

! Dynamic and static routes may be involved in actual deployment. Add related commands as required.

```
Ruijie (config)#ip route 0.0.0.0 0.0.0.0 Async 1
Ruijie (config)#ip route 0.0.0.0 0.0.0.0 Async 2
```

#5) Configure RNS and Track.

```
Ruijie# configure terminal
Ruijie(config)# ip rns 1
```

! Assume that 10.1.1.1 is the IP address of the LNS corresponding to the master card.

```
Ruijie(config-ip-rns)# icmp-echo 10.1.1.1
Ruijie(config-ip-rns)# frequency 1000
Ruijie(config-ip-rns)# timeout 1000
Ruijie(config)# track 10 rns 1
Ruijie(config-track)# delay up 30
Ruijie(config-track)# exit
Ruijie(config)# ip rns 2
```

! Assume that 10.1.1.1 is the IP address of the LNS corresponding to the slave card.

```
Ruijie(config-ip-rns)# icmp-echo 11.1.1.1
Ruijie(config-ip-rns)# frequency 1000
Ruijie(config-ip-rns)# timeout 1000
Ruijie(config)# track 20 rns 2
Ruijie(config-track)# delay up 30
```

6) Configure the 3G interface for China Telecom as the master interface for dual-card backup and associate with Track object.

```
Ruijie#configure terminal
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1) plmn backup slave-interface Async 2 track 10 switch-delay 10
```

7) Configure the 3G interface for China Unicom as the slave interface for dual-card backup and associate with Track object.

```
Ruijie(config)#interface async 2
Ruijie(config-if-Async 2) plmn backup master-interface Async 1 track 20 switch-delay 10
```

Configurations on LNS router

! As for the configurations on LNS router, see *SEC-VPDN-SCG.doc* for the L2TP part.

Example of 3G Supporting Dual-card Backup and RSSI Association

Networking Requirements

See the networking requirements in the "Example of 3G Supporting Dual-card Backup and BFD Association" section.

Network Topology

See the network topology in the "Example of 3G Supporting Dual-card Backup and BFD Association" section.

Configuration Steps

Configurations on the customer router.

This example only lists the required configurations for automatic switchover between two 3G cards. For other configurations, see the steps to configure IPSec support for 3G.

1) Perform dialup configuration of the 3G interface for China Telecom.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#dialer-list 1 protocol ip permit
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)#ip address negotiate
Ruijie(config-if-Async 1)#encapsulation ppp
Ruijie(config-if-Async 1)#ppp chap hostname ruijie
Ruijie(config-if-Async 1)#ppp chap password pass
Ruijie(config-if-Async 1)#ip ref
Ruijie(config-if-Async 1)#plmn backup slave-interface Async 2 rssi -100 interval 15 ntimes
3 percent 100
Ruijie(config-if-Async 1)#async mode dedicated
Ruijie(config-if-Async 1)#dialer in-band
Ruijie(config-if-Async 1)#dialer string #777
Ruijie(config-if-Async 1)#dialer-group 1
```

2) Perform dialup configuration of the 3G interface for China Unicom.

```
Ruijie(config)#interface async 2
Ruijie(config-if-Async 2)#ip address negotiate
Ruijie(config-if-Async 2)#encapsulation ppp
Ruijie(config-if-Async 2)#ppp chap hostname ruijie
Ruijie(config-if-Async 2)#ppp chap password pass
Ruijie(config-if-Async 2)#ip ref
Ruijie(config-if-Async 2)#async mode dedicated
Ruijie(config-if-Async 2)#dialer in-band
Ruijie(config-if-Async 2)#dialer string *99#
Ruijie(config-if-Async 2)#dialer-group 1
Ruijie(config-if-Async 2)#dialer apn ruijie.apn
```

#3) Configure line parameters.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#line tty 1
Ruijie(config-line)#modem inOut
Ruijie(config-line)#speed 115200
Ruijie(config)#line tty 2
Ruijie(config-line)#modem inOut
Ruijie(config-line)#speed 115200
```

#4) Configure the routes.

! This step is optional. Add or delete this command according to the actual situation.

! Dynamic and static routes may be involved in actual deployment. Add related commands as required.

```
Ruijie (config)#ip route 0.0.0.0 0.0.0.0 Async 1
Ruijie (config)#ip route 0.0.0.0 0.0.0.0 Async 2
```

5) Associate dual-card backup with RSSI.

```
Ruijie#configure terminal
Ruijie(config)# interface async 1
```

!Set async 1 to master.

```
Ruijie(config-if-Async 1)#plmn backup slave-interface Async 2 rssi -100 interval 15 ntimes
3 percent 100
Ruijie(config)# interface async 2
```

!Set async 2 to slave.

```
Ruijie(config-if-Async 2)# plmn backup master-interface Async 1 rssi -100 interval 15 ntimes
3 percent 100
```

Configurations on LNS router

! As for the configurations on LNS router, see *SEC-VPDN-SCG.doc* for the L2TP part.

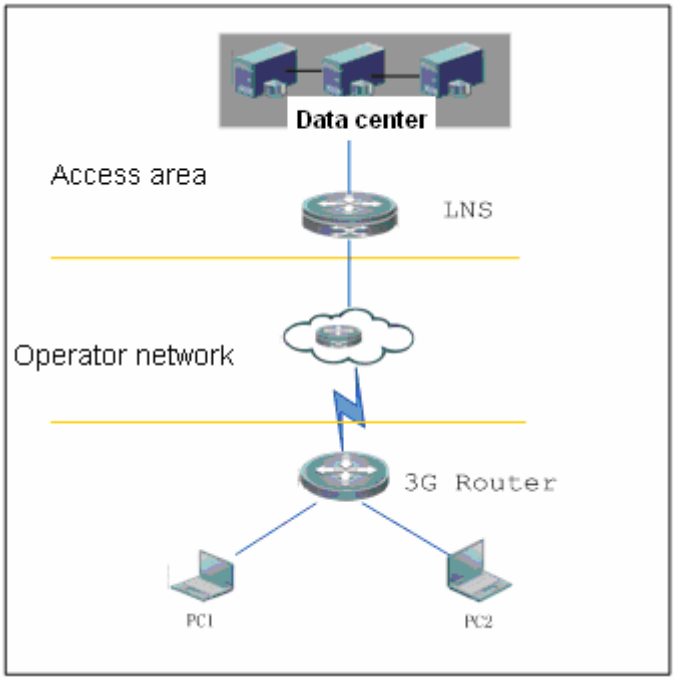
Example of 3G Supporting Single Interface and BFD Association

Networking Requirements

The client accesses the data center through 3G line. Enable the 3G router to periodically detect the public network address for the 3G router to connect to LNS. If the address is unreachable, the router will shut down 3G link. If automatic dialup is configured on the 3G interface, the router will reinitiate dialup. If automatic dialup is not configured, the dialup will be triggered until there is data to be transmitted.

Network Topology

Figure 14 Networking topology for 3G supporting single card and RNS association



Configuration Steps

Configurations on the customer router

1) Perform dialup configuration of the 3G interface for China Telecom.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#dialer-list 1 protocol ip permit
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)#ip address negotiate
Ruijie(config-if-Async 1)#encapsulation ppp
Ruijie(config-if-Async 1)#ppp chap hostname ruijie
Ruijie(config-if-Async 1)#ppp chap password pass
Ruijie(config-if-Async 1)#ip ref
Ruijie(config-if-Async 1)#async mode dedicated
Ruijie(config-if-Async 1)#dialer in-band
Ruijie(config-if-Async 1)#dialer string #777
Ruijie(config-if-Async 1)#dialer-group 1
```

2) Configure line parameters.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#line tty 1
Ruijie(config-line)#modem inOut
Ruijie(config-line)#speed 115200
!
```

3) Configure the route.

! This step is optional. Add or delete this command according to the actual situation.

! Dynamic and static routes may be involved in actual deployment. Add related commands as required.

```
Ruijie (config)#ip route 0.0.0.0 0.0.0.0 Async 1
```

#4) Configure BFD.

! The configurations of BFD are the same as the configurations to associate BFD with the routing protocol. For details, see *BFD-SCG.doc*.

#5) Associate 3G interface with BFD.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1) plmn status bfd
```

Configurations on LNS router

! As for the configurations on LNS router, see *SEC-VPDN-SCG.doc* for the L2TP part and *BFD-SCG.doc* for the BFD part.

Example of 3G Supporting Single Interface and Track Association

Networking Requirements

See the networking requirements in the "Example of 3G Supporting Single Interface and BFD Association" section.

Network Topology

See the network topology in the "Example of 3G Supporting Single Interface and BFD Association" section.

Configuration Steps

Configurations on the customer router

This example only lists the required configurations for automatic switchover between two 3G cards. For other configurations, see the steps to configure IPSec support for 3G.

1) Perform dialup configuration of the 3G interface for China Telecom.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#dialer-list 1 protocol ip permit
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)#ip address negotiate
Ruijie(config-if-Async 1)#encapsulation ppp
Ruijie(config-if-Async 1)#ppp chap hostname ruijie
Ruijie(config-if-Async 1)#ppp chap password pass
Ruijie(config-if-Async 1)#ip ref
Ruijie(config-if-Async 1)#async mode dedicated
Ruijie(config-if-Async 1)#dialer in-band
Ruijie(config-if-Async 1)#dialer string #777
```

```
Ruijie(config-if-Async 1)#dialer-group 1
```

2) Configure line parameters.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#line tty 1
Ruijie(config-line)#modem inOut
Ruijie(config-line)#speed 115200
!
```

3) Configure the route.

! This step is optional. Add or delete this command according to the actual situation.

! Dynamic and static routes may be involved in actual deployment. Add related commands as required.

```
Ruijie (config)#ip route 0.0.0.0 0.0.0.0 Async 1
```

#4) Configure RNS and Track.

```
Ruijie# configure terminal
Ruijie(config)# ip rns 1
```

! Assume that 10.1.1.1 is the IP address of LNS.

```
Ruijie(config-ip-rns)# icmp-echo 10.1.1.1
Ruijie(config-ip-rns)# frequency 1000
Ruijie(config-ip-rns)# timeout 1000
Ruijie(config)# track 10 rns 1
Ruijie(config-track)# delay up 30
Ruijie(config-track)# exit
```

#5) Associate 3G interface with track object.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1) plmn status track 10
```

Configurations on LNS router

! As for the configurations on LNS router, see *SEC-VPDN-SCG.doc* for the L2TP part.

Example of 3G Supporting Single Interface and RSSI Association

Networking Requirements

See the networking requirements in the "Example of 3G Supporting Single Interface and BFD Association" section.

Network Topology

See the network topology in the "Example of 3G Supporting Single Interface and BFD Association" section.

Configuration Steps

Configurations on the customer router

This example only lists the required configurations for automatic switchover between two 3G cards. For other configurations, see the steps to configure IPSec support for 3G.

1) Perform dialup configuration of the 3G interface for China Telecom.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#dialer-list 1 protocol ip permit
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1)#ip address negotiate
Ruijie(config-if-Async 1)#encapsulation ppp
Ruijie(config-if-Async 1)#ppp chap hostname ruijie
Ruijie(config-if-Async 1)#ppp chap password pass
Ruijie(config-if-Async 1)#ip ref
Ruijie(config-if-Async 1)#async mode dedicated
Ruijie(config-if-Async 1)#dialer in-band
Ruijie(config-if-Async 1)#dialer string #777
Ruijie(config-if-Async 1)#dialer-group 1
```

2) Configure line parameters.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#line tty 1
Ruijie(config-line)#modem inOut
Ruijie(config-line)#speed 115200
```

3) Configure the route.

! This step is optional. Add or delete this command according to the actual situation.

! Dynamic and static routes may be involved in actual deployment. Add related commands as required.

```
Ruijie (config)#ip route 0.0.0.0 0.0.0.0 Async 1
```

#4) Associate 3G interface with RSSI.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface async 1
Ruijie(config-if-Async 1) plmn status rssi-detect rssi -90 interval 15 ntimes 3 percent 100
```

Configurations on LNS router

! As for the configurations on LNS router, see *SEC-VPDN-SCG.doc* for the L2TP part.

RGOS Configuration Guide V10.4(3b13)

Based on the application of the terminal services Configuration

1. Application-based Terminal Services Configutation

Application-based Terminal Services Configutation

Ruijie's products provide application-based terminal services and functions of a terminal (access) server (usually known as terminal server). In this case, the device actually serves as a terminal (access) server. The terminal server is mainly used in host-terminal system mode, for example, the banking service system.

Note

In this document, UNIX generally refers to the SCO UNIX, AIX and Linux platforms supported by Ruijie's terminal server host software (also known as the fixed TTY software, including Rginetd, Rgtelnetd and Rgadmin, collectively referred to as Rginted in this document), unless otherwise specified.

Understanding Terminal Services

Overview of the Terminal Server

Ruijie's terminal servers are used in "central server host–central device–site device–terminal" application mode. In other words, the terminal is connected to the async serial port of the device and then connected to the network center server over an IP network, enabling the smooth transition from "central server host-central device-site device-network front end processor and multi-user card-terminal" or "central server host–central device–terminal server–terminal" to "central server host–central device–site device–terminal". This function applies to industries such as banking, securities industry, and telecommunications industry.

When a device acts as the terminal server for fixing terminal numbers, it is used with the Rginted software on the central server to fix the terminal number on the async serial port of the site device. Each terminal connected to the async serial port corresponds to a unique terminal number. If Ruijie's products are only used as terminal servers for implementing the Telnet function, the Rginted software is not required, that is, you do not need to perform related configuration on the UNIX server. If terminal is connected to a UNIX server by using the device, the Rginted program searches for the corresponding entry in the **/etc/rgtelnetd.conf** file on the UNIX host based on the IP address in the connection request message, the connection port number, and the port number of the async serial port connected to the terminal. Then, the Rginted program assigns the terminal a fixed TTY device number.

Ruijie's products provide strong and secure terminal services. When used with the terminal service function provided by the Rginted, Ruijie's products can allocate a fixed terminal device number to a terminal upon each login and allow only terminals specified in the configuration file to log in to the server. All communication between the terminal and server is performed in an encryption way. In this way, only ciphertexts can be obtained when the network is monitored by network monitoring software (for example, Sniffer), greatly improving the security of data transmission over lines. The server regularly queries and authenticates the connected terminals. Once the server detects that a terminal is abnormally disconnected or the network is abnormally interrupted, the terminal is forced to log out and all related processes are terminated. In this way, the workload of the server is not increased due to deadlock, ensuring the security of data transmission.

Some applications may require the use of real terminals. A real terminal is a terminal whose TTY device name is in ttyxx form, instead of the ttypxx form for a virtual terminal. The provided shell program can be used to configure a virtual terminal as a real terminal ttyxx (xx stands for the TTY device number) as required.

Using the terminal service provided by Ruijie's products, a physical terminal can establish multiple connections to remote UNIX hosts by using the device, and users can switch connections by pressing self-defined keys, presenting a similar function to the virtual screen function of a traditional dumb terminal. In this way, multiple service operations can be performed on one counter.

The terminal service can also operate in the way a dumb terminal operates. To be specific, a connection channel is established after a terminal connects to the UNIX host, but the terminal does not log in to the UNIX host. The host can proactively send GUIs to the terminal through the channel, while the terminal cannot operate on the UNIX operating system. The superuser can enable or disable the terminal device number.

Meanwhile, Ruijie's products provide device functions. The terminal is connected to the center through the device. Therefore, the rich functions of the device can be used to implement functions that traditional terminal servers fail to implement, for example, access control for the terminal by using the firewall and time features and QoS provisioning to the terminal.

In terminal service provisioning, different terminal types (for example, ANSI and VT100) can be specified during configuration of remote connection commands to accommodate different terminal displays.

Generally, the terminal server works with the server software Rginted on the UNIX host and can collaborate or with a common UNIX host.

Functions of the Terminal Server

When used with the servosoftware Rginted on the UNIX host, the terminal server has the following functions:

- Every time the terminal connected to the serial interface of the device logs in, a fixed terminal device number (the fixed terminal device number specified for the serial port) is used.
- The communication can be in real terminal mode, that is, TTY, instead of TTYP, is used for communication.
- During the communication, reliable data transmission is implemented using TCP, and you can bind the source address for TCP transmission as required.
- You can run multiple services of a UNIX host on a terminal.
- You can run different services of different UNIX hosts on a terminal.
- The terminal server provides the dumb terminal simulation function that enables the terminal to establish a connection with the UNIX host without starting the login and shell of the UNIX. In this case, the administrator can disable and enable the terminal.
- The terminal server can control the access to each application on a terminal.
- Data transmission between the device and the UNIX can be in ciphertext mode (simple or RC4).
- Multiple types of terminals are supported. You can select the local terminal type for negotiation with the remote service as required.
- The automatic connection function is supported.
- The virtual screen function is supported;
- Router ID matching is supported;
- Terminal shutdown detection is supported;
- MAC address binding is supported.

Table 1 describes the terminal service features of the terminal server.

Table 1 Terminal Service Features of the Terminal Server

Item	Setting
Baud rate	Same as that configured for the interface (9600 by default)
Data bit	Same as that configured for the interface (8 by default)
Stop bit	Same as that configured for the interface (1 by default)
Parity check	Same as that configured for the interface (none by default)
Flow control	Same as that configured for the interface (none by default)
Echo mode	No locally
Terminal simulation type	VT100, allowing manual setting at login

Configuring the Terminal Server

To combine Ruijie's products and Rginted to provide the terminal server function, perform the following configuration:

- Install Rginted on the UNIX and configure the terminal service;
- Configure the terminal service on the device.

Note For more information about the configuration on the UNIX host end, see the dedicated guide to host software configuration for the terminal service.

Configuring Devices

Configuring the Baud Rate of the Async Serial Port

Command	Function
Ruijie(config-line)# **speed** *speed-number*	Sets the baud rate of the async serial port.
Ruijie (config-line)# **no speed**	Restores the default value.

These commands are used to set baud rates for async serial ports (including Aux ports). The default baud rate is 9600 bit/s.

Caution The baud rate of the async serial port must be the same as that of the external terminal to enable normal communication.

Configuring the External Terminal Type of the Async Serial Port

Command	Function
Ruijie(config-line)# **terminal-type** *terminal_type*	Sets the external terminal type.
Ruijie (config-line)# **no terminal-type**	Restores the default value.

These commands are used to set external terminal types for async serial ports. The default external terminal type is VT100.


Caution The external terminal type of the async serial port must match the type of the external terminal to enable normal option. Otherwise, garbled characters or other faults may occur.

Configuring the Flow Control Type of the Async Serial Port

Command	Function
Ruijie(config-line)# **flowcontrol** {**none	hardware [in	out]	software [in	out]**}	Sets the flow control type.
Ruijie(config-line)# **no flowcontrol** { **none	hardware	software** }	Removes the flow control setting.

These commands are used to set flow control types for async serial ports. The default flow control type is **none** (no flow control).


Caution The flow control type of the async serial port must be the same as that of the external terminal to enable normal communication.

Configuring the Disconnection Hot Key of the Terminal Service

Command	Function
Ruijie(config-line)# **disconnect-character hot-key**	Sets the disconnection hot key.
Ruijie(config-line)# **no disconnect-character**	Removes the setting of the disconnection hot key.

These commands are used to set the hot key for the terminal service disconnection. The default hot key is **Ctrl+D**, that is, the ASCII combination of 0x04.


Caution The hot key cannot be common ASCII codes (for example, a to z, A to Z and 0 to 9). Otherwise, the terminal service cannot provisioned normally.

Configuring Link Control Parameters for the Terminal Service (Telnet)

Command	Function

Command	Function
Ruijie(config-line)# **telnet address** *host-ip-address* [*service-port*] [**sec-addr** *second-host-ip-address* [*sec-service-port*]] [/**source-interface** *interface*][**screen** *multi-screen-number*] [**service** *service-name*] [**nego-mode** *nego-mode*]	Sets control parameters of the terminal service link: destination host address, service port, backup host address, backup host service port, local communication port, virtual screen serial number, terminal service name, and the supported private Telnet negotiation mode.
Ruijie(config-line)# **no telnet address** *host-ip-address* [*service-port*] [**sec-addr** *second-host-ip-address* [*sec-service-port*]] [/**source-interface** *interface*] [**screen** *multi-screen-number*] [**service** *service-name*] [**nego-mode** *nego-mode*]	Removes the setting of the control parameters of the terminal service link.

These commands are used to set the terminal service link control parameters (Telnet). For details about the parameters, see the *Terminal Service Command Guide*. The following table describes the meanings and usage of related parameters:

Parameter	Description
host-ip-address	Specifies the IP address of the remote UNIX server corresponding to the terminal service. The configuration of this parameter is mandatory.
service-port	Specifies the terminal service listening port of the remote UNIX server corresponding to the terminal service. The configuration of this parameter is optional. The default value **23** (the Telnet listening port) is used if this parameter is not specified.
sec-addr *second-host-ip-address*	Specifies the IP address of the backup remote server corresponding to the terminal service.
sec-service-port	Specifies the terminal service listening port of the backup remote server corresponding to the terminal service. The default value is **23**.
source-interface *interface*	Specifies the network interface (communication port) of the local device for connecting to the remote UNIX server of the terminal service. The configuration of this parameter is optional. If this parameter is not specified, the device establishes a connection through the interface with the shortest route to the UNIX host of the terminal service.
screen *multi-screen-number*	Specifies the virtual screen serial number of the external terminal corresponding to the terminal service. The configuration of this parameter is optional. If this parameter is not specified, the default value **0** (the first screen) is used. If multiple terminal services correspond to one virtual screen, these terminal services become optional.

Parameter	Description
service *service-name*	Specifies the name of the terminal service. The configuration of this parameter is optional. This parameter is used to identify different terminal services.
nego-mode *nego-mode*	Specifies the private negotiation mode supported by the terminal service for negotiation with the terminal server. The configuration of this parameter is optional.

Configuring Link Control Parameters for the Terminal Service (SSH)

Command	Function
Ruijie(config-line)# **ssh address** *host-ip-address* [*service-port*] [**sec-addr** *second-host-ip-address* [*sec-service-port*]] [**user** *user-name* [**password** *password-string*]] [/**source-interface** *interface*][**screen** *multi-screen-number]* [**service** *service-name*] [**nego-mode** *nego-mode*]	Configures link control parameters of the terminal service: IP address of the destination host, service host, IP address of the backup host, service port of the backup host, user name for login to the server, password for login to the server, local communication interface, virtual screen serial number, name of the terminal service, and the supported private SSH negotiation mode.
Ruijie(config-line)# **no ssh address** *host-ip-address* [*service-port*] [**sec-addr** *second-host-ip-address* [*sec-service-port*]] [**user** *user-name* [**password** *password-string*]] [/**source-interface** *interface*][**screen** *multi-screen-number]* [**service** *service-name*] [**nego-mode** *nego-mode*]	Removes the configuration of control parameters for the terminal service link.

For details about link control parameters (SSH) of the terminal service, see the *Terminal Service Command Guide*. The following table describes meanings and usage of related parameters:

Parameter	Description
host-ip-address	Specifies the IP address of the remote UNIX server corresponding to the terminal service. The configuration of this parameter is mandatory.
service-port	Specifies the terminal service listening port of the remote UNIX server corresponding to this terminal service. The configuration of this parameter is optional. The default value **2081** is used if this parameter is not specified.
sec-addr *second-host-ip-address*	Specifies the IP address of the remote backup server corresponding to the terminal service.
sec-service-port	Specifies the terminal service listening port of the remote backup server corresponding to the terminal service. The default value is **2081**.
user *user-name*	Specifies the user name for login if the terminal service connects to the remote server using the SSH protocol.
password *password-string*	Specifies the password for login if the terminal service

Parameter	Description
	connects to the remote server using the SSH protocol.
source-interface *interface*	Specifies the network interface (communication port) of the local device for connecting to the remote UNIX server of the terminal service. The configuration of this parameter is optional. If this parameter is not specified, the device establishes a connection through the interface with the shortest route to the UNIX host of the terminal service.
screen *multi-screen-number*	Specifies the virtual screen serial number of the external terminal corresponding to the terminal service. The configuration of this parameter is optional. If this parameter is not specified, the default **0** (the first screen) is used. If multiple terminal services correspond to one virtual screen, these terminal services become optional.
service *service-name*	Specifies the name of the terminal service. The configuration of this parameter is optional. This parameter is used to identify different terminal services.
nego-mode *nego-mode*	Specifies the private negotiation mode supported by this terminal service for negotiation with the terminal server. The configuration of this parameter is optional.

Configuring the Virtual Screen Switchover Mapping Rule

If the async serial port is connected to a terminal that supports virtual screens, use the following commands to configure the virtual screen switchover keys for switchover between different services:

Command	Function
Ruijie(config-line)# **screen map** *multi-screen-number* **translate** *translate-string* **response** *response-string*	Sets the virtual screen switchover mapping rules.
Ruijie(config-line)# **no screen map** *multi-screen-number*	Removes the setting of the virtual screen switchover mapping rules.

These commands are used to set the virtual screen switchover mapping rule that matches virtual screens with the virtual screen functional key conversion character sequence of the external terminal. This mapping rule varies by manufacturers and terminal types. For details, see the product manual of the external terminal.

The following examples show how to configure the virtual screen switchover mapping rules:

```
screen map 0 translate 0x01600D response 0x1B213851
screen map 1 translate 0x01610D response 0x1B213951
```

In the preceding rules, the external terminal of the async serial port is STAR560II. After these two mapping rules are configured, the terminal switches to the virtual screen with number 0 if Alt+C is pressed on the terminal keyboard. If Alt+D is pressed on the terminal keyboard, the terminal switches to the virtual screen with number 1.

Configuring the Terminal Service Selection Message

You can configure the terminal service selection message on the external terminal connected to the async serial port.

Command	Function
Ruijie(config-line)# **termsrv-promote** *promote-string*	Sets the prompt message.
Ruijie(config-line)# **no termsrv-promote**	Restores the default prompt message.

If **exec-character-bits** 8 (system default value) is set on the line interface corresponding to the async serial port, the terminal service selection prompt message (*promote-string*) is "Please choose a service:". If **exec-character-bits 7** is set on the corresponding line interface, the terminal service selection prompt message (*promote –string*) is "Choose your service from the following list:".

Note

If the terminal service selection prompt message contains non-ASCII characters (for example, Chinese characters) or spaces, the entire *promote-string* must start with a double quotation mark (") and end with a double quotation mark (").

Configuring the Automatic Connection Function of the Terminal Service

The configuration of this function is mandatory for implementing the automatic connection function for the terminal service.

Command	Function
Ruijie(config-line)# **autoconnect** [*message- display*]	Enables the automatic connection function.
Ruijie(config-line)# **no autoconnect**	Disables the automatic connection function.

In a general sense, terminal services are intended for traditional terminals (those equipped with monitors, keyboards, or even I/O devices such as mouse) capable of human-machine interaction. However, some special application scenarios may require the use of some terminals (like cipher machine) incapable of man-machine interaction for communicating with the remote service ends. In these special application scenarios where man-machine interaction cannot be performed on these terminals, the device (terminal server) must provide the automatic connection function so that these terminals can automatically connect to the remote server after the device is started or a network oscillation occurs. For such special applications, Ruijie's products provide the terminal service automatic connection function. This command can be used to set the terminal service automatic connection function as required at the Line layer of the async serial port of the terminal incapable of man-machine interaction.

Disabling the Activation Prompt Function of the Terminal Session

Use the following commands to configure the system prompt function when the terminal session (including the terminal service) is activated.

Command	Function
Ruijie(config-line)# **vacant-message** [*message-hint*]	Sets the session prompt.
Ruijie(config-line)# **no vacant-message**	Disables the session prompt.

The configuration of this function is optional for implementing the terminal service automatic connection function. You must disable the terminal session activation prompt function before disabling the automatic connection prompt function. If the terminal session activation prompt function is disabled, system prompt messages such as "*Press RETURN to get started!*" are not printed on the async serial port when the terminal service monitoring process of the device async serial port is started.

Starting the Terminal Service

Command	Function
Ruijie# **start-terminal-service** Or Ruijie> **start-terminal-service**	Starts the terminal service.

This command is used to start the terminal service. By default, the async serial port works in interaction mode and is equivalent to a local console. The working mode of the async serial port changes to the terminal service mode after the **start-terminal-service** command is executed. Alternatively, run the **autocommand *start-terminal-service*** command on the corresponding line-layer interface so that the async serial port automatically works in terminal service mode after the device is started.

Note The **autocommand start-terminal-service** command must be completely and correctly entered to ensure that the async serial port automatically works in terminal service mode after device startup.

Configuring the Router ID Matching Function

Use the following commands to set whether the router ID is sent to the host end during terminal service provisioning.

Command	**Function**
Ruijie(config-line)# **termsrv-send-rid**	Enables the sending of the router ID.
Ruijie(config-line)# **no termsrv-send-rid**	Disables the sending of the router ID.

This function is used with the host to allow only the terminals of the specified IP address or router ID to access the host.

Note This function is necessary only when the host allocates fixed TTY using the TCP port number. For more information about configuration on the UNIX host end, see the dedicated guide to host software configuration for the terminal service.

Configuring Terminal Shutdown Detection

You can set whether to automatically detect the shutdown of the async terminal during the terminal service.

The terminal shutdown detection function enables the automatic disconnection between the terminal and the host when the terminal is shut down or the asynchronous connection to the terminal server is disconnected. This function can also enables automatic exit from the service operation page if the service operation page is still open before terminal shutdown.

This function requires that the serial port of the asynchronous terminal (for connecting the terminal server) provide the CTS, DCD or DSR signals and that the high-to-low jump occurs when the terminal is shut down.

The related configuration Commands are as follows:

Use the following commands to enable or disable the terminal shutdown detection function.

Command	Function
Ruijie(config-line)**# termsrv-detect-terminal-connect enable**	Enables terminal shutdown detection.
Ruijie(config-line)**#** **no termsrv-detect-terminal-connect enable**	Disables terminal shutdown detection.

Use the following commands to configure the detected signal type of the async serial port.

Command	Function
Ruijie(config-line)# **termsrv-detect-terminal-connect type {cts | dcd | dsr}**	Configures the detected signal type of the async serial port. The default is CTS.
Ruijie(config-line)# **no termsrv-detect-terminal-connect type**	Restores the default type, that is, CTS.

Note

The signal status of the async serial port can be shown by running the **show line** command. You can know what signals should be configured for the terminal shutdown detection by comparing the async serial port signal status when the terminals are started and shut down.

Use the following commands to configure the detection interval.

Command	Function
Ruijie(config-line)**# termsrv-detect-terminal-connect interval *ms***	Specifies the detection interval in milliseconds. The range is from 100 to 10000 milliseconds. The default is 500 milliseconds.
Ruijie(config-line)**#** **no termsrv-detect-terminal-connect interval**	Restores the default detection interval, that is, 500 milliseconds

Use the following commands to configure the detection times.

Command	Function
Ruijie(config-line)**# termsrv-detect-terminal-connect count *number***	Specifies the detection times. The range is from 1 to 100 times. The default is 5 times.
Ruijie(config-line)**#** **no termsrv-detect-terminal-connect count**	Restores the default detection times, that is, 5.

When the signal status is detected to be DOWN for consecutive *N* times, the terminal is regarded as shut down.

Configuring the MAC Address Binding Function

This function is used with the host to allow only the terminals with the specified IP and MAC addresses to access the host.

Command	Function
Ruijie(config)**# service termsrv-mac-bind**	Enables the MAC address binding function.
Ruijie(config)**# no service termsrv-mac-bind**	Disables the MAC address binding function.

This function is used to control the access of the network terminal to the host and requires that network terminals meet the following conditions:

- Packets must be forwarded by the device;
- MAC addresses match those specified on the host end.

Configuring the Access Service Port

Use the following commands to configure the access service port for the network terminal to connect to the host.

Command	Function
Ruijie(config-line)**# termsrv-listen-port** *number*	Configures the access service port. The range is from 1024 to 65535.
Ruijie(config-line)**# no termsrv-listen-port**	Deletes the configured access service port.

When an IP network terminal (in Telnet or SSH mode) is used to connect to the host, the protocol port (23 for TELNET and 22 for SSH) is used by default. However, the protocol port is generally the port used for device management. If the terminal service is enabled on this VTY line, the device can no longer be managed on the VTY line using Telnet. If an access service port is configured, these two functions can operate separately. In this way, the terminal service is started only when the network terminal is connected to the access service port, while the protocol port can be used for general connection management.

Note This function can only be configured on the VTY line (configurable port number in the range from 1024 to 65535) and should avoid conflicting with commonly used ports. Different ports should be configured for different VTY lines. Existing reserved ports (such as the reverse TELNET port used by RCMS device or other TCP-based ports) cannot be configured as the access service port. If any of the reserved ports is entered, the configuration fails and an error message is displayed.

Caution The terminal service port cannot recognize the SSH connection, Therefore, if the terminal service port is to be used by the SSH connection, the **transport input ssh** command must be executed on the SSH line so that this line uses only the SSH connection. Otherwise, you can only use TELNET to connect to the port.

Configuring Client Access Control

Use to following commands to configure client access control as needed to define network terminals that can access the specified VTY line.

Command	Function
Ruijie(config-line)# **access-class** {*number* | *name*} **in**	Applies the access control list on the VTY line to configure client access control.
Ruijie(config-line)# **no access-class** {*number* | *name*} **in**	Removes the preceding configuration.

This function is used with the access control list (ACL) to apply ACL configurations on the specified VTY line, for the purposes of control access and terminal service initiation. This function can define a fixed IP terminal, that is, limiting an IP network terminal to use only a specific VTY line. In this way, the terminal number can remain consistent every time the connection is initiated by using this IP terminal. This function is generally used with the fixed terminal function of the terminal server. For details, see Functions of the Terminal Server.

Note

The ACLs applied on the line restrict either the incoming connection or outgoing connection. The ACL here restricts the IP network terminal from connecting to the device, and thus "in" should be used in configuration. For details, see the *ACL Configurations*. For details about how to apply ACLs on the line, see the *Line Mode Configuration*.

Configuring Window Number for Virtual Terminal Access

Use the following commands to specify the window number for accessing the server if the IP network terminal accesses the terminal server through the VTY line.

Command	Function
Ruijie(config-line)# **termsrv-win-num** *win_num*	Configures the access window number. The range is from 200 to 1000.
Ruijie(config-line)# **no termsrv-win-num**	Restores the default access window number.

If the IP network terminal connects to the terminal server through the VTY line to implement the fixed terminal function, the terminal service function of the device is required to provide the access window number of the connection.

By default, each VTY line of the device corresponds to a window number with the format of 200+VTY line number. You can also specify a different access window number for each VTY line.

Note

This function can only be configured on the VTY line.
The access window number for VTY line cannot be the same as that for another VTY line, or else the configuration fails and an error message is displayed.

Configuring Random Delay Connection for the Terminal Service

If the terminal device uses the terminal service to connect to the remote UNIX server, the connection can be randomly delayed within a specific time range by using the following commands:

Command	Function

Command	Function
Ruijie(config-line)**#termsrv-delay-time-range** *time-length*	Configures the time range for the terminal service to randomly delay the connection to the remote host. The range is from 0 to 180 seconds.
Ruijie(config-line)# **no termsrv-delay-time-range**	Restores the random delay to default setting.

When many terminal devices use the terminal service to connect to the remote UNIX server at the same time, the UNIX server bears significant loads. When these connections are distributed within a specific time range, the loads on UNIX server can be reduced.

By default, this function is not enabled, that is, the time-length is 0. By default, random delay is not applied when the terminal service connects to the remote UNIX server.

Note

This function only applies to TTY or VTY lines, and is effective only if terminal service is used to connect to the remote UNIX server for the first time. If an existing session is already available on the TTY or VTY line, random delay is not performed on the reestablished session to the remote UNIX server.

Enabling the Terminal Service to Automatically Connect to the Backup Host

If the terminal device uses terminal service to connect to the remote UNIX server but fails to connect with the UNIX server configured, use the following commands to configure automatic connection to the backup host to ensure successful running of the service.

Command	Function
Ruijie(config-line)**#termsrv-sec-addr-autoconn enable**	Enables the terminal service to automatically connect to the backup host.
Ruijie(config-line)**# no termsrv-sec-addr-autoconn enable**	Restores the default setting.

If automatic connection to the backup host is enabled, the terminal service automatically connects to the configured backup host in case of failed connection between the terminal service and the configured UNIX server.

By default, this function is disabled, that is, the terminal service does not automatic connects to the backup host.

Note

The activation of this function relies on the address and port of the backup host. Successful automatic connection to the backup host can be ensured only if this function is enabled after the address and port of the backup host are configured.

For more information about the configuration of the address and port of the backup host, see Configuring Link Control Parameters for the Terminal Service (Telnet) and Configuring Link Control Parameters for the Terminal Service (SSH).

Configuring the DSCP Value of Packets for the Terminal Service

Use the following commands to configure the DSCP value of packets sent by the terminal server during the communication between the terminal server and the remote server.

Command	Function
Ruijie(config-line)#**termsrv-sec-dscp** *dscp_value*	Sets the DSCP value of packets. The range is from 0 to 7.
Ruijie(config-line)# **no termsrv-sec-dscp**	Restores the default setting of the DSCP value.

After the DSCP value of terminal service packets is configured, the related QoS policies can be applied for the terminal service by matching the DSCP value of the packets.

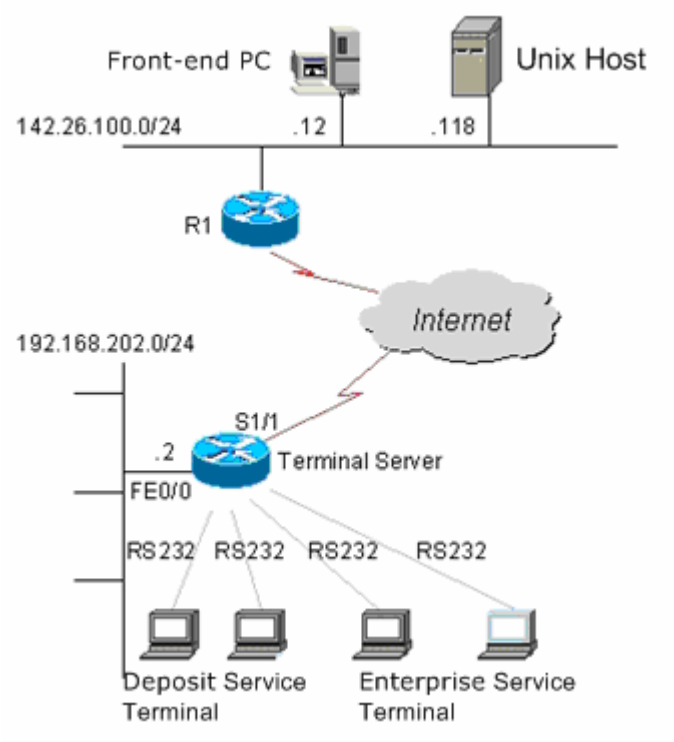
By default, the DSCP value of the terminal service packets transmitted between the terminal server and the remote host is 0.

Note

The configuration takes effect on the subsequent created terminal service sessions, and the DSCP value of the packets transmitted in those sessions is set to the configured value. But this configuration takes no effect for the existing terminal service sessions, that is, the DSCP value of packets used in the existing sessions is not configured.

Typical Configuration Example of the Terminal Server

Figure 1 Network Connection Diagram of the Terminal Server Application Example



Configuring the Device

In the preceding network connection schematic diagram, device R1 only provides common routing functions, while the Terminal Server is configured with and provides the terminal service function to the local terminal. Therefore, only the related configuration of the device Terminal Server is provided in this document.

Related configuration of the Terminal Server:

```
Router# show running-config

Building configuration...
Calander battery is stop, clock is not updated.
Current configuration : 913 bytes

!
hostname Router
!
!
!
!
!
interface serial 1/0
 clock rate 64000
!
interface serial 1/1
 encapsulation frame-relay
 frame-relay map ip 142.16.5.1 55
 frame-relay lmi-type ansi
 ip address 142.16.5.2 255.255.255.0
 clock rate 64000
!
interface serial 1/2
 clock rate 64000
!
interface serial 1/3
 clock rate 64000
!
interface FastEthernet 0/0
 ip address 192.168.202.2 255.255.255.0
 duplex auto
 speed auto
!
interface FastEthernet 0/1
 duplex auto
 speed auto
!
interface Null 0
```

```
!
!
!
line con 0
line aux 0
line tty 1 16
 disconnect-character 4
 autocommand start-terminal-service
 telnet address 142.26.100.118 23 /source-interface FastEthernet 0/0 service "For
organizations"
 telnet address 142.26.100.118 2050 /source-interface FastEthernet 0/0 service "Saving
service"
 flowcontrol software
line vty 0 4
 login
!
!
End
```

Note This document only provides the configuration description of the primary line and the terminal service.

Description of terminal service configuration

If a 16-port card is inserted into the Ruijie's router, the interfaces of the card correspond to line numbers 1 to 16 respectively. The **show line** privileged layer command can be used to view the numbers corresponding to the sync/async card interfaces cannot be determined.

1) Set the coding format of communication characters.

On line con 0, run the **exec-character-bits 8** command to ensure that Chinese characters can be correctly entered and displayed on the console port. In addition, this rule is mandatory for enabling the external terminal to normally display Chinese characters. This rule is a system default.

2) Configure the disconnection hot key of the terminal service.

If the **disconnect-character** 4 rule is configured, the terminal service is forced to disconnect from the network after Ctrl+D is pressed on the terminal keyboard.

3) Configure the working mode of the async serial port as the terminal service mode.

If the **autocommand start-terminal-service** rule is configured, the async serial port automatically works in terminal service mode after the device is started.

4) Set the flow control mode.

The **flowcontrol software** command can be used to set the flow control mode of the async serial port to software flow control.

5) Configure link control parameters for the terminal service.

The command **telnet address 142.26.100.118 23 /source-interface FastEthernet 0 /0 service organization service** is used to set the IP address of the remote login server to 142.26.100.118, the port number to 23, the local communication interface to Ethernet port 0/0, and the terminal service name to Organization Service. The command **telnet address 142.26.100.118 2050 /source-interface FastEthernet 0/0 service Saving service** is used to set the IP address of the remote login server to 142.26.100.118, the port number to 2050, the local communication interface to Ethernet port 0/0, and the terminal service name to Saving Service.

Configuration on the UNIX Host

Note For more information about the specific configuration, see the dedicated guide to host software configuration for the terminal service.

1) Copy the SCO UNIX host service programs Rginetd, Rgtelnetd and Rgadmin to the **/etc** directory;
2) Set the attribute of the Rginetd, Rgtelnetd and Rgadmin to executable;
3) Start the Rginetd. (If the **/etc/rginetd –p 2050 –m /etc/rgtelnetd.conf** command line is added to the end of the **/etc/rc.d/8/userdef** file, the fixed TTY software automatically runs every time the machine is started).
4) Edit the following **Rgtelnetd.conf** file in the **/etc** directory:

```
192.168.202.2 1 tty21
encrypt=1
192.168.202.2 2 tty22
192.168.202.2 3 tty23
192.168.202.2 4 tty24
192.168.202.2 5 tty25
192.168.202.2 6 tty26
192.168.202.2 7 tty27
192.168.202.2 8 tty28
192.168.202.2 9 tty29
192.168.202.2 10 tty30
192.168.202.2 11 tty31
192.168.202.2 12 tty32
192.168.202.2 13 tty33
192.168.202.2 14 tty34
192.168.202.2 15 tty35
192.168.202.2 16 tty36
```

In the preceding information, 192.168.202.2 is the IP address of the network interface specified during terminal service configuration for communicating with the remote SCO UNIX host. Other parameters have been described in details in the above configuration sections. The specified terminal service communication port is Ethernet port 0/0 on the device. Therefore, the Ethernet port 0/0 must be successfully pinged from the server. For this purpose, add the route to the device configured with the terminal service on the SCO UNIX server, so that the SCO UNIX can reach the device network configured with the terminal service.

5) Restart SCO UNIX.

Maintaining and Monitoring the Terminal Server

If the external terminal cannot log in to the remote server, the possible causes are as follows:

- The network between the router and the remote UNIX host is not reachable. You can use the **ping** command to test the reachability of the network (the prerequisite is that both the SCO UNIX end and the device end do not shield the ICMP packets.)
- The terminal server software is improperly installed on the UNIX end. Check the following items: whether Rgtelnetd is copied to the **/etc** directory, whether the Rgtelnetd is configured as executable, whether the IP address in the **/etc/rgtelnetd.conf** file is the IP address of the network interface through which the device establishes the terminal service connection.
- The terminal service software on the UNIX software is not started;
- The link control parameters of the terminal service are improperly configured on the device, for example, non-terminal service configuration or redundant configuration is performed. Check the following items: whether the IP address of the remote service end is correctly configured and whether the service port connected to the remote service end is the listening port generated after the /etc/rgtelnetd is started or the Telnet listening port 23 of the remote service end system;
- The SCO UNIX terminal device numbers in the /**etc/rgtelnetd.conf** file are not found in the **/dev** directory;
- Related modifications are not performed in in the **/etc/inittab** after the dumb terminal control mode is used.
- To identify faults in terminal printing, perform the following:
- If **runtimeout** is set to **1** is set under the corresponding item in the configuration file **/etc/rgtelnetd.conf** and flow control is started on the corresponding async line, the SCO UNIX may proactively disconnect the connection after multiple continuous pages are printed. Therefore, you are recommended not to set the **runtimeout** to **1** in the advanced options for the terminal service item that may involve continuous printing.
- When using the dumb terminal for login, pay attention to the following:
- The dumb terminal mode disables terminal type negotiation. If the terminal type needs to be specified, modify the file **/etc/ttytype**;
- In dumb terminal mode, do not use the exit command to exit the service and disconnect the link. Instead, type the configured disconnect-character to exit the service and disconnect the link of the terminal service.
- The following are possible questions arising from the configuration of the automatic connection function of the terminal service:
- The configuration of the automatic connection function of the terminal service fails. The automatic connection function of the terminal service can be successfully configured only if only one terminal service item is configured on the current Line layer interface. If the message "Please config single terminal service item first" is displayed after you enter the **autoconnect** or **autoconnect message-display** command, no terminal service item is configured on the current Line layer interface. You must first set the terminal service item before configuring the automatic connection function of the terminal service. If the message "Autoconnect require single terminal service item" is displayed after the **autoconnect** or **autoconnect message-display** command is entered, two or more terminal service items are configured on the current Line layer interface. Ensure that there is only one terminal service item on the current Line layer before configuring the automatic connection function of the terminal service.
- The terminal service item is modified (added or deleted), causing the loss of the setting of the automatic connection function. The automatic connection function of the terminal service requires that only terminal service item be configured on the current Line layer interface. If the terminal service item is modified, no or more than one terminal service items may be available on the current Line layer interface. In this case, the default setting is restored for the

automatic connection function of the terminal service resumes on the current Line layer interface, indicating that the automatic connection function is not provided.

- The system does not automatically connect to the remote service end immediately after it is restarted. Initialization and other preparations must be made after the system is restarted. Therefore, the system performs automatic connection 60 seconds after it detects the async serial port to ensure smooth initialization. Within the 60 seconds, the async serial port does not respond to the received data.
- Data (from devices other than the remote service end) is received by the terminal connected to the async serial port corresponding to the Line layer interface that is configured with the automatic connection function The cause is that the terminal session prompt message or the network connection prompt message is not completely disabled during the configuration of the automatic connection function. The **no vacant-message** command can be used to disable the terminal session prompt message. The **autoconnect message-display** command can be used to configure the auto connection function and allow the reception of network connection prompt messages. The **autoconnect** command can be used to disable the network connection prompt message and enable the automatic connection of the terminal service at the same time.
- The automatic connection function is not applicable to scenarios where the virtual screen is used. The automatic connection function and virtual screen switchover function must not be configured on the Line layer interface corresponding with the async serial port at the same time.

RGOS Configuration Guide V10.4(3b13)

Reliability Configuration

1. RLDP Configuration
2. LLDP Configuration
3. VRRP Configuration
4. Hot Swap Configuration
5. Management Module of Redundancy Configuration
6. Multilink Gateway Load Balancing Configuration

RLDP Configuration

RLDP Overview

Understanding RLDP

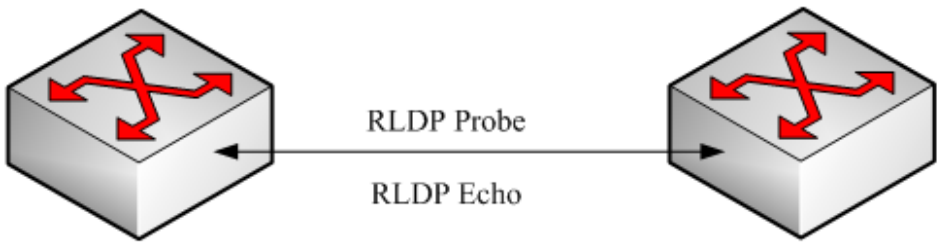
The Rapid Link Detection Protocol (RLDP) is one of Ruijie's proprietary link protocol designed to detect Ethernet link fault quickly.

General Ethernet link detection mechanism only makes use of the status of the physical connections and detects the connectivity of the link via the auto-negotiation of the physical layer. This detection mechanism has restrictions and sometimes cannot provide reliable link detection information for the user. For example, if the optical fiber receiving line pair on the optical interface is misconnected, due to the existence of the optical converter, the related port of the device is "linkup" physically but actually the corresponding layer-2 link cannot work for communications. Here is another example. There is an intermediate network between two Ethernet devices. Due to the existence of the network transmission relay devices, the same problem may occur if those relay devices are faulty.

The RLDP enables easy detection of Ethernet device link fault, including the one-way link fault, two-way link fault and loop link fault.

The RLDP implements the detection by exchanging the RLDP messages at the two ends of the link, as shown in Figure-1:

Figure-1:



The RLDP defines two protocol messages: Probe message and Echo message. The RLDP sends the Probe message of this port to the port with RLDP configured and in linkup status on regular basis, and waits for the Echo message from the neighbor port and waits for the Probe message sent by the neighbor ports. If a link is correct both physically and logically, a port shall be able to receive the Echo message of the neighbor port as well as the Probe message of the neighbor port. Otherwise, the link is considered abnormal.

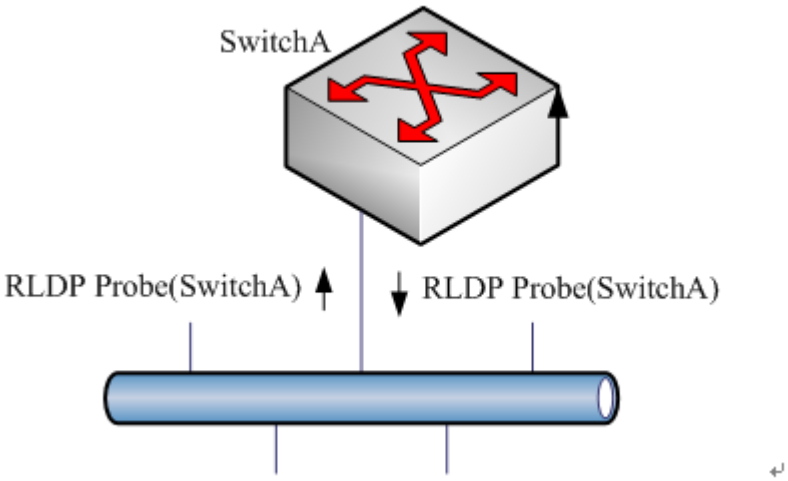
Note

To make use of the one-way detection and two-way detection functions of the RLDP, it is necessary to ensure the RLDP is enabled on the ports at both ends of the link. And, it is not allowed for a port with RLDP enabled to connect multiple neighbor ports. Otherwise, the RLDP cannot detect the health conditions of every neighbor link.

Typical Application

Loop detection

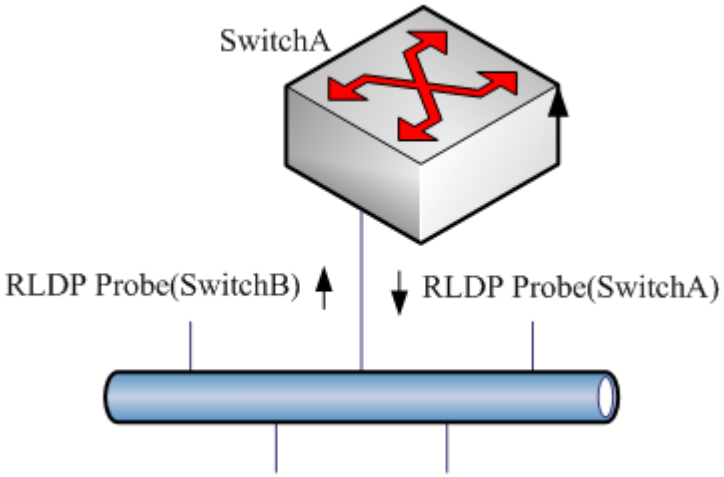
Figure-2: Loop detection



The so-called loop fault means that a loop appears on the links connected with the port. A shown above, on a port the RLDP receives the RLDP message sent from its machine, so the port is considered as loop fault. So, the RLDP deals with the fault according to the user configurations, including alarming, setting port violation, turning off the SVI with that port, turning off the port learning forwarding, and more.

One-way link detection

Figure-3: One-way link detection

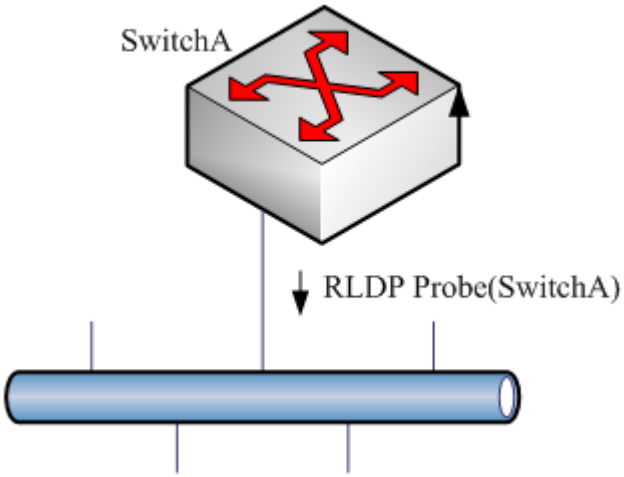


The so-called one-way link detection means the link connected with the port can receive message only or send messages only (due to misconnection of the optical receiving line pair, for example). As shown above, the RLDP only receives the

detection message from the neighbor port on a port, so it is considered one-way link fault. So, the RLDP deals with the fault accordingly according to the user configurations. In addition, if the port cannot receive any RLDP detection message, it is also considered one-way link fault.

Two-way link detection

Figure-4:Two-way link detection



This means that fault occurs at the frame transmission/receiving at both ends of the link. As shown above, the port of the device sends the RLDP probe message but has never received the Echo message or the Probe message from the neighbors. So, it is considered two-way link fault. From the nature of the fault, the two-way fault actually includes the one-way fault.

Note

If the party at one of the two link ends has not enabled the RLDP, the diagnosis also shows two-way or one-way link fault. So, in configuring two-way link detection or one-way link detection, the administrator shall make sure that the RLDP is enabled at both ends to avoid the incorrect diagnosis information.

☑ On RGOS 10.4(3b13) version, the RLDP protocol sends SNAP packets by default (in SNAP encapsulation, DSAP and SSAP fields are 0xAA constantly and the control filed is 0x03. The PID filed is used to distinguish the identification protocol. The PID field of RLDP is 0x0788. If the device receives Ethernet II protocol packets, it communicates with the neighbor via Ethernet II protocol packets exclusively.

☑ Version compatibility requires that the device can receive protocol packets from the neighbor. When a device running on RGOS 10.4(3b13) version is connected with a device running on non-RGOS10.4(3b13) version, if the peer end has detected the link fault, it is recommended to restore the link state first.

Configuring RLDP

The following sections describe how to configure RLDP.

- RLDP defaults
- Configure global RLDP

- Configure port RLDP
- Configure RLDP detection interval
- Configure the RLDP maximum detection times
- Restore the RLDP status of the port

Default Configuration

Feature	Default Settings
Global RLDP status	Disabled
Port RLDP status	Disabled
Detection interval	3 seconds
Maximum detection times	2


Caution The RLDP can be configured only on the physical port (including L2 and L3 AP member port).


Caution On RGOS 10.4(3b13) version, RLDP, TPP and Ruijie broadcast address authentication are mutually exclusive. When RLDP is enabled, TTP or Ruijie broadcast address authentication cannot be performed. If you want to apply RLDP, make sure TPP is disabled.

Configuring RLDP Globally

The RLDP works on the port only when the global RLDP is enabled.

In the global configuration mode, follow these steps to enable RLDP:

Command	Function
Ruijie(config)# **rldp enable**	Turn on the global RLDP function switch.
Ruijie(config)# **end**	Return to the privileged EXEC mode.

The **no** option of the command turns off the global *RLDP*.

Configuring RLDP on the Port

The RLDP operation is port-based, so the user needs to explicitly configure which ports shall run RLDP. In configuring the port RLDP, it is required to specify the diagnosis type and the troubleshooting method for the port at the same time. The diagnosis types include unidirection-detect, bidirection-detect and loop-detect. The troubleshooting methods include warning, block, shutdown-port, and shutdown-svi.

In the configuration mode, follow these steps to configure the RLDP on the port:

Command	Function
Ruijie(config)# **interface** *interface-id*	Enter the interface mode.
Ruijie(config-if)# **rldp port** {**unidirection-detect** | **bidirection-detect** | **loop-detect** } {**warning** | **shutdown-svi** | **shutdown-port** | **block**}	Enable the RLDP on the port and configure the diagnosis type and troubleshooting method at the same time.
Ruijie(config-if)# **end**	Return to the privileged EXEC mode.

The **no** option of the command disables the RLDP on the port and the configured detection types one by one.

In the example below, the RLDP is configured on FastEthernet 0/5, and multiple diagnosis types and troubleshooting methods are specified:

```
Ruijie# configure terminal
Ruijie(config)# interface FastEthernet 0/5
Ruijie(config-if)# rldp port unidirection-detect
shutdown-svi
Ruijie(config-if)# rldp port bidirection-detect warning
Ruijie(config-if)# rldp port loop-detect block
Ruijie(config-if)# end
Ruijie# show rldp interface FastEthernet 0/5
port state     : normal
local bridge   : 00d0.f822.33ac
neighbor bridge : 0000.0000.0000
neighbor port  :
unidirection detect information:
action : shutdown svi
state  :  normal
bidirection detect information :
action : warnning
state  :  normal
loop detect  information    :
action : block
state  :  normal
```

Several precautions in configuring port detection:

- The routing interface does not support the shutdown-svi error handling method, so this method is not executed in case of the occurring of detection error.
- In configuring loop detection, the neighbor devices downward connected with the port cannot enable the RLDP detection; otherwise, the port cannot have correct detection.
- If the block method is configured on the aggregated port and the link detection error happens, do not change the member port relations of the aggregate port before the port reset detection; otherwise, the forwarding status of the member interface may have unexpected effects of forwarding status.
- If the RLDP detects link error, alarm information will be given. The user can send the alarm information to the log server by configuring the log function. At least 3 levels of log shall be ensured.
- You are recommended to specify the diagnosis type of the loop detection to shutdown-port for the reason that for some devices, even if the device detects the loop and specifies the block port, a large amount of packets will be sent to the CPU for the hardware chip limitation.
- If you configure RLDP with port blocking after enabling the port, ERPS, RERP and REUP protocols cannot be run on this port. If you want to run these protocols on this port, you are recommended to specify the diagnosis type of loop detection to shutdown-port.

Configuring RLDP Detection Interval

The port with the RLDP function enabled will send the RLDP Probe messages on a regular basis.

In the global configuration mode, follow these steps to configure the RERP detection interval:

Command	Function
Ruijie(config)# **rldp detect-interval** interval	Configure the detection interval within the range 2-15s, 3s by default.
Ruijie(config)# **end**	Return to the privileged EXEC mode.

The **no** option of the command restores the value to its default.

Configuring the Maximum RLDP Detection Times

If the port with RLDP enabled cannot receive messages from neighbors in the maximum detection period (maximum detection times X detection interval), that port will be diagnosed as faulty. See the Overview for details of the fault types.

In the global configuration mode, follow these steps to configure the RERP maximum detection times:

Command	Function
Ruijie(config)# **rldp detect-max** Num	Configure the maximum detection times, num range 2-10, 2 by default.
Ruijie(config)# **end**	Return to the privileged EXEC mode.

The **no** option of the command restores the value to its default.

Note The maximum detection times only take effect in the unidirectional link detection and bidirectional link detection, and will not take effect if only loop detection is enabled on a port.

Restoring the RLDP Status of the Port

The port with shutdown-port troubleshooting method configured cannot resume the RLDP detection actively after a fault occurs. If the user confirms the fault removed, run the recovery command to restart the RLDP on the shutdown port. This command sometimes may make the other ports with detection errors resume.

In the privileged EXEC mode, follow these steps to resume the RLDP detection of the port:

Command	Function
Ruijie# **rldp reset**	Make any port with RLDP detection failure resume the detection.

Note The **errdisable recover** command can be used in the global configuration mode to restart, instantly or at fixed time, the RLDP detection of the port that is set violation by RLDP. It is worth mentioning that when there are some relay devices between rldp ports, if you use **errdisable recover interval** to restore the fault timely, you need to set the value of rldp detection time greater than that of **errdisable recover interval**, that is, the value of detect-interval* detect-max total time is greater than that of **errdisable recover interval** to prevent error judgment.

Viewing RLDP Information

The following RLDP-related information can be viewed:

- View the RLDP status of all ports
- View the RLDP status of the specified port

Viewing the RLDP Status of All Ports

In the privileged EXEC mode, run the following commands to view the RLDP global configuration and the port detection information with RLDP detection configured:

Command	Function
Ruijie# **show rldp**	View the RLDP global configuration and the port detection information with RLDP detection configured

In the example below, the **show rldp** command is used to view the detection information of all RLDP ports:

```
Ruijie# show rldp
rldp state          : enable
rldp hello interval    : 2
rldp max hello      : 3
rldp local bridge   : 00d0.f8a6.0134
------------------------------------------------
interface FastEthernet 0/1
port state:normal
neighbor bridge     : 00d0.f800.41b0
neighbor port   : FastEthernet 0/2
unidirection detect information:
action  : shutdown svi
state   : normal

interface FastEthernet 0/24
port state:error
neighbor bridge     : 0000.0000.0000
neighbor port   :
bidirection detect information :
action  : warnning
state   : error
```

As shown above, port FastEthernet 0/1 is configured with unidirection detection. No error is detected now, and the port status is normal. Port FastEthernet 0/24 is configured with bidirection detection, and bidirection fault is detected.

Viewing the RLDP Status of the Specified Port

In the privileged EXEC mode, run the following command to view the RLDP detection information of the specified port:

Command	Function
Ruijie# **show rldp interface** interface-id	View the RLDP detection information of interface-id.

In the example below, the **show rldp interface FastEthernet** *0/1* command is used to view the RLDP detection information of port fas0/1:

```
Ruijie# show rldp int FastEthernet 0/1
```

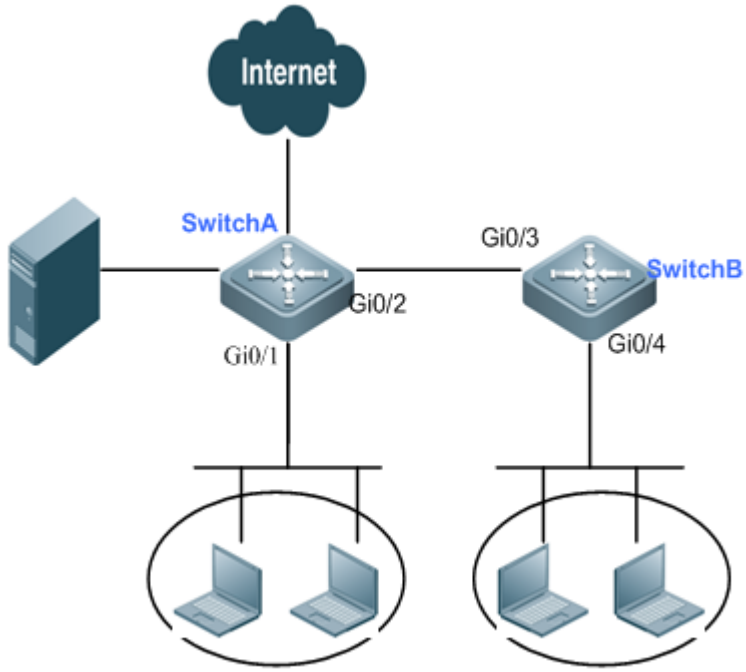
```
port state     :error
local bridge    : 00d0.f8a6.0134
neighbor bridge : 00d0.f822.57b0
neighbor port   : FastEthernet 0/1
unidirection detect information:
action: shutdown svi
state :  normal
bidirection detect information :
action : warnning
state :  normal
loop detect  information    :
action: shutdown svi
state :  error
```

As shown above, the port FastEthernet 0/1 is configured with three detection types: unidirection detection, bidirection detection and loop detection. The troubleshooting methods are shutdown-svi and warning. Error is found in loop detection so the current port status is error. Accordingly, the SVI of the port is shutdown.

Typical RLDP Configuration Example

RLDP Fault Detection and Handling

Network Topology



Topological diagram for RLDP application

Networking Requirements

As shown above, users from respective departments of the enterprise access network through Switch A and Switch B. Due to network interruption caused by link failure or such non-device factors as the contrived network loop, RLDP loop detection and unidirectional/bidirectional link detection must be configured to instantly locate and handle faults, so that the network can be recovered instantly and the losses caused by network failure can be reduced. Major needs include:

- The loop error or unidirectional/bidirectional link failure detected can be handled as per the fault-handling method configured.
- If the port configured with "shutdown-port" fault-handling is failed, the RLDP detection can be recovered and all failed ports can start detection again.

Configuration Tips

1. After enabling global RLDP, enable RLDP on the port and configure diagnosis type and fault-handling method.

Note: For loop detection, RLDP cannot be enabled on the downlink port (the port connecting with department users or servers); for unidirectional/bidirectional link detection, RLDP must be enabled on the port connecting with peer device. If the port is a routing port, only the fault-handling method of warning, block or shutdown-port can be used, and shutdown-svi is not supported.

2. In privilege mode, use "rldp reset" command to enable all failed ports to start RLDP detection again.

Configuration Steps

1) Enable RLDP on the device.

! Enable global RLDP on Switch A.

```
SwitchA#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
SwitchA(config)#rldp enable
```

! Configurations of Switch B are the same as above.

2) Configure diagnosis type and fault-handling method on the port.

! Enable RLDP on the ports of Switch A; configure loop detection and fault-handling method as "block" on port Gi 0/1 and configure unidirectional link detection and fault-handling method as "warning" on port Gi 0/2.

```
SwitchA(config)#interface FastEthernet 0/1
SwitchA(config-if)#rldp port loop-detect block
SwitchA(config-if)#exit
SwitchA(config)#interface FastEthernet 0/2
SwitchA(config-if)#rldp port unidirection-detect warning
SwitchA(config-if)#exit
```

! Enable RLDP on the ports of Switch B; configure loop detection and fault-handling method as "block" on port Gi 0/4 and configure bidirectional link detection and fault-handling method as "shutdown-port" on port Gi 0/3.

```
SwitchB(config)#interface FastEthernet 0/4
SwitchB(config-if)#rldp port loop-detect block
SwitchB(config-if)#exit
SwitchB(config)#interface FastEthernet 0/3
SwitchB(config-if)#rldp port bidirection-detect shutdown-port
```

```
SwitchB(config-if)#exit
```

3) Restore RLDP detection on the port.

! Execute "rldp reset" command on Switch A.

```
SwitchA#rldp reset
```

! Configurations of Switch B are the same as above.

Verification

Display RLDP information about all ports on the device.

! RLDP information of all ports on Switch A

```
SwitchA#show rldp
rldp state       : enable
rldp hello interval: 3
rldp max hello    : 2
rldp local bridge  : 00d0.f822.33aa
----------------------------------
Interface FastEthernet 0/2
port state     : normal
neighbor bridge : 00d0.f800.41b0
neighbor port   :  FastEthernet 0/3
unidirection detect information:
    action: warning
    state : normal

Interface FastEthernet 0/1
port state     : normal
neighbor bridge : 0000.0000.0000
neighbor port   :
loop detect information   :
    action: block
    state : normal
```

! RLDP information of all ports on Switch B

```
SwitchB#show rldp
rldp state       : enable
rldp hello interval: 3
rldp max hello    : 2
rldp local bridge  : 00d0.f800.41b0
----------------------------------
Interface FastEthernet 0/3
port state     : normal
neighbor bridge : 00d0.f822.33aa
neighbor port   :  FastEthernet 0/2
bidirection detect information:
```

```
    action: shutdown-port
    state : normal

Interface FastEthernet 0/4
port state     : normal
neighbor bridge : 0000.0000.0000
neighbor port   :
loop detect information    :
    action: block
    state : normal
```

LLDP Configuration

LLDP Overview

Drafted by IEEE 802.1AB, LLDP (Link Layer Discovery Protocol) can detect network topology change and identify what the change is. With LLDP, a device sends local device information as TLV (Type, Length and Value) triplets in LLDP Data Units (LLDPDUs) to the neighbor devices, and at the same time, stores the device information received in LLDPDUs sent from the LLDP neighbors in a standard management information base (MIB) to be accessed by the network management system.

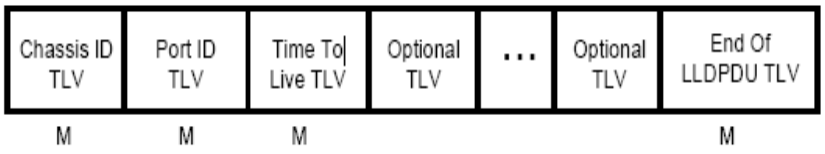
Through LLDP, the network management system can learn about the state of topological connections, such as which ports of the device are connected to other devices, the rate of ports on both sides of link, and whether the duplex mode is matched. The network administrator can quickly locate and eliminate faults according to such information.

Basic Concepts

LLDPDU

LLDPDU refers to the data units encapsulated in LLDP packets, and comprises multiple TLV sequences, including three fixed TLVs, a number of optional TLVs and an End of TLV. The detailed format of LLDPDU is shown in Fig 1:

Fig 1-1 LLDPDU format



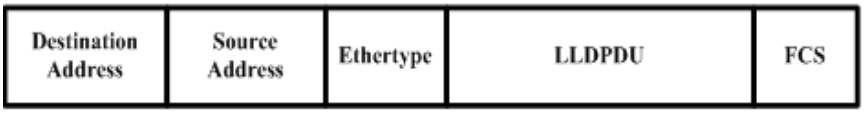
- * M refers to fixed TLV.
- In LLDPDU, Chassis ID TLV, Port ID TLV, Time To Live TLV and End Of LLDPDU TLV are fixed TLVs, while other TLVs are optional.

LLDPDU Encapsulation Format

LLDP packet supports two encapsulation formats: Ethernet II and SNAP (Subnetwork Access Protocols).

Ethernet II encapsulated LLDPDU format is shown in Fig 2:

Figure 1-2 Ethernet II encapsulated LLDPDU format

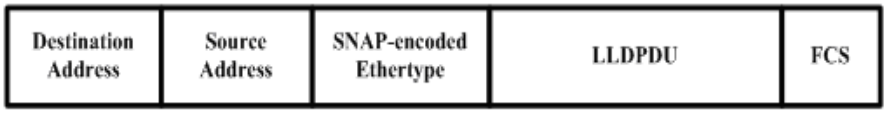


Specifically:

- Destination Address: destination MAC address. It is fixed to 01-80-C2-00-00-0E, a multicast address.
- Source Address: source MAC address, layer-2 MAC address of device.
- Ethertype: the Ethernet type, 0x88CC.
- LLDPDU: LLDP Data Unit.
- FCS: frame check sequence.

SNAP-encapsulated LLDPDU format is shown in Fig 3:

Figure 1-3 SNAP-encapsulated LLDPDU format



Specifically:

- Destination Address: destination MAC address. It is fixed to 01-80-C2-00-00-0E, a multicast address.
- Source Address: source MAC address, layer-2 MAC address of device.
- SNAP-encoded Ethertype: SNAP-encapsulated Ethernet type, AA-AA-03-00-00-00-88-CC.
- LLDPDU: LLDP Data Unit.
- FCS: frame check sequence.

TLV

TLVs encapsulated in LLDPDU can fall into two broad categories:

- Basic management TLVs
- Organizationally specific TLVs

Basic management TLVs are a group of basic TLVs for network management. The organizationally specific TLVs are TLVs defined by standards organizations and other organizations, such as IEEE 802.1, IEEE 802.3 and etc.

4) Basic management TLVs

Basic management TLVs include two types of TLVs: fixed TLVs and optional TLVs. Fixed TLVs must be included in LLDPDU, while optional TLVs can be included or excluded according to need.

Basic management TLVs are shown in Table 1:

Type	Description	Use in LLDPDU
End Of LLDPDU TLV	End mark of LLDPDU, occupying 2 bytes	Fixed
Chassis ID TLV	Used to identify the device, and is generally represented with MAC address	Fixed
Port ID TLV	ID of the LLDPDU sending port	Fixed
Time To Live TLV	Life of local information on the neighbor device. When TLV with 0 TTL is received, the corresponding neighbor information must be deleted.	Fixed
Port Description TLV	Port description of LLDPDU sending port	Optional
System Name TLV	Name of the sending device	Optional
System Description TLV	Description of the sending device, including hardware/software version, operating system and etc.	Optional
System Capabilities TLV	Identifies the primary functions of the sending device, such as bridging, routing and relaying.	Optional
Management Address TLV	Management address, including interface number and OID (object Identifier).	Optional

Table 1 Basic management TLV

☑ Basic management TLVs are supported by the LLDP protocol used by Ruijie router products.

5) Organizationally specific TLVs

Different organizations (such as IEEE 802.1, IEEE 802.3, IETF or device suppliers) may define specific TLVs to advertise specific information about the device, and OUI (Organizationally Unique Identifier) is used to identify different organizations.

Organizationally specific TLVs are optional TLVs advertised in LLDPDU according to user's actual needs. Currently, commonly found organizationally specific TLVs include:

1) IEEE 802.1 organizationally specific TLVs

IEEE 802.1 organizationally specific TLVs are shown in Table 2:

Type	Description
Port VLAN ID TLV	VLAN identifier of the sending port
Port And Protocol VLAN ID TLV	Protocol VLAN identifier of the sending port
VLAN Name TLV	Name of VLAN with which the device is configured
Protocol Identity TLV	Protocols supported by the port

Table 2 IEEE 802.1 organizationally specific TLVs

☑ LLDP protocol used by Ruijie router products doesn't support the sending of Protocol Identity TLV, but allows the reception of such TLV.

2) IEEE 802.3 organizationally specific TLVs

IEEE 802.3 organizationally specific TLVs are shown in Table 3:

Type	Description
MAC/PHY Configuration/Status TLV	The bit-rate and duplex capabilities of the sending port and support for auto negotiation.
Power Via MDI TLV	Power supply capability of the port
Link Aggregation TLV	Indicate the link aggregation capability of the port and the aggregation status.
Maximum Frame Size TLV	The maximum frame size supported by the port.

Table 3 IEEE 802.3 organizationally specific TLVs

☑ IEEE 802.3 organizationally specific TLVs are supported by the LLDP protocol used by Ruijie router products.

3) LLDP-MED TLVs

LLDP-MED is the extension of IEEE 802.1AB LLDP protocol, so that the user can conveniently deploy VoIP (Voice Over IP) network and fault detection. It provides multiple applications such as network policy configuration, device detection, PoE management and directory management, providing a cost-effective and easy-to-use solution for deploying voice devices in Ethernet.

LLDP-MED TLVs are shown in Table 4:

Type	Description
LLDP-MED Capabilities TLV	Whether the device supports LLDP-MED, the type of LLDP-MED TLV encapsulated in LLDPDU, and the type of current device (network connection device or endpoint)
Network Policy TLV	Advertise VLAN configuration of the specific port, supported applications (voice and video, for example), and the Layer 2 priorities.
Location Identification TLV	Location identifier information for an endpoint, used to accurately locate the endpoint in applications such as network topology collection.
Extended Power-via-MDI TLV	Provide more advanced power supply management.
Inventory – Hardware Revision TLV	Hardware version of MED device
Inventory – Firmware Revision TLV	Firmware version of MED device
Inventory – Software Revision TLV	Software version of MED device
Inventory – Serial Number TLV	Serial number of MED device
Inventory – Manufacturer Name TLV	Vendor name of MED device
Inventory – Model Name TLV	Model name of MED device
Inventory – Asset ID TLV	Asset ID of MED device, used for directory management and asset tracking.

Table 4 LLDP-MED TLVs

☑ LLDP-MED TLVs are supported by the LLDP protocol used by Ruijie router products.

Working Principles

Operating Modes of LLDP

LLDP provides three operating modes:

- TxRx: sending and receiving LLDPDUs.
- Rx Only: only sending LLDPDUs.
- Tx Only: only receiving LLDPDUs.

When the LLDP operating mode of a port changes, the port will initialize the protocol state machine. To prevent LLDP from being initialized too frequently during times of frequent operating mode change, you can configure a re-initialization delay.

Mechanism for Transmitting LLDPDUs

An LLDP-enabled port operating in TxRx mode or Tx Only mode will send LLDPDUs both periodically and when the local device information changes. To avoid frequent LLDPDU sending during times of frequent local device information change, an interval is introduced between two successive LLDPDUs. This interval can be configured manually.

LLDP provides two types of packets:

- Standard LLDPDUs: including the management and configuration information about local device.
- Shutdown LLDPDU: When LLDP sending mode is disabled or when the port is administratively shut down, shutdown LLDPDU will be sent. Shutdown LLDPDU generally comprises Chassis ID TLV, Port ID TLV, Time To Live TLV and End Of LLDP TLV, with the TTL in Time To Live TLV being 0. When the device receives shutdown LLDPDUs, it will consider the neighbor on longer available and delete neighbor information.

When LLDP operating mode changes from shutdown or Rx to TxRx or Tx, or when a new neighbor is detected (namely new LLDPDUs are received and no such neighbor information is stored locally), to allow the neighbor device to quickly study the information about this device, the fast sending mechanism will be initiated. The fast sending mechanism adjusts the LLDPDU sending interval to 1 second and continuously transmits a certain number of LLDPDUs.

Mechanism for Receiving LLDPDUs

A LLDP-enabled port operating in TxRx mode or Rx Only mode will be able to receive LLDPDUs, and will check the validity of received LLDPDUs to verify they are new neighbor information or updates of existing neighbor information. The neighbor information will be stored on the local device. Meanwhile, an aging timer will be set according to the value in TTL TLV carried in the LLDPDU. If the TTL value is zero, the information is aged out immediately.

Protocol Specifications

The protocols and standards related to LLDP include:

- IEEE 802.1AB 2005: Station and Media Access Control Connectivity Discovery

- ANSI/TIA-1057: Link Layer Discovery Protocol for Media Endpoint Devices

Configuring LLDP Basic Functions

Function	Default Settings
Globally enable LLDP	Enabled
Enable LLDP on the port	Enabled
Operating mode of LLDP	TxRx
Port re-initialization delay	2 seconds
LLDPDU transmit interval	30 seconds
LLDPDU transmit delay	2 seconds
Neighbor information aging timer	120 seconds
LLDPDU encapsulation format	Ethernet II
Enable LLDP Trap	Disabled
LLDP error detection	Enabled

Enabling LLDP

By default, LLDP is enabled globally and on each port. To make LLDP take effect on certain ports, you must enable LLDP both globally and on these ports.

Execute the following steps to disable LLDP globally and on each port.

Command	Function
Ruijie(config)#**no lldp enable**	Disable LLDP globally.

Ruijie(config)# **interface** *interface-name*	Enter interface configuration mode. LLDP runs on the actual physical interface (for AP port, it runs on AP's member port). LLDP is not supported on stacking port or VSL port.
Ruijie(config-if)#**no lldp enable**	Disable LLDP on the interface.
Ruijie(config-if)#**show lldp status**	Display LLDP state.

To enable LLDP globally or on the port, execute "lldp enable" command.


Caution

Disabling the LLDP globally will disable LLDP on the device. Meanwhile, the device will send Shutdown LLDPDUs to neighbor devices in order to delete the corresponding LLDP information.


Note

The port can learn up to 5 neighbors.
If a neighbor device does not support the LLDP, but its downlink device does, the information of non-directly connected devices may be learnt on the port as the neighbor device may forward the LLDP packets.

Configuration example:

Globally disable LLDP and display LLDP state.

```
Ruijie(config)#no lldp enable

Ruijie(config)#show lldp status

Global status of LLDP: Disable
```

Configuring LLDP Operating Mode

By default, LLDP is enabled on the interface and operates in TxRx mode. The user can change the operating mode to Tx mode or Rx mode as needed. Execute the following steps to configure LLDP operating mode.

Command	Function
Ruijie(config)# **interface** *interface-name*	Enter interface configuration mode. LLDP runs on the actual physical interface (for AP port, it runs on AP's member port). LLDP is not supported on stacking port or VSL port.

Ruijie(config-if)#**lldp mode** { **tx** | **rx** | **txrx** }	Configure LLDP operating mode. The configurable operating modes include Tx, Rx and TxRx.
Ruijie(config-if)#**show lldp status interface** *interface-name*	Display LLDP state on the interface.

Configuration example:

Configure LLDP operating mode as Tx on the interface and display LLDP state on the interface

```
Ruijie(config)#interface FastEthernet 0/1

Ruijie(config-if-FastEthernet 0/1)#lldp mode tx

Ruijie(config-if-FastEthernet 0/1)#show lldp status interface FastEthernet 0/1

Port [FastEthernet 0/1]

Port status of LLDP           : Enable

Port state                   : UP

Port encapsulation            : Ethernet II

Operational mode             : TxOnly

Notification enable           : NO

Error detect enable           : YES

Number of neighbors           : 0

Number of MED neighbors        : 0
```

Configuring the Advertisable TLVs

By default, all TLVs other than Location Identification TLV can be advertised on the interface. Execute the following steps to configure advertisable TLVs on the interface.

Command	Function
Ruijie(config)# **interface** *interface-name*	Enter interface configuration mode. LLDP runs on the actual physical interface (for AP port, it runs on AP's member port).

	LLDP is not supported on stacking port or VSL port.
Ruijie(config-if)# **lldp tlv-enable** { **basic-tlv** { **all** | **port-description** | **system-capability** | **system-description** | **system-name** } | **dot1-tlv** { **all** | **port-vlan-id** | **protocol-vlan-id** [*vlan-id*] | **vlan-name** [*vlan-id*] } | **dot3-tlv** { **all** | **link-aggregation** | **mac-physic** | **max-frame-size** | **power** } | **med-tlv** { **all** | **capability** | **inventory** | **location** { **civic-location** | **elin** } **identifier** *id* | **network-policy profile** [*profile-num*] | **power-over-ethernet** } }	Configure the TLV types that the interface allows the port to advertise. By default, all TLVs other than Location Identification TLV can be advertised on the interface.
Ruijie(config-if)# **show lldp tlv-config interface** *interface-name*	Display the attributes of advertisable TLVs.

☑ S86 switch only supports the advertisement of Basic-TLV.
By default:
For non-S12000 series products, the interface allows to advertise all TLVs except location identification TLVs.
For S12000 series products, only basic TLVs and IEEE 802.1 TLVs can be advertised.
To advertise IEEE 802.3 TLVs and LLDP-MED TLVs, manually configure the advertisement using the **lldp tlv-enable** command.

Note

When configuring basic management TLVs, IEEE 802.1 organizationally specific TLVs and IEEE 802.3 organizationally specific TLVs, if "all" parameter is specified, all corresponding optional TLVs will be advertised.

When configuring LLDP-MED TLVs, if "all" parameter is specified, all LLDP-MED TLVs other than Location Identification TLV will be advertised.

Configure to allow the advertisement of LLDP-MED MAC/PHY TLVs before that of LLDP-MED Capability TLVs.

Configure to cancel the advertisement of LLDP-MED Capability TLVs before that of LLDP-MED MAC/PHY TLVs.

When configuring LLDP-MED TLVs, the LLDP-MED Capability TLV shall be configured as advertisable in order to further configure other LLDP-MED TLVs as advertisable.

In order not to advertise LLDP-MED Capability TLV, other LLDP-MED TLVs shall be configured as non-advertisable, so that LLDP-MED TLVs are not advertised.

For the meaning of respective key words of "lldp tlv-enable", please refer to the descriptions given in "LLDP-CREF".

When associating the device with an IP phone, you can configure the network policy TLV delivery policy to the IP phone if it supports LLDP-MED. Then, the IP phone modifies the voice flow tag and QoS. At this time,

the voice VLAN function is not required, but it is required to configure the port connecting to the IP phone as the QoS trusted port. If the IP phone does not support LLDP-MED, the voice VLAN configuration is required and the phone MAC address must be manually configured to the voice VLAN OUI list.

Configuration example:

Configure to disable the advertisement of Port And Protocol VLAN ID TLV specified by IEEE 802.1.

```
Ruijie(config)#interface FastEthernet 0/1

Ruijie(config-if-FastEthernet 0/1)#no lldp tlv-enable dot1-tlv protocol-vlan-id

Ruijie(config-if-FastEthernet 0/1)#show lldp tlv-config interface FastEthernet 0/1

LLDP tlv-config of port [FastEthernet 0/1]

             NAME               STATUS DEFAULT

------------------------------ ------ -------

Basic optional TLV:

Port Description TLV            YES    YES

System Name TLV                 YES    YES

System Description TLV          YES    YES

System Capabilities TLV         YES    YES

Management Address TLV          YES    YES



IEEE 802.1 extend TLV:

Port VLAN ID TLV                YES    YES

Port And Protocol VLAN ID TLV    NO     YES

VLAN Name TLV                   YES    YES



IEEE 802.3 extend TLV:
```

```
MAC-Physic TLV                  YES    YES

Power via MDI TLV               YES    YES

Link Aggregation TLV            YES    YES

Maximum Frame Size TLV          YES    YES



LLDP-MED extend TLV:

Capabilities TLV                YES    YES

Network Policy TLV              YES    YES

Location Identification TLV     NO     NO

Extended Power via MDI TLV      YES    YES

Inventory TLV                   YES    YES
```

Configuring the Management address Advertised in LLDPDU

The management address of a device is used by the network management system to identify and manage the device.

By default, the management address is advertised in an LLDP packet, and is the IPv4 address of the lowest-ID VLAN allowed by the interface.

Execute the following steps to configure the management address to be advertised in LLDPDU:

Command	Function
Ruijie(config)# **interface** *interface-name*	Enter interface configuration mode. LLDP runs on the actual physical interface (for AP port, it runs on AP's member port). LLDP is not supported on stacking port or VSL port.
Ruijie(config-if)#**lldp management-address-tlv** [*ip-address*]	Configure the management address advertised in the LLDP packet.
Ruijie(config-if)#**show lldp local-information interface** *interface-name*	Display LLDP local information about a specific interface.

Note

By default, the management address is advertised in LLDPDU, and is the IPv4 address of the lowest-ID VLAN carried on the port. If IPv4 address is not configured for this VLAN, the next lowest-ID VLAN carried on the port will be tried until the IPv4 address is obtained.

If the IPv4 address is still not found, the IPv6 address of the lowest-ID VLAN carried on the port will be tried.

If the IPv6 address is still not found, the MAC address of the device will be advertised as the management address.

Configuration example:

Configure the management address advertised in LLDPDU as 192.168.1.1 and display the corresponding configuration.

```
Ruijie(config)#interface FastEtherne 0/1

Ruijie(config-if-FastEthernet 0/1)#lldp management-address-tlv 192.168.1.1

Ruijie(config-if-FastEthernet 0/1)#show  lldp local-information interface FastEthernet 0/1

Lldp local-information of port [FastEthernet 0/1]

   Port ID type                   : Interface name

  Port id                       : FastEthernet 0/1

  Port description               :



  Management address subtype       : ipv4

  Management address              : 192.168.1.1

  Interface numbering subtype      : ifIndex

  Interface number                : 0

  Object identifier               :



  802.1 organizationally information

  Port VLAN ID                   : 1

  Port and protocol VLAN ID(PPVID)  : 1
```

```
    PPVID Supported             : YES

    PPVID Enabled               : NO

 VLAN name of VLAN 1             : VLAN0001

 Protocol Identity               :



 802.3 organizationally information

 Auto-negotiation supported       : YES

 Auto-negotiation enabled         : YES

 PMD auto-negotiation advertised   : 1000BASE-T full duplex mode, 100BASE-TX full duplex mode,
100BASE-TX half duplex mode, 10BASE-T full duplex mode, 10BASE-T half duplex mode

 Operational MAU type             : dot3MauType100BaseTXFD: 2 pair category 5 UTP, full duplex
mode

 PoE support                     : NO

Link aggregation supported       : YES

 Link aggregation enabled         : NO

 Aggregation port ID             : 0

 Maximum frame Size              : 1500



 LLDP-MED organizationally information

 Power-via-MDI device type        : PD

 Power-via-MDI power source       : Local

 Power-via-MDI power priority     :

 Power-via-MDI power value        :

 Model name                      : Model name
```

Configuring the Number of Fast Sent LLDPDUs

When a new neighbor is detected or when LLDP operating mode changes from shutdown or Rx to TxRx or Tx, to allow the neighbor device to quickly study the information about this device, the fast sending mechanism will be initiated. The fast sending mechanism shortens the LLDPDU sending interval to 1 second and continuously transmits a certain number of LLDPDUs before restoring to the normal transmit interval.

Command	Function
Ruijie(config)#**lldp fast-count** *count*	Configure the number of fast sent LLDPDUs. Default: 3; configurable range: 1-10.
Ruijie(config-if)#**show lldp status**	Display LLDP state.

Configuration example:

Configure the number of fast sent LLDPDUs to 5.

```
Ruijie(config)#lldp fast-count 5

Ruijie(config)#show lldp status

Global status of LLDP               : Enable

Neighbor information last changed time :

Transmit interval                   : 30s

Hold multiplier                     : 4

Reinit delay                        : 2s

Transmit delay                      : 2s

Notification interval               : 5s

Fast start counts                   : 5
```

Configuring TTL Multiplier and LLDPDU Transmit interval

The value of Time To Live TLV in LLDPDU = TTL multiplier × LLDPDU transmit interval + 1. Therefore, the TTL of local device information on the neighbor device can be controlled by adjusting TTL multiplier.

The LLDPDU transmit interval can be adjusted. Execute the following steps to configure TTL multiplier and LLDPDU transmit interval.

Command	Function
Ruijie(config)#**lldp hold-multiplier** *value*	Configure TTL multiplier. Default: 4; configurable range: 2-10.
Ruijie(config)#**lldp timer tx-interval** *seconds*	Configure LLDPDU transmit interval. Default: 30 seconds; configurable range: 5-32768 seconds.
Ruijie(config-if)#**show lldp status**	Display LLDP state.

Configuration example:

Configure TTL multiplier to 3 and LLDPDU transmit interval to 20 seconds. By this time, the TTL of local device information on the neighbor device is 61 seconds.

```
Ruijie(config)#lldp hold-multiplier 3

Ruijie(config)#lldp timer tx-interval 20

Ruijie(config)#show lldp status

Global status of LLDP              : Enable

Neighbor information last changed time :

Transmit interval                  : 20s

Hold multiplier                    : 3

Reinit delay                       : 2s

Transmit delay                     : 2s

Notification interval               : 5s

Fast start counts                  : 3
```

Configuring LLDPDU Transmit Delay

An LLDP-enabled port will send LLDPDUs when the local device information changes. To avoid frequent LLDPDU sending during times of frequent local device information change, we can configure LLDPDU transmit delay to control the frequent transmission of LLDPDUs. The default transmit delay is 2 seconds. Execute the following steps to configure the LLDPDU transmit delay.

Command	Function
Ruijie(config)#**lldp timer tx-delay** *seconds*	Configure LLDPDU transmit delay
Ruijie(config)#**show lldp status**	Display LLDP state.

Configuration example:

Configure LLDPDU transmit delay to 3 seconds and display LLDP state.

```
Ruijie(config)#lldp timer tx-delay 3

Ruijie(config)#show lldp status

Global status of LLDP              : Enable

Neighbor information last changed time :

Transmit interval                  : 30s

Hold multiplier                    : 4

Reinit delay                       : 2s

Transmit delay                     : 3s

Notification interval              : 5s

Fast start counts                  : 3
```

Configuring Port Re-initialization Delay

When the LLDP operating mode of a port changes, the port will initialize the protocol state machine. To prevent LLDP from being initialized too frequently during times of frequent operating mode change, you can configure port re-initialization delay. Execute the following steps to configure port re-initialization delay:

Command	Function
Ruijie(config)#**lldp timer reinit-delay** *seconds*	Configure port re-initialization delay.
Ruijie(config)#**show lldp status**	Display LLDP state.

Configuration example:

Configure the port re-initialization delay to 3 seconds and display LLDP state.

```
Ruijie(config)#lldp timer reinit-delay 3

Ruijie(config)#show lldp status

Global status of LLDP              : Enable

Neighbor information last changed time :

Transmit interval                  : 30s

Hold multiplier                    : 4

Reinit delay                       : 3s

Transmit delay                     : 2s

Notification interval              : 5s

Fast start counts                  : 3
```

Configuring LLDP Trap

By configuring LLDP Trap, the LLDP information of local device (such as information about the detection of new neighbor or the fault on the communication link) can be sent to the network management server. The administrator can monitor the network operation status according to such information.

To prevent excessive LLDP traps from being sent, you can set an interval for sending LLDP Traps. If LLDP information change is detected during this interval, traps will be sent to the network management server.

By default, LLDP Trap is disabled.

Execute the following steps to configure LLDP Trap:

Command	Function
Ruijie(config)#**lldp timer notification-interval** *seconds*	Configure the interval for sending LLDP Traps. Default: 5 seconds; configurable range: 5-3600 seconds.
Ruijie(config)# **interface** *interface-name*	Enter interface configuration mode. LLDP runs on the actual physical interface (for AP port, it runs on AP's member port). LLDP is not supported on stacking port or VSL port.
Ruijie(config-if)#**lldp notification remote-change**	Enable LLDP Trap. LLDP Trap is disabled by default.

enable	
Ruijie(config-if)#**show lldp status**	Display LLDP state.

Configuration example:

Enable LLDP Trap and configure the interval for sending LLDP Traps to 10 seconds.

```
Ruijie(config)#lldp timer notification-interval 10

Ruijie(config)#interface FastEthernet 0/1

Ruijie(config-if-FastEthernet 0/1)#lldp notification remote-change enable

Ruijie(config-if-FastEthernet 0/1)#show lldp status

Global status of LLDP              : Enable

Neighbor information last changed time :

Transmit interval                  : 30s

Hold multiplier                    : 4

Reinit delay                       : 2s

Transmit delay                     : 2s

Notification interval               : 10s

Fast start counts                  : 3

------------------------------------------------------------

Port [FastEthernet 0/1]

------------------------------------------------------------

Port status of LLDP           : Enable

Port state                   : UP

Port encapsulation            : Ethernet II

Operational mode             : RxAndTx
```

```
Notification enable           : YES

Error detect enable           : YES

Number of neighbors           : 0

Number of MED neighbors        : 0
```

Configuring LLDP Error Detection

Configure LLDP error detection, including the detection of VLAN configurations on both sides of the link, port state detection, port aggregation configuration detection, MTU configuration detection and loop detection. If any error is detected by LLDP, LOG information will be printed to notify the administrator.

Execute the following steps to configure LLDP error detection:

Command	Function
Ruijie(config)# **interface** *interface-name*	Enter interface configuration mode. LLDP runs on the actual physical interface (for AP port, it runs on AP's member port). LLDP is not supported on stacking port or VSL port.
Ruijie(config-if)#**lldp error-detect**	Configure LLDP error detection. LLDP error detection is enabled by default.
Ruijie(config-if)#**show lldp status interface** *interface-name*	Display LLDP state on the interface.

Configuration example:

Configure LLDP error detection.

```
Ruijie(config)#interface FastEthernet 0/1

Ruijie(config-if-FastEthernet 0/1)#lldp error-detect

Ruijie(config-if-FastEthernet 0/1)#show lldp status interface FastEthernet 0/1

Port [FastEthernet 0/1]

Port status of LLDP           : Enable

Port state                   : UP

Port encapsulation            : Ethernet II
```

```
Operational mode             : RxAndTx

Notification enable          : NO

Error detect enable          : YES

Number of neighbors          : 0

Number of MED neighbors       : 0
```

Configuring LLDPDU Encapsulation Format

By default, LLDPDUs are encapsulated in Ethernet II frames. The configurable encapsulation formats include Ethernet II and SNAP.

When configured to Ethernet II format, the device can only send and receive Ethernet II-encapsulated LLDP packets.

When configured to SNAP format, the device can only send and receive SNAP-encapsulated LLDP packets.

Execute the following steps to configure LLDPDU encapsulation format:

Command	Function
Ruijie(config)# **interface** *interface-name*	Enter interface configuration mode. LLDP runs on the actual physical interface (for AP port, it runs on AP's member port). LLDP is not supported on stacking port or VSL port.
Ruijie(config-if)#**lldp encapsulation snap**	Configure LLDPDU encapsulation format to SNAP.
Ruijie(config-if)#**show lldp status interface** *interface-name*	Display LLDP state on the interface.

Caution To guarantee normal communication between local device and neighbor device, the same LLDPDU encapsulation format must be used.

Configuration example:

Configure LLDPDU encapsulation format to SNAP and display the corresponding configuration.

```
Ruijie(config)#interface FastEthernet 0/1

Ruijie(config-if-FastEthernet 0/1)#lldp encapsulation snap

Ruijie(config-if-FastEthernet 0/1)#show lldp status interface FastEthernet 0/1
```

```
Port [FastEthernet 0/1]

Port status of LLDP           : Enable

Port state                   : UP

Port encapsulation            : Snap

Operational mode             : RxAndTx

Notification enable           : NO

Error detect enable           : YES

Number of neighbors           : 0

Number of MED neighbors        : 0
```

Displaying and Clearing Configurations

Command	Function
Ruijie(config)# **lldp network-policy profile** *profile-num*	Enter the LLDP network-policy configuration mode.
Ruijie(config-lldp-network-policy)# { **voice** | **voice-signaling** } **vlan** { { *vlan-id* [**cos** ***cvalue*** | **dscp** *dvalue*] } | { **dot1p** [**cos** ***cvalue*** | **dscp** *dvalue*] } | **none** | **untagged** } **no** { **voice** | **voice-signaling** } **vlan**	Configure the LLDP network-policy.

Configuration example:

Configure the LLDP packet advertised from interface 1 as follows:
Network Policy TLV: **1**
voice VLAN ID: **3**
cos: **4**
dscp: **6**

```
Ruijie#config

Ruijie(config)#lldp network-policy profile 1

Ruijie(config-lldp-network-policy)# voice vlan 3 cos 4
```

```
Ruijie(config-lldp-network-policy)# voice vlan 3 dscp 6

Ruijie(config-lldp-network-policy)#exit

Ruijie(config)# interface FastEthernet 0/1

Ruijie(config-if-FastEthernet 0/1)# lldp tlv-enable med-tlv network-policy profile 1
```

Configuring the Civic Address Information of a Device

Run the commands listed in the following table to configure the address information of a device.

Command	Function
Ruijie(config)# **lldp location civic-location identifier** *id*	Enters the LLDP Civic Address configuration mode
Ruijie(config-lldp-civic**)# device-type** *device-type*	Configure the device type. The default device type is a router.
Ruijie(config-lldp-civic)# { **country** | **state** | **county** | **city** | **division** | **neighborhood** | **street-group** | **leading-street-dir** | **trailing-street-suffix | street-suffix** | **number** | **street-number-suffix** | **landmark** | **additional-location-information** | **name** | **postal-code** | **building** | **unit** | **floor** | **room** | **type-of-place | postal-community-name** | **post-office-box** | **additional-code** } *ca-word*	Configure the LLDP civic address information.

Configuration example:

Configure the address of device interface 1 as follows:
Device type: router
Country: CH
City: Fuzhou
Postal-code: 350000

```
Ruijie#config

Ruijie(config)#lldp location civic-location identifier 1

Ruijie(config-lldp-civic)# country CH

Ruijie(config-lldp-civic)# city Fuzhou
```

```
Ruijie(config-lldp-civic)# postal-code 350000

Ruijie(config-lldp-civic)# exit

Ruijie(config)# interface FastEthernet 0/1

Ruijie(config-if-FastEthernet 0/1)# lldp tlv-enable location civic-location identifier 1
```

Configuring the Emergency Call Number

Run the commands listed in the following table to configure the emergency call number of a device.

Command	Function
Ruijie(config)# **lldp location elin identifier** *id* **elin-location** *tel-number*	Configure the emergency call number.

Configuration example:

Configure the emergency call number of device interface 1 as 085285555556.

```
Ruijie#config

Ruijie(config)#lldp location elin identifier 1 elin-location 085283671111

Ruijie(config)# interface FastEthernet 0/1

Ruijie(config-if-FastEthernet 0/1)# lldp tlv-enable location elin identifier 1
```

Viewing and Clearing Configurations

Command	Function
show lldp local-information [**global** | **interface** *interface-name*]	Show the device information to be sent to a neighbor.
show lldp location { **civic-location** | **elin** } { **identifier** ***id*** | **interface** *interface-name* | **static** }	Show the civic address information or emergency call number of a local device.
show lldp neighbors [**interface** *interface-name*] [**detail**]	Show the device information about an adjacent neighbor.

show lldp network-policy profile [*profile-num*]	Show the LLDP network-policy configuration.
show lldp statistics [**global** | **interface** *interface-name*]	Show the LLDP statistics.
show lldp status [**interface** *interface-name*]	Show the LLDP status.
show lldp tlv-config [**interface** *interface-name*]	Show the optional TLVs that can be advertised.
clear lldp statistics [**interface** *interface-name*]	Clear LLDP statistics.
clear lldp table [**interface** *interface-name*]	Clear the information about LLDP neighbors.


Caution If you insert wireless switch cards or other line cards with inner ports to S86 or 12000 series devices, you can see these cards when viewing LLDP neighbors.

Configuration example:

Show the device information about an adjacent neighbor connecting a specified port.

```
Ruijie# show lldp neighbors detail

Lldp neighbor-information of port [FastEthernet 0/1]

  Neighbor index                : 1

  Device type                   : LLDP Device

  Update time                   : 12minutes 40seconds

Aging time                      : 5seconds

  Chassis ID type               : MAC address

  Chassis id                    : 00d0.f822.33cd

  System name                   : System name

  System description           : System description

  System capabilities supported    : Repeater, Bridge, Router
```

```
System capabilities enabled      : Repeater, Bridge, Router



Management address subtype       : 802 mac address

Management address              : 00d0.f822.33cd

Interface numbering subtype      :

Interface number                : 0

Object identifier               :



LLDP-MED capabilities           :

Device class                    :

HardwareRev                     :

FirmwareRev                     :

SoftwareRev                     :

SerialNum                       :

Manufacturer name               :

Asset tracking identifier       :



Port ID type                    : Interface name

Port id                         : FastEthernet 0/2

Port description                :



802.1 organizationally information

Port VLAN ID                    : 1
```

```
  Port and protocol VLAN ID(PPVID)  : 1

     PPVID Supported             : YES

     PPVID Enabled               : NO

  VLAN name of VLAN 1             : VLAN0001

  Protocol Identity               :

  802.3 organizationally information

  Auto-negotiation supported       : YES

  Auto-negotiation enabled         : YES

  PMD auto-negotiation advertised   : 1000BASE-T full duplex mode, 100BASE-TX full duplex mode,
100BASE-TX half duplex mode, 10BASE-T full duplex mode, 10BASE-T half duplex mode

  Operational MAU type             : speed(100)/duplex(Full)

  PoE support                     : NO

  Link aggregation supported       : YES

  Link aggregation enabled         : NO

  Aggregation port ID             : 0

  Maximum frame Size              : 1500



  LLDP-MED organizationally information

  Power-via-MDI device type        :

  Power-via-MDI power source       :

  Power-via-MDI power priority     :

  Power-via-MDI power value        :
```

Note For details about LLDP output information, see the description in *LLDP Command Reference*.

Typical LLDP Configuration Examples

Use LLDP to View Topological Connections

Networking Requirements

Devices required

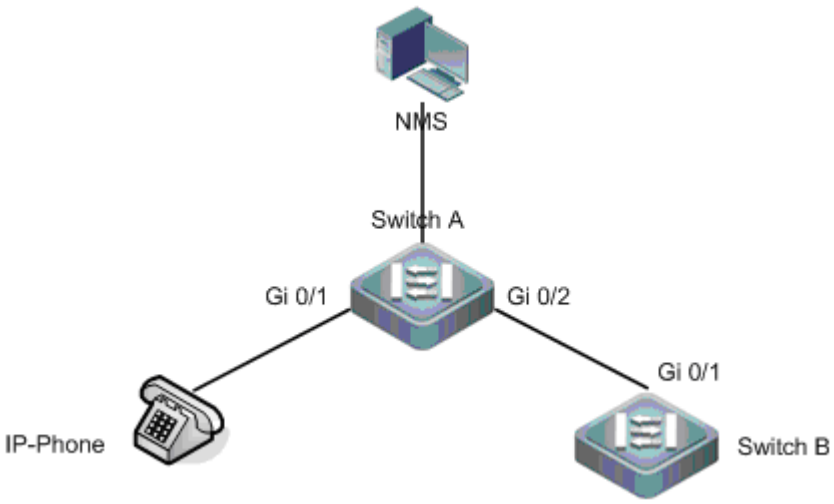
Two Ethernet routers (Switch A and Switch B), one MED device (taking IP Phone as the example) and one NMS (Network management System).

Configuration required

LLDP is enabled by default. No further configuration is needed.

Network Topology

Fig 4 Basic topological diagram of LLDP



Configuration Tips

- LLDP operating mode on the port is TxRx.
- LLDPDU transmit times will use default values, namely LLDPDU transmit interval is 30 seconds and LLDPDU transmit delay is 2 seconds.

Configuration Steps

By default, LLDP is enabled, and no further configuration is needed.

Verification

■ Display the information about the neighbor device connecting with Switch A.

Display the information about the neighbor device on Switch A.

```
Ruijie# show lldp neighbors FastEthernet 0/2

Capability codes:

   (R) Router, (B) Bridge, (T) Telephone, (C) DOCSIS Cable Device

   (W) WLAN Access Point, (P) Repeater, (S) Station, (O) Other



Local Intf  Port ID  Capability   Aging-time

Gi 0/2      Gi 0/1   B,R          120



Total entries displayed: 1
```

The above messages show that the MAC address of neighbor device connected to port 2 of router A is 00d0-f822-33cd and the port connected is Fa 0/1. The neighbor device allows bridging and routing.

Display the detailed information about the neighbor device connected to port Gi 0/2 of Switch A.

```
Ruijie# show lldp neighbor-information interface FastEthernet 0/2

Lldp neighbor-information of port [FastEthernet 0/2]

  Neighbor index                : 1

  Device type                   : LLDP Device

  Update time                   : 5minute 39second



  Chassis ID type               : MAC address

  Chassis id                    : 00d0.f822.33cd

  System name                   : System name

  System description            : System description
```

```
System capabilities supported    : Repeater, Bridge, Router

System capabilities enabled      : Repeater, Bridge, Router



Management address subtype       : 802 mac address

Management address              : 00d0.f822.33cd

Interface numbering subtype      :

Interface number                : 0

Object identifier               :




LLDP-MED capabilities           :

Device class                   :

HardwareRev                    :

FirmwareRev                    :

SoftwareRev                    :

SerialNum                     :

Manufacturer name               :

Asset tracking identifier       :



Port ID type                    : Interface name

Port id                        : FastEthernet 0/1

Port description                :
```

```
  802.1 organizationally information

  Port VLAN ID                  : 1

  Port and protocol VLAN ID(PPVID)  : 1

     PPVID Supported            : YES

     PPVID Enabled              : NO

  VLAN name of VLAN 1            : VLAN0001

  Protocol Identity              :




  802.3 organizationally information

  Auto-negotiation supported      : YES

  Auto-negotiation enabled        : YES

  PMD auto-negotiation advertised   : 1000BASE-T full duplex mode, 100BASE-TX full duplex mode,
100BASE-TX half duplex mode, 10BASE-T full duplex mode, 10BASE-T half duplex mode

  Operational MAU type            : dot3MauType1000BaseTFD: Four-pair Category 5 UTP, full
duplex mode

  PoE support                   : NO

  Link aggregation supported      : YES

  Link aggregation enabled        : NO

  Aggregation port ID            : 0

  Maximum frame Size             : 1500



  LLDP-MED organizationally information

  Power-via-MDI device type       :
```

```
 Power-via-MDI power source       :

 Power-via-MDI power priority     :

           Power-via-MDI power value       :
```

Use LLDP Error Detection Feature to Perform Error Detection

Networking Requirements

- Devices required

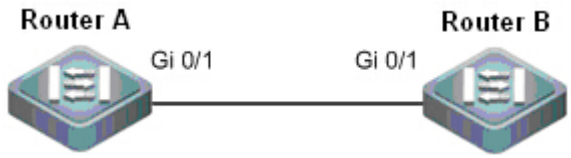
Two Ethernet routers (Router A and Router B)

- Configuration required

LLDP is enabled by default. No further configuration is needed.

Network Topology

Fig 5 Basic topological diagram of LLDP



Configuration Tips

- LLDP operating mode on the port is TxRx.
- LLDPDU transmit times will use default values, namely LLDPDU transmit interval is 30 seconds and LLDPDU transmit delay is 2 seconds.
- LLDP error detection is enabled by default. No further configuration is needed.

Configuration Steps

1. Configure the bit-rate of port Fi 0/1 of Router A to 100M.

```
Ruijie#config

Ruijie(config)#interface FastEthernet 0/1

Ruijie(config-if-FastEthernet 0/1)#speed 100

%Warning: the speed/duplex of port FastEthernet 0/1 may not match with it's neighbor.
```

The above messages show that bit-rate and duplex capabilities of port 1 may not match with that of port on neighbor device.

Verification

While the administrator is carrying out VLAN configuration, port bit-rate and duplex configuration, aggregation port configuration and port MTU configuration, if the information doesn't match with the configurations of neighbor device the corresponding error messages will be prompted.

VRRP Configuration

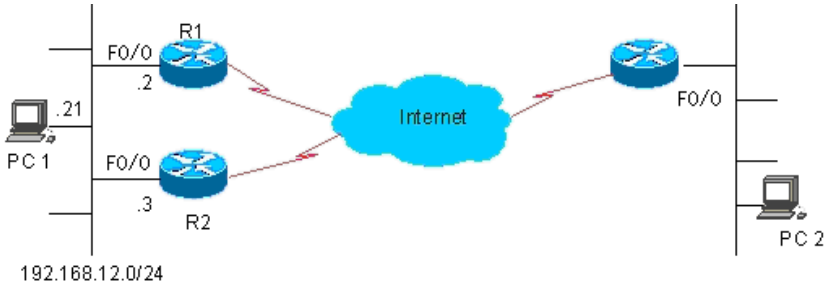
Overview

The Virtual Router Redundancy Protocol (VRRP) is designed to work in master/backup mode, so that traffic can switch over to a backup router without affecting internal or external data communication when the master router fails. In this process, parameters of the internal network do not need to be modified. Multiple routers in a VRRP group map to one virtual router. VRRP ensures that only one router transmits packets at a time, whereas hosts send data packets to the virtual router. The router that forwards data packets is elected as the master router. If the master router cannot work due to certain reasons at a time, a backup router is used to perform tasks of the original master router. Using VRRP allows all hosts in a local area network (LAN) looking like using only one router, and guarantees route connectivity even if the first-hop router fails.

RFC 2338, RFC 3768, and RFC 5798 define the format and operating mechanism of VRRP packets. A VRRP packet is a multicast packet with a specified destination address. It is sent by the master router to indicate that the master router is running properly or used to elect the master router. VRRP allows another router to automatically take over the router that fails to support the routing and forwarding function in an IP LAN, therefore implementing the hot backup and error tolerance of IP routes. VRRP also guarantees the communication continuity and reliability of hosts inside the LAN. One VRRP group consists of multiple routers in redundancy mode. At any moment, however, only one router serves as the master router to perform routing and forwarding functions. All other routers in the VRRP group are backup routers. The switchover between routers in the VRRP group is completely transparent to hosts in the LAN. RFC defines the following router switchover rules:

- VRRP elects the master router using a simple election method. First, it compares the VRRP priority of interfaces on various routers in the VRRP group and elects the router with the highest interface priority as the master router. The status of the elected router changes to Master. If the routers have the same priority, VRRP compares the primary IP address of network interfaces of the routers. The router with the biggest primary IP address becomes the master router to provide actual routing and forwarding services.
- After the master router is elected, other routers serve as backup routers whose status changes to Backup. These backup routers monitor the status of the master router by receiving VRRP packets that are periodically sent by the master router. When working normally, the master router sends a VRRP multicast packet that is known as an advertisement packet at a certain interval to inform the backup routers that the master router itself is running properly. If a backup router in the VRRP group does not receive any advertisement packet from the master router within the specified time, it sets its own status to Master. If multiple routers in the VRRP group exist in Master state, an election process as described previously is implemented again so that a router with the highest priority is selected as the new master router to implement the backup function of the VRRP.

Figure 1 Operating principles of VRRP



Once the master router is selected out of the VRRP group, the packets of all hosts in the LAN are routed and forwarded by the master router. Figure 1 shows the specific communication process. Routers R1 and R2 are connected to the LAN segment 192.168.12.0/24 through the Ethernet interface F0/0. VRRP is enabled on the Ethernet interface F0/0 of routers R1 and R2. The virtual router IP address of the VRRP group is set as the default gateway on all hosts in the LAN. Hosts in the LAN can detect only the virtual router of the VRRP group, whereas the master router that practically performs routing and forwarding functions is transparent to all of them. For example, the host PC 1 in the LAN sends a data packet to PC 2 by using the virtual router of the VRRP group as the default gateway so as to communicate with PC 2 in the same LAN. Upon receipt of the data packet, the master router of the VRRP group forwards the data packet to PC 2. In this communication process, PC 1 can detect only the virtual router but does not know whether R1 or R2 is the master router that plays the role of the virtual router. The master router of the VRRP group is selected between R1 and R2. Once the master router fails, the other router takes over traffic and becomes the new master router.

RFC 5798 redefines the format of a VRRP packet. The RGOS IPv6 VRRP complies with RFC 5798. In later descriptions, RGOS IPv6 VRRP is called VRRPv3 for short whereas the original VRRP implementation is simply called VRRPv2. In IPv4 VRRP, VRRPv2 and VRRPv3 are strictly distinguished from each other. The two VRRP standards define different fields in a VRRP packet. For this reason, RGOS IPv4 VRRP supports VRRPv3 and provide compatibility with VRRPv2. In contrast, IPv6 does not distinguish VRRPv2 from VRRPv3, because IPv6 VRRP is defined only in VRRPv3.

Currently, VRRP is defined in the following three protocols:

- RFC 2338
- RFC 3768
- RFC 5798

RFC 3768 is an update of RFC 2338 and defines mechanisms such as IPv4 VRRP. RFC 5798 is an improvement and extension of RFC 3768, and defines IPv4 VRRP and IPv6 VRRP.

Caution To provide compatibility with widely deployed devices that do not support VRRPv3, IPv6 VRRP, however, invariably uses VRRPv3.

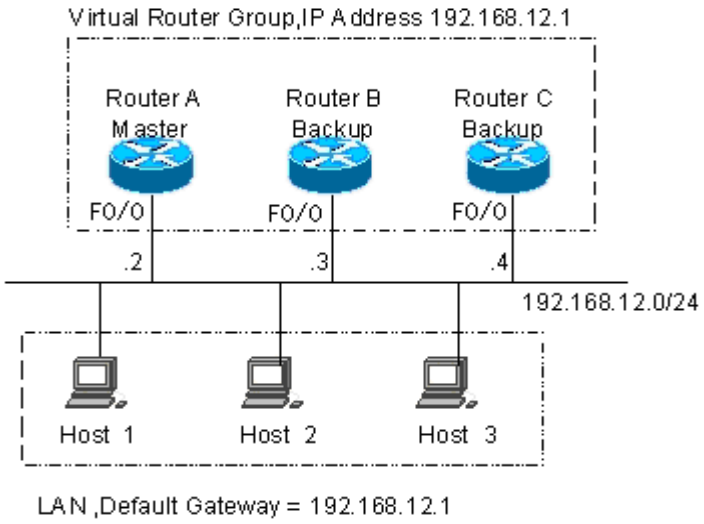
VRRP Application

VRRP supports two application modes: basic applications and advanced applications. In basic applications, only one VRRP group is used to implement simple route redundancy. In advanced applications, multiple VRRP groups are used to implement route redundancy and load balancing.

Route Redundancy

Figure 2 shows an example of basic VRRP applications.

Figure 2 Example of basic VRRP applications

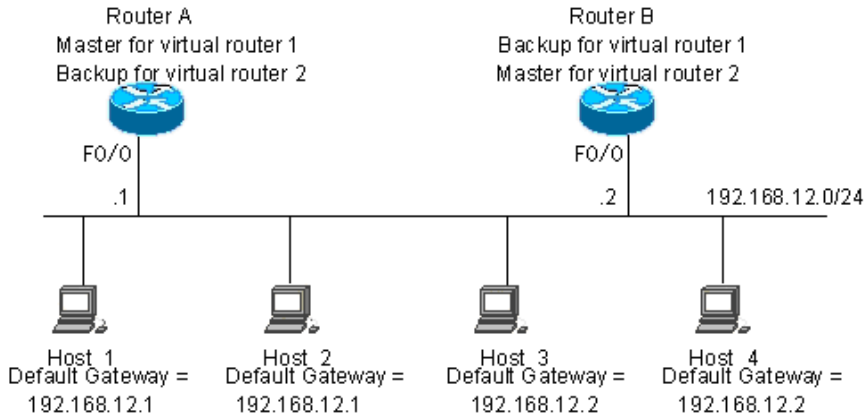


As shown in Figure 2, routers A, B, and C are connected to a LAN through Ethernet interfaces on which VRRP is enabled. Routers A, B, and C belong to the same VRRP group. The virtual IP address of the VRRP group is 192.168.12.1. Router A is elected as the master router of the VRRP group, whereas routers B and C are backup routers. The virtual router IP address 192.168.12.1 is set as the default gateway on hosts 1, 2, and 3 in the LAN. Data packets from hosts in the LAN to other networks are routed and forwarded by the master router A. If router A fails, a new master router is elected between routers B and C to route and forwards packets as a virtual router, therefore implementing simple route redundancy.

Load Balancing

Figure 3 shows an example of advanced VRRP applications.

Figure 3 Example of advanced VRRP applications



As shown in Figure 3, two virtual routers are set. For virtual router 1, the IP address 192.168.12.1 of the Ethernet interface F0/0 on router A is set as the IP address of the virtual router, so router A is the master router and router B is a backup router. For virtual router 2, the IP address 192.168.12.2 of the Ethernet interface F0/0 on router B is set as the IP address of the virtual router, so router B is the master router and router A is a backup router. The IP address 192.168.12.1 of virtual router 1 is set as the default gateway on hosts 1 and 2, and the IP address 192.168.12.2 of virtual router 2 is set as the default gateway on hosts 3 and 4 in the LAN. In this VRRP application example, routers A and B back up each other to implement route redundancy and share traffic from the LAN to implement load balancing.

Configuring VRRP

VRRP Configuration Task List

VRRP is applicable to multicast or broadcast LANs, such as Ethernets. VRRP configurations are mostly Ethernet interface configurations and involve the following configuration tasks:

- Enabling the VRRP function (Mandatory)
- Setting the authentication string of the VRRP group (Optional)
- Setting the advertisement interval of the VRRP group (Optional)
- Setting the preemption mode of the router in the VRRP group (Optional)
- Setting the Accept_Mode of the IPv6 VRRP virtual router
- Setting the priority of the router in the VRRP group (Optional)
- Setting the tracked interface of the VRRP group (Optional)
- Setting the tracked IP address of the VRRP group (Optional)
- Setting the periodic learning function of VRRP advertisement packets (Optional)
- Setting the description string of the VRRP group on the router (Optional)
- Setting the start delay of the VRRP group (Optional)
- Setting the IPv4 VRRP version (Optional)

You can determine which tasks to be configured based on your actual requirement.

Enabling the VRRP Function

You can add a VRRP group to a specific LAN segment by setting a group number and a virtual IPv4/IPv6 address for the VRRP group so as to enable the VRRP function on the corresponding Ethernet interface.

Command	Function
Ruijie(config-if)# **vrrp** *group* **ip** *ipaddress* [**secondary**]	Enables IPv4 VRRP.
Ruijie(config-if)# **no vrrp** *group* **ip** *ipaddress* [**secondary**]	Disables IPv4 VRRP.
Or:	
Ruijie(config-if)# **vrrp** *group* **ipv6** *ipv6-address*	Enables IPv6 VRRP.
Ruijie(config-if)# **no vrrp** *group* **ipv6** *ipv6-address*	Disables IPv6 VRRP.

The group number specified by the *group* parameter ranges from 1 to 255. If the virtual IP address is not specified, the router does not participate in the VRRP group. If the *secondary* parameter is not specified, the specified IP address becomes the primary IP address of the virtual router. The system does not identify whether an IPv6 address is a primary or secondary address. The first virtual IP address configured for an IPv6 VRRP group, however, must be a link-local address.

Caution

If the virtual IP address (primary or secondary) or virtual IPv6 address (link-local or non-link-local) of the VRRP group is consistent with the IP address (primary or secondary) or IPv6 address (link-local or non-link-local) of an Ethernet interface, the VRRP group is considered as owning the real IP address of the Ethernet interface. In this case, the priority of the VRRP group is 255. If the Ethernet interface is available, the VRRP group is automatically in Master state.

☑ The NMX-2GEH line card supports listening to a maximum of 15 MAC addresses. The number of configurable VRRP groups depends on the number of MAC addresses supported by the current line card. If the number of configured VRRP groups is larger than the maximum number allowed by the line card, an error message is displayed. Note that the line card may also need to support MAC address listening according to other protocols, such as Open Shortest Path First (OSPF) and Routing Information Protocol (RIP).

Setting the Authentication String of the VRRP Group

VRRP supports two authentication modes: plain text authentication and no-authentication. When setting the authentication string of a VRRP group, you can also set the authentication mode of the VRRP group to plain text authentication or no-authentication. All members of the VRRP group must be set to the same authentication mode so as to normally communicate with one another. In plain text authentication mode, all routers in the VRRP group must have the same authentication password. The plain text authentication password does not guarantee security but is used only to prevent or prompt VRRP configuration errors.

Command	Function
Ruijie(config-if)# **vrrp group authentication** *string*	Sets the authentication string of the IPv4 VRRP group.
Ruijie(config-if)# **no vrrp group authentication**	Sets the authentication mode of the IPv4 VRRP group to no-authentication.

By default, the authentication mode of a VRRP group is no-authentication. If the plain text authentication mode is specified, the plain text authentication password consists of up to eight bytes.


Caution

The authentication mode is already abandoned in RFC 5798 and no longer adopted in new specifications. Therefore, the user-specified authentication mode is applicable to VRRPv2 packets only.

Setting the Advertisement Interval of the VRRP Group

Command	Function
Ruijie(config-if)# **vrrp group timers advertise** { *advertise-interval* | **csec** *centisecond-interval* }	Sets the VRRP advertisement interval of the IPv4 VRRP master router.
Ruijie(config-if)# **no vrrp group timers advertise**	Restores the default VRRP advertisement interval of the IPv4 VRRP master router.
Or:	
Ruijie(config-if)# **vrrp ipv6 group timers advertise**{ *advertise-interval* | **csec** *centisecond-interval* }	Sets the VRRP advertisement interval of the IPv6 VRRP master router.
Ruijie(config-if)# **no vrrp ipv6 group timers advertise**	Restores the default VRRP advertisement interval of the IPv6 VRRP master router.

If the current router is the master router of the VRRP group, it sends VRRP advertisement packets at the set interval to advertise its own VRRP status, priority, and other information. By default, the master router sends VRRP advertisement packets at an interval of one second. The time for a VRRP backup router to switch over to the master router is defined in RFC 2338, RFC 3768, and RFC 5798. It is three times the advertisement interval plus a Skew_Time. The Skew_Time is calculated with the following formula: Skew_Time = (((256 – Priority of the VRRP group) x VRRP advertisement interval) / 256). VRRPv3 supports a VRRP advertisement interval of the master router ranging from 50 to 99 milliseconds to accelerate VRRP convergence time without correlation with BFD. If the network traffic is heavy, an interval in milliseconds

is not recommended, as the backup router may fail to receive the VRRP advertisement packets from the master router within the interval due to heavy traffic, causing status change.


Caution

If periodic VRRP learning is not enabled on routers, the same VRRP advertisement interval must be set on all routers in a VRRP group; otherwise, backup routers discard received VRRP advertisement packets.

Setting the Preemption Mode of the Router in the VRRP Group

A router in a VRRP group that works in preemption mode preempts other routers in the VRRP group to become the master router once detecting that its own priority is higher than the priority of the existing master router. If the VRRP group works in non-preemption mode, the router does not preempt other routers in the VRRP group to become the master router even when detecting that its own priority is higher than the priority of the existing master router. Setting the preemption mode is insignificant for a VRRP group whose virtual router address is an Ethernet interface IP address, because the router configured with the Ethernet interface IP address has the highest priority and automatically becomes the master router of the VRRP group.

Command	Function
Ruijie(config-if)# **vrrp** *group* **preempt** [**delay** *seconds]*	Sets the IPv4 VRRP group to the preemption mode.
Ruijie(config-if)# **no vrrp** *group* **preempt** [**delay]**	Sets the IPv4 VRRP group to the non-preemption mode or restores the default delay.
or	
Ruijie(config-if)# **vrrp ipv6** *group* **preempt** [**delay** *seconds]*	Sets the IPv6 VRRP group to the preemption mode.
Ruijie(config-if)# **no vrrp ipv6** *group* **preempt** [**delay]**	Sets the IPv6 VRRP group to the non-preemption mode or restores the default delay.

The optional parameter *delay seconds* defines a delay before a backup VRRP router advertises itself as the master router of the VRRP group. It is 0 seconds by default. Once the VRRP function is enabled, the VRRP group works in preemption mode by default.

Setting the Accept_Mode of the IPv6 VRRP Virtual Router

The Accept_Mode can be set for the IPv6 VRRP virtual router that serves as the master router to determine whether to receive and process packets destined to the IP address of the IPv6 VRRP virtual router itself. If the Accept_Mode is enabled, the IPv6 VRRP virtual router receives and processes packets destined to the IP address of the virtual router itself. If the Accept_Mode is not enabled, the IPv6 VRRP virtual router discards packets destined to the IP address of the virtual router itself but does not discard NA and NS packets. By default, the Accept_Mode is disabled. In addition, the IPv6 VRRP virtual router in Owner state receives and processes packets destined to the IP address of the virtual router itself, no matter whether the Accept_Mode is enabled or disabled.

Command	Function
Ruijie(config-if)# **vrrp ipv6** *group* **accept_mode**	Enables the Accept_Mode for an IPv6 VRRP group.
Ruijie(config-if)# **no vrrp ipv6** *group* **accept_mode**	Disables the Accept_Mode for an IPv6 VRRP group.

Setting the Priority of the Router in the VRRP Group

According to VRRP, the role of a router in a VRRP group is determined by the priority of the router in the VRRP group. A router in a VRRP group becomes the active or master router of the VRRP group if it works in preemption mode, has the highest priority, and has obtained a virtual IP address. The other routers that have a priority lower than the priority of the master router in the VRRP group becomes backup or listening routers. Once the VRRP function is enabled on a router, the priority of the router in a VRRP group is 100 by default.

Command	Function
Ruijie(config-if)# **vrrp** *group* **priority** *level*	Sets the priority of a router in an IPv4 VRRP group.
Ruijie(config-if)# **no vrrp** *group* **priority**	Restores the default priority of a router in an IPv4 VRRP group.
Or:	
Ruijie(config-if)# **vrrp ipv6** *group* **priority** *level*	Sets the priority of a router in an IPv6 VRRP group.
Ruijie(config-if)# **no vrrp ipv6** *group* **priority**	Restores the default priority of a router in an IPv6 VRRP group.

The priority defined by the *level* parameter ranges from 1 to 254. If the virtual IP address of a VRRP group is consistent with the real IP address of an Ethernet interface on the local router, the priority of the local router in the VRRP group is 255. In this case, the VRRP group configured on the router is automatically in Master state as long as the Ethernet interface is available, no matter whether the VRRP group works in preemption mode or not.

Setting the Tracked Interface of the VRRP Group

After a tracked interface is set for the VRRP group, the system dynamically adjusts the priority of the local router according to the status of the tracked interface. When the tracked interface becomes unavailable, the local router decreases its VRRP group priority based on settings. At this time, another router in the VRRP group may become the active or master router of the VRRP group if its status is more stable and its priority is higher.

Command	Function
Ruijie(config-if)# **vrrp** *group* **track** *interface-type number* [*interface-priority*]	Sets the tracked interface of an IPv4 VRRP group.
Ruijie(config-if)# **no vrrp** *group* **track** *interface-type number*	Cancels the tracked interface set for an IPv4 VRRP group.
Or:	
Ruijie(config-if)# **vrrp ipv6** *group* **track** *interface-type number* [*interface-priority*]	Sets the tracked interface of an IPv6 VRRP group.
Ruijie(config-if)# **no vrrp ipv6** *group* **track** *interface-type number*	Cancels the tracked interface set for an IPv6 VRRP group.

By default, no tracked interface is set for a VRRP group. The value of the *interface-priority* parameter ranges from 1 to 255. It is 10 by default if not specified.

Note The tracked interface can only be a reachable logical Layer 3 (L3) interface, such as a routed port, SVI, loopback interface, or tunnel interface.

Setting the Tracked IPv4/IPv6 Address of the VRRP Group

After a tracked IP address is set for the VRRP group, the system dynamically adjusts the priority of the local router depending on whether the tracked IP address is reachable. When the tracked IP address is unreachable and cannot be pinged, the local router decreases its VRRP group priority based on settings. At this time, another router in the VRRP group may become the active or master router of the VRRP group if its priority is higher. In the following commands, the optional parameter *interval* defines an interval at which the system detects whether the destination address is reachable, the optional parameter *timeout* defines a timeout interval that is used to determine that the destination is unreachable, and the optional parameter *retry* defines the number of retries when the destination is unreachable.

Command	Function
Ruijie(config-if)# **vrrp** *group* **track** *ip-address* [**interval** *interval-value]* [**timeout** *timeout-value]* [**retry** *retry-value]* [*priority]*	Sets the tracked IP address of an IPv4 VRRP group.
Ruijie(config-if)# **no vrrp** *group* **track** *ip-address*	Cancels the tracked IP address set for an IPv4 VRRP group.
Or:	
Ruijie(config-if)# **vrrp ipv6** *group* **track** { *ipv6-global-address* | { *ipv6-linklocal-address interface-type number* } } [**interval** *interval-value]* [**timeout** *timeout-value]* [**retry** *retry-value]* [*priority]*	Sets the tracked IP address of an IPv6 VRRP group.
Ruijie(config-if)# **no vrrp ipv6** *group* **track** { *ipv6-global-address* | { *ipv6-linklocal-address interface-type number* } }	Cancels the tracked IP address set for an IPv6 VRRP group.

By default, no tracked IP address is set for a VRRP group. The value of the *interval-value* parameter ranges from 1 to 3600 seconds. It is 3 seconds by default if not specified. The value of the *timeout-value* parameter ranges from 1 to 60 seconds. It is 1 second by default if not specified.

The value of the *timeout-value* parameter must be smaller than or equal to that of the *interval-value* parameter. The value of the *retry-value* parameter ranges from 1 to 60. It is 1 by default if not specified. The value of the p*riority* parameter ranges from 1 to 255. It is 10 seconds by default if not specified. A VRRP IPv6 link-local IP address is preferred as the tracked IP address of an IPv6 VRRP group. If you set the tracked IP address to a link-local IP address, you must also set the specified interface.

Setting the Periodic Learning of VRRP Advertisement Packets

If the periodic learning function is enabled on the local router that is a VRRP backup router, the local router learns a VRRP advertisement interval from VRRP advertisement packets sent by the master router and calculates a VRRP master invalidity interval using the learned VRRP advertisement interval instead of the VRRP advertisement interval set on the local router itself. This command enables a backup router to synchronize the VRRP advertisement interval locally set on itself to the VRRP advertisement interval of the master router.

Command	Function
Ruijie(config-if)# **vrrp** *group* **timers learn**	Enables the periodic learning of IPv4 VRRP advertisement packets.

Ruijie(config-if)# **no vrrp** *group* **timers learn**	Disables the periodic learning of IPv4 VRRP advertisement packets.
Or:	
Ruijie(config-if)# **vrrp ipv6** *group* **timers learn**	Enables the periodic learning of IPv6 VRRP advertisement packets.
Ruijie(config-if)# **no vrrp ipv6** *group* **timers learn**	Disables the periodic learning of IPv6 VRRP advertisement packets.

By default, the periodic learning function is disabled for a VRRP group.

Note

If the advertisement interval that a VRRP backup router learns from a received VRRP advertisement packet is inconsistent with the VRRP advertisement interval locally set on the VRRP backup router and the periodic learning function is disabled on the VRRP backup router, the VRRP backup router discards the VRRP advertisement packet. Otherwise, the VRRP backup router receives the VRRP advertisement packet and calculates a VRRP master invalidity interval using the advertisement interval carried in the VRRP advertisement packet.

Setting the Description String of the VRRP Group on the Router

You can set a description string for a VRRP group to distinguish it from other VRRP groups.

Command	Function
Ruijie(config-if)# **vrrp** *group* **description** *text*	Sets the description string of an IPv4 VRRP group.
Ruijie(config-if)# **no vrrp** *group* **description**	Cancels the description string set for an IPv4 VRRP group.
Or:	
Ruijie(config-if)# **vrrp ipv6** *group* **description** *text*	Sets the description string of an IPv6 VRRP group.
Ruijie(config-if)# **no vrrp ipv6** *group* **description**	Cancels the description string set for an IPv6 VRRP group.

By default, no description string is set for a VRRP group. The description string of a VRRP group consists of at most 80 bytes.

Note

If the description string of a VRRP group contains blanks, the quotation mark (") must be used to identify the description string.

Setting the Start Delay of the VRRP Group

You can set the start delay of a VRRP group on a certain interface. The system supports two types of delay: system start delay and interface activity delay, which can be configured separately or together.

In non-preemption mode, a router with a higher VRRP group priority does not preempt the master router in the same VRRP group when it is started. In some cases, however, a router newly started preempts other routers to become the

VRRP master router, even if it is set to the non-preemption mode. This is because the VRRP group on the interface does not receive the VRRP advertisement packet from the master router in the same VRRP group in time when the router is started or the interface becomes active.

To resolve the preceding problem, you can run a command to configure a start delay for the VRRP group. Then the VRRP group on the interface waits for a certain time before being started when the router is started or the interface becomes active, so that the non-preemption configuration takes effect.

If a VRRP advertisement packet is received on the interface after the start delay is set, the start delay is canceled and VRRP is immediately started on the interface.

Command	Function
Ruijie(config-if)# **vrrp delay** { **minimum** *min-seconds* | **reload** *reload-seconds* }	Sets the start delay of the VRRP group on the interface.
Ruijie(config-if)# **no vrrp delay**	Cancels the start delay set for the VRRP group on the interface.

By default, no start delay is configured for the VRRP group on an interface. Both the system start delay and the interface activity delay as mentioned previously range from 0 to 60 seconds. After this command is configured on an interface, the configurations apply to both IPv4 VRRP and IPv6 VRRP groups on the interface.

Setting the IPv4 VRRP Version

You can set the version of IPv4 VRRP to VRRPv2 or VRRPv3. By default, VRRPv2 is applied.

Command	Function
Ruijie(config-if)# **vrrp** *group* **version** { **2 | 3** }	Sets the IPv4 VRRP version.
Ruijie(config-if)# **no vrrp** *group* **version**	Uses the VRRPv2 by default.

Monitoring and Maintenance of VRRP

The **show vrrp**, **show ipv6 vrrp**, and **debug vrrp** commands are available for monitoring and maintaining VRRP. You can run the **show vrrp** command to check the IPv4 VRRP status of the local router, the **show ipv6 vrrp** command to check the IPv6 VRRP status of the local router, and the **debug vrrp** command to check VRRP information, such as status changes to a VRRP group, VRRP advertisement transmitting/receiving, and VRRP events.

show vrrp

Run the following **show vrrp** commands to check the IPv4 VRRP status of the local router:

Command	Function
Ruijie# **show** [**ipv6] vrrp** [**brief** | *group]*	Displays the IPv4 or IPv6 VRRP status of the local router.
Ruijie# **show** [**ipv6] vrrp interface** *type number* [**brief]**	Displays the IPv4 or IPv6 VRRP status of a specific network interface.

Command examples:

6) show [ipv6] vrrp

```
Ruijie# show vrrp
FastEthernet 0/0 - Group 1
```

```
State is Backup
Virtual IP address is 192.168.201.1 configured
Virtual MAC address is 0000.5e00.0101
Advertisement interval is 3 sec
Preemption is enabled
min delay is 0 sec
Priority is 100
Master Router is 192.168.201.213 , priority is 120
Master Advertisement interval is 3 sec
Master Down interval is 10.82 sec
FastEthernet 0/0 - Group 2
State is Master
Virtual IP address is 192.168.201.2 configured
Virtual MAC address is 0000.5e00.0102
Advertisement interval is 3 sec
Preemption is enabled
min delay is 0 sec
Priority is 120
Master Router is 192.168.201.217 (local), priority is 120
Master Advertisement interval is 3 sec
Master Down interval is 10.59 sec
Ruijie#show ipv6 vrrp
GigabitEthernet 0/13 - Group 1
  State is Master
  Virtual IPv6 address is as follows:
    FE80::2
    1::2
  Virtual MAC address is 0000.5e00.0201
  Advertisement interval is 1 sec
  Preemption is enabled
    min delay is 0 sec
  Priority is 100
  Master Router is FE80::1 (local), priority is 100
  Master Advertisement interval is 1 sec
  Master Down interval is 3.60 sec
```

The command outputs include the following information:

- Names of Ethernet interfaces where IPv4/IPv6 VRRP groups are configured
- ID, status, priority, preemption mode, VRRP advertisement interval, virtual IP address, and virtual MAC address of each VRRP group configured on the interfaces
- IP address, priority, advertisement interval, and invalidity interval of the master router in each VRRP group
- Tracked interface and priority change metric of each VRRP group

7) show [ipv6] vrrp brief

```
Ruijie# show vrrp brief
Interface        Grp  Pri  Time  Own  Pre  State   Master addr     Group addr
FastEthernet 0/0  1    100  3.60  -    P    Backup  192.168.201.213  192.168.201.1
```

```
FastEthernet 0/0  2   120  3.53  -    P    Master  192.168.201.217  192.168.201.2
Ruijie#show ipv6 vrrp brief
Interface           Grp  Pri  timer  Own  Pre  State   Master addr   Group addr
GigabitEthernet 0/13  1    100  3.60   -    P    Master  FE80::1      FE80::2
```

- The command outputs include the following information:
- Names of Ethernet interfaces where IPv4/IPv6 VRRP groups are configured
- ID, status, priority, preemption mode, and virtual IP address of each VRRP group configured on the interfaces
- IP address of the mater router in each VRRP group

8) show [ipv6] vrrp interface

```
Ruijie# show vrrp interface FastEthernet 0/0
FastEthernet 0/0 - Group 1
State is Backup
Virtual IP address is 192.168.201.1 configured
Virtual MAC address is 0000.5e00.0101
Advertisement interval is 3 sec
Preemption is enabled
VRRP standard version is V3
min delay is 0 sec
Priority is 100
Master Router is 192.168.201.213 , priority is 120
Master Advertisement interval is 3 sec
Master Down interval is 10.82 sec
FastEthernet 0/0 - Group 2
State is Master
Virtual IP address is 192.168.201.2 configured
Virtual MAC address is 0000.5e00.0102
Advertisement interval is 3 sec
Preemption is enabled
min delay is 0 sec
Priority is 120
Master Router is 192.168.201.217 (local), priority is 120
Master Advertisement interval is 3 sec
Master Down interval is 10.59 sec
Ruijie#
Ruijie#show ipv6 vrrp inter gig 0/13
GigabitEthernet 0/13 - Group 1
  State is Master
  Virtual IPv6 address is as follows:
    FE80::2
    1::2
  Virtual MAC address is 0000.5e00.0201
  Advertisement interval is 1 sec
  Preemption is enabled
    min delay is 0 sec
  Priority is 100
  Master Router is FE80::1 (local), priority is 100
```

```
 Master Advertisement interval is 1 sec
 Master Down interval is 3.60 sec
```

The command outputs include the following information:

- Names of Ethernet interfaces where IPv4/IPv6 VRRP groups are configured
- ID, status, priority, preemption mode, VRRP advertisement interval, virtual IP address, and virtual MAC address of each VRRP group configured on the interfaces
- IP address, priority, advertisement interval, and invalidity interval of the master router in each VRRP group
- Tracked interface and priority change metric of each VRRP group

Debug vrrp

You can run the following **debug [ipv6] vrrp** commands to enable or disable VRRP debugging on the local router:

Command	Function
Ruijie# **debug** [**ipv6] vrrp errors**	Enables VRRP error debugging.
Ruijie# **no debug** [**ipv6] vrrp errors**	Disables VRRP error debugging.
Ruijie# **debug** [**ipv6] vrrp events**	Enables VRRP event debugging.
Ruijie# **no debug** [**ipv6] vrrp events**	Disables VRRP event debugging.
Ruijie# **debug** [**ipv6] vrrp packets**	Enables VRRP packet debugging.
Ruijie# **no debug** [**ipv6] vrrp packets**	Disables VRRP packet debugging.
Ruijie# **debug** [**ipv6] vrrp state**	Enables VRRP status debugging..
Ruijie# **no debug** [**ipv6] vrrp state**	Disables VRRP status debugging.
Ruijie# **debug** [**ipv6] vrrp**	Enables VRRP debugging.
Ruijie# **no debug** [**ipv6] vrrp**	Disables VRRP debugging.

Command examples:

1) debug [ipv6] vrrp

```
Ruijie# debug vrrp
Ruijie#
%VRRP-6-STATECHANGE: FastEthernet 0/0 IPv4 VRRP Grp 1 state Master -> Backup
VRRP: IPv4 VRRP Grp 1 Advertisement from 192.168.201.213 has invalid virtual address 192.168.1.1
VRRP: IPv4 VRRP Grp 1 on interface Gi0/13 is sending IPv4 VRRP V2 advertisement checksum a352.
Ruijie# debug ipv6 vrrp
Ruijie#
VRRP: IPv6 VRRP Grp 1 Event - Advert higher or equal priority
%VRRP-6-STATECHANGE: FastEthernet 0/0 IPv6 VRRP  Grp 1 state Backup -> Master
Ruijie#
VRRP: IPv6 VRRP Grp 1 on interface Gi0/13 is sending IPv6 VRRP v3 advertisement checksum 6de3.
```

The **debug [ipv6] vrrp** command is equivalent to a combination of commands **debug [ipv6] vrrp errors**, **debug [ipv6] vrrp events**, **debug [ipv6] vrrp packets**, and **debug [ipv6] vrrp state**.

2) debug [ipv6] vrrp errors

```
Ruijie# debug vrrp errors
Ruijie#
VRRP: IPv4 VRRP Grp 1 Advertisement from 192.168.1.1 has wrong checksum.
VRRP: IPv4 VRRP Grp 1 Advertisement from 192.168.1.1 has wrong checksum.
```

```
VRRP: IPv4 VRRP Grp 1 Advertisement from 192.168.1.1 has wrong checksum.
```

The preceding information indicates that the local router has received VRRP advertisement packets that contain checksum errors for IPv4 VRRP group 1 from 192.168.1.1.

```
Ruijie# debug ipv6 vrrp errors
Ruijie#
VRRP: IPv6 VRRP Grp 1 Advertisement from FE80::2D0:F8FF:FE22:DE00 has different IP address.
VRRP: IPv6 VRRP Grp 1 Advertisement from FE80::2D0:F8FF:FE22:DE00 has different IP address.
VRRP: IPv6 VRRP Grp 1 Advertisement from FE80::2D0:F8FF:FE22:DE00 has different IP address.
```

The preceding information indicates that the local router has received VRRP advertisement packets that carry different IPv6 group addresses for the same IPv6 VRRP group.

3) debug [ipv6] vrrp events

```
Ruijie# debug vrrp events
Ruijie#
VRRP: IPv4 VRRP Grp 1 Event - Advert higher or equal priority
VRRP: IPv4 VRRP Grp 1 Event - Advert higher or equal priority
Ruijie# debug ipv6 vrrp events
VRRP: IPv6 VRRP Grp 1 Event - Advert higher or equal priority
Ruijie#
```

The preceding information indicates that the local router has received VRRP advertisement packets with a priority higher than or equal to the local priority for local IPv4 VRRP and IPv6 VRRP groups.

4) debug [ipv6] vrrp packets

```
Ruijie# debug vrrp packets
Ruijie#
VRRP: IPv4 VRRP Grp 1 on interface Gi0/13 is sending IPv4 VRRP V2 advertisement checksum a352.
VRRP: IPv4 VRRP Grp 1 on interface Gi0/13 is sending IPv4 VRRP V2 advertisement checksum a352.
Ruijie# debug ipv6 vrrp packets
VRRP: IPv6 VRRP Grp 1 on interface Gi0/13 is sending IPv6 VRRP v3 advertisement checksum 6de3.
VRRP: IPv6 VRRP Grp 1 on interface Gi0/13 is sending IPv6 VRRP v3 advertisement checksum 6de3.
```

The preceding information indicates that local IPv4 VRRP group 1 and local IPv6 VRRP group 1 are sending VRRP advertisement packets.

```
Ruijie# debug vrrp packets
Ruijie#
VRRP: IPv4 VRRP Grp 1 on interface Gi0/13 received ipv4 v2 advertisement priority 100, source
192.168.1.1.
Ruijie# debug ipv6 vrrp packets

VRRP: IPv6 VRRP Grp 1 on interface Gi0/13 received ipv6 v3 advertisement priority 100, source
FE80::1.
```

The preceding information indicates that the local router has received a VRRP advertisement packet with the priority of 100 for IPv4 VRRP group 1 from 192.168.1.1 and also a VRRP advertisement for IPv6 VRRP group 1 from fe80::1.

5) debug [ipv6] vrrp state

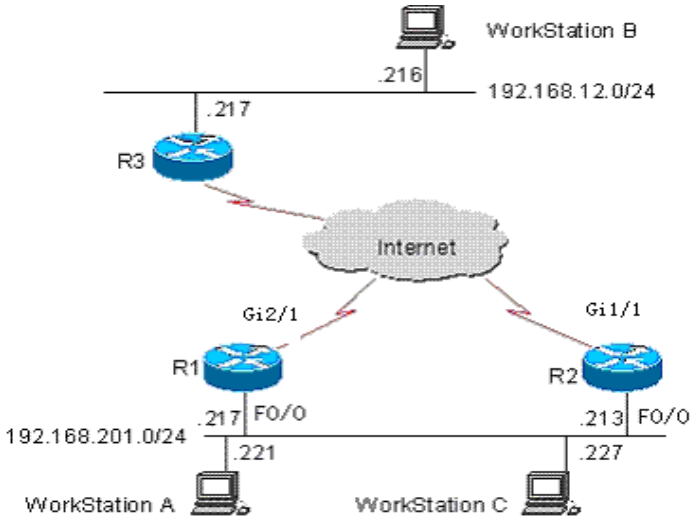
```
Ruijie# debug vrrp state
Ruijie#
VRRP: IPv4 VRRP Grp 1 add primary virtual IP, startup
Ruijie# debug ipv6 vrrp state
VRRP: IPv6 VRRP Grp 1 add primary virtual IP, startup.
```

The preceding information indicates that both the IPv4 VRRP group and the IPv6 VRRP group on the interface FastEthernet 0/0 are configured with a primary IP address and started.

Example of Configuring an IPv4 VRRP Group

As shown in Figure 4, a VRRP group is configured on routers R1 and R2 to provide the VRRP service for the internal network segment 192.168.201.0/24, whereas only the common routing function instead of any VRRP group is enabled on R3. This example shows VRRP-related configurations on routers R1 and R2 only.

Figure 4 VRRP network topology



In the following example, the configuration of router R3 is invariable. The following shows configurations on R3:

```
!
!
hostname "R3"
!
!
!
interface FastEthernet 0/0
/* The no switchport command needs to be run on a switch only*/
no switchport
ip address 192.168.12.217 255.255.255.0
!
interface GigabitEthernet 1/1
/* The no switchport command needs to be run on a switch only*/
no switchport
ip address 60.154.101.5 255.255.255.0
!
```

```
interface GigabitEthernet 2/1
/* The no switchport command needs to be run on a switch only*/
no switchport
ip address 202.101.90.61 255.255.255.0
!
router ospf
network 202.101.90.0 0.0.0.255 area 10
network 192.168.12.0 0.0.0.255 area 10
network 60.154.101.0 0.0.0.255 area 10
!
!
!
end
```

Example of Configuring a VRRP Group

Devices are connected, as shown in Figure 1-4. In this example, a workstation group (192.168.201.0/24) uses a VRRP group formed by routers R1 and R2. Its gateway is set to the virtual router IP address 192.168.201.1 of the VRRP group, so that the workstation group can access a remote workstation group whose network address is 192.168.12.0/24 through the virtual router 192.168.201.1. Here, R1 is set as the master router of the VRRP group. In normal cases, R1 provides the gateway (192.168.201.1) function. If R1 is unreachable because it is shut down or faulty, R2 takes the place of R1 to provide the gateway function. Below are related configurations on R1 and R2.

Configurations on R1:

```
!
!
hostname "R1"
!
!
interface FastEthernet 0/0
ip address 192.168.201.217 255.255.255.0
vrrp 1 priority 120
vrrp 1 version 3

vrrp 1 timers advertise 3
vrrp 1 ip 192.168.201.1
!
interface GigabitEthernet 2/1
ip address 202.101.90.63 255.255.255.0
!
router ospf
network 202.101.90.0 0.0.0.255 area 10
network 192.168.201.0 0.0.0.255 area 10
!
```

Configurations on R2:

```
!
```

```
hostname "R2"
!
interface FastEthernet 0/0
ip address 192.168.201.213 255.255.255.0
vrrp 1 ip 192.168.201.1
 vrrp 1 version 3
vrrp 1 timers advertise 3
!
interface GigabitEthernet 1/1
/* The no switchport command needs to be run on a switch only*/
no switchport
ip address 60.154.101.3 255.255.255.0
!
!
router ospf
network 60.154.101.0 0.0.0.255 area 10
network 192.168.201.0 0.0.0.255 area 10
!
!
end
```

As can be seen, R1 and R2 belong to IPv4 VRRP group 1. Both routers use VRRPv3, point to the same virtual router IP address 192.168.201.1, and work in VRRP preemption mode. Since the priority of R1 in the IPv4 VRRP group is 120 but that of R2 is the default value 100, R1 works as the master router of the IPv4 VRRP group in normal cases.

Example of Configuring the Tracked Interface of an IPv4 VRRP Group

Devices are connected, as shown in Figure 4. In this example, a workstation group (192.168.201.0/24) uses a VRRP group formed by routers R1 and R2. Its gateway is set to the virtual router IP address 192.168.201.1 of the VRRP group, so that the workstation group can access a remote workstation group whose network address is 192.168.12.0/24 through the virtual router 192.168.201.1. Here, R1 is set as the master router of the VRRP group. Different from the example as described previously for configuring a single VRRP group, a VRRP tracked interface (GigabitEthernet 2/1) is set on R1. In normal cases, R1 provides the virtual gateway (192.168.201.1) function. If R1 is unreachable because it is shut down or faulty, R2 takes the place of R1 to provide the virtual gateway function. In particular, when the interface GigabitEthernet 2/1 on R1 to connect to a wide area network (WAN) is unavailable, R1 decreases its VRRP group priority based on settings, so that R2 has a chance to become the master router and provide the virtual gateway function. If the interface GigabitEthernet 2/1 on R1 is recovered later, R1 restores its own VRRP group priority and then become the master router to provide the virtual gateway function. Below are related configurations on R1 and R2.

Configurations on R1:

```
!
!
hostname "R1"
!
!
interface FastEthernet 0/0
ip address 192.168.201.217 255.255.255.0
```

```
vrrp 1 priority 120
vrrp 1 timers advertise 3
vrrp 1 ip 192.168.201.1
vrrp 1 track GigabitEthernet 2/1 30
!

interface GigabitEthernet 2/1
ip address 202.101.90.63 255.255.255.0
!
router ospf
network 202.101.90.0 0.0.0.255 area 10
network 192.168.201.0 0.0.0.255 area 10
!
!
end
```

Configurations on R2:

```
!
!
hostname "R2"
!
interface FastEthernet 0/0
ip address 192.168.201.213 255.255.255.0
vrrp 1 ip 192.168.201.1
vrrp 1 timers advertise 3
!
interface GigabitEthernet 1/1
ip address 60.154.101.3 255.255.255.0
!
router ospf
network 60.154.101.0 0.0.0.255 area 10
network 192.168.201.0 0.0.0.255 area 10
!
!
end
```

As can be seen, R1 and R2 belong to VRRP group 1. Both routers use the same VRRP group authentication mode (no-authentication), point to the same virtual router IP address 192.168.201.1, and work in VRRP preemption mode. The VRRP advertisement interval is set to three seconds on both R1 and R2. Since the priority of R1 in the VRRP group is 120 but that of R2 is the default 100, R1 works as the master router of the VRRP group in normal cases. If R1 detects that its interface GigabitEthernet 2/1 to the WAN is unavailable, it decreases its VRRP group priority by 30 to 90, so that R2 becomes the master router. If R1 detects later that its interface GigabitEthernet 2/1 to the WAN is available again, it increases its own VRRP group priority by 30 to 120, so that R1 again becomes the master router.

Configuring Multiple IPv4 VRRP Groups

Multiple VRRP groups can be configured on one Ethernet interface to implement load balancing and backup one another to provide more reliable and stable network services.

Devices are connected, as shown in Figure 4. In this example, a workstation group (192.168.201.0/24) uses two VRRP groups formed by routers R1 and R2. The gateway of some workstations such as workstation A is set to the virtual IP address 192.168.201.1 of VRRP group 1, and that of the rest workstations such as workstation C is set to the virtual IP address 192.168.201.2 of VRRP group 2. R1 serves as the master router of VRRP group 2 and the backup router of VRRP group 1, whereas R2 serves as the master router of VRRP group 1 and the backup router of VRRP group 2. Below are related configurations on R1 and R2.

Configurations on R1:

```
!
!
hostname "R1"
!
interface FastEthernet 0/0
ip address 192.168.201.217 255.255.255.0
vrrp 1 timers advertise 3
vrrp 1 ip 192.168.201.1
vrrp 2 priority 120
vrrp 2 timers advertise 3
vrrp 2 ip 192.168.201.2
vrrp 2 track GigabitEthernet 2/1 30
!
interface GigabitEthernet 2/1
ip address 202.101.90.63 255.255.255.0
!
router ospf
network 202.101.90.0 0.0.0.255 area 10
network 192.168.201.0 0.0.0.255 area 10
!
!
end
```

Configurations on R2:

```
!
!
hostname "R2"
!
interface FastEthernet 0/0
ip address 192.168.201.213 255.255.255.0
vrrp 1 ip 192.168.201.1
vrrp 1 timers advertise 3
vrrp 1 priority 120
vrrp 2 ip 192.168.201.2
```

```
vrrp 2 timers advertise 3
!
interface GigabitEthernet 1/1
ip address 60.154.101.3 255.255.255.0
!
router ospf
network 60.154.101.0 0.0.0.255 area 10
network 192.168.201.0 0.0.0.255 area 10
!
!
!
end
```

As can be seen, R1 and R2 back up each other. They serve as the master router in VRRP group 1 or 2 to provide different virtual gateways.

Example of Configuring an IPv6 VRRP Group

Configuring a VRRP Group

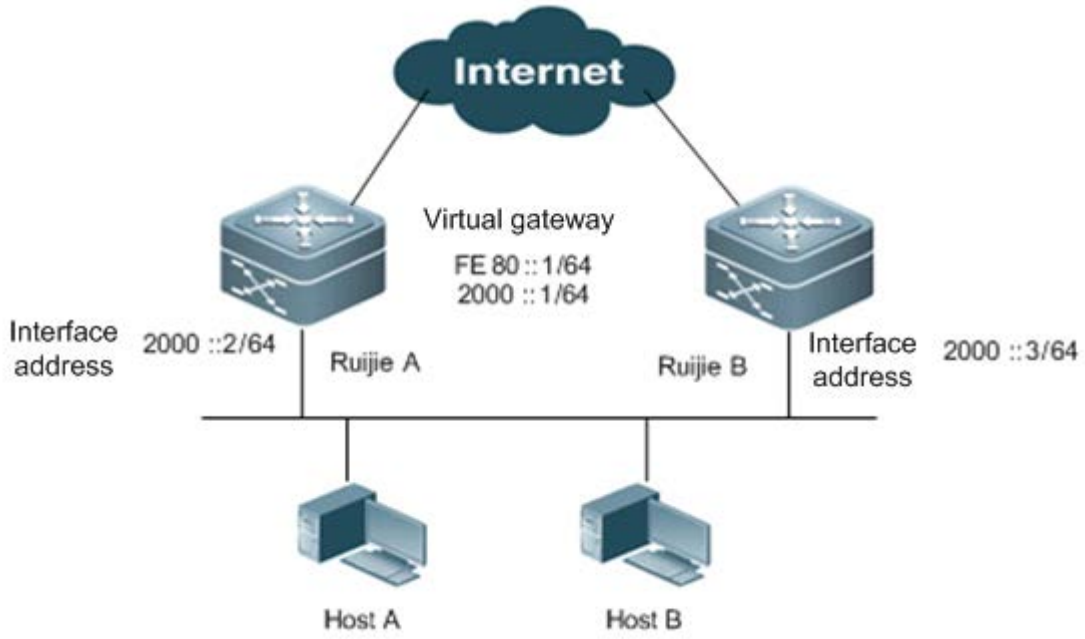
Networking Requirements

This configuration instance is applicable to both switches and routers.

- Hosts A and B access the Internet through a gateway. The default gateway is 2000::1/64 on both hosts.
- Ruijie A and Ruijie B are two routers that form IPv6 VRRP group 1. The virtual addresses are 2000::1/64 and FE80::1.
- When Ruijie A works properly, the packets of Host A to the Internet are forwarded by Ruijie A. When Ruijie A fails, the packets of Host A to the Internet are forwarded by Ruijie B.

Networking Topology

Figure 5 Network topology of the example for configuring an IPv6 VRRP group



Configuration Steps

Configurations on Ruijie A:

Configure an IPv6 address on an interface to enable the IPv6 service on the interface.

```
interface FastEthernet 0/1
```

/* The **no switchport** command needs to be run on a switch only*/

```
no switchport
ipv6 address 2000::2/64
!
```

Create IPv6 VRRP group 1 and configure virtual IPv6 addresses FE80::1 and 2000::1.

```
interface FastEthernet 0/0
vrrp 1 ipv6 FE80::1
vrrp 1 ipv6 2000::1
```

Change the priority of IPv6 VRRP group 1 to 120.

```
vrrp ipv6 1 priority 120
```

Change the advertisement interval of IPv6 VRRP group 1 to 3s.

```
vrrp ipv6 1 timers advertise 3
```

Set the Accept_Mode of the IPv6 VRRP group.

```
vrrp ipv6 1 accept_mode
!
```

Configurations on Ruijie B:

Create IPv6 VRRP group 1 and configure virtual IPv6 addresses FE80::1 and 2000::1.

```
interface FastEthernet 0/1
```

/* The **no switchport** command needs to be run on a switch only*/

```
no switchport
ipv6 address 2000::3/64
!
```

Create IPv6 VRRP group 1 and configure virtual IPv6 addresses FE80::1 and 2000::1.

```
interface FastEthernet 0/0
vrrp 1 ipv6 FE80::1
vrrp 1 ipv6 2000::1
```

Change the priority of IPv6 VRRP group 1 to 120.

```
vrrp ipv6 1 priority 100
```

Change the advertisement interval of IPv6 VRRP group 1 to 3s.

```
vrrp ipv6 1 timers advertise 3
```

Set the Accept_Mode of the IPv6 VRRP group.

```
vrrp ipv6 1 accept_mode
```

As can be seen, Ruijie A and Ruijie B belong to IPv6 VRRP group 1, point to the same virtual router IPv6 address (2000::1), and work in VRRP preemption mode. Since the priority of Ruijie A in the IPv6 VRRP group is 120 and that of Ruijie B is the default 100, Ruijie A works as the master router of the IPv6 VRRP group in normal cases.

Verification

Run the **show ipv6 vrrp 1** command to check VRRP configuration information after the configuration is complete.

Show configurations on Ruijie A

```
Ruijie#show ipv6 vrrp 1
FastEthernet 0/1 - Group 1
  State is Master
  Virtual IPv6 address is as follows:
FE80::1
2000::1
  Virtual MAC address is 0000.5e00.0201
  Advertisement interval is 3 sec
  Accept_Mode is enabled
  Preemption is enabled
    min delay is 0 sec
  Priority is 120
  Master Router is FE80::1234 (local), priority is 120
  Master Advertisement interval is 3 sec
  Master Down interval is 10.59 sec
```

Show configurations on Ruijie B

```
Ruijie#show ipv6 vrrp 1
FastEthernet 0/1 - Group 1
  State is Backup
  Virtual IPv6 address is as follow:
FE80::1
2000::1
  Virtual MAC address is 0000.5e00.0201
  Advertisement interval is 3 sec
  Accept_Mode is enabled
  Preemption is enabled
    min delay is 0 sec
  Priority is 100
  Master Router is FE80::1234, priority is 120
  Master Advertisement interval is 3 sec
  Master Down interval is 10.82 sec
```

Example of Configuring the Tracked Interface of an IPv6 VRRP Group

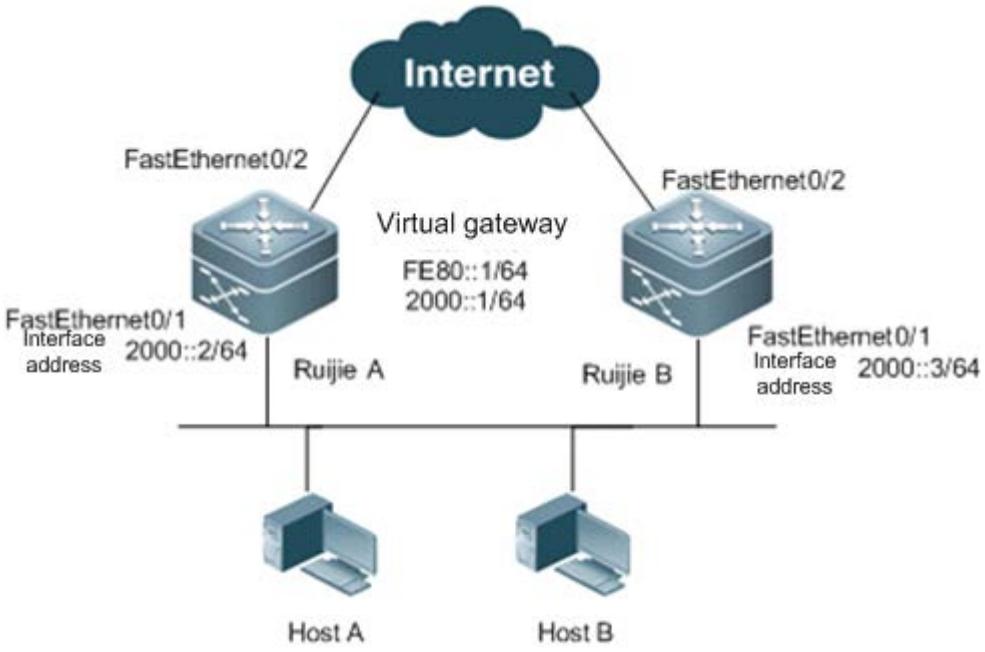
Networking Requirements

This configuration instance is applicable to both switches and routers.

- Host A and Host B access the Internet through a gateway. The default gateway is 2000::1/64 on both hosts.
- Ruijie A and Ruijie B are two routers that form IPv6 VRRP group 1. The virtual addresses are 2000::1/64 and FE80::1.
- Ruijie A tracks the interface FastEthernet 0/2 to the Internet. When the interface FastEthernet 0/2 is unavailable, Ruijie A decreases its VRRP group priority so that Ruijie B serves as the master router to provide the gateway function.

Networking Topology

Figure 6 Network topology of the example for configuring the tracked interface of an IPv6 VRRP group



Configuration Steps

Configurations on Ruijie A:

Configure an IPv6 address on an interface to enable the IPv6 service on the interface.

```
interface FastEthernet 0/0
```

/* The **no switchport** command needs to be run on a switch only*/

```
no switchport
ipv6 address 2000::2/64
!
```

Create IPv6 VRRP group 1 and configure virtual IPv6 addresses FE80::1 and 2000::1.

```
interface FastEthernet 0/0
vrrp 1 ipv6 FE80::1
vrrp 1 ipv6 2000::1
!
```

Change the priority of IPv6 VRRP group 1 to 120.

```
vrrp ipv6 1 priority 120
!
```

Change the advertisement interval of IPv6 VRRP group 1 to 3s.

```
vrrp ipv6 1 timers advertise 3
!
```

Configure the tracked interface FastEthernet 0/2 for IPv6 VRRP group 1.

```
vrrp ipv6 1 track FastEthernet 0/2 50
```

Set the Accept_Mode of the IPv6 VRRP group.

```
vrrp ipv6 1 accept_mode
```

Configurations on Ruijie B:

Create IPv6 VRRP group 1 and configure virtual IPv6 addresses FE80::1 and 2000::1.

```
interface FastEthernet 0/0
```

/* The **no switchport** command needs to be run on a switch only*/

```
no switchport
ipv6 address 2000::3/64
!
```

Create IPv6 VRRP group 1 and configure virtual IPv6 addresses FE80::1 and 2000::1.

```
interface FastEthernet 0/0
vrrp 1 ipv6 FE80::1
vrrp 1 ipv6 2000::1
```

Change the priority of IPv6 VRRP group 1 to 100.

```
vrrp ipv6 1 priority 100
!
```

Change the advertisement interval of IPv6 VRRP group 1 to 3s.

```
vrrp ipv6 1 timers advertise 3
```

Set the Accept_Mode of the IPv6 VRRP group.

```
vrrp ipv6 1 accept_mode
```

As can be seen, Ruijie A and Ruijie B belong to IPv6 VRRP group 1, point to the same virtual router IPv6 address (2000::1), and work in IPv6 VRRP preemption mode. Since the priority of Ruijie A in the IPv6 VRRP group is 120 and that of Ruijie B is the default 100, Ruijie A works as the master router of the IPv6 VRRP group in normal cases. If Ruijie A detects that its interface FastEthernet 0/2 is unavailable, it decreases its VRRP group priority by 50 to 70, so that Ruijie B becomes the master router. If Ruijie A detects later that its interface FastEthernet 0/2 is available again, it increases its VRRP group priority by 50 to 120, so that Ruijie A again becomes the master router.

Verification

Run the **show ipv6 vrrp 1** command to check VRRP configuration information after the configuration is complete.

Show configurations on Ruijie A

```
Ruijie#show ipv6 vrrp 1
FastEthernet 0/1 - Group 1
  State is Master
  Virtual IPv6 address is as follows:
```

```
FE80::1
2000::1
  Virtual MAC address is 0000.5e00.0201
  Advertisement interval is 3 sec
  Accept_Mode is enabled
  Preemption is enabled
    min delay is 0 sec
  Priority is 120
  Master Router is FE80::1234 (local), priority is 120
  Master Advertisement interval is 3 sec
  Master Down interval is 10.59 sec
Tracking state of 1 interface, 1 up:
   up FastEthernet 0/2 priority decrement=50
```

Show configurations on Ruijie B

```
Ruijie#show ipv6 vrrp 1
FastEthernet 0/1 - Group 1
  State is Backup
  Virtual IPv6 address is as follow:
FE80::1
2000::1
  Virtual MAC address is 0000.5e00.0201
  Advertisement interval is 3 sec
  Accept_Mode is enabled
  Preemption is enabled
    min delay is 0 sec
  Priority is 100
  Master Router is FE80::1234, priority is 120
  Master Advertisement interval is 3 sec
  Master Down interval is 10.82 sec
```

Example of Configuring Multiple IPv6 VRRP Groups

Multiple VRRP groups can be configured on one Ethernet interface to implement load balancing and backup one another to provide more reliable and stable network services.

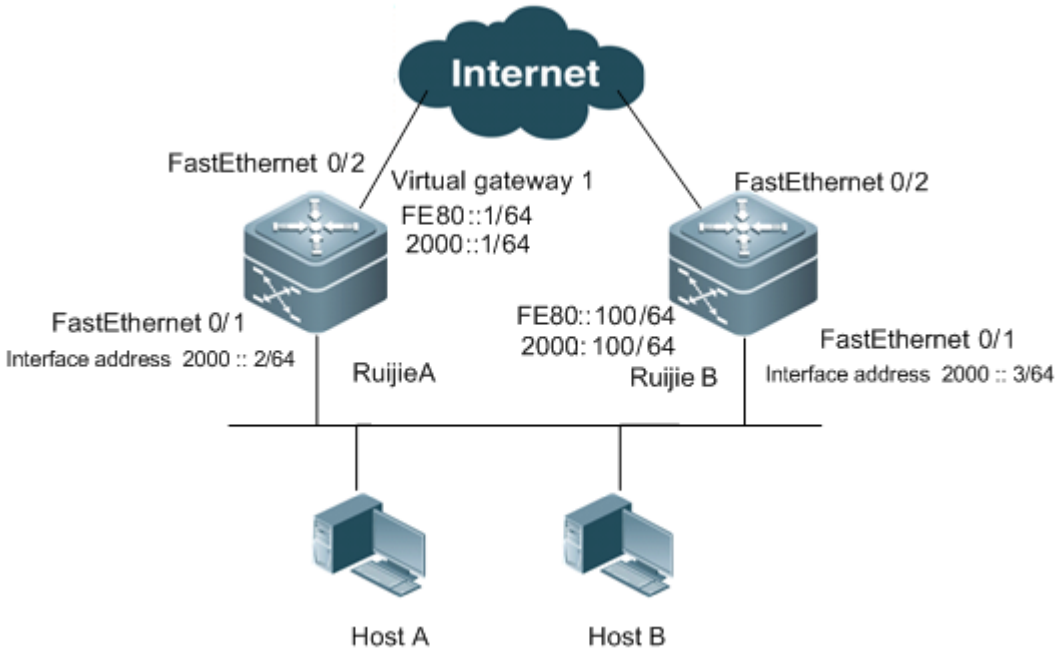
Networking Requirements

This configuration instance is applicable to both switches and routers.

- Host A and Host B access the Internet through gateways. The default gateway for Host A is 2000::1/64, and that for Host B is 2000::100/64.
- Ruijie A and Ruijie B are two routers that form IPv6 VRRP group 1. The virtual addresses are 2000::1/64 and FE80::1.
- Ruijie A and Ruijie B also form IPv6 VRRP group 2. The virtual addresses are 2000::100/64 and FE80::100.
- Ruijie A and Ruijie B serve as gateways to forward traffic and back up each other.

Networking Topology

Figure 7 Network topology of the example for configuring multiple IPv6 VRRP groups



Configuration Steps

Configurations on Ruijie A:

Configure an IPv6 address on an interface to enable the IPv6 service on the interface.

```
interface FastEthernet 0/0
```

/* The **no switchport** command needs to be run on a switch only*/

```
no switchport
ipv6 address 2000::2/64
!
```

Create IPv6 VRRP group 1 and configure virtual IPv6 addresses FE80::1 and 2000::1.

```
interface FastEthernet 0/0
vrrp 1 ipv6 FE80::1
vrrp 1 ipv6 2000::1
!
```

Change the priority of IPv6 VRRP group 1 to 120.

```
vrrp ipv6 1 priority 120
!
```

Change the advertisement interval of IPv6 VRRP group 1 to 3s.

```
vrrp ipv6 1 timers advertise 3
```

Set the Accept_Mode of IPv6 VRRP group 1.

```
vrrp ipv6 1 accept_mode
```

```
!
```

Create IPv6 VRRP group 2 and configure virtual IPv6 addresses FE80::100 and 2000::100.

```
vrrp 2 ipv6 FE80::100
vrrp 2 ipv6 2000::100
!
```

Change the priority of IPv6 VRRP group 2 to 100.

```
vrrp ipv6 2 priority 100
```

Change the advertisement interval of IPv6 VRRP group 2 to 3s.

```
vrrp ipv6 2 timers advertise 3
```

Set the Accept_Mode of IPv6 VRRP group 2.

```
vrrp ipv6 2 accept_mode
```

Configurations on Ruijie B:

```
interface FastEthernet 0/0
```

/* The **no switchport** command needs to be run on a switch only*/

```
no switchport
ipv6 address 2000::3/64
!
```

Create IPv6 VRRP group 1 and configure virtual IPv6 addresses FE80::1 and 2000::1.

```
interface FastEthernet 0/0
vrrp 1 ipv6 FE80::1
vrrp 1 ipv6 2000::1
```

Change the priority of IPv6 VRRP group 1 to 100.

```
vrrp ipv6 1 priority 100
!
```

Change the advertisement interval of IPv6 VRRP group 1 to 3s.

```
vrrp ipv6 1 timers advertise 3
```

Set the Accept_Mode of IPv6 VRRP group 1.

```
vrrp ipv6 1 accept_mode
!
!
```

Create IPv6 VRRP group 2 and configure virtual IPv6 addresses FE80::100 and 2000::100.

```
vrrp 2 ipv6 FE80::100
vrrp 2 ipv6 2000::100
!
```

Change the priority of IPv6 VRRP group 2 to 120.

```
vrrp ipv6 2 priority 120
```

Change the advertisement interval of IPv6 VRRP group 2 to 3s.

```
vrrp ipv6 2 timers advertise 3
!
```

Set the Accept_Mode of IPv6 VRRP group 2.

```
vrrp ipv6 2 accept_mode
!
```

As can be seen, Ruijie A and Ruijie B belong to IPv6 VRRP group 1, point to the same virtual router IPv6 address (2000::1), and work in IPv6 VRRP preemption mode. Since the priority of Ruijie A in IPv6 VRRP group 1 is 120 and that of Ruijie B is the default 100, Ruijie A works as the master router of IPv6 VRRP group 1 in normal cases. In IPv6 VRRP group 2, however, the priority of Ruijie A is 100 and that of Ruijie B is 120 and IPv6 VRRP group 2 works in preemption mode. Therefore, Ruijie B works as the master router of IPv6 VRRP group 2 in normal cases. For hosts in the same LAN, Host A uses IPv6 VRRP group 1 as the default gateway whereas Host B uses IPv6 VRRP group 2 as the default gateway. Route redundancy is implemented between Ruijie A and Ruijie B, which share LAN traffic and implement load balancing. In this example, default gateways must be manually set on IPv6 hosts to implement load balancing based on IPv6 VRRP groups.

Verification

Run the **show ipv6 vrrp** command to check VRRP configuration information after the configuration is complete.

Show configurations on Ruijie A

```
Ruijie#show ipv6 vrrp
FastEthernet 0/1 - Group 1
  State is Master
  Virtual IPv6 address is as follows:
FE80::1
2000::1
  Virtual MAC address is 0000.5e00.0201
  Advertisement interval is 3 sec
  Accept_Mode is enabled
  Preemption is enabled
    min delay is 0 sec
  Priority is 120
  Master Router is FE80::1234 (local), priority is 120
  Master Advertisement interval is 3 sec
  Master Down interval is 10.59 sec
FastEthernet 0/1 - Group 2
  State is Backup
  Virtual IPv6 address is as follows:
FE80::100
2000::100
  Virtual MAC address is 0000.5e00.0202
```

```
  Advertisement interval is 3 sec
  Accept_Mode is enabled
  Preemption is enabled
    min delay is 0 sec
  Priority is 100
  Master Router is FE80::5678, priority is 120
  Master Advertisement interval is 3 sec
  Master Down interval is 10.82 sec
```

Show configurations on Ruijie B

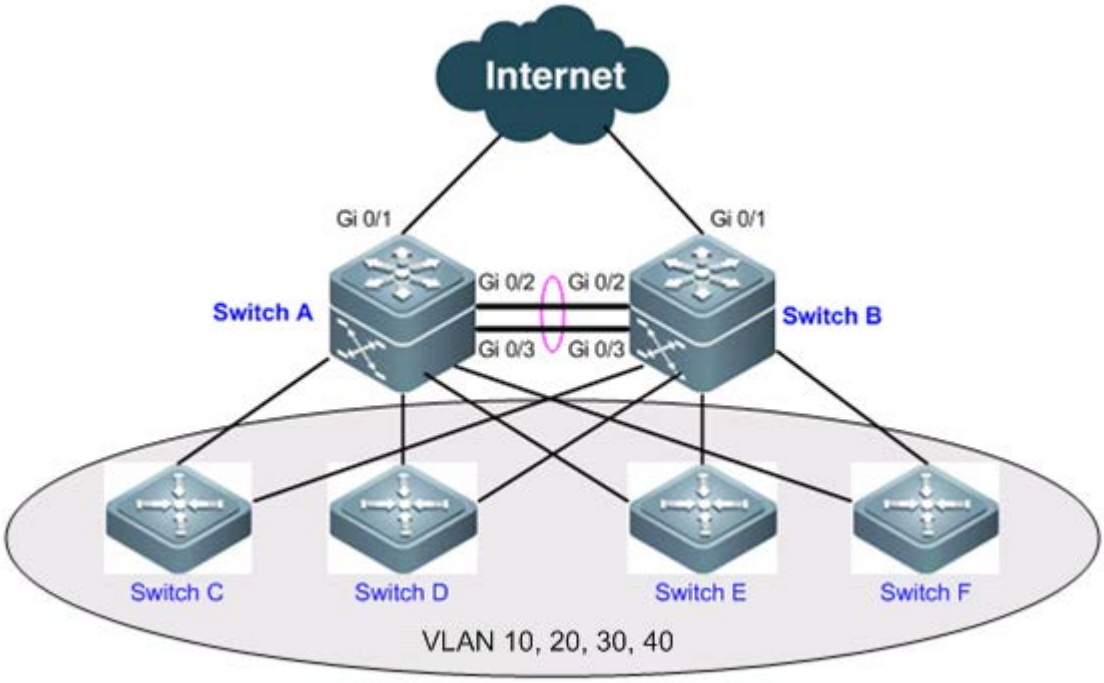
```
Ruijie#show ipv6 vrrp 1
FastEthernet 0/1 - Group 1
  State is Backup
  Virtual IPv6 address is as follow:
FE80::1
2000::1
  Virtual MAC address is 0000.5e00.0201
  Advertisement interval is 3 sec
  Accept_Mode is enabled
  Preemption is enabled
    min delay is 0 sec
  Priority is 100
  Master Router is FE80::1234, priority is 120
  Master Advertisement interval is 3 sec
  Master Down interval is 10.82 sec

FastEthernet 0/1 - Group 2
  State is Master
  Virtual IPv6 address is as follows:
FE80::100
2000::100
  Virtual MAC address is 0000.5e00.0202
  Advertisement interval is 3 sec
  Accept_Mode is enabled
  Preemption is enabled
    min delay is 0 sec
  Priority is 120
  Master Router is FE80::5678(local), priority is 120
  Master Advertisement interval is 3 sec
  Master Down interval is 10.59 sec
```

Configuring VRRP+MSTP

Networking Topology

Figure 8 Network topology of the VRRP dual-core solution



Networking Requirements

Figure 8 shows a typical network topology of the dual-core solution. This configuration instance is applicable to switches or switching cards of routers only. Users access Switches C, D, E, and F, which belong to VLAN 10, 20, 30, and 40 respectively. Switches A and B serve as gateways to enable users to communicate with external networks. The specific application requirements are described as follows:

- The Multiple Spanning Tree Protocol (MSTP) runs on devices to back up physical links and avoid loops. Different VLAN packets are forwarded along respective instances to implement layer 2 traffic load balancing.
- VRRP runs on devices to back up gateway routes and share LAN traffic.
- All links from access switches to the master router are monitored. When a link to the master router fails, the backup router immediately takes over the master router to forward data.

Configuration Tips

- Enable the MSTP function on devices (Switches A, B, C, D, E, and F in this example), configure mappings between VLANs and instances (VLANs 10 and 20 map to instance 1, VLANs 30 and 40 map to instance 2, and the rest VLANs map to instance 0 in this example), and set gateways (Switches A and B in this example) as the root bridges of respective instances.
- Add the switch virtual instances (SVIs) of various VLANs to respective VRRP groups, and set the master and backup routers of respective VRRP groups as gateways. The following table shows the specific configurations.

Gateway	VLAN ID	SVI	VRRP Group	Virtual IP Address	Status
Switch A	10	192.168.10.2	VRRP 10	192.168.10.1	Master
Switch B		192.168.10.3			Backup
Switch A	20	192.168.20.2	VRRP 20	192.168.20.1	Master
Switch B		192.168.20.3			Backup
Switch A	30	192.168.30.2	VRRP 30	192.168.30.1	Backup

Gateway	VLAN ID	SVI	VRRP Group	Virtual IP Address	Status
Switch B		192.168.30.3			Master
Switch A	40	192.168.40.2	VRRP 40	192.168.40.1	Backup
Switch B		192.168.40.3			Master

- Set the uplink ports on the master routers of VRRP groups as the tracked interfaces of the master routers. In this example, the tracked interfaces are two ports Gi 0/1 on Switches A and B.

Caution When setting the tracked interface of a VRRP group, ensure that the value of the *Priority decrement* parameter is larger than the difference between the priority of the master router and the priority of the backup router. The system automatically decreases or increases the priority value of a router according to the status of the tracked interface on the router.

Configuration Steps

In this example, only VRRP+MSTP configurations on Switches A and B are listed. This example does not provide details about how to define VLANs on Switches C, D, E, and F or how to configure MSTP on devices. For details about MSTP configuration, see *MSTP Configuration*.

- Step 1: Create VLANs on devices.

! Create VLANs 10, 20, 30, and 40 on Switch A:

```
SwitchA#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
SwitchA(config)#vlan range 10,20,30,40
SwitchA(config-vlan-range)#exit
```

! Configure the same as above on Switch B.

- Step 2: Configure the Multiple Spanning Tree (MST) domain.

! Configure mappings from VLANs 10 and 20 to instance 1, from VLANs 20 and 30 to instance 2, and from the rest VLANs to instance 0 on Switch A.

```
SwitchA(config)#spanning-tree mst configuration
SwitchA(config-mst)#instance 1 vlan 10,20
%Warning: you must create vlans before configuring instance-vlan relationship
SwitchA(config-mst)#instance 2 vlan 30,40
%Warning: you must create vlans before configuring instance-vlan relationship
SwitchA(config-mst)#exit
```

! Configure the same as above on Switch B.

Step 3: Set Switch A as the root bridges of MST instances 0 and 1, and set Switch B as the root bridge of MST instance 2.

! Set the priority of MST instances 0 and 1 to 4096 and that of MST instance 2 to 8192 on Switch A.

```
SwitchA(config)#spanning-tree mst 0 priority 4096
SwitchA(config)#spanning-tree mst 1 priority 4096
SwitchA(config)#spanning-tree mst 2 priority 8192
```

! Set the priority of MST instances 0 and 1 to 8192 and that of MST instance 2 to 4096 on Switch B.

```
SwitchB(config)#spanning-tree mst 2 priority 4096
SwitchB(config)#spanning-tree mst 0 priority 8192
SwitchB(config)#spanning-tree mst 1 priority 8192
```

- Step 4: Enable MSTP.

! Enable MSTP on Switch A.

```
SwitchA(config)#spanning-tree
Enable spanning-tree.
```

! Configure the same as above on Switch B.

- Step 5: Configure the SVIs of VLANs, add the SVIs to VRRP groups, and set the virtual IP addresses of VRRP groups. For details, see the preceding table.

! Configurations on Switch A:

```
SwitchA(config)#interface vlan 10
SwitchA(config-if-VLAN 10)#ip address 192.168.10.2 255.255.255.0
SwitchA(config-if-VLAN 10)#vrrp 10 ip 192.168.10.1
SwitchA(config-if-VLAN 10)#exit
SwitchA(config)#interface vlan 20
SwitchA(config-if-VLAN 20)#ip address 192.168.20.2 255.255.255.0
SwitchA(config-if-VLAN 20)#vrrp 20 ip 192.168.20.1
SwitchA(config-if-VLAN 20)#exit
SwitchA(config)#interface vlan 30
SwitchA(config-if-VLAN 30)#ip address 192.168.30.2 255.255.255.0
SwitchA(config-if-VLAN 30)#vrrp 30 ip 192.168.30.1
SwitchA(config-if-VLAN 30)#exit
SwitchA(config)#interface vlan 40
SwitchA(config-if-VLAN 40)#ip address 192.168.40.2 255.255.255.0
SwitchA(config-if-VLAN 40)#vrrp 40 ip 192.168.40.1
SwitchA(config-if-VLAN 40)#exit
```

! Configurations on Switch B:

```
SwitchB(config)#interface vlan 10
SwitchB(config-if-VLAN 10)#ip address 192.168.10.3 255.255.255.0
SwitchB(config-if-VLAN 10)#vrrp 10 ip 192.168.10.1
SwitchB(config-if-VLAN 10)#exit
SwitchB(config)#interface vlan 20
SwitchB(config-if-VLAN 20)#ip address 192.168.20.3 255.255.255.0
SwitchB(config-if-VLAN 20)#vrrp 20 ip 192.168.20.1
SwitchB(config-if-VLAN 20)#exit
SwitchB(config)#interface vlan 30
SwitchB(config-if-VLAN 30)#ip address 192.168.30.3 255.255.255.0
SwitchB(config-if-VLAN 30)#vrrp 30 ip 192.168.30.1
SwitchB(config-if-VLAN 30)#exit
```

```
SwitchB(config)#interface vlan 40
SwitchB(config-if-VLAN 40)#ip address 192.168.40.3 255.255.255.0
SwitchB(config-if-VLAN 40)#vrrp 40 ip 192.168.40.1
SwitchB(config-if-VLAN 40)#exit
```

- Step 6: Configure the master and backup routers of VRRP groups.

! Raise the priority of VRRP groups 10 and 20 on Switch A to 120, so that Switch A works as the master router of VRRP groups 10 and 20.

```
SwitchA(config)#interface vlan 10
SwitchA(config-if-VLAN 10)#vrrp 10 priority 120
SwitchA(config-if-VLAN 10)#exit
SwitchA(config)#interface vlan 20
SwitchA(config-if-VLAN 20)#vrrp 20 priority 120
SwitchA(config-if-VLAN 20)#exit
```

! Similarly, raise the priority of VRRP groups 30 and 40 on Switch B to 120.

```
SwitchB(config)#interface vlan 30
SwitchB(config-if-VLAN 30)#vrrp 30 priority 120
SwitchB(config-if-VLAN 30)#exit
SwitchB(config)#interface vlan 40
SwitchB(config-if-VLAN 40)#vrrp 40 priority 120
SwitchB(config-if-VLAN 40)#exit
```

- Step 7: Set the uplink ports on the master routers of VRRP groups as the tracked interfaces of VRRP groups. Ensure that the configured tracked interfaces are L3 interfaces.

! Set the port Gi 0/1 on Switch A as a route port and its IP address to 10.10.1.1/24.

```
SwitchA(config)#interface gigabitEthernet 0/1
SwitchA(config-if-GigabitEthernet 0/1)#no switchport
SwitchA(config-if-GigabitEthernet 0/1)#ip address 10.10.1.1 255.255.255.0
SwitchA(config-if-GigabitEthernet 0/1)#exit
```

! Set the port Gi 0/1 on Switch A as the tracked interface of VRRP groups 10 and 20, and *Priority decrement* to 30.

```
SwitchA(config)#interface vlan 10
SwitchA(config-if-VLAN 10)#vrrp 10 track gigabitEthernet 0/1 30
SwitchA(config-if-VLAN 10)#exit
SwitchA(config)#interface vlan 20
SwitchA(config-if-VLAN 20)#vrrp 20 track gigabitEthernet 0/1 30
SwitchA(config-if-VLAN 20)#exit
```

! Set the port Gi 0/1 on Switch B as a route port and its IP address to 10.10.2.1/24.

```
SwitchB(config)#interface gigabitEthernet 0/1
SwitchB(config-if-GigabitEthernet 0/1)#no switchport
SwitchB(config-if-GigabitEthernet 0/1)#ip address 10.10.2.1 255.255.255.0
SwitchB(config-if-GigabitEthernet 0/1)#exit
```

! Set the port Gi 0/1 on Switch B as the tracked interface of VRRP groups 30 and 40, and *interface-priority* to 30.

```
SwitchB(config)#interface vlan 30
SwitchB(config-if-VLAN 30)#vrrp 30 track gigabitEthernet 0/1 30
SwitchB(config-if-VLAN 30)#exit
SwitchB(config)#interface vlan 40
SwitchB(config-if-VLAN 40)#vrrp 40 track gigabitEthernet 0/1 30
SwitchB(config-if-VLAN 40)#exit
```

- Step 8: Set the interconnection ports between the two core devices (Switches A and B) as aggregation ports.

! Configurations on Switch A:

Set ports Gi 0/2 and Gi 0/3 as aggregation ports, which serve as trunk ports.

```
Ruijie#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Ruijie(config)#interface range gigabitEthernet 0/2-3
Ruijie(config-if-range)#port-group 1
Ruijie(config)#interface aggregateport 1
Ruijie(config-if-AggregatePort 1)#switchport mode trunk
```

! Configure the same as above on Switch B.

Verification

- Step 1: Check configuration information on devices.

! Check configuration information on Switch A.

```
SwitchA#show running-config
!
vlan 10
!
vlan 20
!
vlan 30
!
vlan 40
!
spanning-tree
spanning-tree mst configuration
 instance 0 vlan 1-9, 11-19, 21-29, 31-39, 41-4094
 instance 1 vlan 10, 20
 instance 2 vlan 30, 40
spanning-tree mst 0 priority 4096
spanning-tree mst 1 priority 4096
spanning-tree mst 2 priority 8192
interface GigabitEthernet 0/1
 no switchport
 no ip proxy-arp
 ip address 10.10.1.1 255.255.255.0
!
```

```
interface GigabitEthernet 0/2
 port-group 1
!
interface GigabitEthernet 0/3
 port-group 1
!
interface AggregatePort 1
 switchport mode trunk
!
interface VLAN 10
 no ip proxy-arp
 ip address 192.168.10.2 255.255.255.0
 vrrp 10 priority 120
 vrrp 10 ip 192.168.10.1
 vrrp 10 track GigabitEthernet 0/1 30
!
interface VLAN 20
 no ip proxy-arp
 ip address 192.168.20.2 255.255.255.0
 vrrp 20 priority 120
 vrrp 20 ip 192.168.20.1
 vrrp 20 track GigabitEthernet 0/1 30
!
interface VLAN 30
 no ip proxy-arp
 ip address 192.168.30.2 255.255.255.0
 vrrp 30 ip 192.168.30.1
!
interface VLAN 40
 no ip proxy-arp
 ip address 192.168.40.2 255.255.255.0
 vrrp 40 ip 192.168.40.1
```

! Check configuration information on Switch B.

```
SwitchB#show running-config
!
vlan 10
!
vlan 20
!
vlan 30
!
vlan 40
!
spanning-tree
spanning-tree mst configuration
```

```
 instance 0 vlan 1-9, 11-19, 21-29, 31-39, 41-4094
 instance 1 vlan 10, 20
 instance 2 vlan 30, 40
spanning-tree mst 0 priority 8192
spanning-tree mst 1 priority 8192
spanning-tree mst 2 priority 4096
interface GigabitEthernet 0/1
 no switchport
 no ip proxy-arp
 ip address 10.10.2.1 255.255.255.0
!
interface GigabitEthernet 0/2
 port-group 1!
interface GigabitEthernet 0/3
 port-group 1
!
interface AggregatePort 1
 switchport mode trunk
!
interface VLAN 10
 no ip proxy-arp
 ip address 192.168.10.3 255.255.255.0
 vrrp 10 ip 192.168.10.1
!
interface VLAN 20
 no ip proxy-arp
 ip address 192.168.20.3 255.255.255.0
 vrrp 20 ip 192.168.20.1
!
interface VLAN 30
 no ip proxy-arp
 ip address 192.168.30.3 255.255.255.0
 vrrp 30 priority 120
 vrrp 30 ip 192.168.30.1
 vrrp 30 track GigabitEthernet 0/1 30
!
interface VLAN 40
 no ip proxy-arp
 ip address 192.168.40.3 255.255.255.0
 vrrp 40 priority 120
 vrrp 40 ip 192.168.40.1
 vrrp 40 track GigabitEthernet 0/1 30
```

- Step 2: Check the VRRP status of each device.

! Check the VRRP status of Switch A.

```
SwitchA#show vrrp brief
```

```
Interface  Grp  Pri  timer  Own  Pre  State   Master addr   Group addr
VLAN 10    10   120  3      -    P    Master  192.168.10.2  192.168.10.1
VLAN 20    20   120  3      -    P    Master  192.168.20.2  192.168.20.1
VLAN 30    30   100  3      -    P    Backup  192.168.30.3  192.168.30.1
VLAN 40    40   100  3      -    P    Backup  192.168.40.3  192.168.40.1
```

! Check the VRRP status of Switch B.

```
SwitchB#show vrrp brief
Interface  Grp  Pri  timer  Own  Pre  State   Master addr   Group addr
VLAN 10    10   100  3      -    P    Backup  192.168.10.2  192.168.10.1
VLAN 20    20   100  3      -    P    Backup  192.168.20.2  192.168.20.1
VLAN 30    30   120  3      -    P    Master  192.168.30.3  192.168.30.1
VLAN 40    40   120  3      -    P    Master  192.168.40.3  192.168.40.1
```

As can be seen from above, Switch A serves as the master router of VRRP groups 10 and 20 and has a priority of 120 when links are normal, whereas Switch B serves as the backup routers of VRRP groups 10 and 20.

- Step 3: Disconnect the uplink of Switch A, and then check the VRRP status of Switches A and B.

! Check the VRRP status of Switch A.

```
SwitchA#show vrrp brief
Interface  Grp  Pri  timer  Own  Pre  State   Master addr   Group addr
VLAN 10    10   90   3      -    P    Backup  192.168.10.3  192.168.10.1
VLAN 20    20   90   3      -    P    Backup  192.168.20.3  192.168.20.1
VLAN 30    30   100  3      -    P    Backup  192.168.30.3  192.168.30.1
VLAN 40    40   100  3      -    P    Backup  192.168.40.3  192.168.40.1
```

! Check the VRRP status of Switch B.

```
SwitchB#show vrrp brief
Interface  Grp  Pri  timer  Own  Pre  State   Master addr   Group addr
VLAN 10    10   100  3      -    P    Master  192.168.10.3  192.168.10.1
VLAN 20    20   100  3      -    P    Master  192.168.20.3  192.168.20.1
VLAN 30    30   120  3      -    P    Master  192.168.30.3  192.168.30.1
VLAN 40    40   120  3      -    P    Master  192.168.40.3  192.168.40.1
```

As can be seen from above, when the uplink of Switch A fails, the system automatically decreases the priority of VRRP groups 10 and 20 to 90 and changes the VRRP status of Switch A to Backup, so that Switch B becomes the master router of VRRP groups 10 and 20.

Fault Diagnosis and Clearance

You can analyze and clear VRRP faults by checking configuration and debugging information. Below are some common faults and analysis methods:

Symptom

The virtual IPv4/IPv6 address of a VRRP group cannot be pinged.

Analysis

- Ensure that at least one router is active in the VRRP group.
- If the virtual IPv4/IPv6 address cannot be pinged from a device on another network, possibly the fault is caused because a short time is needed for VRRP status switching. Run the **show [ipv6] vrrp** command to check VRRP information and verify the root cause.
- If the virtual IPv4/IPv6 address cannot be pinged from a local network device in the same network segment as the virtual router, check whether the ARP table or neighbor discovery (ND) table on the local network device contains an ARP entry for the virtual IPv4/IPv6 address. If there is no ARP entry for the virtual IPv4/IPv6 address, check network lines.
- If the virtual IPv4/IPv6 address cannot be pinged from a local network device in a network segment that is different from the network segment where the virtual router resides, check whether a route to the virtual IPv4/IPv6 address has been configured on the local network device.

Symptom

Multiple master routers exist in a VRRP group.

Analysis

- Ethernet interfaces on the routers of the VRRP group are set to different VRRP group authentication modes.
- For VRRPv2, Ethernet interfaces on the routers of the VRRP group are set to the same plain text authentication mode but the configured authentication strings are inconsistent.
- The cables of the Ethernet interfaces on the routers of the VRRP group are disconnected, but the routers fail to detect the disconnection.
- The VRRP advertisement intervals configured on routers of the VRRP group are inconsistent, and the periodic learning of VRRP advertisement packets is disabled on the routers.
- Different virtual IPv4/IPv6 addresses are set for routers of the VRRP group.

Hot Swap Configuration

Understanding Hot Swap

Overview

Hot swap refers to the ability of allowing removing a faulty line card and inserting the standby line card in a high-reliable system without restarting and shutting down the system.

Ruijie designs hot-swap products by complying with the rule of separating software settings from hardware application and separating the existence of line cards from the startup of line cards.

Ruijie employs the install/no install concept so that users can run the **install** command to pre-install and pre-configure a certain type of line card in a slot even if no line card is inserted in the slot. Management software can reserve all configurations of the line card. Whether to configure hardware depends on actual situations.

After users save settings, all pre-configuration information is stored. After routers are reset, this pre-configuration information is still effective.

During normal running of routers, removing and then inserting a line card will not lead to the loss of related hardware settings.

If the actual type of the newly inserted line card is different from the pre-configured type, the inserted line card is not enabled and users need to uninstall the original configuration to enable the line card.


Caution

Comply with the following rules during hot swap to avoid causing abnormalities of software and hardware or even damaging line cards:
Insert one line card only at a time. Before inserting and removing a line card during hot swap, allow the system to spend some time in completing the previous removal and insertion of the line card.
Smoothly and securely insert and remove line cards.
Before removing a line card, run the **remove** command.
During system startup, the line card must not be inserted or removed.

Configuring Hot Swap

Hot Swap Configuration Task List

Hot swap can be configured by following the task list below:

Installing and Uninstalling a Line Card Module

The pre-configuration function of Ruijie products allows users to run the **install** command to virtualize a line card module of the specified type (the line card module is not actually inserted in the slot), and then configure the line card module. After the line card module is inserted in the slot, all configuration automatically takes effect.

Command	Function
Ruijie(config)# **install** *slot-num moduletype*	Installs a line card module.
Ruijie(config)# **no install** *slot-num*	Uninstalls a line card module.

Inserting and Removing a Line Card Module

Follow the rules in the "Overview" section to insert and remove a line card.

You do not need to configure a command to insert a line card.

Before removing a line card, run the **remove** command.

Command	Function
Ruijie(config)# **remove** *slot-num*	Removes a line card.
Ruijie(config)# **no remove** *slot-num*	Restores line card configuration.

Note

When you run the **no remove** command, or directly insert the NMX-8E1/CE1 or NMX-4E1/CE1 line card, the communication over the interface that is not added to the fast forwarding group is interrupted for about 30 seconds. Therefore, it is not recommended that you carry out such operation during peak hours of communication.

During system startup, the line card must not be inserted or removed.

A line card can be inserted and removed only after the system is started completely (namely, the console prompts “%SYS-5-WARMSTART:System warmstart.” or “%SYS-5-WARMSTART:System coldstart.”).

Resetting a Line Card Module Hot Swap

Hot swap resetting includes a series of operations: run the **remove** command, remove a line card, run the **no install** command, run the **install** command, and insert the line card. After the hot swap resetting is complete, line card hardware is reset and configuration information on the software is initialized again.

Command	Function
Ruijie(config)# **reset** *slot-num*	Resets a line card module hot swappable.

Monitoring and Maintaining Hot Swap

The **show version slots** command is used to display the information of the line card modules in each slot, including line card types configured by users, actual line card types, and hot swap status of line cards.

Command	Function
Ruijie# **show version slots**	Displays details of the slot.

Management Module of Redundancy Configuration

This chapter describes how to configure the management module redundancy to implement nonstop forwarding(NSF) and the system file management method of the the management module.

This chapter includes:

1. Understanding redundant NSF of the management module
2. NSF configuration method

Understanding Redundant NSF of Management Module

Overview

NSF means that in the network device with the structure of separating control panel from forward panel, the control panel is planned to shut down(such as software upgrade) or not planned to shut down(such as software and hardware defect) while the forward panel goes on forwarding and there is no forward halt or topology fluctuation during the reboot of control side. NSF is an important part of High Availability Architecture

In the machine which is installed with dual the management modules, the the master management module is used normally while the other backup one is the slave management module which is a substitute for the master one when the master one is broken off or requires for the switchover. It not only enlarges exchanging capacity but also offers management redundancy to improve the stability of device. In the running process of the device, if the the master management module does not work well, the device will switch to the slave one automatically without losing user's corresponding configuration, which ensures that the network runs well. Generally, the slave management module does not join in the switch management but monitors the status of master one. These events below will trigger the management module switchover:

1) System suspend or reset due to hardware fault of the master management module
2) No heartbeat between two management modules
3) Manual switchover

When booting dual management modules at the same time or hot-plugging another when one board is enabled, they will do some batch synchronization configuration before they are in Active/Standby Hot status. At this time, if disturbance sources are configured, the slave management module will reboot and both are in Active/Boot Hot status. If all disturbance sources are cleared in Active/Boot Hot status, the slave one will reboot too and both are in Active/Standby Hot status. If new disturbance sources are configured in Active/Boot Hot status, this brings no influence and both are still in Active/Boot Hot status.

Caution

Now, the disturbance sources include the following entities:

- PTLVLAN: Protocol VLAN, VLAN classification technology based on package protocol type. It can divide the null VLAN ID of a protocol typet to a same VLAN.
- MCAST6: Multicast for ipv6

Postscript: the dual managemetn panels are in Boot Cold/Boot Cold status if the system detects the in consistency of the software version of the dual ones when starting up. In other words, they can detect the other side respectively, but they are not in Active/Standby Hot status untill the automatic upgrade is finished and the slave one is reset. Finally, the software version of the dual the management modules is consistent.

NSF Advantages and Limits

The advantages of NSF technology implementation in network service are:

- Improving the network availability:

  NSF technology maintains the information of data forwarding and user session status in the process of device change.

- Preventing the neighbour from detecting link flap:

  The forwarding side does not reboot during the switchover, so the neighbour can not detect the link status change from Down to Up.

- Preventing routing flaps:

  The forwarding side maintains to forward and communicate during the switchover and the control side forms new forwarding list quickly without apparent substitution between the new and oil forwarding list, thus preventing routing flaps.

- User sessions will not be lost:

  User sessions built before the switchover will not be lost due to the synchronization in real time.

The limits of using NSF technology in the switch are:

- NSF works well on the premise that the software and hardware constitution of the dual the management modules are consistent.
- It should synchronizes the master and the slave management modules in batch to make them consistent, before which is the window period when NSF can not take effect.
- Not all the functions related with forwarding are synchronized. The switch function can be classified into the following types according to NSFsupporting degree:
  - High availability support function;
  - Real time synchronization of status information between master and the slave management module. For example, it synchronizes the control side function directly related with L2 forwarding in real time.
  - High availability compatibility function
  - These features do not support high availability for the status datas are not synchronized. However, when enabling high availability, these functions that starts to run from initialization can still be used after switching.
  - High availability incompatibility function

Caution	These features do not support high availability for the status datas are not synchronized. When enabling high availability, these functions can not be used, or it may lead to system abnormity. When enabling these functions, the system status is changed from Standby Hot to Boot Hot and the system can only synchronize running-config.

Key Technology of NSF

The key technologies of implementing NSF include:

- **Status synchronization**

  The the master management module synchronizes the running status with the slave one in order to enable the slave one to be a substitute for the master one at any time without noticeable changes.

- **Configuration synchronization**

  It synchronizes the configurations of the functions that are not associated with NAF directly. The user configuration keeps consistent during the switchover by the synchronization of running-config and startup-config.

Conducting running-config when user configuration returns to the privileged EXEC mode from the global mode, while conducting startup-config synchronization when the user executes command write or copy to save the configuration.

It can not synchronize SNMP configuration automatically untill running-config synchronization is triggered by CLI configuration method.

Caution

You can configure auto-sync mode as the following steps. In the global configuration mode, execute command **redundancy** first and then **auto-sync { standard | startup-config | running-config }.** To view the current auto-sync mode, use **show redundancy auto-sync** in the privileged EXEC mode. To configure the auto-sync interval in an unit of second, execute command **redundancy** first and then **auto-sync time-period value.**

Auto-sync has three modes:

a) standard: synchronizes all the system files. In other words, it synchronizes both startup-config and running-config.

b) startup-config: synchronizes startup configuration file.

c) running-config: synchronizes configuration file of running time.

The **no** form of the command disables all the modes, making the configuration file out of auto-sync. By default , the mode of auto-sync is standard, which synchronizes both startup-config and running-config.

NSF Configuration Method

Caution

In the management module redundancy constitution methods, only the master management module supports all CLI commands, while the slave management module supports a few commands in user EXEC and privileged EXEC mode.

Configuring Redundant Management

This chapter includes:

- Automatic selection of the master management module
- Manual selection of the master management module

Automatic selection of the master management module

You can plug or unplug the the management modules while the switch is working. Based on the current conditions, the switch automatically selects an engine for its operation without normal data switching. In case of any conditions below during you use, the the master management module will be selected accordingly:

- If only one the management module is plugged when the switch is started up, the switch will select it as the the master management module no matter whether it is in slot M1 or M2.
- If both the management modules are plugged when the switch is started up, by default, the one in slot M1 will be selected as the master and the one in slot M2 as the slave for purpose of redundancy. Related prompt message will be provided.
- If only one the management module is plugged when the switch is started up, and the other the management module is plugged while the switch is in normal operation, the latter will be regarded as the the slave management module for purpose of redundancy, no matter whether it is slot M1 or M2. Related prompt message will be provided.
- If both the management modules are plugged when the switch is started up, and one of them is unplugged while the switch is in normal operation (or one becomes abnormal): if the unplugged the management module is the slave before it is unplugged (or abnormal), the switch only prompts that the the slave management module is unplugged (or becomes abnormal); if the unplugged the management module is the master before it is unplugged (or abnormal), the other the management module will turn from slave to master, and related prompt will be provided.

During the normal operation of the switch, the parameters must be saved when the configurations are done; otherwise, the configuration will be lost in case of master/salve switchover.

During the startup of the device inserted with two the management modules, if the main program of any the management module is incomplete or absent, the switch cannot start. The symptom is that the two boards restart repeatedly or suspend during the startup process.

During the startup of the device inserted with one the management module, if the management module with incomplete or absent CTRL program or main program is inserted before the success of the startup, the switch also cannot start.

Caution

In the above two case, remove the faulty the management modules. If the device is still abnormal, power off the switch and restart it.

During the batch backup of master and the slave management module, do not unplug the master one, or it will lead to data flow breakoff due to system reset. If the software of dual the management modules are abnormal during the period of batch backup, it will also lead to data flow breakoff due to system reset.

Please unplug one of the dual the management modules quickly if you want to unplug one of them when they are working simultaneously. Slow unplugging may make the management module work abnormally. Please make sure that the management module is plugged tightly and the screw id tightened.

Manual selection of the master management module

In the privileged user mode, execute the following commands to forcibly switch over the the master management module:

Command	Meaning
redundancy force-switchover switch	This command is executed immediately without the necessity for global configuration mode.

For example, the current the master management module is the one in slot M1. When the following commands are executed, the the management module will be switched over to the the slave management module, and the one in slot M2 becomes the master.

```
Ruijie# redundancy  force-switchover switch
```

Configuring the Synchronization Mode

Run the following commands to configure the configuration files to be synchronized:

Command	Function
Ruijie(config)# **redundancy**	Enter the redundancy configuration mode
Ruijie**(config-red)# auto-sync** {**standard** | **running-config** | **startup-config**}	Configure the configuration files to be synchronized.

Command	Function
Ruijie#**show running-config**	Confirm the hot-backup started.
Ruijie#**show redundancy state**	Show the current redundancy operation mode.

Configuring the Heart-beat Check Time

Run the following command to configure the heart-beat check time between the master and the slave management modules.

Command	Function
Ruijie(config)# **redundancy**	Enter the redundancy configuration mode
Ruijie(config-red)# **switchover timeout** *timerout-period*	Control the heart-beat check time between the master and slave boards
Ruijie#**show running-config**	Confirm the hot-backup started.
Ruijie#**show redundancy state**	Show the current redundancy operation mode.

Resetting the Management Module

Run the following command to reset the specified the management module or both the master and salve ones.

Command	Function
Ruijie(config)#**redundancy reload {peer | shelf}**	peer: reset the slave management module only. shelf: reset both of master and slave management modules.

Multilink Gateway Load Balancing Configuration

Introduction to Multilink Gateway Load Balancing

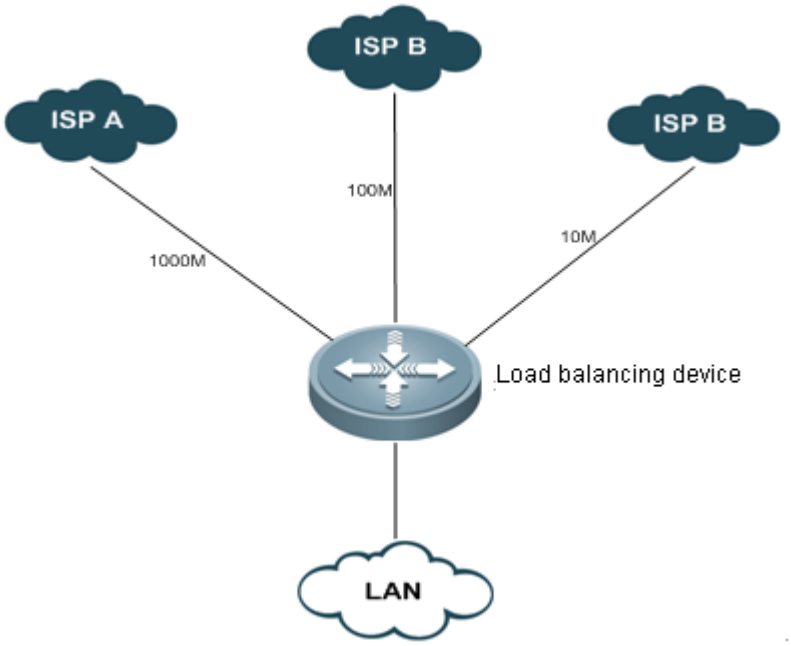


Fig 1 Typical application diagram of multilink gateway load balancing

Overview

The network gateway is generally connected with two or more ISP links. For example, the gateway of an educational institution will be connected with an education communication link and a Telecom/CNC link; the gateway of a governmental agency may be connected with a Telecom link and a CNC link. Multiple ISP links handles traffic as per certain policy or act as the backup link.

Multilink load balancing allows reasonable flow distribution among multiple links as per certain policy, well improving the utilization efficiency of link resources.

Basic Concept

Link bandwidth

Link bandwidth is the indicator for measuring available resources, and is different from the transmission rate of physical interface. It is the maximum transmission rate provided by ISP, and generally refers to the inbound bandwidth.

Link latency

When there are multiple gateways, packets can reach the same destination address through different gateways. The link latency used in load balancing refers to the different response times

when packets reach the same destination address through different gateways. It is used to compare the access speed of different gateways, focusing mainly on the difference between links in terms of latency.

Link load

Link load refers to the current resource utilization rate of the link. It can be calculated by dividing the packet reception rate of physical interface by link bandwidth.

Load balancing policy

The policy to share traffic between different links. You can choose load balancing according to bandwidth, access speed, link utilization rate, comprehensive link bandwidth, latency, or load.

Working Principle

In accordance with the load balancing policy selected, the system will calculate the weight of respective links according to link bandwidth, latency and load, and regenerate WCMP routes as per the weight of each link. The subsequent traffic will select the gateway according to the routes generated, thus controlling the traffic handled by each link.

Protocol specification

NA

Default Configurations

The following table describes the default configurations of multilink gateway load balancing.

Function	Default setting
Configure multilink gateway load balancing	Disabled

Configure Multilink Gateway Load Balancing

The following section describes how to configure multilink load balancing:

- (Required) Enable/disable multilink load balancing
- (Optional) Configure link bandwidth
- (Optional) Configure link load threshold
- (Optional) Configure load balancing policy
- (Optional) Configure weight base
- Display configurations

Enable/Disable Multilink Load Balancing

By default, multilink load balancing function is disabled on the device. Enter privilege mode and execute the following steps to enable multilink load balancing:

Command	Function
Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **mllb enable**	Enable multilink load balancing
Ruijie(config)# **no mllb enable**	Disable multilink load balancing

Configuration example:

Enable global multilink load balancing

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mllb
```

Disable global multilink load balancing

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# no mllb
```

Configure Link Bandwidth

To configure the bandwidth of interface, execute the following commands in interface configuration mode:

Command	Function
Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **interface** *interface-name*	Enter interface configuration mode.
Ruijie(config-if)# **bandwidth** *kilobits*	Configure link bandwidth.
Ruijie(config-if)# **no bandwidth**	Restore link bandwidth to default value.

Configuration example:

Configure link bandwidth to 1M:

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface fastEthernet 0/1
Ruijie(config-if)# bandwidth 1000
```

Remove link bandwidth configurations:

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface fastEthernet 0/1
Ruijie(config-if)# no bandwidth
```

Configure Link Load Threshold

If the link load exceeds the threshold configured, the system will then no longer use this link as the gateway link for load balancing. This threshold shall apply to all gateway links. The load threshold will be expressed in percentage (1-100).

To configure link load threshold, execute the following steps:

Command	Function
Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **mllb threshold** *percent*	Configure link load threshold to "percent" (integer between 1-100).
Ruijie(config)# **no mllb threshold**	Restore the link load threshold to the default value of 100.

Configuration example:

Configure link load threshold to 95:

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mllb threshold 95
```

Restore link load threshold to the default value:

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# no mllb threshold
```

Configure Load Balancing Policy

Load balancing policy provides four different load balancing options for the user. In case of bandwidth based load balancing, the gateway traffic will be shared according to gateway bandwidth; in case of latency based load balancing, the link with shorter latency will handle more traffic and the link with longer latency will handle less traffic; in case of load based load balancing, the traffic will be shared according to the load situation of each gateway link, so that loads are balanced on links; in case of intelligent load balancing, the traffic will be routed by giving comprehensive consideration to bandwidth, latency and load. The user can further configure the weight base of these three factors (see "Configure weight base"), so as to adjust the specific influence of the corresponding factor on flow distribution.

To configure load balancing policy, execute the following steps:

Command	Function
Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **mllb policy** { **bandwidth** | **latency** | **load** | **intelligent** }	Specify load balancing policy as bandwidth/latency/load/intelligent policy, with bandwidth being the default policy.

Ruijie(config)# **no mllb policy**	Restore load balancing policy to default setting

Configuration example:

Configure load balancing policy to bandwidth:

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mllb policy bandwidth
```

Configure weight base

This refers to the corresponding weight base for calculating the link weight as per bandwidth, latency and load when intelligent is selected as the load balancing policy. By adjusting the weight base of bandwidth, latency and load, we can change the specific influence of these three factors on the link weight.

Configure the weight base of bandwidth, latency and load according to the following steps.

Command	Function
Ruijie# **configure terminal**	Enter global configuration mode.
Ruijie(config)# **mllb policy intelligent** [**bandwidth** *base1*] [**latency** *base2*] [**load** *base3*] }	Configure the weight bases of bandwidth, latency and load to base1, base2 and base3 respectively (1-100, with 1 being the default value).
Ruijie(config)# **no mllb policy intelligent**	Restore all weight bases to default value.

Configuration example:

Configure load balancing policy to bandwidth, and configure the weight bases of bandwidth, latency and load to 20, 50 and 100 respectively:

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mllb policy intelligent bandwidth 50 latency 20 load 100
```

Note

Weight base will only take effect when load balancing policy is configured to intelligent.

Display Configurations

In privilege mode, execute "show mllbconfig" command to display configurations related to multilink load balancing.

Command	Function

Ruijie (config)# **show mllb config**	Display system configurations, including load balancing configurations.

Configuration example:

In privilege mode, execute "**show running-config**" command to display load balancing configurations:

```
Ruijie# show mllb config
muti-link load balance configure:
muti-link load balance state: enabled
muti-link load balance threshold: 95
muti-link load balance policy: intelligent
     bandwidth weight base = 100
     latency weight base = 100
    load weight base = 100
```

Typical Multilink Load Balancing Configuration Example

Networking Requirements

One 1000M telecom link is connected to interface gigabitEthernet 0/1 of the device, while two CNC links (with bandwidth being 100M and 10M respectively) are connected to interface gigabitEthernet 0/2 and interface gigabitEthernet 0/3 of the device.

Network topology

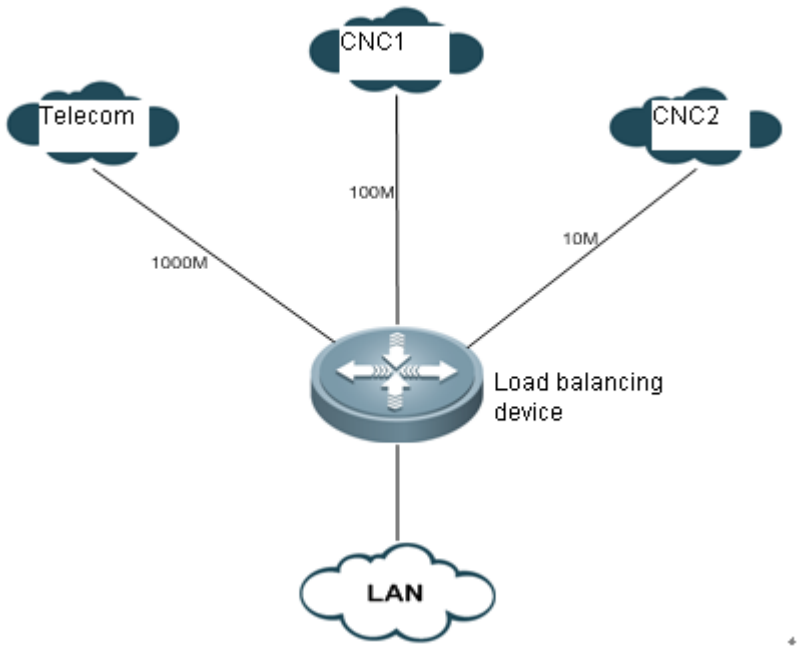


Fig 2 Networking topology of multilink load balancing

Configuration Steps

1) Enable multilink load balancing

Enable global multilink load balancing

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# mllb enable
```

2) Configure link bandwidth

```
Ruijie# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
```

Configure the bandwidth of telecom link

```
Ruijie(config)# interface gigabitEthernet 0/1

Ruijie(config-if)# bandwidth 1000000

Ruijie# exit
```

Configure the bandwidth of CNC link 1

```
Ruijie(config)# interface gigabitEthernet 0/2

Ruijie(config-if)# bandwidth 100000

Ruijie# exit
```

Configure the bandwidth of CNC link 2

```
Ruijie(config)# interface gigabitEthernet 0/3

Ruijie(config-if)# bandwidth 10000

Ruijie# exit
```

3) Configure load balancing policy to bandwidth load balancing

Configure load balancing policy to bandwidth

```
Ruijie(config)#mllb policy bandwidth
```

4) Configure link load threshold

Configure link load threshold to 95

```
Ruijie(config)# mllb threshold 95
```

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IPv6 Configuration

Configuring IPv6

Understanding IPv6

Overview

As the Internet is growing rapidly and the IPv4 address space is exhausting, the limitation of the IPv4 is more obvious. The research and practice of the next generation Internet Protocol (IPng) become popular. Furthermore, the IPng working group of the IETF has determined the protocol specification of IPng referred to as IPv6. See RFC 2460 for details.

Key Features

- More address space

The length of an address is extended to 128 bits from 32 bits of IPv4. Namely, there are 2^128-1 addresses for IPv6. IPv6 adopts hierarchical address mode and supports multiple-level IP address assignment, for example, from the Internet backbone network to the internal subnet of enterprises.

- Simplified format of packet header

The design principle of the new IPv6 packet header is to minimize the overhead. For this reason, some non-critical fields and optional fields are removed from the packet header and placed into the extended packet header. The length of an IPv6 address is 4 times the length of an IPv4 address; the size of the IPv6 packet header is only 2 times the size of the IPv4 packet header. The improved IPv6 packet header is more efficient for forwarding, for example, there is no checksum in the IPv6 packet header and it is not necessary for an IPv6 device to process the fragments during forwarding (the fragments are completed by the originator).

- High-efficient hierarchical addressing and routing structure

IPv6 adopts the aggregation mechanism and defines a flexible hierarchical addressing and routing structure, and several networks at the same level are represented with a unified network prefix at a higher-layer device. So it obviously reduces the routing entries that the device must maintain and greatly minimizes the routing and storage overhead.

- Simple management: plug and play

The management and maintenance of network nodes are simplified by the implementation of a series of auto-discovery and auto-configuration functions. For example, the neighbor discovery, MTU discovery, router advertisement (RA), router solicitation (RS) and auto-configuration technologies provide the related service for plug and play. It should be mentioned that IPv6 supports such address configuration methods as stateful configuration and stateless configuration. In IPv4, the Dynamical Host Configuration Protocol (DHCP) implements the automatic configuration of a host IP address and related configuration, while IPv6 inherits this auto-configuration service of IPv4 and refers to it as the stateful auto-configuration. Furthermore, IPv6 also adopts an auto-configuration service, referred to as stateless auto-configuration. During the stateless auto-configuration, the host obtains the link-local address, the address prefix of the local device and some other related configuration information automatically.

- Security

IPSec is an optional extended protocol of IPv4, but it is only a component of IPv6 used to provide security. At present, IPv6 implements the authentication header (AH) and encapsulated security payload (ESP) mechanisms. The former authenticates the integrity of data and the source of an IP packet to ensure that the packet does come from the node marked by the source address, while the latter provides the data encryption function to implement end-to-end encryption.

- More excellent QoS support

A new field in the IPv6 packet header defines how to identify and process a data flow. The Flow Label field in an IPv6 packet header is used to identify the data flow ID, by which IPv6 allows users to put forward the requirement for the QoS of communication. The device can identify all packets of a specified data flow by this field and provide special processing for these packets as required.

- New protocol for interactions between neighbor nodes

The Neighbor Discovery Protocol of IPv6 uses a series of IPv6 control information messages (ICMPv6) to manage the interactions between neighbor nodes (the nodes on the same link). The Neighbor Discovery Protocol and high-efficient multicast and unicast neighbor discovery messages replace the previous broadcast-based Address Resolution Protocol (ARP) and the ICMPv4 router discovery messages.

- Extensibility

IPv6 provides powerful extensibility and the new features can be added to the extended packet header after the IPv6 packet header. Unlike the IPv4 packet header, the IPv6 packet header can only support the options of up to 40 bytes, while the size of the IPv6 extended packet header is only limited by the maximum number of bytes of the whole IPv6 packet.

IPv6 supports the following features:

- IPv6 protocol
- IPv6 address format
- Type of IPv6 address
- ICMPv6
- IPv6 neighbor discovery
- Path MTU discovery
- ICMPv6 redirection
- Duplicate address detection
- IPv6 stateless auto-configuration
- IPv6 address configuration
- IPv6 route forwarding (supporting static route configuration)
- Configuration of various IPv6 parameters
- Diagnosis tool ping IPv6

IPv6 Address Format

The basic format of an IPv6 address is X : X : X : X : X : X : X : X, where X is a 4-digit hexadecimal integer (16 bits). Each digit contains 4 bits, each integer contains 4 hexadecimal digits, and each address contains 8 integers, so the address includes a total of 128 bits. Some legal IPv6 addresses are as follows:

2001:ABCD:1234:5678:AAAA:BBBB:1200:2100

800 : 0 : 0 :0 : 0 : 0 : 0 : 1

1080 : 0 : 0 : 0 : 8 : 800 : 200C : 417A

These integers are hexadecimal integers, where A to F denote 10 to 15 respectively. Each integer in the address must be denoted and the starting 0 need not be denoted. Some IPv6 addresses may contain a series of 0s (such as the second and third examples). In this case, colons (: :) are allowed to denote this series of 0s. Namely, the address 800:0:0:0:0:0:0:1 can be denoted as: 800 :: 1.

These two colons denote that this address can be extended to a complete 128-bit address. In this way, the 16-bit group can be replaced with two colons only when they are all 0s and the two colons can only be present once.

In the hybrid environment of IPv4 and IPv6, there is a hybrid denotation method. The lowest 32 bits in an IPv6 address can be used to denote an IPv4 address. The address can be expressed in a hybrid mode, that is, X: X : X : X : X : X : d . d . d . d, where, X denotes a 16-bit integer, while d denotes an 8-bit decimal integer. For instance, the address 0 : 0 : 0 : 0 : 0 : 0 : 192 .168 . 20 : 1 is a legal IPv6 address. After the abbreviated expression method is used, this address can be denoted as follows: : : 192.168. 20. 1. One typical example is an IPv4-compatible IPv6 address, which is expressed as “::A.B.C.D”, with the first 96 bits being all 0s, such as “::1.1.1.1”, but this expression method is revoked. Another typical example is an IPv4-mapped IPv6 address, which is expressed as “::FFFF:A.B.C.D” and used to express an IPv4 address as an IPv6 address, that is, map the IPv4 address”1.1.1.1” to the IPv6 address”::FFFF:1.1.1.1”.

Because the IPv6 address is divided into two parts, the subnet prefix and the interface identifier, it can be denoted as an address including an additional numeric value by the method like the CIDR address. This numeric value indicates how many bits represent the network part (the network prefix). Namely the IPv6 node address indicates the length of the prefix, and the length is differentiated from the IPv6 address by a slash. For instance: 12AB::CD30:0:0:0:0/60. The length of the prefix used for routing in this address is 60 bits.

Type of IPv6 Address

RFC 4291 defines three types of IPv6 addresses:

- Unicast: Identifier of a single interface. The packet to be sent to a unicast address will be transmitted to the interface identified by this address.
- Anycast: Identifiers of a set of interfaces. The packet to be sent to an anycast address will be transmitted to one of the interfaces identified by this address (the nearest one is selected according to the routing protocol).
- Multicast: Identifiers of a set of interfaces (In general, these interfaces belong to different nodes). The packet to be sent to a multicast address will be transmitted to all the interfaces that join this multicast address.

Caution The broadcast address is not defined in IPv6.

The following describes these types of addresses one by one.

Unicast Addresses

The unicast addresses are divided into unspecified address, loopback address, link-local address, site-local address and global unicast address. Now the site-local address has been revoked. The unicast addresses excepting the unspecified address, loopback address and link-local address are all global unicast addresses.

1) Unspecified address

The unspecified address is 0:0:0:0:0:0:0:0, generally abbreviated as :: and used for the following purposes.

- If there is no unicast address when a host is started, use the unspecified address as the source address, send an RS, and obtain the prefix information from the gateway to automatically generate the unicast address.
- When configuring an IPv6 address for the host, check whether the IPv6 address conflicts with the address of any other host in the same network segment or not. If so, use the unspecified address as the source address to send a neighbor solicitation (NS) message, same as free ARP.

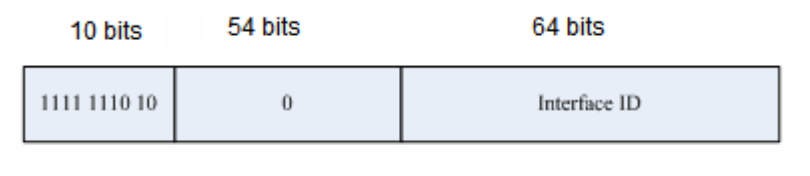
2) Loopback address

The loopback address is 0:0:0:0:0:0:0:1, abbreviated as ::1, which is equal to the IPv4 address 127.0.0.1 and used when the node sends the packets to itself.

3) Link–local address

The format of link-local address:

Figure 1

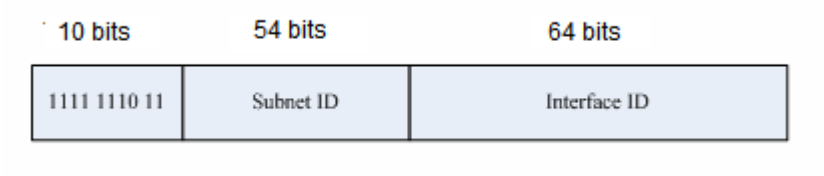


The link-local address is used to number the host on the single network link. The address identified by the first 10 bits of the prefix is the link-local address. The device will never forward the packet of the source address or the destination address with the link-local address. The intermediate 54 bits are all 0s. The last 64 bits indicate the interface identifier, and this part allows the single network to connect up to 2^{64}-1 hosts.

4) Site-local address

The format of site-local address:

Figure 2

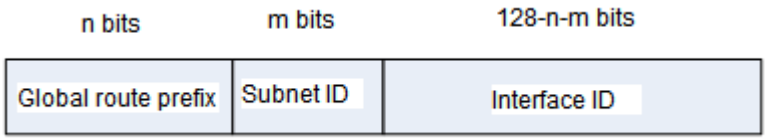


The site-local address can be used to transmit data within the site, and the device will not forward the packet of the source address or the destination address with the site-local address to the Internet. Namely, such packet can only be forwarded within the site, but cannot be forwarded out of the site. The site may be deemed as the LAN of a company, and the site-local address is similar to a private IPv4 address, for example, 192.168.0.0/16. RFC 3879 has revoked the site-local address. In new implementations, this prefix is no longer supported and is uniformly deemed as a global unicast address. In existing implementations and deployments, this prefix may be still used.

5) Global unicast address

The format of global unicast address:

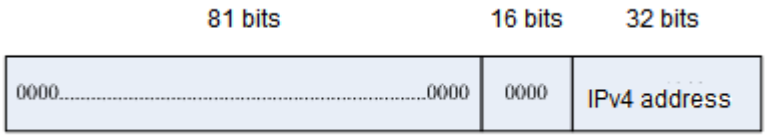
Figure 3



One class of the global unicast address is the IPv6 address embedded with an IPv4 address, which is used to interconnect the IPv4 nodes and the IPv6 nodes and divided into IPv4-compatible IPv6 address and IPv4-mapped IPv6 address.

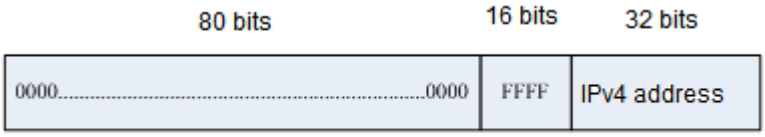
The format of IPv4-compatible IPv6 address:

Figure 4



The format of IPv4-mapped IPv6 address:

Figure 5



The IPv4-compatible IPv6 address is mainly used for automatic tunneling, which supports both IPv4 and IPv6. The IPv4-compatible IPv6 address is used to transmit an IPv6 packet via an IPv4 device in the tunneling way. Now the IPv4-compatible IPv6 address has been revoked. The IPv4-mapped IPv6 address is used by IPv6 nodes to access the nodes that only support IPv4. For example, when one IPv6 application of the IPv4/IPv6 host requests the resolution of a host name (the host only supports IPv4), the name server will internally generate an IPv4-mapped IPv6 address dynamically and return it to the IPv6 application.

Multicast Addresses

The format of the IPv6 multicast address is as follows:

| 8 | 4 | 4 | 112 bits |

+----------+----+----+----------+

|11111111|flgs|scop| group ID |

+----------+----+----+----------+

The first byte of the address format is all 1s, which denote a multicast address.

- Flag field:

It consists of 4 bits. At present, only the fourth bit is specified. The bit is used to indicate whether the address is a known multicast address specified by the Internet Assigned Numbers Authority (IANA) or a temporary multicast address used on a specific occasion. If this flag bit is 0, it indicates this address is a known multicast address. If this bit is 1, it indicates that this address is a temporary one. Other 3 flag bits are reserved for future use.

- Range field:

The Range field is composed of 4 bits and used to denote the range of multicast, namely, whether the multicast group contains the local node, the local link and the local site or nodes in any positions in the IPv6 global address space.

- Group ID field:

This field is 112 bits long and used to identify a multicast group. Depending on whether a multicast address is temporary or known and the range of the address, a multicast identifier can denote different groups.

The multicast address of IPv6 is this type of address using FF00::/8 as the prefix. One multicast address of IPv6 usually identifies the interfaces of a serial of different nodes. When one packet is sent to one multicast address, this packet will be distributed to the interfaces of each node with this multicast address. One node (host or device) should join the following multicast addresses:

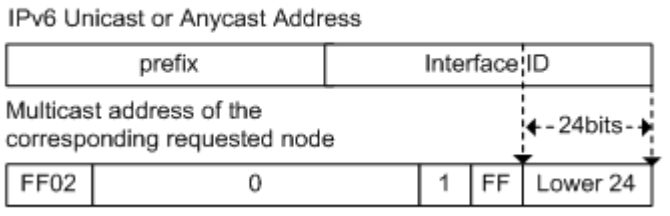
- The multicast address of all nodes on the local link, that is, FF02::1
- The multicast address of the solicited node, with the prefix of FF02:0:0:0:0:1:FF00:0000/104

For the device, it is necessary to join the multicast address FF02::2 of all devices on the local link.

If the multicast address of the solicited node corresponds to the IPv6 unicast and anycast address, it is necessary for the IPv6 node to join the corresponding multicast address of the solicited node for each configured unicast address and anycast address. The prefix of the multicast address of the solicited node is FF02:0:0:0:0:1:FF00:0000/104, another 24 bits are comprised of the unicast address or the lower 24 bits of the anycast address, for example, the multicast address of the solicited node corresponding to the unicast address FE80::2AA:FF:FE21:1234 is FF02::1:FF21:1234.

The multicast address of the solicited node is usually used in an NS message. The format of the solicited node is as follows:

Figure 6



Anycast Addresses

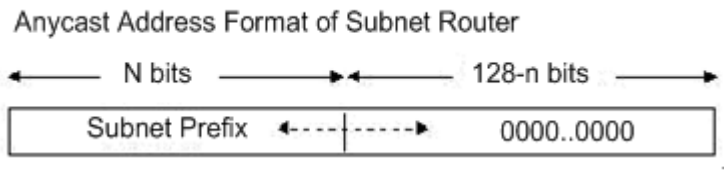
The anycast address is similar to the multicast address as more than one node shares an anycast address. The difference is that only one node expects to receive the data packet of the anycast address, while all nodes of the multicast group members expect to receive all packets sent to this address. The anycast address is assigned to the normal IPv6 unicast address space, so the anycast address cannot be differentiated from the unicast address from the style. For this reason, each member of an anycast group represented by an anycast address must be configured explicitly to identify the anycast address.

Caution The anycast address can only be assigned to the device, but cannot be assigned to the host. Furthermore, the anycast address cannot be used as the source address of the packet.

RFC 2373 predefines an anycast address, referred to as the anycast address of a subnet router. The following figure shows the anycast address format of the subnet router, which consists of the subnet prefix followed by a series of 0s (as the interface identifier).

The subnet prefix identifies a specified link (subnet) and the packet to be sent to the anycast address of the subnet router will be distributed to a device of this subnet. The anycast address of the subnet router is usually used for a node which needs to communicate with one device of a remote subnet.

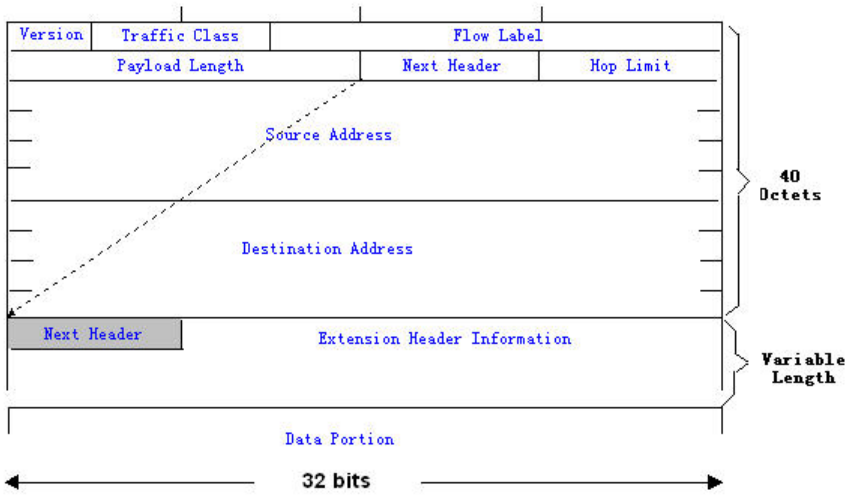
Figure 7



IPv6 Packet Header Structure

The format of the IPv6 packet header is shown in the following figure.

Figure 8



In IPv4, the packet header is measured in units of 4 bytes; in IPv6, the packet header is measured in units of 8 bytes, and the total size of the packet header is 40 bytes. In the IPv6 packet header, the following fields are defined:

- Version:

The length is 4 bits. For IPv6, the field must be 6.

- Traffic Class:

The length is 8 bits. It indicates a type of service provided to the packet and is equal to the “TOS” in IPv4.

- Flow Label:

The length is 20 bits. This field is used to identify the packets of the same service flow. One node can be used as the source of several service flows. The flow label and source node IP address identify a service flow uniquely.

- Payload Length:

The length is 16 bits, including the byte length of the payload and the length of various IPv6 extension options (if any). In other words, it includes the length of an IPv6 packet except for the IPv6 header.

- Next Header:

This field indicates the protocol type in the header field following the IPv6 header. Similar to the IPv4 protocol field, the Next Header field can be used to indicate whether the upper layer protocol is TCP or UDP. It can also be used to indicate whether an extended IPv6 header exists.

- Hop Limit:

The length is 8 bits. When the device forwards the packet for one time, the value of this field will decrease by 1. When the value of this field is 0, this packet will be discarded. It is similar to the lifetime field in the IPv4 packet header.

- Source Address:

The length is 128 bits. It indicates the sender address of an IPv6 packet.

- Destination Address:

The length is 128 bits. It indicates the receiver address of an IPv6 packet.

At present, the following extended headers are defined in IPv6:

- Hop-by-Hop Options:

This extended header must immediately follow an IPv6 header. It contains the option data that must be checked by each node along the path.

- Routing Header (Routing (Type 0)):

This extended header indicates the nodes that a packet will go through before reaching the destination. It contains the addresses of various nodes that the packet goes through. The initial destination address of the IPv6 header is the first one of a series of addresses in the routing header, other than the final destination address of the packet. After receiving this packet, the node of this address will process the IPv6 header and the routing header, and send the packet to the second address in the routing header. This process continues until the packet reaches the final destination.

- Fragment:

This extended header is used to fragment the packets longer than the MTU of the path between the source node and destination node.

- Destination Options:

This extended header replaces the IPv4 option field. At present, the only defined destination option is an option to be filled with an integral multiple of 64 bits (8 bytes) when necessary. This extended header can be used to carry the information checked by the destination node.

- Upper-layer header:

It indicates the upper layer transmission protocol, such as TCP(6) and UDP(17).

Furthermore, the extended header of Authentication and Encapsulating Security Payload will be described in the IPSec section. At present, the IPv6 implemented by the device does not support IPSec.

IPv6 Path MTU Discovery

Similar to the path MTU discovery of IPv4, the path MTU discovery of IPv6 allows one host to discover and adjust the size of the MTU in the data transmission path.

Furthermore, when the data packet to be sent is larger than the MTU of the data transmission path, the host will fragment the packet by itself. This behavior makes it not necessary for the device to process the fragment, and thus save resources and improve the efficiency of the IPv6 network.

Caution The minimum link MTU is 68 bytes in IPv4, indicating that the links along the path over which the packets are transmitted should support at least the link MTU of 68 bytes. The minimum link MTU is 1280 bytes in IPv6. It is strongly recommended that the link MTU of 1500 bytes should be used for the link in IPv6.

IPv6 Neighbor Discovery

The main functions of the IPv6 Neighbor Discovery Protocol include router discovery, prefix discovery, parameter discovery, address auto-configuration, address resolution (ARP), next-hop determination, neighbor unreachability detection, duplicate address detection, and redirection. Neighbor discovery defines 5 types of ICMP messages, which are router solicitation (ICMP type133), RA (ICMP type134), NS or ARP request (ICMP type135), neighbor advertisement or APR response (ICMP type136) and ICMP redirection message (ICMP type137).

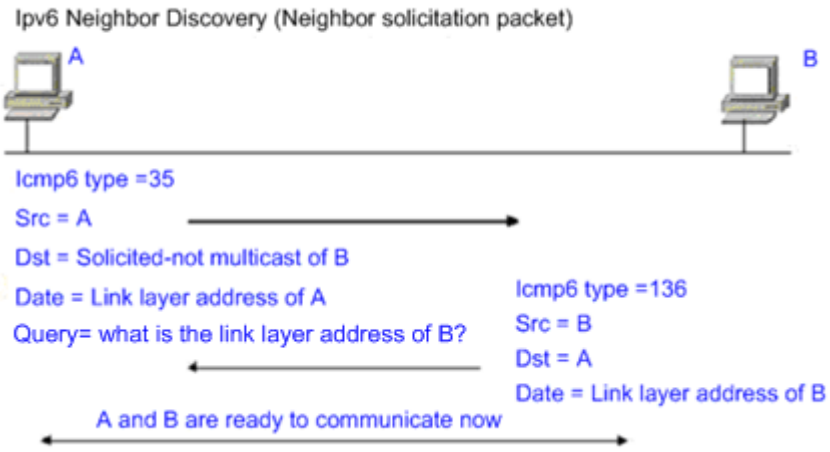
The following describes the neighbor discovery function in detail:

Address Resolution

A node must obtain the link layer address of another node before communicating with it. At this time, the node should send an NS message to the solicited multicast address, that is, the IPv6 address of the destination node. The NS message also contains the link layer address of itself. After receiving this NS message, the destination node responds with a message, referred to as neighbor advertisement (NA), with its link layer address. After receiving the response message, the source node can communicate with the destination node.

The following is the address resolution procedure:

Figure 9



Neighbor Unreachability Detection

When the reachable time of a neighbor expires, neighbor unreachability detection is performed if an IPv6 unicast packet needs to be sent to this neighbor.

Neighbor unreachability detection and sending the IPv6 packet to the neighbor can be performed concurrently. During the detection, the device continues to forward the IPv6 packet to the neighbor.

Duplicate Address Detection

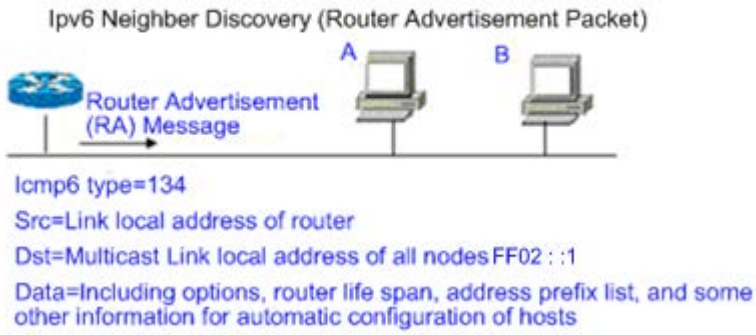
After an IPv6 address is configured for the host, duplicate address detection may be performed to know whether the IPv6 address is unique on the link, by sending an NS message with the source IPv6 address being an unspecified address.

Router, Prefix and Parameter Discovery

The router sends an RA to all the local nodes of the link periodically.

The following figure shows the process of sending the RA.

Figure 10



In general, the RA contains the following contents:

- One or more IPv6 address prefixes used for the on-link determination or the stateless address auto-configuration.
- Effective period of the IPv6 address prefix.
- Host auto-configuration mode (stateful or stateless).

- Information for the default device (namely, the device determines whether it is used as the default device. If yes, it will announce the time to act as the default device).
- Other information for host configuration such as the hop limit, the MTU and the NS retransmission interval.

The RA is also used to respond to the RS message sent by the host. The RS message allows the host to obtain the auto-configuration information immediately without waiting for the device to send the RA. If there is no unicast address when the host is started, the RS message sent by the host will use the unspecified address (0:0:0:0:0:0:0:0) as the source address of the RS message. Otherwise, the existing unicast address is used as the source address, while the RS message uses the multicast address (FF02::2) of all devices on the local link as the destination address. The RA message, in response to the RS message, will use the source address of the RS message as the destination address (if the source address is the unspecified address, it will use the multicast address FF02::1) of all nodes on the local link.

The following parameters can be configured in the RA message.

Ra-interval: interval for sending the RA

Ra-lifetime: router lifetime, namely, whether the device acts as the default router of the local link and the time to act this role

Prefix: IPv6 address prefix of the local link, which can be used for the on-link determination or the stateless address auto-configuration, including the configuration of other parameters for the prefix

Rs-initerval: interval for sending the NS message

Reachabletime: time maintained after the neighbor is considered reachable

The above parameters are configured in the IPv6 interface properties.

Caution

1. No RA message is sent actively on the interface by default. To allow the device to send the RA message, you can use the **no ipv6 nd suppress-ra** command in interface configuration mode.
2. In order to enable normal stateless address auto-configuration of the node, the length of the prefix for the RA message should be 64 bits.

Redirection

After receiving the IPv6 packets, the router discovers an optimal next hop and sends an ICMP redirection message to notify the host of the optimal next hop. Next time the host sends the IPv6 packets to the optimal next hop directly.

Configuring IPv6

The following will describe the configuration of various functional modules of IPv6 respectively.

Configuring an IPv6 Address

This section describes how to configure an IPv6 address on an interface. No IPv6 address is configured by default.

Caution

Once an interface is created and its link state is UP, the system will automatically generate the link-local address for the interface. At present, IPv6 does not support anycast address.

For S57 and S76 series, the range of the length of the prefix of the interface IPv6 address is [0, 64] or [128, 128], because the range of the length of the routing prefix supported by the hardware forwarding table of the chip is [0, 64] or [128, 128]. For S86 and S96 series, the range of the length of the prefix of the interface IPv6 address is not limited, but the total number of IPv6 routes within the range [65, 127] of the length of the routing prefix supported by switches is 512.

To configure an IPv6 address, use the following commands.

Command	Function
Ruijie#**configure terminal**	Enters global configuration mode.
Ruijie(config)#**interface** *interface-id*	Enters interface configuration mode. Note that the **no switchport** command must be used to switch the layer-2 interface to the layer-3 interface.
Ruijie(config-if)#**ipv6 enable**	Enables the IPv6 protocol on an interface. If this command is not run, the system automatically enables the IPv6 protocol when you configure an IPv6 address for an interface.
Ruijie(config-if)#**ipv6 address** *ipv6-address/prefix-length* Ruijie(config-if)#**ipv6 address** *ipv6-prefix/prefix-length* [**eui-64**]	Configures an IPv6 unicast address for this interface. When the command includes the keyword **Eui-64**, only the prefix must be specified, and the interface ID is automatically generated in the EUI-64 format. The generated IPv6 address consists of the configured address prefix and the 64-bit interface ID. Note: Whether the keyword **eui-64** is used, it is necessary to enter the complete address format to delete an IPv6 address (prefix + interface ID or prefix length). When you configure an IPv6 address on an interface, the IPv6 protocol is automatically enabled on the interface. Even if you use **no ipv6 enable**, you cannot disable the IPv6 protocol.
Ruijie(config-if)#**end**	Returns to privileged EXEC mode.
Ruijie#show **ipv6 interface** *interface-id*	Displays the IPv6 interface information.
Ruijie#copy **running-config startup-config**	Saves the configuration.

To delete the configured IPv6 address, use the **no ipv6 address** *ipv6-prefix/prefix-length* **[eui-64]** command.

The following example configures an IPv6 address.

```
Ruijie(config)# interface GigabitEthernet 0/1
Ruijie(config-if)# ipv6 enable
Ruijie(config-if)# ipv6 address fec0:0:0:1::1/64
Ruijie(config-if)# end
Ruijie(config-if)# show ipv6 interface GigabitEthernet 0/1
Interface GigabitEthernet 0/1 is Up, ifindex: 1
address(es):
Mac Address: 00:00:00:00:00:01
INET6: fe80::200:ff:fe00:1 , subnet is fe80::/64
```

```
INET6: fec0:0:0:1::1 , subnet is fec0:0:0:1::/64
Joined group address(es):
ff01:1::1
ff02:1::1
ff02:1::2
ff02:1::1:ff00:1
MTU is 1500 bytes
ICMP error messages limited to one every 100 milliseconds
ICMP redirects are enabled
ND DAD is enabled, number of DAD attempts: 1
ND reachable time is 30000 milliseconds
ND advertised reachable time is 0 milliseconds
ND retransmit interval is 1000 milliseconds
ND advertised retransmit interval is 0 milliseconds
ND router advertisements are sent every 200 seconds<160--240>
ND router advertisements live for 1800 seconds
```

Configuring ICMPv6 Redirection

This section describes how to configure the ICMPv6 redirection function on the interface. The redirection function of the IPv6 on the interface is enabled by default. The device needs to send a redirection message to the initiator during packet forwarding in the following cases:

- The destination address of the message is not a multicast address.
- The destination address of the message is not the device itself.
- The output interface of the next hop determined by the device for this message is the same as the interface that receives this message, namely, the next hop and the initiator are on the same link.
- The node identified by the source IP address of the packet is a neighbor of the local device. Namely, this node exists in the device's neighbor table.

Caution The device other than the host can generate the redirection message, and the device will not update its routing table when it receives the redirection message.

To enable redirection on the interface, use the following commands.

Command	Function
Ruijie#**configure terminal**	Enters global configuration mode.
Ruijie(config)#**interface** *interface-id*	Enters interface configuration mode. Note that the **no switchport** command must be used to switch the layer-2 interface to the layer-3 interface.
Ruijie(config-if)#**ipv6 redirects**	Enables the IPv6 redirection function.
Ruijie(config-if)#**end**	Returns to privileged EXEC mode.
Ruijie#**show ipv6 interface** *interface-id*	Displays the interface configuration information.
Ruijie#**copy running-config startup-config**	Saves the configuration.

To disable the redirection function, use the **no ipv6 redirects** command.

The example configures the redirection function.

```
Ruijie(config)# interface GigabitEthernet 0/1
Ruijie (config-if)# ipv6 redirects
Ruijie (config-if)# end
Ruijie # show ipv6 interface GigabitEthernet 0/1
Interface GigabitEthernet 0/1 is Up, ifindex: 1
address(es):
Mac Address: 00:d0:f8:00:00:01
INET6: fe80::2d0:f8ff:fe00:1 , subnet is fe80::/64
INET6: fec0:0:0:1::1 , subnet is fec0:0:0:1::/64
Joined group address(es):
ff01:1::1
ff02:1::1
ff02:1::2
ff02:1::1:ff00:1
MTU is 1500 bytes
ICMP error messages limited to one every 10 milliseconds
ICMP redirects are enabled
ND DAD is enabled, number of DAD attempts: 1
ND reachable time is 30000 milliseconds
ND advertised reachable time is 0 milliseconds
ND retransmit interval is 1000 milliseconds
ND advertised retransmit interval is 0 milliseconds
ND router advertisements are sent every 200 seconds<160--240>
ND router advertisements live for 1800 seconds
```

Configuring a Static Neighbor

This section describes how to configure a static neighbor. No static neighbor is configured by default. In general, a neighbor learns and maintains its status by the Neighbor Discovery Protocol (NDP) dynamically. Moreover, you can configure the static neighbor manually.

To configure the static neighbor, use the following commands.

Command	Function
Ruijie#**configure terminal**	Enters global configuration mode.
Ruijie(config)#**ipv6 neighbor** *ipv6-address interface-id hardware-address*	Configure a static neighbor on the interface.
Ruijie(config)#**end**	Returns to privileged EXEC mode.
Ruijie#**show ipv6 neighbors**	View the neighbor list.
Ruijie#**copy running-config startup-config**	Saves the configuration.

To delete the specified neighbor, use the **no ipv6 neighbor** *ipv6-address interface-id* command.

The following example configures a static neighbor on the GigabitEthernet 0/1 interface.

```
Ruijie(config)# ipv6 neighbor fec0:0:0:1::100 GigabitEthernet 0/1 00d0.f811.1234
Ruijie (config)# end
```

```
Ruijie# show ipv6 neighbors verbose fec0:0:0:1::100
IPv6 Address       Linklayer Addr   Interface
fec0:0:0:1::100    00d0.f811.1234   GigabitEthernet 0/1
State: REACH/H Age: - asked: 0
```

Caution

When you configure a static neighbor, the configuration takes effect only when the neighbor prefix matches the interface. Specifically, the configured static neighbor prefix belongs to the network segment of an address configured for the interface, and does not conflict with the address. An invalid static neighbor is in the inactive state. Data sent to the destination is not sent to the MAC address specified by the static neighbor, but the MAC address is learned based on routes in dynamic learning mode. To view the validity status of a static neighbor, run the **show ipv6 neighbor static** command.

Configuring Duplicate Address Detection

This section describes how to configure duplicate address detection times. Duplicate address detection is mandatory to assign unicast addresses to interfaces. The purpose is to detect the uniqueness of an address. Duplicate address detection should be performed for addresses that are configured in manual configuration mode, stateless auto-configuration mode, and stateful auto-configuration mode. However, it is not necessary to perform duplicate address detection under the following two conditions:

- The management prohibits the duplicate address detection, namely, the number of the NS messages sent for the duplicate address detection is set to 0.
- Duplicate address detection cannot be performed for a configured anycast address.

Furthermore, if the duplicate address detection function is not disabled on the interface, the system will restart the duplicate address detection process for the configured address when the interface changes to the Up state from the Down state.

To configure the number of NS messages sent for duplicate address detection, use the following commands.

Command	Function
Ruijie#**configure terminal**	Enters global configuration mode.
Ruijie(config)#**interface** *interface-id*	Enters interface configuration mode. Note that the **no switchport** command must be used to switch the layer-2 interface to the layer-3 interface.
Ruijie(config-if)#**ipv6 nd dad attempts** *attempts*	Configures the number of NS messages sent for duplicate address detection. When it is set to 0, the duplicate address detection function is disabled on the interface.
Ruijie(config-if)#**end**	Returns to privileged EXEC mode.
Ruijie#**show ipv6 interface vlan** *1*	Displays the IPv6 information on the interface.
Ruijie#**copy running-config startup-config**	Saves the configuration.

To restore the default value, use the **no ipv6 nd dad attempts** command.

The following example configures the number of NS messages sent for duplicate address detection on the SVI1.

```
Ruijie(config)# interface GigabitEthernet 0/1
Ruijie(config-if)# ipv6 nd dad attempts 3
Ruijie(config-if)# end
Ruijie# show ipv6 interface GigabitEthernet 0/1
Ruijie(config)# interface vlan 1
Ruijie(config-if)# ipv6 nd dad attempts 3
Ruijie(config-if)# end
Ruijie# show ipv6 interface vlan 1
Interface GigabitEthernet 0/1 is Up, ifindex: 1
address(es):
Mac Address: 00:d0:f8:00:00:01
INET6: fe80::2d0:f8ff:fe00:1 , subnet is fe80::/64
INET6: fec0:0:0:1::1 , subnet is fec0:0:0:1::/64
Joined group address(es):
ff01:1::1
ff02:1::1
ff02:1::2
ff02:1::1:ff00:1
MTU is 1500 bytes
ICMP error messages limited to one every 10 milliseconds
ICMP redirects are enabled
ND DAD is enabled, number of DAD attempts: 3
ND reachable time is 30000 milliseconds
ND advertised reachable time is 0 milliseconds
ND retransmit interval is 1000 milliseconds
ND advertised retransmit interval is 0 milliseconds
ND router advertisements are sent every 200 seconds<160--240>
ND router advertisements live for 1800 seconds
```

Configuring Other Interface Parameters

The IPv6 parameters on an interface are divided into two parts. One is used to control the behavior of the device itself, and the other is used to control the contents of the RA sent by the device to determine what action should be taken by the host when the host receives this RA.

The following table describes these commands.

Command	Function
Ruijie#**configure terminal**	Enters global configuration mode.
Ruijie(config)#**interface** *interface-id*	Enters interface configuration mode. Note that the **no switchport** command must be used to switch the layer-2 interface to the layer-3 interface.
Ruijie(config-if)#**ipv6 enable**	Enables the IPv6 function.
Ruijie(config-if)#**ipv6 nd ns-interval** *milliseconds*	(Optional) Defines the retransmission interval of the NS message, in milliseconds. The default value is 1000 milliseconds.
Ruijie(config-if)#**ipv6 nd reachable-time** *milliseconds*	(Optional) Defines the time during which the neighbor is considered as reachable, in milliseconds. The default value is 30000

Command	Function
	milliseconds.
Ruijie(config-if)# **ipv6 nd prefix** {*ipv6-prefix*/*prefix-length* | **default**} [[*valid-lifetime preferred-lifetime*] | [**at** *valid-date preferred-date*] | [**infinite** {**infinite** | *preferred-lifetime*}]] [**no-advertise**] | [[**off-link**] [**no-autoconfig**]]	(Optional) Sets the address prefix to be advertised in the RA message.
Ruijie(config-if)#**ipv6 nd ra-lifetime** *seconds*	(Optional) Sets the lifetime of the router in the RA message, namely, the time to act as the default device. The value 0 indicates that the device will not act as the default device of the directly-connected network. The default value is 1800 seconds.
Ruijie(config-if)#**ipv6 nd ra-interval** {*seconds* **min-max** *min_value max_value*}	(Optional) Sets the time interval for the device to send the RA message periodically, in seconds. The default value is 200 seconds. With **min-max** specified, the actual interval for sending the RA message is a random value between the minimum value and the maximum value. Without **min-max** specified, the actual interval for sending the RA message is the configured value multiplied by 1.2 or 0.8.
Ruijie(config-if)#**ipv6 nd managed-config-flag**	(Optional) Sets the **managed address configuration** flag bit of the RA message, and determines whether the host receiving the RA message will use the stateful auto-configuration to obtain the address. The flag bit is not configured for the RA message by default.
Ruijie(config-if)#**ipv6 nd other-config-flag**	(Optional) Sets the **other stateful configuration** flag bit of the RA message, and determines whether the host receiving the RA message will use the stateful auto-configuration to obtain information other than the address. The flag bit is not configured for the RA message by default.
Ruijie(config-if)#**ipv6 nd suppress-ra**	(Optional) Sets whether to suppress the RA message on this interface. The flag bit is not configured for the RA message by default.
Ruijie(config-if)#**end**	Returns to privileged EXEC mode.
Ruijie#**show ipv6 interface** [*interface-id*] [**ra-info**]	Displays the IPv6 information or the information of the RA sent by this interface.
Ruijie#**copy running-config startup-config**	(Optional) Saves the configuration.

To restore the default value, use the **no** commands of above commands. For details, see the *IPv6 Command Reference*.

Monitoring and Maintaining IPv6

Use the following commands to display some internal information of the IPv6 protocol, such as the IPv6 information, the neighbor table, and the routing table information of an interface.

Command	Function

show ipv6 interface [*interface-id*] [**ra-info**]	Displays the IPv6 information of the interface.
Show ipv6 neighbors [vrf *vrf-name***]** [**verbose**] [*interface-id*] [*ipv6-address*]	Displays the neighbor information.
Show ipv6 route [vrf *vrf-name***]** [**static** | **local | connected | bgp | rip | ospf | isis**]	Displays the information of the IPv6 routing table.

- Display the IPv6 information of an interface.

```
Ruijie# show ipv6 interface
interface GigabitEthernet 0/1 is Down, ifindex: 1
address(es):
Mac Address: 00:d0:f8:00:00:01
INET6: fe80::2d0:f8ff:fe00:1 , subnet is fe80::/64
INET6: fec0:1:1:1::1 , subnet is fec0:1:1:1::/64
Joined group address(es):
ff01:1::1
ff02:1::1
ff02:1::2
ff02:1::1:ff00:1
MTU is 1500 bytes
ICMP error messages limited to one every 10 milliseconds
ICMP redirects are enabled
ND DAD is enabled, number of DAD attempts: 1
ND reachable time is 30000 milliseconds
ND advertised reachable time is 0 milliseconds
ND retransmit interval is 1000 milliseconds
ND advertised retransmit interval is 0 milliseconds
ND router advertisements are sent every 200 seconds<160--240>
ND router advertisements live for 1800 seconds
```

- Display the information of the RA message to be sent on an interface.

```
Ruijie# show ipv6 interface ra-info
GigabitEthernet 0/1: DOWN
RA timer is stopped
waits: 0, initcount: 3
statistics: RA(out/in/inconsistent): 4/0/0, RS(input): 0
Link-layer address: 00:00:00:00:00:01
Physical MTU: 1500
ND router advertisements live for 1800 seconds
ND router advertisements are sent every 200 seconds<160--240>
Flags: !M!O, Adv MTU: 1500
ND advertised reachable time is 0 milliseconds
ND advertised retransmit time is 0 milliseconds
ND advertised CurHopLimit is 64
Prefixes: (total: 1)
fec0:1:1:1::/64(Def, Auto, vltime: 2592000, pltime: 604800, flags: LA)
```

- Display the neighbor table information of IPv6.

```
Ruijie# show ipv6 neighbors
IPv6 Address               Linklayer Addr  Interface
```

```
fe80::200:ff:fe00:1      0000.0000.0001 GigabitEthernet 0/1
State: REACH/H Age: - asked: 0
fec0:1:1:1::1          0000.0000.0001 GigabitEthernet 0/1 State: REACH/H Age: - asked: 0
```

Configuring IPv6 Tunnels

Overview

IPv6 is designed to inherit and replace IPv4. However, the evolution from IPv4 to IPv6 is a gradual process. Therefore, it is inevitable that these two protocols coexist for a period before IPv6 completely replaces IPv4. At the beginning of this transition stage, IPv4 networks are still main networks. IPv6 networks are similar to isolated islands in IPv4 networks. The problems about transition can be divided into the following two types:

1) Communication among isolated IPv6 networks via IPv4 networks
2) Communication between IPv6 networks and IPv4 networks

This article discusses the tunnel technology that is used to solve problem 1. The solution to problem 2 is Network Address Translation-Protocol Translation (NAT-PT), which is not covered in this article.

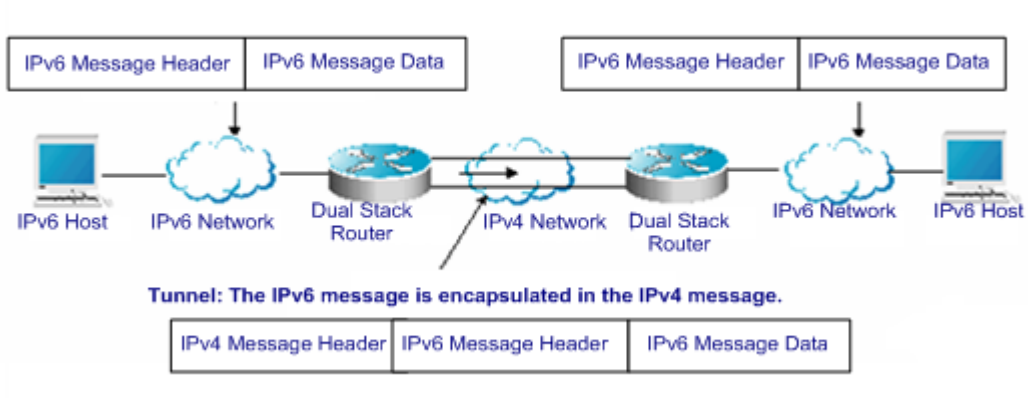
The IPv6 tunnel technology encapsulates IPv6 packets in IPv4 packets. In this way, IPv6 packets can communicate via IPv4 networks. Therefore, with the IPv6 tunnel technology, isolated IPv6 networks can communicate with each other via existing IPv4 networks, avoiding any modification and upgrade to existing IPv4 networks. An IPv6 tunnel can be configured between area border routers (ABRs) or between an ABR and a host. However, all the nodes at the two ends of the tunnel must support the IPv4 and IPv6 protocol stacks. At present, the following tunnel technologies are supported.

Tunnel Type	Reference
Manually Config Tunnel	RFC 2893
Automatic 6to4 Tunnel	RFC 3056
Intra-Site Automatic Tunnel Addressing Protocol(ISATAP)	draft-ietf-ngtrans-isatap-22


Caution Interconnecting the isolated IPv6 networks through the IPv6 tunnel technology is not the ultimate IPv6 network architecture. Instead, it is a transitional technology.

The model using the tunnel technology is shown in the following figure:

Figure 11



The features of various tunnels are respectively described below.

Manually Configured IPv6 Tunnel

One manually configured tunnel is similar to one permanent link set up between two IPv6 domains via the IPv4 backbone network. It is applicable to the relatively fixed connections that have a higher requirement on security between two ABRs or between an ABR and a host.

On a tunnel interface, you must manually configure the IPv6 address, source IPv4 address (tunnel source) and destination IPv4 address (tunnel destination) of the tunnel. The nodes at the two ends of the tunnel must support the IPv6 and IPv4 protocol stacks. In practical applications, tunnels are always manually configured in pairs. You can think it as a point-to-point tunnel.

Configuring GRE Tunnel

A GRE tunnel allows a user to use a transport protocol (such as IP) to transmit network packets of any protocol. Our products support four types of GRE tunnels: IPv4 over IPv4, IPv6 over IPv4, IPv6 over IPv6, and IPv4 over IPv6.

On the tunnel interface, the IP address of the tunnel source and the IP address of the tunnel destination must be configured manually, and nodes at both ends of the tunnel must support IPv6 and IPv4 protocol stacks. The GRE tunnel is always configured simultaneously on two edge devices, and can be considered as a point-to-point tunnel.

Note

1. IPv4 over IPv6 GRE tunnel and IPv6 over IPv6 GRE tunnel are evaluation indicators.
2. IPv4 over IPv4 GRE is an evaluation indicator on the switch.
3. IPv6 over IPv4 GRE is an evaluation indicator on S5750 series switches.

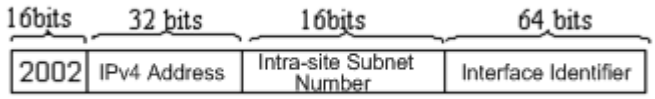
Configuring Automatic 6to4 Tunnel

The automatic 6to4 tunnel technology allows isolated IPv6 networks to be interconnected via IPv4 networks. The difference between the automatic 6to4 tunnel and manually configured tunnel technologies is that the manual configured tunnel is a point-to-point tunnel, while a 6to4 tunnel is a point -to-multipoint tunnel.

The 6to4 tunnel uses an IPv4 network as a nonbroadcast multi-access (NBMA) link. Therefore, the devices of 6to4 need not be configured in pairs. The IPv4 address embedded in an IPv6 address will be used to look for the other end of the

automatic tunnel. The 6to4 tunnel can be deemed as a point -to-multipoint tunnel. The automatic 6to4 tunnel can be configured on an ABR of one isolated IPv6 network. For each packet, it will automatically set up a tunnel to an ABR in another IPv6 network. The destination address of the tunnel is the IPv4 address of an ABR in the IPv6 network at the other end. The IPv4 address will be extracted from the destination IPv6 address of the packet. The destination IPv6 address begins with the prefix 2002::/16 in the following format.

Figure 12



IPv6 6to4 Address Format

The 6to4 address is an address for the automatic 6to4 tunnel technology. The IPv4 address embedded in it is usually the global IPv4 address of the egress of the ABR of the site. When the automatic tunnel is set up, the address is used as the destination IPv4 address for tunnel packet encapsulation. All the routers at the two ends of the 6ot4 tunnel must support the IPv6 and IPv4 protocol stacks. A 6to4 tunnel is usually configured between ABRs.

For example, if the global IPv4 address of the egress of the ABR of the site is 211.1.1.1 (D301:0101 in hexadecimal notation), a subnet number in the site is 1 and the interface identifier is 2e0:ddff:fee0:e0e1, then the corresponding 6to4 address can be denoted as follows:

2002: D301:0101:1: 2e0:ddff:fee0:e0e1

Caution The IPv4 address embedded in the 6to4 address cannot be a private IPv4 address (i.e., the address of the network interface segment 10.0.0.0/8, 172.16.0.0/12 or 192.168.0.0/16) and must be the global IPv4 address.

Common application models of 6to4 tunnels:

- Simple application models

The simplest and most common application of 6to4 tunnels is used to interconnect multiple IPv6 sites. Each of the sites must have one connection to one of their shared IPv4 networks at least. This IPv4 network can be the Internet or a internal backbone network of an organization. The key is that each site must have a unique global IPv4 address. The 6to4 tunnel will use the address to form the IPv6 prefix of 6to4/48: 2002:IPV4 address/48.

- Hybrid application models

Based on the application described above, other 6to4 networks access the IPv6-only network through 6to4 relay devices at the edge. The router used to implement the function is called a 6to4 relay router.

Configuring ISATAP Automatic Tunnel

The Intra-site Automatic Tunnel Addressing Protocol (ISATAP) is a type of IPv6 tunnel technology by which an intra-site IPv6 architecture uses an IPv4 network as one nonbroadcast multi-access (NBMA) link layer, namely, using an IPv4 network as the virtual link layer of IPv6.

ISATAP is applicable to the case where the IPv6-only network inside a site is not ready for use yet and an IPv6 packet needs to be transferred internally in the site. For example, a few IPv6 hosts for test need to communicate with each other inside the site. By using an ISATAP tunnel, the IPv4/IPv6 dual stack hosts on a same virtual link can communicate with each other inside the site.

At the ISATAP site, the ISATAP device provides a standard router advertisement message, allowing the ISATAP host to be automatically configured inside the site. At the same time, the ISATAP device forwards the packets between an intra-site ISATAP host and an external IPv6 host.

The IPv6 address prefix used by ISATAP can be any legal 64-bit prefix for IPv6 unicast, including the global address prefix, link-local prefix and site-local prefix. The IPv4 address is placed as the last 32 bits of the IPv6 address, allowing a tunnel to be automatically set up.

ISATAP can be easily used with other transition technologies. Especially when used with the 6to4 tunnel technology, it can enable the dual-stack host of an intranet access an IPv6 backbone network very easily.

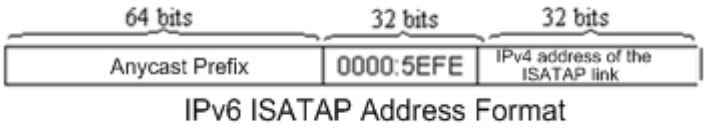
- ISATAP interface identifier

The unicast address used by ISATAP is in the form of a 64-bit IPv6 prefix plus a 64-bit interface identifier. The 64-bit interface identifier is generated in the revised EUI-64 address format. The value of the first 32 bits of the interface identifier is 0000:5EFE, an interface identifier of ISATAP.

- ISATAP address structure

An ISATAP address refers to a unicast address containing an ISATAP interface identifier in its interface identifier. An ISATAP address structure is shown in the following figure.

Figure 13



IPv6 ISATAP Address Format

The above figure shows that the interface identifier contains an IPv4 address. The address is the IPv4 address of a dual-stack host and will be used when an automatic tunnel is automatically set up.

For example, the IPv6 prefix is 2001::/64 and the embedded IPv4 address is 192.168.1.1. In the ISATAP address, the IPv4 address is denoted as the hexadecimal numeral C0A8:0101. Therefore, its corresponding ISATAP address is as follows:

2001::0000:5EFE:C0A8:0101

Configuring 6RD Tunnel

If you want to configure a IPv6 rapid development (6RD) tunnel, configure the tunnel interface with both the source IPv4 address and destination IPv4 address. The host or device at the peer end of the tunnel should be configured in the same way.

Command	Description
Ruijie#**configure terminal**	Enters global configuration mode.

Ruijie(config)#**interface tunnel** *tunnel-number*	Configures a tunnel by specifying the tunnel number and enters interface configuration mode.
Ruijie(config-if-Tunnel id)#**tunnel mode ipv6ip 6rd**	Sets the tunnel type to 6RD tunnel,
Ruijie(config-if-Tunnel id)#**ipv6 enable**	Enables the IPv6 function on the interface. You can also enable the IPv6 function directly by configuring an IPv6 address.
Ruijie(config-if-Tunnel id)#**tunnel 6rd prefix** *ipv6-prefix* **/** *prefix-length*	Sets the 6RD prefix. If 6RD prefix is not configured, the 6RD tunnel cannot be up. If the prefix length is set to 0, it indicates that the prefix is deleted.
Ruijie(config-if-Tunnel id)#**tunnel 6rd ipv4 prefix-length** *length* **suffix-length** *length*	Sets the IPv4 prefix and suffix length for the 6RD domain. The valid range is from 0 to 31. The sum of the prefix and suffix length cannot be greater than 31. The default is 0.
Ruijie(config-if-Tunnel id)#**tunnel source** { *ipv4-address* | *interface-type interface-number* }	Sets the IPv4 source address of the tunnel or the referenced source interface number. The interface that is specified must be configured with an IPv4 address.
Ruijie(config-if-Tunnel id)#**tunnel 6rd br** *ipv4-address*	Sets the border relay (BR) IPv4 address for the 6RD customer edge (CE). This command is configured only on the 6RD CE. Configuring this command allows the 6RD router to disable security check on the tunnel packet containing this source address.
Ruijie(config-if-Tunnel id)#**exit**	Returns to privileged EXEC mode.
Ruijie(config)#**ipv6 route** *prefix::/prefix-length next-hop*	Configures the tunnel route.

The following example configures the 6RD tunnel on the device.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  Exit with CNTL/Z.
Ruijie(config)#interface Tunnel 100
Ruijie(config-if-Tunnel 100)#tunnel mode ipv6ip 6rd
Ruijie(config-if-Tunnel 100)#tunnel source 10.1.1.1
Ruijie(config-if-Tunnel 100)#tunnel 6rd prefix 2001:DA8::/32
Ruijie(config-if-Tunnel 100)#tunnel 6rd ipv4 prefix-length 16 suffix-length 0
Ruijie(config-if-Tunnel 100)#tunnel 6rd br 10.1.4.1
Ruijie(config-if-Tunnel 100)#ipv6 enable
Ruijie(config)#ipv6 address 2004::1/128
Ruijie(config)#ipv6 route 2001:da8::/32 Tunnel 100
Ruijie(config)#ipv6 route ::/0 Tunnel8 2001:DA8:401::1
Ruijie(config)#ipv6 route 2001:da8:101::/48 Null 0
```

Configuring 6RD Tunnel via DHCP Automatic Configuration

You can configure the 6RD parameter for the DHCP client via the DHCP option on the DHCP server. The 6RD parameter includes the generic IPv4 prefix and suffix length, 6RD prefix length, 6RD prefix, and IPv4 address of the 6RD BR for a given 6RD domain. If you want to create a 6RD tunnel for the DHCP client, you can configure the DHCP option 212 for the client to obtain the 6RD parameter. Use the following command in DHCP address pool configuration mode to configure the 6RD parameter available for the DHCP client.

Command	Function
Ruijie(dhcp-config)# **option 6rd ipv4masklen** <*mask-length*> **ipv6prefixlen** <*prefix-length*> **ipv6prefix** <*ipv6-prefix*> **br-addr** <*ipv4-address*>	Configures the 6RD parameter.
Use the following command to enable the DHCP 6RD client interface to obtain IP address.**Command**	**Function**
Ruijie(config-if-GigabitEthernet 0/0)#ip address dhcp 6rd	Enables the DHCP client to obtain the IP address.

The following example configures the 6RD parameter for the DHCP client on the DHCP server.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  Exit with CNTL/Z.
Ruijie(config)#ip dhcp pool 6rd
Ruijie(dhcp-config)#option 6rd ipv4masklen 16 ipv6prefixlen 32 ipv6prefix 2002:DA8:: br-addr
1.1.1.1
```

Configuring IPv6 Tunnels

Manually Configuring IPv6 Tunnels

This section describes how to configure tunnels manually.

To configure a tunnel manually, configure an IPv6 address on the tunnel interface and manually configure the IPv4 addresses of the source and destination of the tunnel. Then, configure the hosts or devices at the two ends of the tunnel to ensure that they support the dual stacks (the IPv6 and IPv4 protocol stacks).

Caution Do not configure tunnels manually with the same runnel source and tunnel destination.

Brief steps

```
config terminal
interface tunnel tunnel-num
tunnel mode ipv6ip
ipv6 enable
tunnel source {ip-address | type num}
tunnel destination ip-address
end
```

To configure an IPv6 tunnel manually, use the following commands in global configuration mode.

Command	Function
configure terminal	Enters global configuration mode.
interface tunnel *tunnel-num*	Specifies a tunnel interface number to create a tunnel interface and enters interface configuration mode.

Command	Function
tunnel mode ipv6ip	Sets the tunnel type to manually configured tunnel.
ipv6 enable	Enables the IPv6 function on the interface. You can also configure the IPv6 address to directly enable the IPv6 function on the interface.
tunnel source {*ip-address* | *type num*	Specifies the IPv4 source address or referenced source interface number of the tunnel. Note: If you specify an interface, the IPv4 address must have been configured on the interface.
tunnel destination *ip address*	Specifies the destination address of the tunnel.
end	Returns to privileged EXEC mode.
copy running-config startup-config	Saves the configuration information.

See the "Verifying and Monitoring IPv6 Tunnel Configuration" section to check the operation of the tunnel.

Configuring GRE Tunnels

This section describes how to configure GRE tunnels.

To configure a GRE tunnel, you need to manually configure the tunnel source IP address and tunnel destination IP address on the tunnel interface. The corresponding configurations must also be done on the peer host or device.

Caution Do not configure a GRE tunnel with the same tunnel source IP address and tunnel destination IP address on the device.

Use the following commands to configure a GRE tunnel.

Command	Function
Ruijie# **configure terminal**	Enters global configuration mode.
Ruijie(config)# **interface tunnel** *tunnel-num*	Specifies the tunnel interface number to create a tunnel interface and enters interface configuration mode.
Ruijie(config-if-Tunnel id)# **tunnel mode gre** {**ip | ipv6**}	Sets the tunnel type to GRE tunnel, and specifies the carrier protocol as IPv4 or IPv6.
Ruijie(config-if-Tunnel id)# **tunnel source** {*ipv4-address* | *ipv6-address* | *interface-type interface-num* }	Specifies the IPv4 address of the tunnel source or source interface number referenced. If the interface is specified, the IPv4 address must have been configured on the interface.
Ruijie(config-if-Tunnel id)# **tunnel destination** *{ipv4-address | ipv6-address}*	Specifies the destination address of the tunnel. If the carrier protocol is IPv6, the IP address must be configured as the IPv6 address of the peer device.
Ruijie(config-if-Tunnel id)# **end**	Returns to privileged EXEC mode.
Ruijie# **copy running-config startup-config**	Saves the configuration information.

See the "Verifying and Monitoring IPv6 Tunnel Configuration" section to check the operation of the tunnel.

Caution Because GRE features differ from device to device, the aforementioned commands may not be available on certain products.

Configuring 6to4 Tunnels

This section describes how to configure a 6to4 tunnel.

The destination address of a 6to4 tunnel is determined by the IPv4 address which is extracted from a 6to4 IPv6 address. The devices at the two ends of the 6to4 tunnel must support the dual stacks, namely, the IPv4 and IPv6 protocol stacks.

Caution A device supports only one 6to4 tunnel. The encapsulation source address (IPv4 address) used by the 6to4 tunnel must be a globally routable address. Otherwise, the 6to4 tunnel will not work normally.

Brief steps

```
config terminal
interface tunnel tunnel-num
tunnel mode ipv6ip 6to4
ipv6 enable
tunnel source {ip-address | type num}
exit
ipv6 route 2002::/16 tunnel tunnel-number
end
```

To configure a 6to4 tunnel, use the following commands.

Command	Function
configure terminal	Enters global configuration mode.
interface tunnel *tunnel-num*	Specifies a tunnel interface number to create a tunnel interface and enters interface configuration mode.
tunnel mode ipv6ip 6to4	Sets the tunnel type to 6to4 tunnel.
ipv6 enable	Enables the IPv6 function of the interface. You can also configure the IPv6 address to directly enable the IPv6 function of the interface.
tunnel source {*ip-address* | *type num*}	Specifies the encapsulation source address or referenced source interface number of the tunnel. Note: The IPv4 address must have been configured on the referenced interface. The used IPv4 address must be a globally routable address.
Exit	Returns to global configuration mode.

Command	Function
ipv6 route *2002::/16* **tunnel** *tunnel-number*	Configures a static route for the IPv6 6to4 prefix 2002::/16 and associates the output interface with the tunnel interface, i.e., the tunnel interface specified above.
End	Returns to privileged EXEC mode.
copy running-config startup-config	Saves the configuration information.

See the "Verifying and Monitoring IPv6 Tunnel Configuration" to check the operation of the tunnel.

Configuring ISATAP Tunnels

This section describes how to configure ISATAP tunnels.

On an ISATAP tunnel interface, the configuration of an ISATAP IPv6 address and the advertisement configuration of a prefix are the same as that of a common IPv6 interface. However, the address configured for an ISATAP tunnel interface must be a revised EUI-64 address. The reason is that the last 32 bits of the interface identifier in the IPv6 address are composed of the IPv4 address of the interface referenced by the tunnel source address. See the above sections for the information about ISATAP address formats.


Caution A device supports multiple ISATAP tunnels. However, the source of each ISATAP tunnel must be different. Otherwise, there is no way to know which ISATAP tunnel a received ISATAP tunnel message belongs to.

Brief steps

```
config terminal
interface tunnel tunnel-num
tunnel mode ipv6ip isatap
ipv6 address ipv6-prefix/prefix-length eui-64
tunnel source interface-type num
no ipv6 nd suppress-ra
end
```

To configure an ISATAP tunnel, use the following commands.

Command	Function
configure terminal	Enters global configuration mode.
interface tunnel *tunnel-num*	Specifies a tunnel interface number to create a tunnel interface and enters interface configuration mode.
tunnel mode ipv6ip isatap	Sets the tunnel type to ISATAP tunnel.
ipv6 address ipv6-prefix/prefix-length eui-64	Configures the IPv6 ISATAP address. Be sure to use the **eui-64** keyword. In this way, the ISATAP address will be automatically generated. The address configured on an ISATAP interface must be an ISATAP address.

Command	Function
tunnel source type *num*	Specifies the source interface number referenced by the tunnel. On the referenced interface, the IPv4 address must have been configured.
no ipv6 nd suppress-ra	Sending router advertisement messages on an interface is disabled by default. You can use the command to enable the function, allowing the ISATAP host to be automatically configured.
End	Returns to privileged EXEC mode.
copy running-config startup-config	Saves the configuration information.

See the "Verifying and Monitoring IPv6 Tunnel Configuration" to check the operation of the tunnel.

Configuring the Tunnel to Support IPv6 Multicast

Currently, on the IPv6 network, both IPv6 unicast and multicast services need to be able to traverse the IPv4 network.

It is easy to configure IPv6 tunnel multicast. The tunnel interface can be configured in the same way as other common interfaces such as an SVI interface.

Caution Multicast is supported only in the manually configured IPv6 tunnel. For tunnels of other types, multicast can be configured, but multicast data cannot be received or forwarded after the configuration.
For the manually configured IPv6 tunnel, if the tunnel is created based on an IPv6 tunnel of any type, multicast can be configured, but multicast data cannot be received or forwarded after the configuration.
When IPv6 multicast data traverses the IPv4 network, the MTU restrictions are the same as those for IPv6 unicast data.

Verifying and Monitoring IPv6 Tunnel Configuration

This section describes how to verify the configuration and operation of an IPv6 tunnel.

Brief steps

```
enable
show interface tunnel number
show ipv6 interface tunnel mumber
ping protocol destination
show ip route
show ipv6 route
```

To verify the configuration and operation of a tunnel, use the following commands.

Command	Function
show interface tunnel *tunnel-num*	Displays the information of a specified tunnel interface.
show ipv6 interface tunnel *tunnel-num*	Displays the IPv6 information of the tunnel interface.

Command	Function
ping protocol destination	Checks the basic connectivity of a network.
show ip route	Displays the IPv4 routing table.
show ipv6 route	Displays the IPv6 router table.

3) Display the information of a tunnel interface.

```
Ruijie# show interface tunnel 1
Tunnel 1 is up, line protocol is Up
Hardware is Tunnel, Encapsulation TUNNEL
Tunnel source 192.168.5.215 , destination 192.168.5.204
Tunnel protocol/transport IPv6/IP
Tunnel TTL is 9
Tunnel source do conformance check set
Tunnel source do ingress filter set
Tunnel destination do safety check not set
Tunnel disable receive packet not set
```

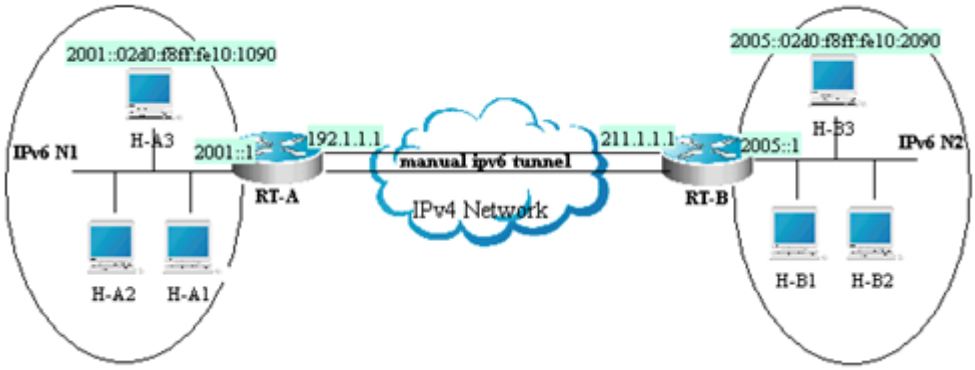
4) Display the IPv6 information of a tunnel interface.

```
Ruijie# show ipv6 interface tunnel 1
interface Tunnel 1 is Up, ifindex: 6354
address(es):
Mac Address: N/A
INET6: fe80::3d9a:1601 , subnet is fe80::/64
Joined group address(es):
ff02::2
ff01::1
ff02::1
ff02::1:ff9a:1601
INET6: 3ffe:4:0:1::1 , subnet is 3ffe:4:0:1::/64
Joined group address(es):
ff02::2
ff01::1
ff02::1
ff02::1:ff00:1
MTU is 1480 bytes
ICMP error messages limited to one every 100 milliseconds
ICMP redirects are enabled
ND DAD is enabled, number of DAD attempts: 1
ND reachable time is 30000 milliseconds
ND advertised reachable time is 0 milliseconds
ND retransmit interval is 1000 milliseconds
ND advertised retransmit interval is 0 milliseconds
ND router advertisements are sent every 200 seconds<240--160>
ND router advertisements live for 1800 seconds
```

IPv6 Tunnel Configuration Examples

Example of Configuring IPv6 Tunnels Manually

Figure 14



As shown in the above figure, IPv6 networks N1 and N2 are isolated by the IPv4 network. Now, the two networks are interconnected by configuring a tunnel manually. For example, the H-A3 host in N1 can access the H-B3 host in N2.

In the figure, RT-A and RT-B are routers that support the IPv4 and IPv6 protocol stacks. Tunnel configuration is performed on the ABRs (RT-A and RT-B) in N1 and N2. Note that the tunnel must be configured manually in pairs, that is, on RT-A and RT-B.

The following presents the tunnel configuration on routers:

Prerequisite: Assume that the routes of IPv4 are connected. In the following content, no more route configuration condition about IPv4 is listed.

RT-A:

#Connect the interfaces of the IPv4 network.

```
interface FastEthernet 2/1
no switchport
ip address 192.1.1.1 255.255.255.0
```

#Connect the interfaces of the IPv6 network.

```
interface FastEthernet 2/2
no switchport
ipv6 address 2001::1/64
no ipv6 nd suppress-ra  (optional)
```

#Configure the manual tunnel interface.

```
interface Tunnel 1
tunnel mode ipv6ip
ipv6 enable
tunnel source FastEthernet 2/1
tunnel destination 211.1.1.1
```

#Configure the route to the tunnel.

```
ipv6 route 2005::/64 tunnel 1
```

RT-B:

#Connect the interfaces of the IPv4 network.

```
interface FastEthernet 2/1
no switchport
ip address 211.1.1.1 255.255.255.0
```

Connect the interfaces of the IPv6 network.

```
interface FastEthernet 2/2
no switchport
ipv6 address 2005::1/64
no ipv6 nd suppress-ra  (optional)
```

#Configure the manual tunnel interface.

```
interface Tunnel 1
tunnel mode ipv6ip
ipv6 enable
tunnel source FastEthernet 2/1
tunnel destination 192.1.1.1
```

#Configure the route to the tunnel.

```
ipv6 route 2001::/64 tunnel 1
```

Example of Manually Configuring IPv6 Tunnels to Support Multicast

Assume that the network topology is shown in Figure 4. On the basis of the previous example, the additional support to PIM SMv6 multicast is required. Detailed configurations related to multicast are shown below:

- RT-A

Globally enable multicast.

```
ipv6 multicast-routing
```

Enable PIM SMv6 on the interface.

```
interface Tunnel 1
IPv6 pim sparse-mode
```

- RT-B

Globally enable multicast.

```
ipv6 multicast-routing
```

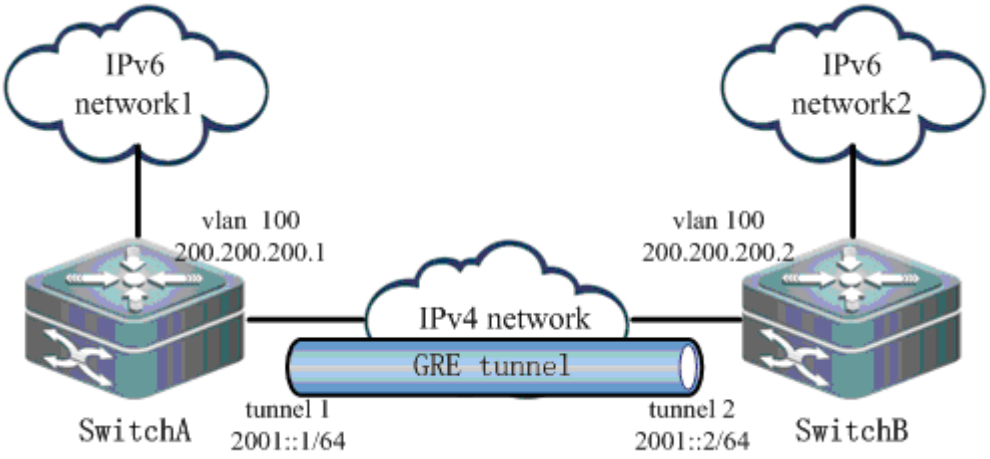
Enable PIM SMv6 on the interface.

```
interface Tunnel 1
```

```
IPv6 pim sparse-mode
```

Example of Configuring IPv6 over IPv4 GRE Tunnels

Figure 15



As shown in Figure 5, two IPv6 networks, IPv6 network1 and IPv6 network2, need to be connected via a public IPv4 network to realize intercommunication. Layer-3 devices Switch A and Switch B supports both IPv4 and IPv6 stacks, and are interconnected via the IPv4 network. An IPv6 over IPv4 GRE tunnel needs to be created over this IPv4 network.

Assuming that IPv6 network1 is 2002::/64 and IPv6 network2 is 2003::/64, the configurations on Switch A and Switch B are shown below:

5) Configure Switch A.

Configure interface vlan 100.

```
interface vlan 100
ip address 200.200.200.1 255.255.255.0
```

Configure interface Tunnel 1.

```
interface Tunnel 1
 ipv6 address 2001::1/64
 tunnel mode gre ip
 tunnel source vlan 100
 tunnel destination 200.200.200.2
```

Configure the route to pass through the tunnel interface to reach IPv6 network2.

```
ipv6 route 2003::/64 tunnel 1 2001::2
```

6) Configure Switch B.

Configure interface vlan 100.

```
interface vlan 100
 ip address 200.200.200.2 255.255.255.0
```

Configure interface Tunnel 1.

```
interface Tunnel1
 ipv6 address 2001::2/64
 tunnel mode gre ip
 tunnel source vlan 100
 tunnel destination 200.200.200.1
```

Configure the route to pass through the tunnel interface to reach IPv6 network1.

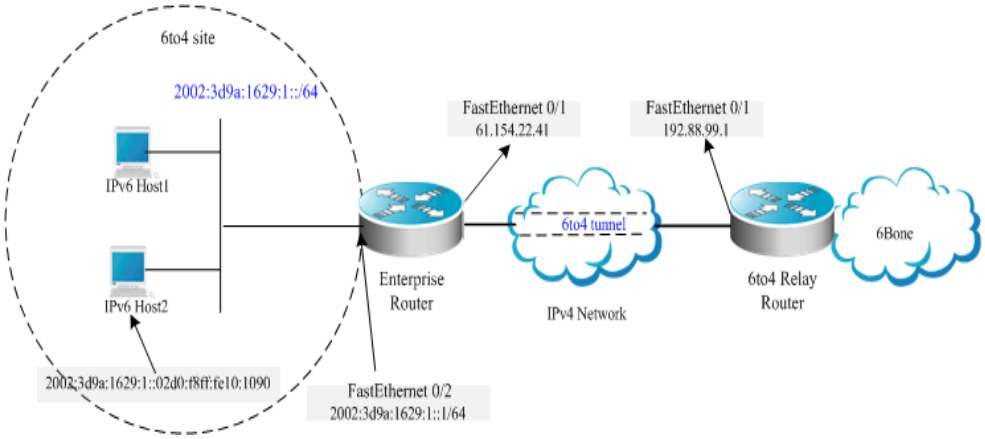
```
ipv6 route 2002::/64 tunnel 1 2001::1
```

7) View the operation of the tunnel, taking Switch A as an example.

```
show interface tunnel 1
Index(dec):3 (hex):3
Tunnel 1 is UP  , line protocol is UP
Hardware is  Tunnel
Interface address is: no ip address
  MTU 1496 bytes, BW 9 Kbit
  Encapsulation protocol is Tunnel, loopback not set
  Keepalive set (10 sec), retries 3
  Carrier delay is 2 sec
  RXload is 1 ,Txload is 1
  Tunnel source 200.200.200.1 (VLAN 100), destination 200.200.200.2
  Tunnel TOS 0x14,  Tunnel TTL 255
  Tunnel protocol/transport GRE/IP
   Key disabled, Sequencing disabled
   Checksumming of packets disabled
  Path MTU Discovery, ager 10 mins, min MTU 92, MTU 0, expires never
  Queueing strategy: FIFO
    Output queue 0/40, 0 drops;
    Input queue 0/75, 0 drops
  5 minutes input rate 0 bits/sec, 0 packets/sec
  5 minutes output rate 0 bits/sec, 0 packets/sec
    0 packets input, 0 bytes, 0 no buffer, 0 dropped
    Received 0 broadcasts, 0 runts, 0 giants
    0 input errors, 0 CRC, 0 frame, 0 overrun, 0 abort
    0 packets output, 0 bytes, 0 underruns , 0 dropped
    0 output errors, 0 collisions, 0 interface resets
```

Example of Configuring 6to4 Tunnels

Figure 16



As shown in the above figure, an IPv6 network (6to4 site) uses a 6to4 tunnel to access the IPv6 backbone network (6bone) via a 6to4 relay router.

As described above, the 6to4 tunnel technology is used to interconnect isolated IPv6 networks and the IPv6 backbone network can be accessed via the 6to4 relay router very easily. The 6to4 tunnel is an automatic tunnel and the IPv4 address embedded in the IPv6 address will be used to look for the other end of the automatic tunnel. Therefore, you need not configure the destination end for the 6to4 tunnel. Additionally, unlike a manual tunnel, the 6to4 tunnel need not be configured in pairs.

61.154.22.41 is 3d9a:1629 in hexadecimal notation.

192.88.99.1 is c058:6301 in hexadecimal notation.

Caution When configuring a 6to4 tunnel on an ABR, be sure to use a globally routable IPv4 address. Otherwise, the 6to4 tunnel will not work normally.

The following is the configuration of the two routers in the figure (Assume that IPv4 routes are connected. Ignore the configuration of IPv4 routes.):

Enterprise router:

Connect the interfaces of the IPv4 network.

```
interface FastEthernet 0/1
no switchport
ip address 61.154.22.41 255.255.255.128
```

Connect the interfaces of the IPv6 network.

```
interface FastEthernet 0/2
no switchport
ipv6 address 2002:3d9a:1629:1::1/64
no ipv6 nd suppress-ra
```

Configure the 6to4 tunnel interface.

```
interface Tunnel 1
tunnel mode ipv6ip 6to4
```

```
ipv6 enable
tunnel source FastEthernet 0/1
```

Configure the route to the tunnel.

```
ipv6 route 2002::/16 Tunnel 1
```

Configure the route to the 6to4 relay router to access 6bone.

```
ipv6 route ::/0 2002:c058:6301::1
```

ISP 6to4 relay router:

Connect the interface of the IPv4 network.

```
interface FastEthernet 0/1
no switchport
ip address 192.88.99.1 255.255.255.0
```

Configure the 6to4 tunnel interface.

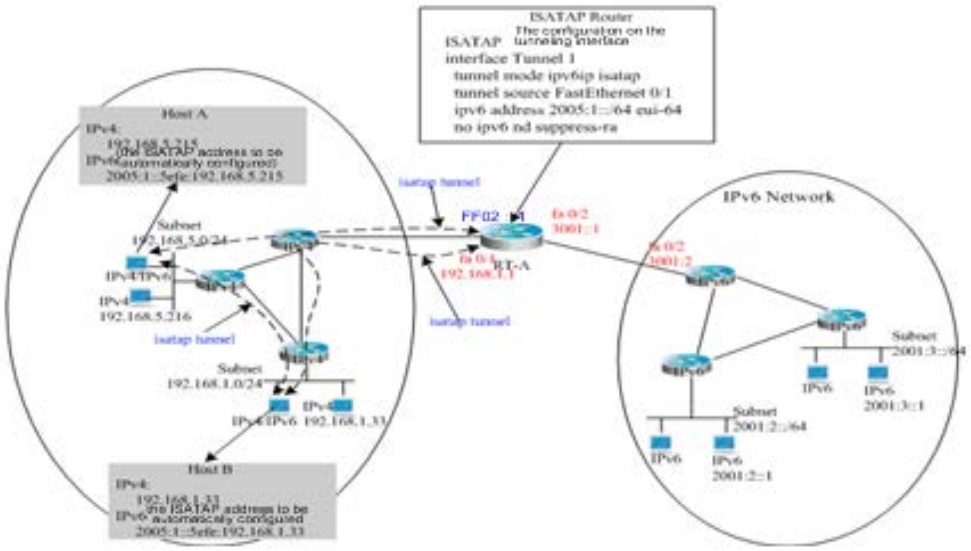
```
interface Tunnel 1
tunnel mode ipv6ip 6to4
ipv6 enable
tunnel source FastEthernet 0/1
```

Configure the route to the tunnel.

```
ipv6 route 2002::/16 Tunnel 1
```

Example of Configuring ISATAP Tunnels

Figure 17



The above figure is one typical topology using an ISATAP tunnel. The ISATAP tunnel is used to communicate between isolated IPv4/IPv6 dual-stack hosts inside the IPv4 site. The ISATAP router has the two following functions inside the ISATAP site:

- Receive a router solicitation message from the ISATAP host inside the site and then respond with a router advertisement message for the ISATAP host inside the site to be automatically configured.
- Be responsible for the message forwarding function of the ISATAP host inside the site and the IPv6 host outside the site.

In the above figure, when Host A and Host B send the router solicitation message to the ISATAP router, the ISATAP router will respond with a router advertisement message. After receiving the message, the hosts will automatically perform configuration and generate their own ISATAP addresses respectively. Then, the IPv6 communication between Host A and Host B will be done via the ISATAP tunnel. When Host A or Host B need to communicate with the IPv6 host outside the site, Host A sends the message to the ISATAP router RT-A via the ISATAP tunnel and then RT-A forwards the message to the IPv6 network.

In the above figure, the ISATAP router (RT-A) is configured as follows:

Connect the interfaces of the IPv4 network.

```
interface FastEthernet 0/1
no switchport
ip address 192.168.1.1 255.255.255.0
```

Configure the ISATAP tunnel interface.

```
interface Tunnel 1
tunnel mode ipv6ip isatap
tunnel source FastEthernet 0/1
ipv6 address 2005:1::/64 eui-64
no ipv6 nd suppress-ra
```

Connect the interfaces of the IPv6 network.

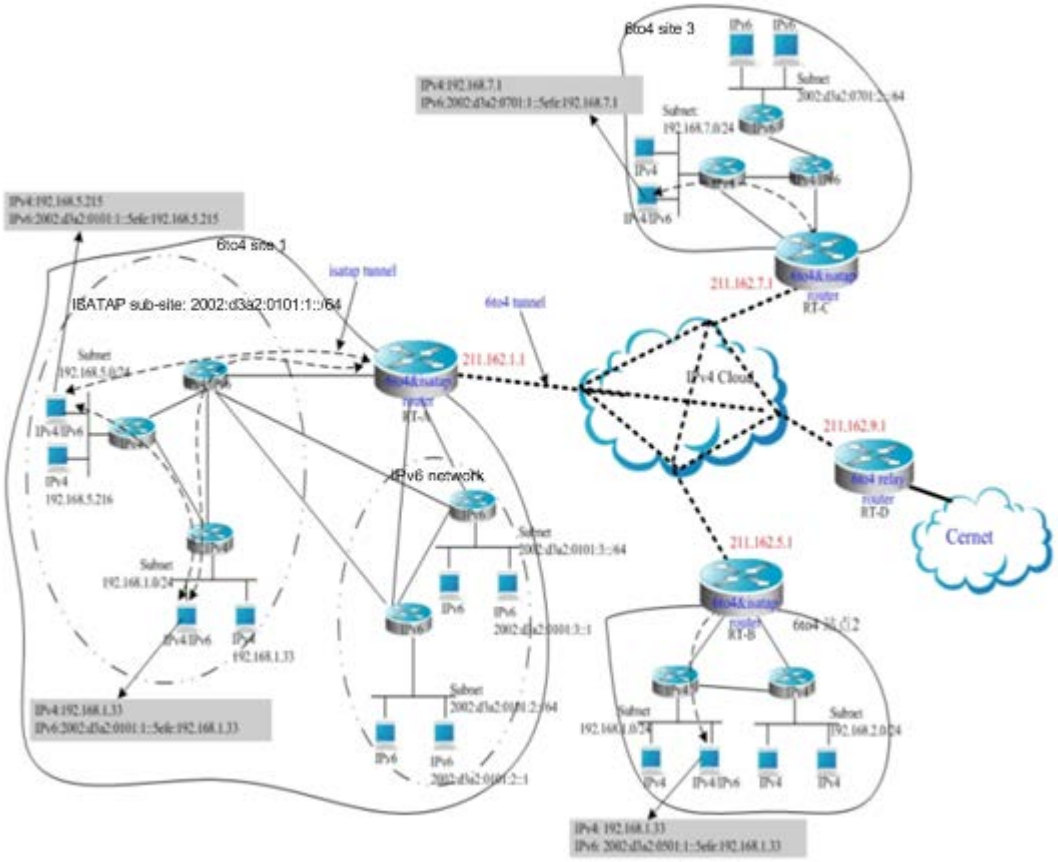
```
interface FastEthernet  0/2
no switchport
ipv6 address 3001::1/64
```

Configure the route to the IPv6 network.

```
ipv6 route 2001::/64 3001::2
```

Example of Configuring ISATAP and 6to4 Tunnels

Figure 18



Note

The above figure shows a hybrid application of a 6to4 tunnel and an ISATAP tunnel. By using the 6to4 tunnel technology, various 6to4 sites are interconnected and the 6to4 sites access the Cernet network via the **6to4 relay router**. At the same time, by using the ISATAP tunnel technology inside the 6to4 sites, the IPv6 hosts isolated by IPv4 inside the sites perform IPv6 communication via the ISATAP tunnel.

Caution

In the above figure, the used global IP addresses including the address of the 6to4 relay router are only for convenience. When actually planning topologies, you should use a true global IP address and the address of the 6to4 relay. At present, many organizations provide the addresses of open and free 6to4 relay routers.

The configurations of ABRs at the 6to4 sites shown in the above figure are described respectively below. Note that only main related configurations are listed here.

RT-A:

Connect the interfaces of the Internet.

```
interface GigabitEthernet 0/1
no switchport
ip address 211.162.1.1 255.255.255.0
```

Connect the interfaces of the IPv4 network inside the site.

```
interface FastEthernet  0/1.
```

```
no switchport
ip address 192.168.0.1 255.255.255.0
```

Configure the ISATAP tunnel interface.

```
interface Tunnel 1
tunnel mode ipv6ip isatap
tunnel source FastEthernet 0/1
ipv6 address 2002:d3a2:0101:1::/64 eui-64
no ipv6 nd suppress-ra
```

Connect interface 1 of the IPv6 network.

```
interface FastEthernet 0/2
no switchport
2002:d3a2:0101:10::1/64
```

Connect interface 2 of the IPv6 network.

```
interface FastEthernet  0/2
no switchport
2002:d3a2:0101:20::1/64
```

Configure the 6to4 tunnel interface.

```
interface Tunnel 2
tunnel mode ipv6ip 6to4
ipv6 enable
tunnel source GigabitEthernet 0/1
```

Configure the route to the 6to4 tunnel.

```
ipv6 route 2002::/16 Tunnel 2
```

Configure the route to the 6to4 relay router RT-D to access the Cernet network.

```
ipv6 route ::/0 2002:d3a2::0901::1
```

RT-B:

Connect the interfaces of the Internet.

```
interface GigabitEthernet 0/1
no switchport
ip address 211.162.5.1 255.255.255.0
```

Connect interface 1 of the IPv4 network inside the site.

```
interface FastEthernet  0/1
no switchport
ip address 192.168.10.1 255.255.255.0
```

Connect interface 2 of the IPv4 network inside the site.

```
interface FastEthernet  0/2
```

```
no switchport
ip address 192.168.20.1 255.255.255.0
```

Configure the ISATAP tunnel interface.

```
tunnel mode ipv6ip isatap
tunnel source FastEthernet 0/1
ipv6 address 2002:d3a2:0501:1::/64 eui-64
no ipv6 nd suppress-ra
```

Configure the 6to4 tunnel interface.

```
interface Tunnel 2
tunnel mode ipv6ip 6to4
ipv6 enable
tunnel source GigabitEthernet 0/1
```

Configure the route to the 6to4 tunnel.

```
ipv6 route 2002::/16 Tunnel 2
```

Configure the route to the 6to4 relay router RT-D to access the Cernet network.

```
ipv6 route ::/0 2002:d3a2::0901::1
```

RT-C:

Connect the interfaces of the Internet.

```
interface GigabitEthernet 0/1
no switchport
ip address 211.162.7.1 255.255.255.0
```

Connect the interfaces of the IPv4 network inside the site.

```
interface FastEthernet 0/1
no switchport
ip address 192.168.0.1 255.255.255.0
```

Configure the ISATAP tunnel interface.

```
interface Tunnel 1
tunnel mode ipv6ip isatap
tunnel source FastEthernet 0/1
ipv6 address 2002:d3a2:0701:1::/64 eui-64
no ipv6 nd suppress-ra
```

Connect the interfaces of the IPv6 network.

```
interface FastEthernet 0/2
no switchport
2002:d3a2:0701:10::1/64
```

Configure the 6to4 tunnel interface.

```
interface Tunnel 2
tunnel mode ipv6ip 6to4
ipv6 enable
tunnel source GigabitEthernet 0/1
```

Configure the route to the 6to4 tunnel.

```
ipv6 route 2002::/16 Tunnel 2
```

#Configure the route to the 6to4 relay router RT-D to access the Cernet network.

```
ipv6 route ::/0 2002:d3a2::0901::1
```

RT-D (6to4 relay):

Connect the interfaces of the Internet.

```
interface GigabitEthernet 0/1
no switchport
ip address 211.162.9.1 255.255.255.0
```

Connect the interfaces of the IPv6 network.

```
interface FastEthernet 0/1
no switchport
2001::1/64
no ipv6 nd suppress-ra
```

Configure the 6to4 tunnel interface.

```
interface Tunnel 1
tunnel mode ipv6ip 6to4
ipv6 address 2002:d3a2::0901::1/64
tunnel source GigabitEthernet 0/1
```

#Configure the route to the 6to4 tunnel.

```
ipv6 route 2002::/16 Tunnel 1
```

Configuring Stateful NAT64

Understanding Stateful NAT64

Overview

With the fast development of the Internet, IPv4 can no longer meet Internet requirements. Under this circumstance, IPv6 is about to be deployed. To support an IPv6 network, you must make full use of existing network resources to construct a next-generation Internet, thereby implementing smooth transition and avoiding excessive investment. The current Internet is based on IPv4 and cannot be transformed to the IPv6 network in a short time. Therefore, the IPv4 and IPv6 networks will coexist in a rather long time.

The coexistence, however, causes the following problems: how to keep current network services and functions at minimum cost; and how to implement transparent transmission between the IPv6 network and the IPv4 network. Network Address Translation 64 (NAT64, also called the IPv6-to-IPv4 address mapping), includes Stateful NAT64 and Stateless NAT64. Stateful NAT64 is mainly used when IPv6 network users initiate access requests to hosts/servers on the IPv4 network.

Basic Concepts

Stateful NAT64: Stateful IPv6-to-IPv4 network address translation protocol

Port Address Translation (PAT)

Network-Specific Prefix (NSP): Mainly used to check IPv6 destination addresses and IPv6 network addresses mapping to IPv4 host addresses.

Well-Known Prefix (WKP): Network prefix used by Stateful NAT64. It is used by default with the value of 64:ff9b::/96.

Working Principle

Stateful NAT64 provides a translation mechanism between IPv6 packets and IPv4 packets. This mechanism uses a Stateful NAT6 IPv6 prefix to implement translation from IPv4 host addresses to IPv6 addresses and takes NAT to implement translation from IPv6 host addresses to IPv4 addresses. Moreover, Statefull NAT64 performs protocol translation. NAT64 implements intercommunication between the pure IPv6 network and the IPv4 network.

Protocol Specification

RFC6052: IPv6 Addressing of IPv4/IPv6 Translators

RFC6144: Framework for IPv4/IPv6 Translation

RFC6145: IP/ICMP Translation Algorithm

RFC6146: Stateful NAT64: Network Address and Protocol Translation from IPv6 Clients to IPv4 Servers

Typical Application

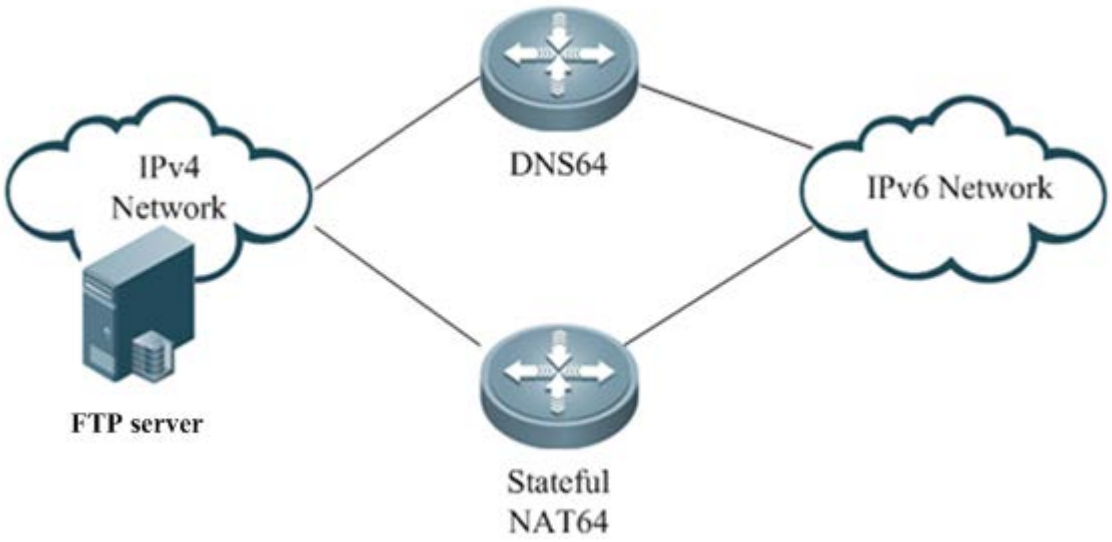


Figure 1-1 IPv6 Network Initiating a Session to IPv4 Network

Configuring Stateful NAT64

Default Configuration

Feature	Default setting
Stateful NAT64	Disabled
Default WKP	64:ff9b::/96

Configuring Static NAT64

Command	Function
Ruijie>**enable**	Enters privileged EXEC mode.
Ruijie#**configure terminal**	Enters global configuration mode.
Ruijie(config)#**ipv6 unicast-routing**	(Optional) Enables unicast routing, which is enabled by default.
Ruijie(config)#**interface** *interface-name interface-number*	Specifies an IPv6 network interface and enters interface configuration mode.
Ruijie(config-if)#**ipv6 enable**	Enables IPv6.
Ruijie(config-if)# **ipv6 address** *ipv6-address/prefix-length*	Configures the IPv6 address of the interface.
Ruijie(config-if)#**nat64 enable**	Enables NAT64 on the interface.
Ruijie(config-if)#**exit**	Exits interface configuration mode and returns to global configuration mode.
Ruijie(config)#**interface** *interface-name interface-number*	Specifies an IPv4 network interface and enters interface configuration mode.
Ruijie(config-if)#**ip address** *ip-address mask*	Configures the IPv4 address of the interface.
Ruijie(config-if)#**nat64 enable**	Enables NAT64 on the interface.

Ruijie(config-if)#**exit**	Exits interface configuration mode and returns to global configuration mode.
Ruijie(config)#**nat64 prefix stateful** *ipv6-address/prefix-length*	Allocates an IPv6 prefix as a global Stateful NAT64 prefix.
Ruijie(config)#**nat64 v6v4 static** *ipv6-address ipv4-address*	Configures NAT64 to map an IPv6 address to an IPv4 address in static mode.
Ruijie(config)#**end**	Exits global configuration mode and retunes to privileged mod.

The following example configures static Stateful NAT64.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface gigabitethernet 0/0/0
Ruijie(config-if)#ipv6 enable
Ruijie(config-if)#ipv6 address 2001:db8:1::1/96
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitethernet 1/2/0
Ruijie(config-if)#ip address 209.165.201.1 255.255.255.0
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#nat64 prefix stateful 2001:db8:0:1::/96
Ruijie(config)#nat64 v6v4 static 2001:db8:1::fffe 209.165.201.2
Ruijie(config)#end
```

Configuring Dynamic NAT64

Command	Function
Ruijie>**enable**	Enters privileged EXEC mode.
Ruijie**#configure terminal**	Enters global configuration mode.
Ruijie(config)#**ipv6 unicast-routing**	Enables unicast routing, which is enabled by default.
Ruijie(config)#**interface** *interface-name interface-number*	Specifies an IPv6 network interface and enters interface configuration mode.
Ruijie(config-if)#**ipv6 enable**	Enables IPv6.
Ruijie(config-if)# **ipv6 address** *ipv6-address/prefix-length*	Configures the IPv6 address of the interface.
Ruijie(config-if)#**nat64 enable**	Enables NAT64 on the interface.
Ruijie(config-if)#**exit**	Exits interface configuration mode and returns to global configuration mode.
Ruijie(config)#**interface** *interface-name interface-number*	Specifies an IPv4 network interface and enters interface configuration mode.
Ruijie(config-if)#**ip address** *ip-address mask*	Configures the IPv4 address of the interface.
Ruijie(config-if)#**nat64 enable**	Enables NAT64 on the interface.
Ruijie(config-if)#**exit**	Exits interface configuration mode and returns to global configuration mode.

Ruijie(config)#**ipv6 access-list** *access-list-name*	Configures an IPv6 ACL permit entry and enters IPv6 ACL mode.
Ruijie(config-ipv6-acl)#**permit ipv6** *ipv6-address* **any**	Filters IPv6 addresses based on ACL.
Ruijie(config-ipv6-acl)#**exit**	Exits interface configuration mode and returns to global configuration mode.
Ruijie(config)#**nat64 prefix stateful** *ipv6-address/prefix-length*	Allocates an IPv6 prefix as a global Stateful NAT64 prefix.
Ruijie(config)#**nat64 v4 pool** *pool-name start-ip-address end-ip-address*	Configures a NAT64 IPv4 address pool.
Ruijie(config)#**nat64 v6v4 list** *access-list-name* **pool** *pool-name*	Enables dynamic **NAT64.** *access-list-name* specifies an IPv6 ACL. The IPv6 addresses match the ACL are mapped to the addresses in *pool-name* address pool. *pool-name* specifies the name of an IPv4 address pool.
Ruijie(config)#**end**	Exits global configuration mode and returns to privileged EXEC mode.

The following example configures dynamic Stateful NAT64.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface gigabitethernet 0/0/0
Ruijie(config-if)#ipv6 enable
Ruijie(config-if)#ipv6 address 2001:db8:1::1/96
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitethernet 0/0/1
Ruijie(config-if)#ip address 209.165.201.24 255.255.255.0
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#ipv6 access-list nat64-acl
Ruijie(config-ipv6-acl)#permit ipv6 2001:db8:2::/96 any
Ruijie(config-ipv6-acl)#exit
Ruijie(config)#nat64 prefix stateful 2001:db8:1::/96
Ruijie(config)#nat64 v4 pool v4pool 209.165.201.1 209.165.201.254
Ruijie(config)#nat64 v6v4 list nat64-acl pool v4pool
Ruijie(config)#end
```

Configuring Dynamic PAT-Based NAT64

Command	Function
Ruijie>**enable**	Enters privileged EXEC mode.
Ruijie#**configure terminal**	Enters global configuration mode.
Ruijie(config)#**ipv6 unicast-routing**	(Optional) Enables unicast routing, which is enabled by default.

Ruijie(config)#**interface** *interface-name interface-number*	Specifies an IPv6 network interface and enters interface configuration mode.
Ruijie(config-if)#**ipv6 enable**	Enables IPv6.
Ruijie(config-if)# **ipv6 address** *ipv6-address/prefix-length*	Configures the IPv6 address of the interface.
Ruijie(config-if)#**nat64 enable**	Enables NAT64 on the interface.
Ruijie(config-if)#**exit**	Exits interface configuration mode and returns to global configuration mode.
Ruijie(config)#**interface** *interface-name interface-number*	Specifies an IPv4 network interface and enters interface configuration mode.
Ruijie(config-if)#**ip address** *ip-address mask*	Configures the IPv4 address of the interface.
Ruijie(config-if)#**nat64 enable**	Enables NAT64 on the interface.
Ruijie(config-if)#**exit**	Exits interface configuration mode and returns to global configuration mode.
Ruijie(config)#**ipv6 access-list** *access-list-name*	Configures an IPv6 ACL permit entry and enters IPv6 ACL mode.
Ruijie(config-ipv6-acl)#**permit ipv6** *ipv6-address* **any**	Filters IPv6 addresses based on ACL.
Ruijie(config-ipv6-acl)#**exit**	Exits interface configuration mode and returns to global configuration mode.
Ruijie(config)#**nat64 prefix stateful** *ipv6-address/prefix-length*	Allocates an IPv6 prefix as a global Stateful NAT64 prefix.
Ruijie(config)#**nat64 v4 pool** *pool-name start-ip-address end-ip-address*	Configures a NAT64 IPv4 address pool.
Ruijie(config)#**nat64 v6v4 list** *access-list-name* **pool** *pool-name* **overload**	Enables dynamic NAT64. *access-list-name* specifies an IPv6 ACL. The IPv6 addresses match the ACL are mapped to the addresses in *pool-name* address pool. *pool-name* specifies the name of an IPv4 address pool.
Ruijie(config)#**end**	Exits global configuration mode and returns to privileged EXEC mode.

The following example configures dynamic Stateful NAT64.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface gigabitethernet 0/0/0
Ruijie(config-if)#ipv6 enable
Ruijie(config-if)#ipv6 address 2001:db8:1::1/96
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitethernet 0/0/1
Ruijie(config-if)#ip address 209.165.201.24 255.255.255.0
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#ipv6 access-list nat64-acl
Ruijie(config-ipv6-acl)#permit ipv6 2001:db8:2::/96 any
Ruijie(config-ipv6-acl)#exit
```

```
Ruijie(config)#nat64 prefix stateful 2001:db8:0:1::/96
Ruijie(config)#nat64 v4 pool v4pool 209.165.201.1 209.165.201.254
Ruijie(config)#nat64 v6v4 list nat64-acl pool v4pool overload
Ruijie(config)#end
```

Configuring VRF-Based Stateful NAT64

Command	Function
Ruijie>**enable**	Enters privileged EXEC mode.
Ruijie**#configure terminal**	Enters global configuration mode.
Ruijie(config)#**ipv6 unicast-routing**	(Optional) Enables unicast routing, which is enabled by default.
Ruijie(config)#**vrf definition** *vrf-name*	Creates a multi-protocol VRF.
Ruijie(config-vrf)#**address-family ipv4**	Enables an IPv4 address family.
Ruijie(config-vrf-af)#**exit-address-family**	Exits a VRF address family.
Ruijie(config-vrf)#**address-family ipv6**	Enables an IPv6 address family.
Ruijie(config-vrf-af)#**exit-address-family**	Exits the VRF address family.
Ruijie(config-vrf)#**interface** *interface-name interface-number*	Specifies an IPv6 network interface and enters interface configuration mode.
Ruijie(config-if)#**vrf forwarding** *vrf-name*	Binds the multi-protocol VRF on the interface.
Ruijie(config-if)#**ipv6 enable**	Enables IPv6.
Ruijie(config-if)# **ipv6 address** *ipv6-address/prefix-length*	Configures the IPv6 address of the interface.
Ruijie(config-if)#**nat64 enable**	Enables NAT64 on the interface.
Ruijie(config-if)#**exit**	Exits interface configuration mode and returns to global configuration mode.
Ruijie(config)#**interface** *interface-name interface-number*	Specifies an IPv4 network interface and enters interface configuration mode.
Ruijie(config)#**vrf forwarding** *vrf-name*	Binds the multi-protocol VRF on the interface. The IPv4 and IPv6 protocol families of the multi-protocol VRF need to be enabled.
Ruijie(config-if)#**ip address** *ip-address mask*	Configures the IPv4 address of the interface.
Ruijie(config-if)#**nat64 enable**	Enables NAT64 on the interface.
Ruijie(config-if)#**exit**	Exits interface configuration mode and returns to global configuration mode.
Ruijie(config)#**ipv6 access-list** *access-list-name*	Configures an IPv6 ACL permit entry and enters IPv6 ACL mode.
Ruijie(config-ipv6-acl)#**permit ipv6** *ipv6-address* **any**	Filters IPv6 addresses based on ACL.
Ruijie(config-ipv6-acl)#**exit**	Exits interface configuration mode and returns to global configuration mode.
Ruijie(config)#**nat64 prefix stateful** *ipv6-address/prefix-length* [**vrf** *vrf-name*]	Allocates an IPv6 prefix to *vrf-name* as a Stateful NAT64 prefix.
Ruijie(config)#**nat64 v4 pool** *pool-name start-ip-address end-ip-address* [**vrf** *vrf-name*]	Configures a NAT64 IPv4 address pool for *vrf-name*.

Ruijie(config)#**nat64 v6v4 list** *access-list-name* **pool** *pool-name* [**vrf** *vrf-name*]	Enables dynamic NAT64. *access-list-name* specifies an IPv6 ACL. The IPv6 addresses match the ACL are mapped to the addresses in *pool-name* address pool. *pool-name* specifies the name of an IPv4 address pool. *vrf-name* specifies the name of the VRF.
Ruijie(config)#**ipv6 route vrf** *vrf-name ipv6-prefix/prefix-length interface next-hop*	Adds an IPv6 route. *vrf-name* specifies the name of the VRF; *ipv6-prefix* specifies an IPv6 prefix; *prefix-length* specifies the length of the IPv6 prefix; *interface* specifies an outbound interface; *next-hop* specifies a next-hop address.
Ruijie(config)#**ip route vrf** *vrf-name network mask interface next-hop*	Adds an IPv4 route. *vrf-name* specifies the name of VRF; *network* specifies a destination network segment; *mask* specifies a mask; *interface* specifies an outbound interface; *next-hop* specifies a next-hop address.
Ruijie(config)#**end**	Exits global configuration mode and returns to privileged EXEC mode.

The following example configures VRF-based dynamic Stateful NAT64.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#vrf definition vrf-name1
Ruijie(config-vrf)#address-family ipv4
Ruijie(config-vrf-af)#exit-address-family
Ruijie(config-vrf)#address-family ipv6
Ruijie(config-vrf-af)#exit-address-family
Ruijie(config-vrf)#interface gigabitethernet 0/0/0
Ruijie(config-if)#vrf forwarding vrf-name1
Ruijie(config-if)#ipv6 enable
Ruijie(config-if)#ipv6 address 2001:db8:1::1/96
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitethernet 0/0/1
Ruijie(config-if)#vrf forwarding vrf-name1
Ruijie(config-if)#ip address 209.165.201.24 255.255.255.0
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#ipv6 access-list nat64-acl
Ruijie(config-ipv6-acl)#permit ipv6 2001:db8:2::/96 any
Ruijie(config-ipv6-acl)#exit
Ruijie(config)#nat64 prefix stateful 2001:db8:0:1::/96 vrf vrf-name1
Ruijie(config)#nat64 v4 pool v4pool 209.165.201.1 209.165.201.254 vrf vrf-name1
Ruijie(config)#nat64 v6v4 list nat64-acl pool v4pool vrf vrf-name1
Ruijie(config)#ip route vrf vrf-name1 209.165.201.0 255.255.255.0 gigabitethernet 0/0/1
Ruijie(config)#ipv6 route vrf vrf-name1 2001:db8:0:1::D1A5:C918/120 gigabitethernet 0/0/0
```

```
Ruijie(config)#end
```

Monitoring and Maintaining Stateful NAT64

Command	Function
clear nat64 stateful statistics	Clears statistics about Stateful NAT64.
debug nat64 stateful {alg | control | event | memory | packet | pool | rule | translations}	Enables NAT64 debugging. Use the **no** form of this command to disable NAT64 debugging.
show nat64 stateful debug-buf	Displays the debugging buffer.
show nat64 mappings dynamic	Displays NAT64 dynamic mapping information.
show nat64 mappings static	Displays NAT64 static mapping information.
show nat64 prefix stateful [interfaces]	Displays all configured IPv6 prefixes of Stateful NAT64.
show nat64 services	Displays related NAT64 application layer gateway (ALG) information.
show nat64 stateful statistics	Displays statistics about Stateful NAT64.
show nat64 translations	Displays translation records of NAT64.

Configuration Examples

Static NAT64 Configuration Example

Networking Requirements

Host B on the IPv6 network can initiate a session to Host A on the IPv4 network and record the session entry. To meet the requirements, deploy a NAT64 device between the IPv6 network and the IPv4 network.

Networking Topology

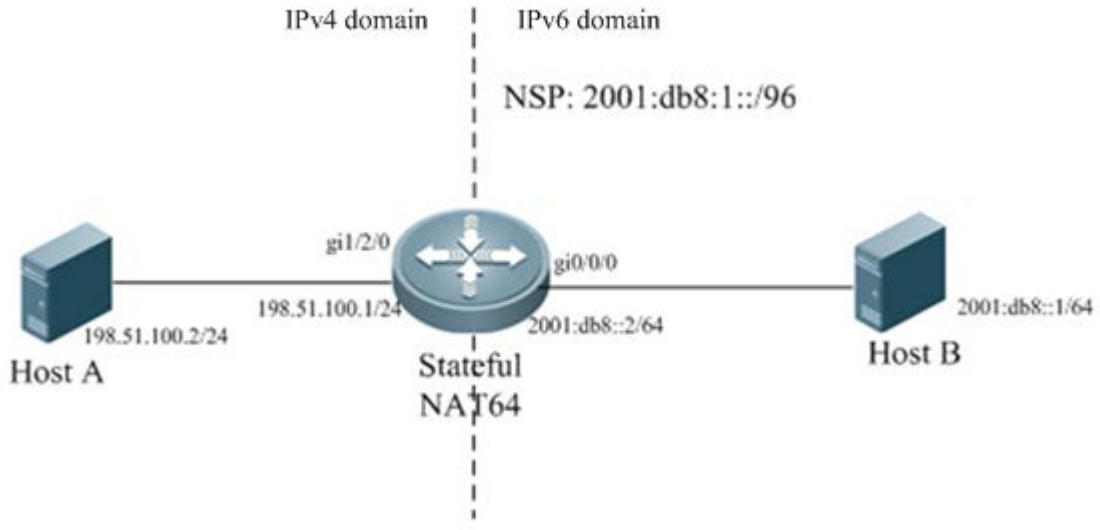


Figure 1-2 Topology of Static Stateful NAT64

Configuration Tips

- Configure the IPv6 address of an IPv6 network interface and enable NAT64 on the interface.
- Configure the IPv4 address of an IPv4 network interface and enable NAT64 on the interface.
- Configure a global NAT64 prefix.
- Configures static IPv6-to-IPv4 address translation.

Configuration Steps

1) Perform the following configurations on the Stateful NAT64 device.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface gigabitethernet 0/0/0
Ruijie(config-if)#ipv6 enable
Ruijie(config-if)#ipv6 address 2001:db8::2/64
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitethernet 1/2/0
Ruijie(config-if)#ip address 198.51.100.2 255.255.255.0
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#nat64 prefix stateful 2001:db8:1::/96
Ruijie(config)#nat64 v6v4 static 2001:db8::1 198.51.100.4
Ruijie(config)#end
```

2) On Host B

Configure the IPv6 address 2001:db8::1/64 on Host B and configure a static route to the prefix 2001:db8:0:1::/96.

3) On Host A

Configure the IP address 198.51.100.2/24 on Host A.

Verification

Run the **ping 2001:db8:1::c633:6401** command on Host B.

```
Ping statistics for 2001:db8:1::c633:6401:
   Packets: Sent = 3, Received = 3, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 0ms, Maximum = 0ms, Average = 0ms
Ruijie#show nat64 translations
Prot  IPv4 source           IPv6 source
     IPv4 destination        IPv6 destination
icmp  198.51.100.4,47       2001:db8::1 ,47
     198.51.100.1 ,47       2001:db8:1::c633:6401,47
```

Dynamic NAT64 Configuration Example

Networking Requirements

Host B, Host C or another host on the IPv6 network can initiate a session to Host A on the IPv4 network and record the session entry. To meet the requirements, deploy a NAT64 device between the IPv6 network and the IPv4 network. Dynamic NAT64 takes effect as long as the number of IPv6-domain hosts that initiate a session to Host A does not exceed the number of IPv4 addresses in the address pool.

Networking Topology

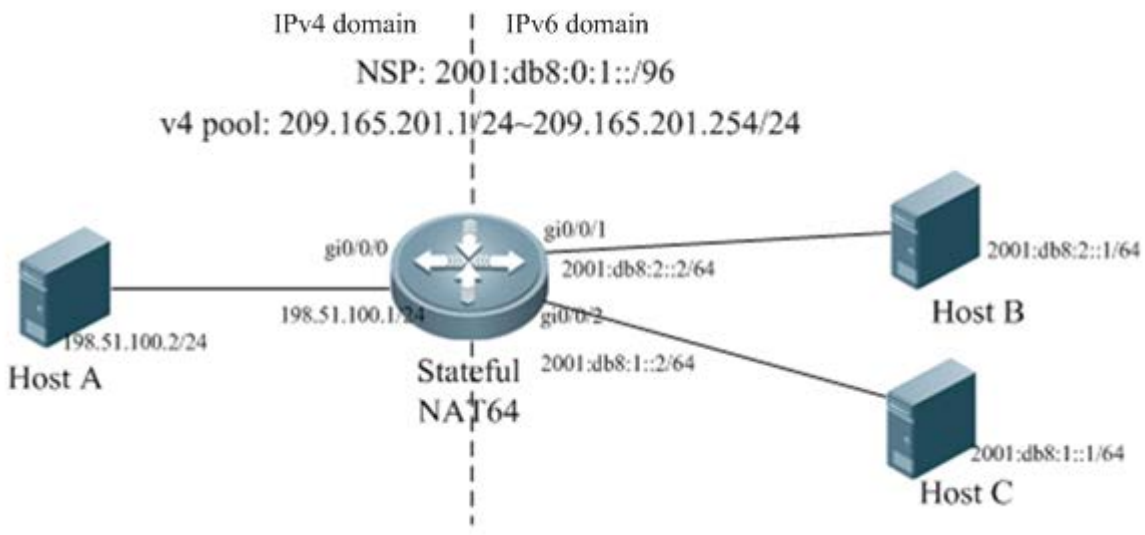


Figure 1-3 Topology of Dynamic Stateful NAT64

Configuration Tips

- Configure the IPv6 address of an IPv6 network interface and enable NAT64 on the interface.
- Configure the IPv4 address of an IPv4 network interface and enable NAT64 on the interface.
- Configure an ACL entry.
- Configure a global NAT64 prefix.
- Configures an IPv4 address pool.
- Configure a dynamic IPv6-to-IPv4 address translation list.

Configuration Steps

1) Perform the following configurations on the Stateful NAT64 device.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface gigabitethernet 0/0/1
Ruijie(config-if)#ipv6 enable
Ruijie(config-if)#ipv6 address 2001:db8:2::2/64
Ruijie(config-if)#nat64 enable
```

```
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitethernet 0/0/2
Ruijie(config-if)#ipv6 enable
Ruijie(config-if)#ipv6 address 2001db8:1::2/64
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitethernet 0/0/0
Ruijie(config-if)#ip address 198.51.100.1 255.255.255.0
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#ipv6 access-list v6_list1
Ruijie(config-ipv6-acl)#permit ipv6 any any
Ruijie(config-ipv6-acl)#exit
Ruijie(config)#nat64 prefix stateful 2001:db8:0:1::/96
Ruijie(config)#nat64 v4 pool v4_pool 209.165.201.1 209.165.201.254
Ruijie(config)#nat64 v6v4 list v6_list1 pool v4_pool
Ruijie(config)#end
```

2) On Host B

Configure the IPv6 address 2001:db8:2::1/64 on Host B and configure a static route to the prefix 2001:db8:0:1::/96.

3) On Host C

Configure the IPv6 address 2001:db8:1::1/64 on Host C and configure a static route to the prefix 2001:db8:0:1::/96.

4) On Host A

Configure the IP address 198.51.100.2/24 on Host A and configure a static route to the destination network segment 209.165.201.0/24.

Verification

Run the **ping 2001:db8:0:1::c633:6401** command on Host B.

```
Ping statistics for 2001:db8:0:1::c633:6401:
   Packets: Sent = 3, Received = 3, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

Run the **ping 2001:db8:0:1::c633:6401** command on Host C.

```
Ping statistics for 2001:db8:0:1::c633:6401:
   Packets: Sent = 3, Received = 3, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 0ms, Maximum = 0ms, Average = 0ms
Ruijie#show nat64 translations
Prot  IPv4 source            IPv6 source
     IPv4 destination         IPv6 destination
---    ----                 -----
```

```
icmp  209.165.201.1,47         2001:db8:2::1,47
     198.51.100.1 ,47        2001:db8:0:1::c633:6401,47
icmp  209.165.201.2,47         2001:db8:1::1,47
      198.51.100.1,47        2001:db8:0:1::c633:6401,47
```

Configuration Example of Dynamic PAT-Based NAT64

Networking Requirements

When the number of IPv6-domain hosts that initiate a session to Host A does not exceed the number of IPv4 addresses in the address pool, Host B or Host C on the IPv6 network can initiate a session to Host A on the IPv4 network and record the session entry. Otherwise, deploy a dynamic PAT-based NAT64 device between the IPv6 network and the IPv4 network, so that Host B or Host C can continue to access Host A.

Networking Topology

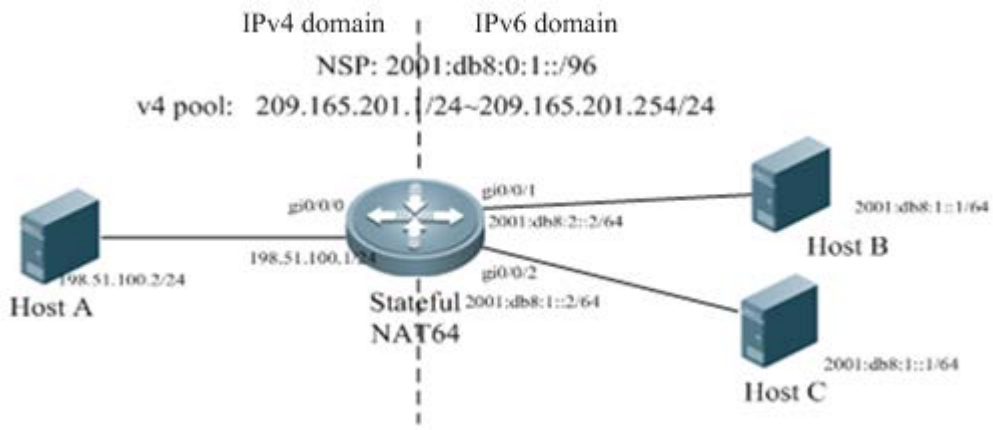


Figure 1-4 Topology of Dynamic PAT-Based NAT64

Configuration Tips

- Configure the IPv6 address of an IPv6 network interface and enable NAT64 on the interface.
- Configure the IPv4 address of an IPv4 network interface and enable NAT64 on the interface.
- Configure an ACL entry.
- Configure a global NAT64 prefix.
- Configures an IPv4 address pool.
- Configure a dynamic PAT-based IPv6-to-IPv4 address translation list.

Configuration Steps

1) Perform the following configurations on the Stateful NAT64 device.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface gigabitethernet 0/0/1
```

```
Ruijie(config-if)#ipv6 enable
Ruijie(config-if)#ipv6 address 2001:db8:2::2/64
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitethernet 0/0/2
Ruijie(config-if)#ipv6 enable
Ruijie(config-if)#ipv6 address 2001:db8:1::2/64
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitethernet 0/0/0
Ruijie(config-if)#ip address 198.51.100.1 255.255.255.0
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#ipv6 access-list v6_list1
Ruijie(config-ipv6-acl)#permit ipv6 any any
Ruijie(config-ipv6-acl)#exit
Ruijie(config)#nat64 prefix stateful 2001:db8:0:1::/96
Ruijie(config)#nat64 v4 pool v4_pool 209.165.201.1 209.165.201.254
Ruijie(config)#nat64 v6v4 list v6_list1 pool v4_pool overload
Ruijie(config)#end
```

2) On Host B

Configure the IPv6 address 2001:db8:2::1/64 on Host B and configure a static route to the prefix 2001:db8:0:1::/96.

3) On Host C

Configure the IPv6 address 2001:db8:1::1/64 on Host B and configure a static route to the prefix 2001:db8:0:1::/96.

4) On Host A

Configure the IPv address 198.51.100.2/24 on Host A and configure a static route to the destination network segment 209.165.201.0/24.

Verification

Run the **ping 2001:db8:0:1::c633:6401** command on Host B.

```
Ping statistics for 2001:db8:0:1::c633:6401:
    Packets: Sent = 3, Received = 3, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

Run the **ping 2001:db8:0:1::c633:6401** command on Host C.

```
Ping statistics for 2001:db8:0:1::c633:6401:
    Packets: Sent = 3, Received = 3, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 0ms, Maximum = 0ms, Average = 0ms
Ruijie#show nat64 translations
```

```
Prot  IPv4 source            IPv6 source
     IPv4 destination         IPv6 destination
---    ----                   -----
icmp  209.165.201.1,47        2001:db8:2::1 ,47
      198.51.100.1,47        2001:db8:0:1::c633:6401,47
icmp  209.165.201.1,1029       2001:db8:1::1, 1029
      198.51.100.1, 1029      2001:db8:0:1::c633:6401, 1029
```

Configuration Example of VRF-Based Stateful NAT64

Networking Requirements

Only hosts on the IPv6 network can initiate a session to Host A on the IPv4 network. Meanwhile, the router device can be divided into independently logical routers. To meet the requirements, deploy a VRF-based Stateful NAT64 device on the boundary between the IPv6 network and the IPv4 network, so that logical translation devices can communicate with each other.

Networking Topology

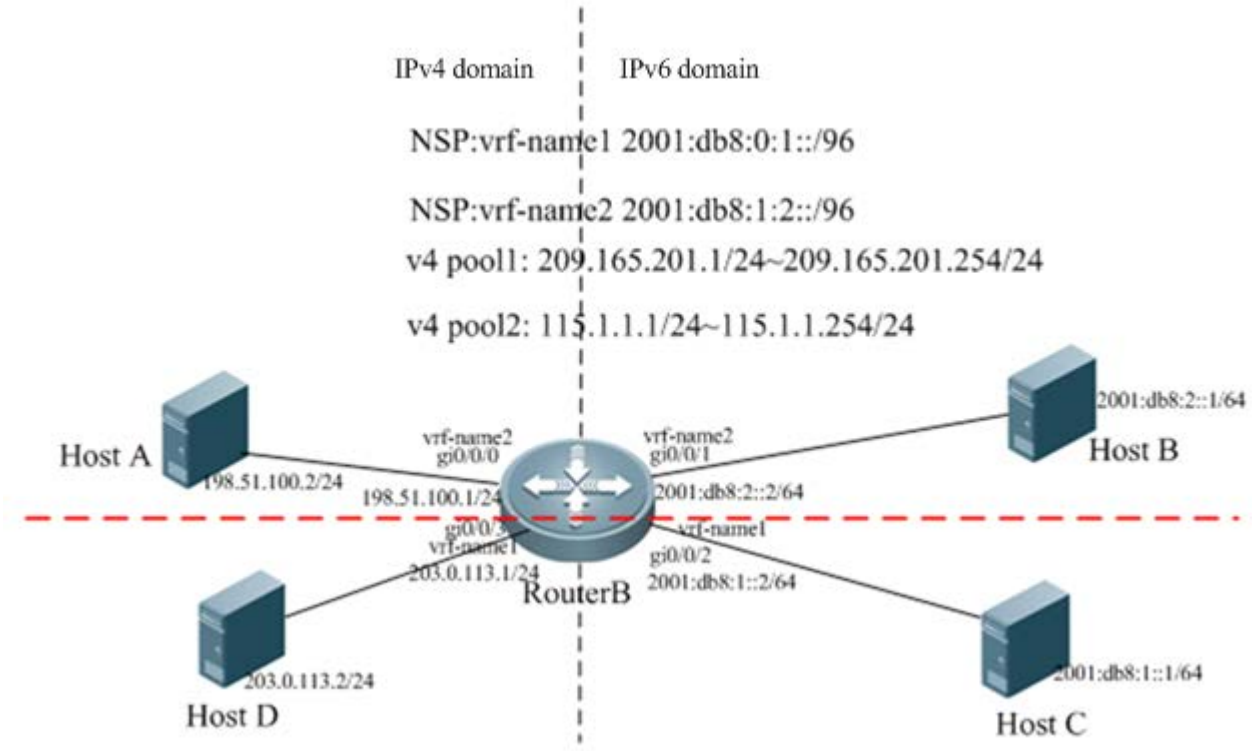


Figure 1-5 Topology of VRF-Based Stateful NAT64

Configuration Tips

- Create VRFs.
- Enable VRFs on interfaces.
- Configure the IPv6 address of an IPv6 network interface and enable NAT64 on the interface.

- Configure the IPv4 address of an IPv4 network interface and enable NAT64 on the interface.
- Configure a routing protocol.
- Configure an ACL.
- Configure global NAT64 prefixes for different VRFs.
- Configure IPv4 address pools for different VRFs.
- Configure dynamic IPv6-to-IPv4 translation access lists for different VRFs.

Configuration Steps

1) Perform the following configurations on Router B, which serves as the Stateful NAT64 device.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#vrf definition vrf-name1
Ruijie(config-vrf)#address-family ipv4
Ruijie(config-vrf-af)#exit-address-family
Ruijie(config-vrf)#address-family ipv6
Ruijie(config-vrf-af)#exit-address-family
Ruijie(config-vrf)#interface gigabitethernet 0/0/0
Ruijie(config-if)#vrf forwarding vrf-name1
Ruijie(config-if)#ip address 198.51.100.1 255.255.255.0
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitethernet 0/0/1
Ruijie(config-if)#vrf forwarding vrf-name1
Ruijie(config)#ipv6 enable
Ruijie(config-if)#ipv6 address 2001:db8:2::2/64
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#vrf definition vrf-name2
Ruijie(config-vrf)#address-family ipv4
Ruijie(config-vrf-af)#exit-address-family
Ruijie(config-vrf)#address-family ipv6
Ruijie(config-vrf-af)#exit-address-family
Ruijie(config-vrf)#interface gigabitethernet 0/0/3
Ruijie(config-if)#vrf forwarding vrf-name2
Ruijie(config-if)#ip address 203.0.113.2 255.255.255.0
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config-vrf)#interface gigabitethernet 0/0/2
Ruijie(config-if)#vrf forwarding vrf-name2
Ruijie(config-if)#ipv6 address 2001:db8:1::2/64
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
```

```
Ruijie(config)#ipv6 access-list nat64-acl1
Ruijie(config-ipv6-acl)#permit ipv6 2001:db8:2::/64 any
Ruijie(config-ipv6-acl)#exit
Ruijie(config)#nat64 prefix stateful 2001:db8:0:1::/96 vrf vrf-name1
Ruijie(config)#nat64 v4 pool v4pool1 209.165.201.1 209.165.201.254
Ruijie(config)#nat64 v4 pool v4pool2 115.1.1.1 115.1.1.20
Ruijie(config)#nat64 v6v4 list nat64-acl1 pool v4pool1 vrf vrf-name1
Ruijie(config)#ipv6 access-list nat64-acl2
Ruijie(config-ipv6-acl)#permit ipv6 4001::/64 any
Ruijie(config-ipv6-acl)#exit
Ruijie(config)#nat64 prefix stateful 2001:db8:1:2::/96 vrf vrf-name2
Ruijie(config)#nat64 v6v4 list nat64-acl2 pool v4pool2 vrf vrf-name2
Ruijie(config)#ip route vrf vrf-name1 209.165.201.0 255.255.255.0 gi0/0/0
Ruijie(config)#ip route vrf vrf-name1 209.165.201.0 255.255.255.0 gi0/0/3
Ruijie(config)#ipv6 route vrf vrf-name1 2001:db8:0:1::/96 gi0/0/2
Ruijie(config)#ipv6 route vrf vrf-name1 2001:db8:0:1::/96 gi0/0/1
Ruijie(config)#ipv6 route vrf vrf-name2 2001:db8:1:2::/96 gi0/0/1
Ruijie(config)#ipv6 route vrf vrf-name2 2001:db8:1:2::/96 gi0/0/2
Ruijie(config)#ip route vrf vrf-name2 115.1.1.0 255.255.255.0 gi0/0/0
Ruijie(config)#ip route vrf vrf-name2 115.1.1.0 255.255.255.0 gi0/0/3
Ruijie(config)#end
```

2) On Host B

Configure the IPv6 address 2001:db8:2::1/64 on Host B and configure a static route to the prefix 2001:db8:0:1::/96.

3) On Host C

Configure the IPv6 address 2001:db8:1::1/64 on Host C and configure static routes to the prefixes 2001:db8:0:1::/96 and 2001:db8:1:2::/96.

4) On Host A

Configure the IP address 198.51.100.2/24 on Host A and configure a static route to the destination network segment 209.165.201.0/24.

5) On Host D

Configure the IPv6 address 203.0.113.2/24 on Host D and configure a static route to the destination network segment 209.165.201.0/24.

Verification

Run the **ping 2001:db8:0:1::c633:6401** command on Host B.

```
Ping statistics for 2001:db8:0:1::c633:6401:
    Packets: Sent = 3, Received = 3, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

Run the **ping 2001:db8:0:1::c633:6401** command on Host C.

```
Ping statistics for 2001:db8:0:1::c633:6401:
   Packets: Sent = 3, Received = 3, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 0ms, Maximum = 0ms, Average = 0ms
Ruijie#show nat64 translations
Prot  IPv4 source            IPv6 source
     IPv4 destination         IPv6 destination
---    ----                   -----
icmp  209.165.201.1,47        2001:db8:2::1 ,47
      198.51.100.1,47        2001:db8:0:1::c633:6401,47
icmp  209.165.201.2,1027       2001:db8:1::1 ,1027
     198.51.100.1 ,1027      2001:db8:0:1::c633:6401,1027
```

Configuration Example of ALG-Based Stateful NAT64

Networking Requirements

The various typical applications in address translation scenario on the pure IPv6 network or IPv4 network need not only address translation but also application-layer information transformation. For example, when IPv6 users on the IPv6 network initiate access requests to the IPv4 FTP server, the FTP ALG function needs to be added to the NAT64 device to meet application requirements. NAT64 can only translate addresses.

☑ When some applications (such as DNS, VoIP, and multimedia applications) perform address family traversal, the corresponding protocols must ensure that the traversal function works well. NAT64 is only a transition technology and cannot meet all application requirements.

Networking Topology

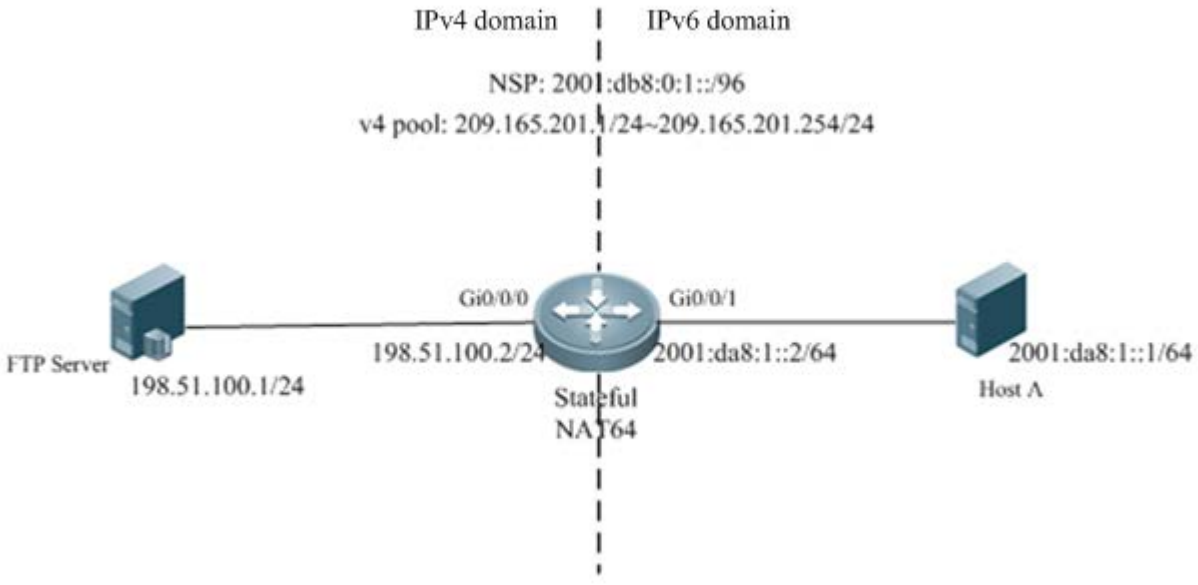


Figure 1-6 Topology of FTP ALG-Based Stateful NAT64

Configuration Tips

- Configure the IPv6 address of an IPv6 network interface and enable NAT64 on the interface.
- Configure the IPv4 address of an IPv4 network interface and enable NAT64 on the interface.
- Configure an ACL entry.
- Configure a global NAT64 prefix.
- Configures an IPv4 address pool.
- Configure a dynamic IPv6-to-IPv4 address translation list.
- Enable FTP ALG (enabled by default).

Configuration Steps

1) Perform the following configurations on the Stateful NAT64 device.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface gigabitethernet 0/0/1
Ruijie(config-if)#ipv6 enable
Ruijie(config-if)#ipv6 address 2001:da8:1::2/64
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitethernet 0/0/0
Ruijie(config-if)#ipv4 address 198.51.100.2 255.255.255.0
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#ipv6 access-list v6_list1
Ruijie(config-ipv6-acl)#permit ipv6 any any
Ruijie(config-ipv6-acl)#exit
Ruijie(config)#nat64 prefix stateful 2001:db8:0:1::/96
Ruijie(config)#nat64 v4 pool v4_pool 209.165.201.1 209.165.201.254
Ruijie(config)#nat64 v6v4 list v6_list1 pool v4_pool
Ruijie(config)#end
```

2) On Host A in the IPv6 domain

Configure the IP address 2001:da8:1::1/64 for Host A and configure a corresponding static route.

3) On the FTP server

Configure the IPv4 address as 198.51.100.1/24 and configure a static route to the destination network segment 209.165.201.0/24.

Verification

1) Run the **ping 2001:db8:0:1::c633:6401** command on Host A.

```
Ping statistics for 2001:db8:0:1::c633:6401:
    Packets: Sent = 3, Received = 3, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
```

```
Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

2) Enter FTP mode.

Running the **put**, **get**, and **dir** commands can upload a file to the FTP server or download a file from it.

Configuring Stateless NAT64

Understanding Stateless NAT64

Overview

With the fast development of the Internet, IPv4 can no longer meet Internet requirements. Under this circumstance, IPv6 is about to be deployed. To support an IPv6 network, you must make full use of existing network resources to construct a next-generation Internet, thereby implementing smooth transition and avoiding excessive investment. The current Internet is based on IPv4 and cannot be transited to the IPv6 network in a short time. Therefore, the IPv4 and IPv6 networks will coexist in a rather long time.

The coexistence however, causes the following problems: how to keep current network services and functions at minimum cost; and how to implement transparent transmission between the IPv6 network and the IPv4 network. Network Address Translation 64 (NAT64, also called the IPv6-to-IPv4 network address translation protocol) includes Stateful NAT64 and Stateless NAT64. Stateless NAT64 is mainly used when IPv4 network users initiate access requests to hosts on the IPv6 network.

Basic Concepts

Stateless Network Address Translation 64 (Stateless NAT64): Stateless IPv6-to-IPv4 network address translation protocol. Stateless NAT64 provides a translation mechanism, which implements translation between IPv4 addresses and IPv6 addresses. The translation involves parsing the entire IPv6 header, obtaining related information and translating it into an IPv4 header or a completely converse translation process. Stateless NAT64 can translate the IP addresses of only some types of ICMPv4 and ICMPv6 packets due to the protocol features, such as translation between ICMPv4 request/response packets and ICMPv6 request/response packets and translation between unreachable ICMPv4 packets and unreachable ICMPv6 packets. Address translation for each packet relies on interface configurations. Stateless NAT64 does not maintain data flow statuses.

IPv4-translatable IPv6 address: IPv6 address after Stateless NAT64 that is allocated to an IPv6 host

---

- ☑ Stateless NAT64 can be used only when there are IPv4-translatable IPv6 addresses.
- ☑ Stateless NAT64 does not support multicast.
- ☑ Stateless NAT64 cannot be used by the application without a corresponding ALG.
- ☑ Stateless NAT64 cannot translate an IPv4 option, an IPv6 routing header in an IPv6 extension header, a hop-by-hop extension header, or a destination option header.

Working Principle

Stateless NAT64 works on the boundary device between the IPv6 network and the IPv4 network. The Stateless NAT64 module translates IP headers between the two networks and performs semantic translation for packets according to different protocols so as to implement transparent transmission between the two networks.

Protocol Specification

RFC6052: IPv6 Addressing of IPv4/IPv6 Translators

RFC6144: Framework for IPv4/IPv6 Translation

RFC6145: IP/ICMP Translation Algorithm

Typical Application

Application Scenario 1

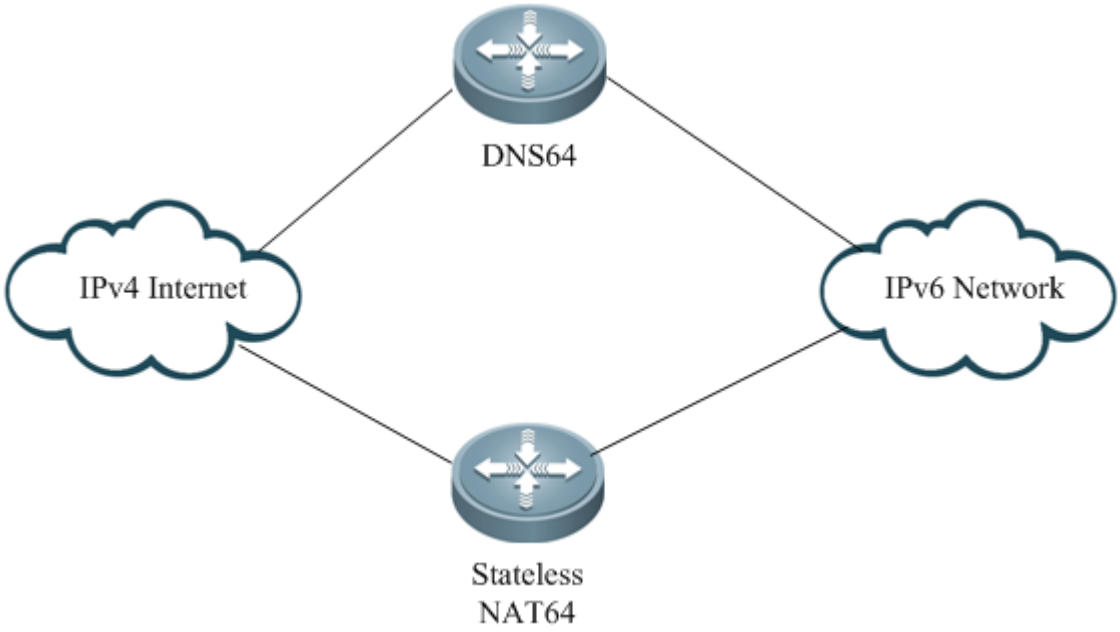


Figure 2-1 Interaction Between the IPv4 Internet and the IPv6 Network

This application scenario supports IPv4 network users to access IPv6 network resources.

Users of the IPv4 Internet can access IPv6 network resources in a specific scope.

This scenario has the following functions:

3) A new IPv6 content provider can provide resources for users both on the IPv6 network and the IPv4 Internet.

4) An IPv4 content provider that is transited to the pure IPv6 network can still provide resources for original IPv4 users and keep the connections with them.

This scenario has the following access modes:

- IP-based access
- Domain name-based access

Application Scenario 2

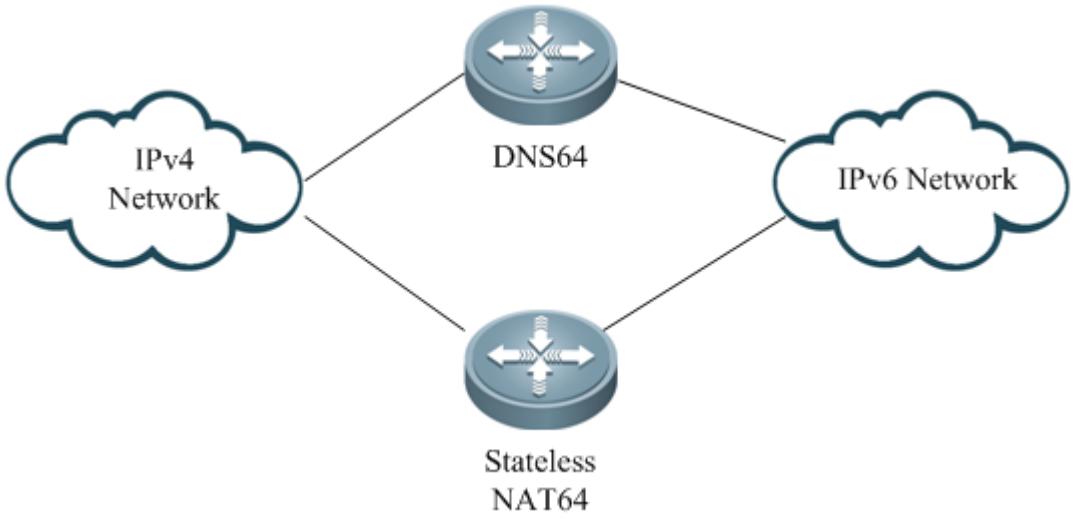


Figure 2-2 Interaction Between the IPv4 Network and the IPv6 Network

This application scenario mainly allows IPv4 network users to initiate access requests.

This scenario supports interaction between the IPv4 network and the IPv6 network, and mainly allows IPv4 network users to initiate access requests. The internal address can be a public address or a private address. The host addresses on the IPv6 network must be IPv4-translatable IPv6 addresses.

Configuring Stateless NAT64

Configuring Stateless NAT64

Command	Function
Ruijie>**enable**	Enters privileged EXEC mode.
Ruijie**#configure terminal**	Enters global configuration mode.
Ruijie(config)#**ipv6 unicast-routing**	(Optional) Enables unicast routing, which is enabled by default.
Ruijie(config)#**interface** *interface-name interface-number*	Specifies an IPv6 network interface and enters interface configuration mode.
Ruijie(config-if)#**ipv6 enable**	Enables IPv6.
Ruijie(config-if)# **ipv6 address** *ipv6-address/prefix-length*	Configures the IPv6 address of the interface.
Ruijie(config-if)#**nat64 enable**	Enables NAT64 on the interface.
Ruijie(config-if)#**exit**	Exits interface configuration mode and returns to global configuration mode.
Ruijie(config)#**interface** *interface-name interface-number*	Specifies an IPv4 network interface and enters interface configuration mode.
Ruijie(config-if)#**ip address** *ip-address mask*	Configures the IPv4 address of the interface.
Ruijie(config-if)#**nat64 enable**	Enables NAT64 on the interface.
Ruijie(config-if)#**exit**	Exits interface configuration mode and returns to global configuration mode.

Ruijie(config)#**nat64 prefix stateless** *ipv6-address/prefix-length*	Allocates an IPv6 prefix as a global Stateless NAT64 prefix.
Ruijie(config)#**nat64 route** *ipv4-prefix/length interface-name interface-number*	Configures a route which starts from an IPv4 network segment and is destined for a specific IPv6 interface. Running this command can configure a route with a specific prefix and the default route with the prefix 0.0.0.0/0 in a VRF.
Ruijie(config)#**ipv6 route** *ipv6-prefix/length interface-name interface-number nexthop-address*	Configures an IPv6 route, which is used to transmit the packets whose routes are changed to the destination IPv6 address.
Ruijie(config)#**end**	Exits global configuration mode and returns to privileged EXEC mode.

The following example configures Stateless NAT64.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface gigabitethernet 0/0
Ruijie(config-if)#ipv6 enable
Ruijie(config-if)#ipv6 address 2001:db8::1/96
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitethernet 0/1
Ruijie(config-if)#ip address 198.51.100.1 255.255.255.0
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#nat64 prefix stateless 2001:db8:0:1::/96
Ruijie(config)#nat64 route 203.0.113.0/24 gigabitethernet 0/0
Ruijie(config)#ipv6 route 2001:db8:0:1::/96 gigabitethernet 0/0 2001:db8::2
Ruijie(config)#ip route 0.0.0.0 0.0.0.0 198.51.100.2
Ruijie(config)#end
```

Configuring Multi-Prefix Stateless NAT64

Command	Function
Ruijie>**enable**	Enters privileged EXEC mode.
Ruijie**#configure terminal**	Enters global configuration mode.
Ruijie(config)#**ipv6 unicast-routing**	(Optional) Enables unicast routing, which is enabled by default.
Ruijie(config)#**interface** *interface-name interface-number*	Specifies an IPv6 network interface and enters interface configuration mode.
Ruijie(config-if)#**ipv6 enable**	Enables IPv6.
Ruijie(config-if)# **ipv6 address** *ipv6-address/prefix-length*	Configures the IPv6 address of the interface.
Ruijie(config-if)#**nat64 enable**	Enables NAT64 on the interface.

Ruijie(config-if)#**nat64 prefix stateless v6v4** *ipv6-address/prefix-length*	Configures the IPv6 prefix for Statelesss NAT64 (IPv6-to-IPv4 address translation) on an interface. The prefix must work with the global Stateless NAT64 prefix (v4v6). Otherwise, addresses cannot be translated.
Ruijie(config-if)#**exit**	Exits interface configuration mode and returns to global configuration mode.
Ruijie(config)#**interface** *interface-name interface-number*	Specifies an IPv4 network interface and enters interface configuration mode.
Ruijie(config-if)#**ip address** *ip-address mask*	Configures the IPv4 address of the interface.
Ruijie(config-if)#**nat64 enable**	Enables NAT64 on the interface.
Ruijie(config-if)#**exit**	Exits interface configuration mode and returns to global configuration mode.
Ruijie(config)#**nat64 prefix stateless v4v6** *ipv6-address/prefix-length*	Allocates an IPv6 prefix as a global Stateless NAT64 prefix. The prefix must work with the Stateless NAT64 prefix (v6v4). Otherwise, addresses cannot be translated.
Ruijie(config)#**nat64 route** *ipv4-prefix/length interface-name interface-number*	Configures a route which starts from an IPv4 network segment and is destined for a specific IPv6 interface. Running this command can configure a route with a specific prefix and the default route with the prefix 0.0.0.0/0 in a VRF.
Ruijie(config)#**ipv6 route** *ipv6-prefix/length interface-name interface-number*	Configures an IPv6 route, which is used to transmit the packets whose routes are changed to the destination IPv6 address.
Ruijie(config)#end	Exits global configuration mode and returns to privileged EXEC mode.

The following example configures multi-prefix Stateless NAT64.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface gigabitethernet 0/0
Ruijie(config-if)#ipv6 enable
Ruijie(config-if)#ipv6 address 2001:db8::1/96
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#nat64 prefix stateless v6v4 2001:db8:0:1::/96
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitethernet 0/1
Ruijie(config-if)#ip address 198.51.100.1 255.255.255.0
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#nat64 prefix stateless v4v6 2001:db8:2::1/96
Ruijie(config)#nat64 route 203.0.113.0/24 gigabitethernet 0/0
Ruijie(config)#ipv6 route 2001:db8:0:1::/96 gigabitethernet 0/0 2001:db8::2
Ruijie(config)#ip route 0.0.0.0 0.0.0.0 198.51.100.2
Ruijie(config)#end
```

Configuring VRF-Based Stateless NAT64

Command	Function
Ruijie>**enable**	Enters privileged EXEC mode.
Ruijie**#configure terminal**	Enters global configuration mode.
Ruijie(config)#**ipv6 unicast-routing**	(Optional) Enables unicast routing, which is enabled by default.
Ruijie(config)#**interface** *interface-name interface-number*	Specifies an IPv6 network interface and enters interface configuration mode.
Ruijie(config-if)#**vrf forwarding vrf** *vrf-name*	Enables a VRF on an interface. The IPv4 and IPv6 protocol families of the VRF also need to be enabled.
Ruijie(config-if)#**ipv6 enable**	Enables IPv6.
Ruijie(config-if)# **ipv6 address** *ipv6-address/prefix-length*	Configures the IPv6 address of the interface.
Ruijie(config-if)#**nat64 enable**	Enables NAT64 on the interface.
Ruijie(config-if)#**exit**	Exits interface configuration mode and returns to global configuration mode.
Ruijie(config)#**interface** *interface-name interface-number*	Specifies an IPv4 network interface and enters interface configuration mode.
Ruijie(config-if)#**vrf forwarding vrf** *vrf-name*	Enables a VRF on an interface. The IPv4 and IPv6 protocol families of the VRF also need to be enabled.
Ruijie(config-if)#**ip address** *ip-address mask*	Configures the IPv4 address of the interface.
Ruijie(config-if)#**nat64 enable**	Enables NAT64 on the interface.
Ruijie(config-if)#**exit**	Exits interface configuration mode and returns to global configuration mode.
Ruijie(config)#**nat64 prefix stateless** *ipv6-address/prefix-length* **vrf** *vrf-name*	Configures Stateless NAT64 *ipv6-address/prefix-length* under *vrf-name*.
Ruijie(config)#**nat64 route** *ipv4-prefix/length interface-name interface-number* **vrf** *vrf-name*	Configures a route which starts from an IPv4 network segment and is destined for a specific IPv6 interface. Running this command can configure a route and the default route with the prefix 0.0.0.0/0 in a VRF.
Ruijie(config)#**ipv6 route** *ipv6-prefix/length interface-name interface-number*	Configures an IPv6 route, which is used to transmit the packets whose routes are changed to the destination IPv6 address.
Ruijie(config)#end	Exits global configuration mode and returns to privileged EXEC mode.

The following example configures VRF-based Stateless NAT64.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface gigabitethernet 0/0
Ruijie(config-if)# vrf forwarding 1
Ruijie(config-if)#ipv6 enable
Ruijie(config-if)#ipv6 address 2001:db8::1/96
Ruijie(config-if)#nat64 enable
```

```
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitethernet 0/1
Ruijie(config-if)# vrf forwarding 1
Ruijie(config-if)#ip address 198.51.100.1 255.255.255.0
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#nat64 prefix stateless 2001:db8:0:1::/96 vrf 1
Ruijie(config)#nat64 route 203.0.113.0/24 gigabitethernet 0/0 vrf 1
Ruijie(config)#ipv6 route vrf 1 2001:db8:0:1::/96 gigabitethernet 0/0 2001:db8::2
Ruijie(config)#ip route vrf 1 0.0.0.0 0.0.0.0 198.51.100.2
Ruijie(config)#end
```

Monitoring and Maintaining Stateless NAT64

Command	Function
clear nat64 stateless statistics	Clears statistics about Stateless NAT64.
debug nat64 stateless { **control** | **packet**]	Enables Stateless NAT64 debugging. Use the **no** form of this command to disable Stateless NAT64 debugging.
show nat64 stateless debug-buf	Displays the debugging buffer.
show nat64 prefix stateless [**interfaces**]	Displays all configured IPv6 prefixes of Stateless NAT64.
show nat64 stateless statistics	Displays statistics about Stateless NAT64.

Configuration Examples

Stateless NAT64 Configuration Example

Networking Requirements

Host A with the address 198.51.100.2/24 in the IPv4 domain can access Host B with the address 2001:db8:0:1::cb00:7101 in the IPv6 domain. To meet this requirement, deploy a NAT64 device (Router B) between the IPv4 domain and the IPv6 domain and configure a global IPv6 prefix for NAT64 on Router B to implement intercommunication between the two domains.

Networking Topology

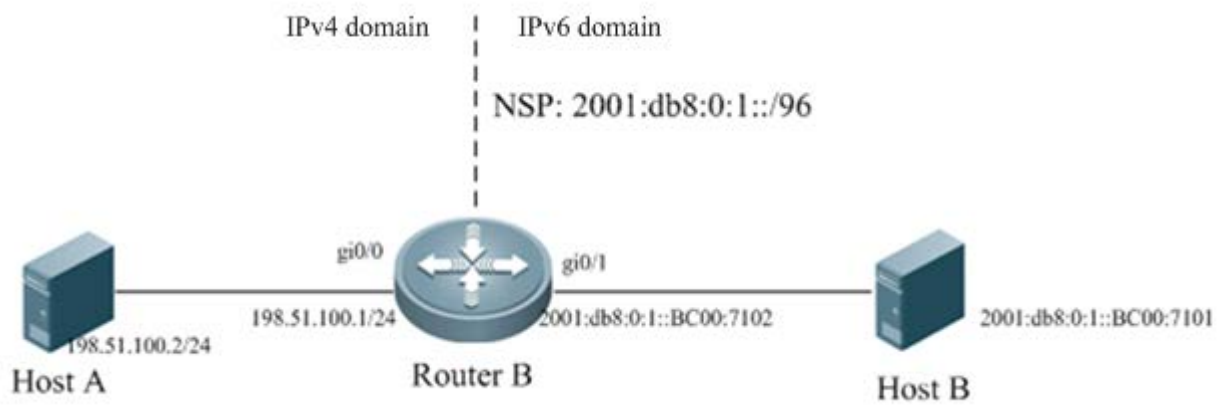


Figure 2-3 Topology of Stateless NAT64

Configuration Tips

Perform the following configurations on the Stateless NAT64 device:

- Configure the IPv6 address of an IPv6 network interface.
- Configure the IPv4 address of an IPv4 network interface.
- Configure a global NAT64 prefix and enable NAT64 on the interface.
- Configure a route which starts from the IPv4 network segment and is destined for the interface for NAT64.
- Configure a static route that is used to transmit translated packets to the IPv6 address.

Configuration Steps

5) Perform the following configurations on Router B, which serves as the Stateless NAT64 device.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)#interface gigabitethernet 0/1
Ruijie(config-if)#ipv6 enable
Ruijie(config-if)#ipv6 address 2001:db8:0:1::cb00:7102/96
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitethernet 0/0
Ruijie(config-if)#ip address 198.51.100.1 255.255.255.0
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#nat64 prefix stateless 2001:db8:0:1::/96
Ruijie(config)#nat64 route 203.0.113.0/24 gigabitethernet 0/1
Ruijie(config)#ipv6 route 2001:db8:0:1::/96 gigabitethernet 0/0 2001:db8:0:1::cb00:7101
Ruijie(config)#ip route 0.0.0.0 0.0.0.0 198.51.100.2
Ruijie(config)#end
```

6) On Host B

Configure the IPv6 address 2001:db8:0:1::cb00:7101/128 on Host B and configure a static route to the prefix 2001:db8:0:1::/96.

7) On Host A

Configure the IP address 198.51.100.2/24 on Host A and configure a static route to the destination network segment 203.0.113.0/24.

Verification

Run the **ping 203.0.113.1** command on Host A.

```
Ping statistics for 203.0.113.1:
   Packets: Sent = 3, Received = 3, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 0ms, Maximum = 0ms, Average = 0ms
Ruijie#sh nat64 stateless statistics
NAT64 Stateless Global stats:
   Created Packets translation (IPv4 -> IPv6): 0.
   Created Packets translation (IPv6 -> IPv4): 0.
   Packets droped in IPv4: 0.
   Packets droped in IPv6: 0.
NAT64 Stateless Interface stats:
   Gi0/1:
      Created Packets translation (IPv4 -> IPv6): 0.
      Created Packets translation (IPv6 -> IPv4): 0.
   Gi0/0:
      Created Packets translation (IPv4 -> IPv6): 0.
      Created Packets translation (IPv6 -> IPv4): 0.
```

Configuration Example of Multi-Prefix Stateless NAT64

Networking Requirements

Host A with the address 198.51.100.2/24 in the IPv4 domain can access Host B and Host C in different network segments of the IPv6 network. To meet this requirement, configure IPv6 prefixes on the IPv6 interfaces of different network segments on the Stateless NAT64 device (Router B).

Networking Topology

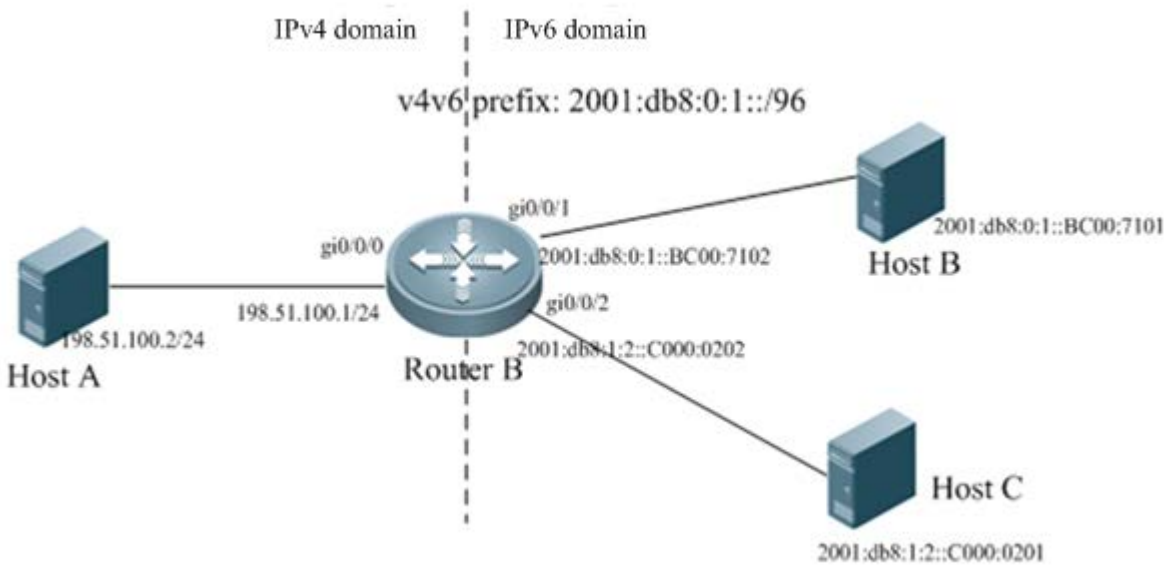


Figure 2-4 Multi-Prefix Stateless NAT64

Host A accesses Host B and Host C in two IPv6 network segments.

Configuration Tips

Perform the following configurations on the Stateless NAT64 device:

- Configure the IPv6 address of an IPv6 network interface, enable NAT64, and configure the Stateless NAT64 prefix (v6v4).
- Configure the IPv4 address of an IPv4 network interface and enable NAT64.
- Configure the Stateless NAT64 prefix (v4v6) in global mode.
- Configure a route which starts from an IPv4 network segment and is destined for the IPv6 interface for NAT64.
- Configure a static route that is used to transmit translated packets to the IPv6 address.

Configuration Steps

8) Perform the following configurations on Router B, which serves as the Stateless NAT64 device.

```
Ruijie#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Ruijie(config)# interface gigabitethernet 0/0/0
Ruijie(config-if)#ip address 198.51.100.1 255.255.255.0
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitethernet 0/0/1
Ruijie(config-if)#ipv6 enable
Ruijie(config-if)#ipv6 address 2001:db8:0:1::cb00:7102/96
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#nat64 prefix stateless v6v4 2011:db8:0:1::/96
```

```
Ruijie(config-if)#exit
Ruijie(config)#interface gigabitethernet 0/0/2
Ruijie(config-if)#ipv6 enable
Ruijie(config-if)#ipv6 address 2001:db8:1:2::C000:0202/96
Ruijie(config-if)#nat64 enable
Ruijie(config-if)#nat64 prefix stateless v6v4 2011:db8:1:2::/96
Ruijie(config-if)#exit
Ruijie(config)#nat64 prefix stateless v4v6 2011:db8:2::1/96
Ruijie(config)#nat64 route 203.0.113.0/24 gigabitethernet 0/0/1
Ruijie(config)#ipv6 route 2011:db8:0:1::/96 gigabitethernet 0/0/1 2001:db8:0:1::cb00:7101
Ruijie(config)#nat64 route 0.0.0.0/0 gigabitethernet 0/0/2
Ruijie(config)#ipv6 route 2011:db8:1:2::/96 gigabitethernet 0/0/2 2001:db8:1:2::C000:0201
Ruijie(config)#end
```

9) On Host B

Configure the IPv6 address 2001:db8:0:1::cb00:7101/128 on Host B and configure a static route to the prefix 2001:db8:0:1::/96.

10) On Host C

Configure the IPv6 address 2001:db8:0:1::c000:0201/128 on Host C and configure a static route to the prefix 2001:db8:1:2::/96.

11) On Host A

Configure the IPv6 address 198.51.100.2/24 on Host A and configure a static route to the destination network segment 203.0.113.0/24.

Verification

Run the **ping 203.0.113.1** command on Host A.

```
Ping statistics for 203.0.113.1:
    Packets: Sent = 3, Received = 3, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

Run the **ping 192.0.2.1** command on Host A.

```
Ping statistics for 192.0.2.1:
    Packets: Sent = 3, Received = 3, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 0ms, Maximum = 0ms, Average = 0ms
Ruijie#sh nat64 stateless statistics
NAT64 Stateless Global stats:
    Created Packets translation (IPv4 -> IPv6): 16.
    Created Packets translation (IPv6 -> IPv4): 31.
    Packets droped in IPv4: 0.
    Packets droped in IPv6: 0.
```

```
NAT64 Stateless Interface stats:
   Gi0/0/0:
      Created Packets translation (IPv4 -> IPv6): 16.
      Created Packets translation (IPv6 -> IPv4): 0.
   Gi0/0/1:
      Created Packets translation (IPv4 -> IPv6): 0.
      Created Packets translation (IPv6 -> IPv4): 19.
   Gi0/0/2:
      Created Packets translation (IPv4 -> IPv6): 0.
      Created Packets translation (IPv6 -> IPv4): 12.
```

RGOS Configuration Guide V10.4(3b13)

Speech Configuration

1. VoIP Configutation
2. The SIP Access Gateway Configuration

VoIP Configutation

Overview

Voice over IP (VoIP) is a popular technology that emerges recently and has attracted wide attention thanks to its low price. The so-called IP telephone is a typical application of VoIP, which transmits voice on the IP network.

At the beginning of 1995, a software product first appeared, allowing people to make long-distance calls over the Internet, and this telephone service was referred to as Internet telephone, the early form of IP telephone. After years of rapid development, IP telephone has become a new type of telephone service, which has been widely applied all over the world and poses an increasingly great threat for its traditional counterpart.

After years of technical accumulation, the technology for integrated transmission of voice, video, fax, and data over the IP network becomes increasingly mature. At the same time, the rapid growth of the integrated circuit (IC) technology greatly reduces the price of the core component — digital processor of the IP telephone. All these make it technically possible for the wide application of IP telephone.

Ever since its emergence in the early 1990's, the IP telephone has evolved from the IP telephone software stage to the IP telephone gateway stage. In addition, the current VoIP application has developed from the simple PC products with voice services to the telecom services with the voice and data transmission function featuring multiple services, high reliability and excellent QoS. Currently, the IP telephone gateway is used to implement the interworking between the PSTN and the Internet, so the technologies for PC to phone, phone to PC, and phone to phone have been mature, and the voice quality also greatly increases to meet the requirements of commercial applications.

The driving of the economic interests is an important reason for the rapid development of IP telephone. By using packet switching and statistical multiplexing for integrated transmission of voice and data, IP telephone greatly reduces the operating cost of the entire network, and the communication cost of the users also decreases accordingly. The VoIP network built by using the IP voice gateways can bypass the toll calls to the data network, greatly saving toll call charges and bringing about significant economic benefits to the users.

Technology advancement and interest driving fuel the rapid growth of the IP telephone service. Currently, the Ministry of Information Technology of China has approved multiple companies including China Telecom to carry out commercial pilot of IP telephone.

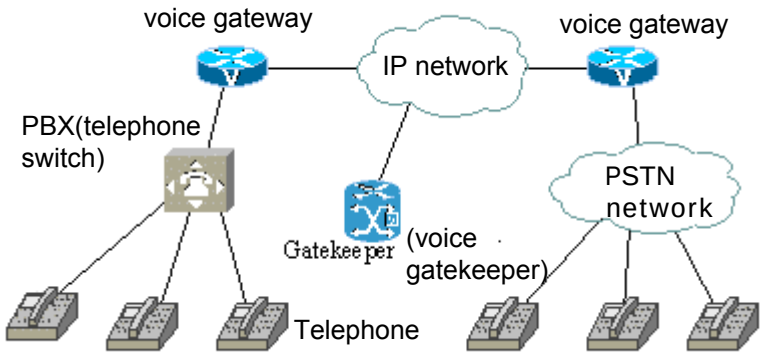
The IP telephone uses the network as the communication carrier for transmitting voice information. The voice gateway (GW) is located between the PSTN and the network access point to collect analog voice signals from the PSTN, convert the signals into digital signals, and compress and encode the digital signals. Then, it transmits the signals to the voice gateway at the other end via the network, and meanwhile, receives the voice IP packets from the network, decompresses them, and restores them into the analog voice signals through digital-analog conversion. The implementation of the VoIP telephone on the router is in fact the function expansion of the router and also represents the trend that data services gradually extend to voice services.

Basic Principles of VoIP

Basic Network Model of VoIP

To build a VoIP network, the voice gateway is the key device in the entire VoIP network. The voice gateway provides the interface between the IP network and an analog telephone and performs conversion between analog signals and digital signals. The analog signals from the PSTN telephone network of the caller are collected by the voice gateway and converted into digital voice signals. Then, the signals are compressed and encoded by using the standard protocols into packets that can be transmitted on the IP network to the voice gateway of the callee. Next, the voice gateway of the callee converts the digital voice signals into analog voice signals and sends the signals to the PSTN network of the callee, and finally the signals reach the telephone terminal of the callee. During this process, the digital-analog conversion and analog-digital conversion occur continuously.

Figure 1 Basic components of the VoIP system



The above figure shows the simple topology of a VoIP network. Because each network device has its IP address in an IP network, the voice gatekeeper controls the relationship between telephone numbers and IP addresses.

H.323 Protocol Family and Related Protocols

Same as other network service applications, VoIP also needs a universal standard. Currently, nearly all manufacturers adopt the ITU-T H.323 protocol, which provides the basic standard for transmitting voice, video and data services based on IP networks (including the Internet). H.323 is a framework protocol, and has related protocols about transmission, control, voice, and video compression. The H.323 protocol is currently the mainstream standard for implementing IP telephone.

The H.323 protocol family includes the following members: H.225.0 (Q.931 amd RAS), H.245, G.729, G.723, G.711, H.261, H.263, T.120, and T.38. H.225.0 (Q.931 amd RAS) and H.245 are control protocols, while G.729, G.723 and G.711 are audio coding/decoding protocols. H.261 and H.263 are video coding/decoding protocols. T.38 is the coding protocol of the FAXoIP protocol, and T.120 is the multimedia data transmission protocol. H.323 also defines the four basic units of the network transmission system: terminal, gateway, gatekeeper and multipoint control unit (MCU).

The basic structure of the H.323 protocol stack is shown as below:

Table 1 H.323 protocol family

<table>
<tr><th>Audio</th><th>Video</th><th colspan="3">Control Signaling</th><th>Data</th></tr>
<tr><td rowspan="2">G.711
G.729
G.723</td><td rowspan="2">H.261
H.263</td><td rowspan="3">RTCP</td><td rowspan="3">RAS</td><td rowspan="3">Q.931
H.245</td><td>T.125</td></tr>
<tr><td>T.124</td></tr>
<tr><td colspan="2">RTP</td><td>T.123</td></tr>
<tr><td colspan="4">UDP</td><td colspan="2">TCP</td></tr>
<tr><td colspan="6">Network layer (IP layer)</td></tr>
<tr><td colspan="6">Link layer</td></tr>
<tr><td colspan="6">Physical layer</td></tr>
</table>

The audio coding/decoding protocols and video coding/decoding protocols define the compression/decompression standard of streaming media. The compressed streaming media are transmitted by using the RTP/RTCP protocol (RTP defines the actual streaming media transmission protocol, while RTCP defines the auxiliary streaming media status and control protocols), while the RTP/RTCP protocol is based on the UDP protocol. In other words, the streaming media data is finally sent via UDP packets. Different from media streams, the signal transmission of the H.323 protocol stack is based on the TCP protocol, and it includes the RAS (registration, access admission, and status management of an H.323 terminal), Q.931 (call setup and termination) and H.245 (used to negotiate the data stream transmission capability of the H.323 terminal).


Caution The RAS is based on the UDP protocol.

Typical VoIP Telephone Call Process

This section describes the typical call process of VoIP telephone.

The caller picks up the phone and the voice module of the router detects this action of the caller, and sends an off-hook signal to the VoIP signal processing part of the router.

The VoIP processing software sends the dial tone via the analog signal line and waits for the dialing of the user.

The user starts to dial and the VoIP processing software collects and stores the digits dialed according to the signal frequencies.

The user finishes dialing, and the device queries the IP address of the telephone number according to the relationship between the configured telephone number and the IP address or by sending the collected telephone number to the gatekeeper, in order to set up the call with the voice gateway of the other party. If the call is directly connected to the voice gateway, the call connection is established directly between two phones. If the voice gateway is connected to the PBX of the phone, the PBX will complete the remaining part of the call.

The VoIP processing software at both ends uses the H.323 protocol to establish the channel for sending and receiving voice data in two directions on the IP network. After the end-to-end RTP voice channel is established, the voice signals of the users at the two ends and other signals that can be transmitted in-band are transmitted over the IP network through the channel. RTCP packets are mainly used to transmit QoS for voice data transmission between both parties during the call.

When one party of the call hangs up, the session stops, and both ends become idle again, waiting for the next call to be triggered.

VoIP Features

1) Standard protocol support

System control protocols: H.225.0 (Q.931 and RAS) and H.245

Audio coding protocol: G.729, G.723, and G.711

The above protocols are a set of protocols used by all major VoIP manufacturers. This ensures good interoperatability and compatibility between their products.

2) Voice interface support

FXO and FXS are supported, that is, the E1 interface is supported.

3) Software function

The VoIP products support all the functions of the router products:

- **Simple configuration**

The Ruijie voice gateway products are based on the Ruijie router platforms, have the functions of both voice gateways and routers and are easy to configure and manage.

- **Silence compression**

The products can automatically detect silence and avoid the transmission of silence over the network to reduce the invalid load on the network.

- **Comfortable noise**

In case of silence, comfortable background noise is sent to the local user to please the ears of the user.

- **Header compression**

The products support the CRTP protocol on the PPP, FR, and HDLC; support the compression of TCP/IP headers defined by RFC 2507 and RFC 1144.

- **Voice tuning**

Commands can be used to tune the input/output gains of the voice port for a better voice effect.

- **QoS**

The products support the advanced queuing policies such as CQ, PQ, WFQ, and WRED; the WFQ policy most suitable for real-time applications is used by default.

- **Call forwarding on busy (hunting)**

Multiple ports on a VoIP module can form a group. When a port receives a call while it is busy, the call will be forwarded to an idle port in the same group. This process is known as hunting (or forwarding on busy). A group has a primary port, and other group member ports can join the group by setting the primary port.

- **Gatekeeper**

The embedded gatekeeper software is implemented on the device for easy management and maintenance of the VoIP network.

- **Caller ID display**

The products support caller ID display, by presenting the numbers of the callers on the telephone screens, no matter whether the calls are from the PSTN or the Internet.

Basic Terms of VoIP

PBX: private branch exchange. It is usually a small private exchange of an enterprise or organization.

FXO: foreign exchange office interface, that is, a 2-wire loop trunk interface. Using an RJ-11 interface, it can be directly connected to the PBX.

FXS: foreign exchange station interface, that is, a plain old telephone service (POTS) interface. Its physical interface is a common RJ-11 interface. The standard home telephone line is set as an FXS. The FXS interface can be directly connected to a POTS phone, or to the PBX via the AT0 trunk line.

Dial peer: a call endpoint or a remote destination. Receiving and forwarding a call via the device with the voice function requires multiple dial peers. Each dial peer represents a separate call leg. There are two types of call legs: One is associated with the connection from the device to the phone set; the other is associated with the voice call set up between the devices on the network. In these associations between the call leg and the dial peer, the first type of call leg is referred to as a POTS dial peer, and the second type is known as a VoIP dial peer.

Hunting: Multiple ports on a VoIP module can form a group. When a port receives a call while it is busy, the call will be forwarded to an idle port in the same group. This process is known as hunting (or forwarding on busy). A group has a primary port, and other group member ports can join the group by setting the primary port.

Coding algorithm: Common voice coding technologies include the waveform coding technology and source coding technology. The waveform coding technology, for example, PCM and ADPCM, utilizes the redundancy feature of the waveforms. The source coding technology uses the voice compression and only transmits the simplified parameters. The source coding technology needs less bandwidth, including linear predictive coding (LPC), code excited linear prediction (CELP) and multipulse maximum likelihood quantization (MP-MLQ).

G.711: 64 kbps PCM coding.

G.723.1: G.723.1 supports the compression coding forms of two rates, which are 5.3 kbps and 6.3 kbps. The low rate is based on the CELP technology, while the high rate is based on the ML_MLQ technology, and the latter provides higher voice quality.

G729: 64 kbps CELP compression coding.

Gatekeeper: According to the definition of the ITU-T specification, the gatekeeper (GK) is an H323 entity that provides address translation, access admission, bandwidth control and management, and zone management for the H323 terminals, gateways, and some multipoint control units of the LAN or WAN. In a zone controlled by the GK, the GK not only provides call service control and but also acts as the center control point for all users.

Advantages of VoIP over Traditional Telephone

Low cost: With the IP network used to replace the toll phone line for transmission, enormous call charges are saved. Usually, the cost of IP calls is much lower than that of toll calls.

Easy access: As data networks are built at an increasingly greater speed, nearly every corner of the world has easy access to the Internet. The bandwidth of the network also grows at a high speed, and various applications can be easily run on the IP network. The H.323 protocol provides a unified platform for the integration of various voice, data, and video applications, so that the old separate networks for various voice, video and data applications can be incorporated in a single IP network.

Diversified application: On the application platform based on the H.323 protocol, diversified applications such as call, email, videoconference, and call center can be easily integrated. All the developers of the current computer telephony integration (CTI) products focus on VoIP.

Configuring VoIP

The VoIP configuration includes:

- Configuring the Dial Peer
- Configuring a CODEC List
- Configuring the POTS Dial Peer
- Configuring the VoIP Dial Peer
- Configuring Abbreviated Dialing
- Configuring the Voice Port
- Configuring the IP Address of the Voice Interface
- Configuring the Maximum Number of Concurrent Voice Communication Channels
- Configuring the Caller ID Display Function Globally
- Configuring Hunt Groups
- Configuring the Fast Call Function

Configuring the Dial Peer

Configuring the dial peer is a key task of VoIP configuration. When the traditional PSTN is used, a physical link of 64 kbps bandwidth is occupied exclusively at either end. On the VoIP network, the route from the caller to the callee is divided into four discontinuous segments (call legs), which are logical connections. Each segment between two routers and between the router and the phone set corresponds to a dial-up peer.

Figure 2 Call legs from the perspective of the caller router

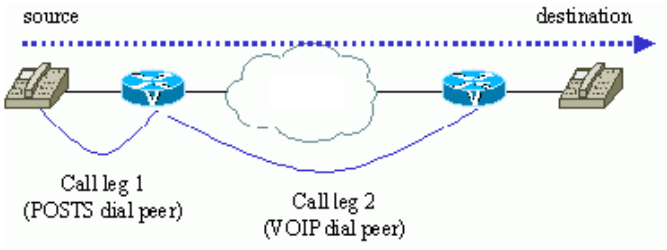
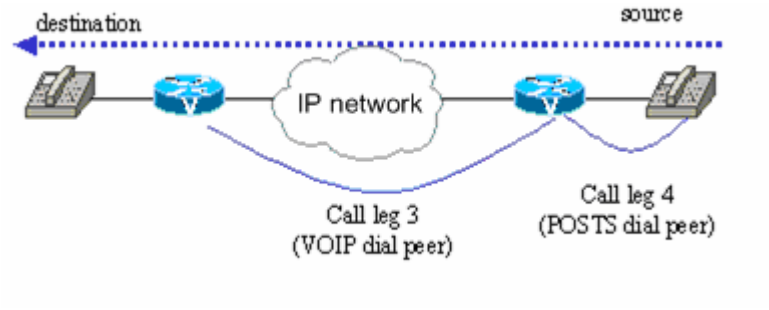


Figure 3 Call legs from the perspective of the callee router



As shown in the above figure, VoIP uses two types of dial peers:

- **POTS**: describes the connection characteristics of the traditional telecom network. The POTS points to the specific voice port on the IP voice device.
- **VoIP**: describes the connection characteristics of the IP network. The voice network dial peer points to the specific voice network device.

Configuring a CODEC List

To improve the success ratio of codec negotiation between a local router and a peer router, the router defines a codec list beforehand for differentiating priorities, and sends a capability negotiation message carrying the codec list to the peer router. According to the priorities, the peer router selects a codec from the codec list for coding/decoding.

Enter global configuration mode and use the following commands to define a codec list.

Command	Function
Ruijie(config)# **voice class codec** *tag*	Creates a codec list, where the tag range is 1 to 10000, and the tag value is uniquely determined on the router.
Ruijie(config-voice-class)# **codec preference** *priority codec* [**bytes** *payload-size*]	Defines codec types, priorities, and payload sizes.

Configuring the POTS Dial Peer

POTS means plain old telephone service. Configuring the POTS dial peer establishes a relationship between the physical voice port of the device and the local telephone set. To configure the POTS dial pair, you must use the key commands **port** and **destination-pattern**. The **destination-pattern** command defines the phone number associated with the POTS dial peer. The **port** command associates the POTS dial peer with the specified voice port. Usually, the IP telephone set is connected to a phone port or the phone port of the local PBX.

To configure the POTS dial peer, first enter dial peer configuration mode. In global configuration mode, use the following commands to enter dial peer configuration mode.

Command	Function
Ruijie(config)# **dial-peer voice** *number* **pots**	Enters POTS dial peer configuration mode.
Ruijie(config)# **no dial-peer voice** *number*	Deletes the specified POTS dial peer.

The *number* parameter is a valid dial peer ID ranging from 1 to 2147483647. The dial peer ID should be unique.

After you enter dial peer configuration mode, you can use the following commands to configure the features of POTS.

Command	Function
Ruijie(config-dial-peer)# **destination-pattern** *string*	Configures the phone number of the local voice port.
Ruijie(config-dial-peer)# **no destination-pattern**	Cancels the phone number of the dial peer.
Ruijie(config-dial-peer)# **description** *string*	Uses a short character string to describe the POTS peer.
Ruijie(config-dial-peer)# **no description**	Cancels the description of the POTS peer.
Ruijie(config-dial-peer)# **port** *slot-number*/*port-number*	Specifies the dial port of the peer.
Ruijie(config-dial-peer)# **no port**	Cancels the local dial port number.
Ruijie(config-dial-peer)# **no shutdown**	Enables the POTS dial peer.
Ruijie(config-dial-peer)# **shutdown**	Shuts down the POTS dial peer.
Ruijie(config-dial-peer)# **group** *slot-number*/*port-number*	Adds the current peer to a hunt group with the primary port specified by *slot-number/port-number*. If the parameters are not set, the current peer does not join any hunt group by default.
Ruijie(config-dial-peer)# **no group**	Cancels the hunt group.
Ruijie(config-dial-peer)#**preference *value***	Specifies a preference for the dial peer. *value*: specifies the value of the preference, in the range of 0 to 9. The smaller the value is, the higher the preference is.
Ruijie(config-dial-peer)#no **preference**	Cancels the preference setting.

Note The voice ports in the hunt group should be of the same type, either FXS port or FXO port.

Configuring the VoIP Dial Peer

You can associate a phone number with an IP address so as to dial a specified number. To configure the VoIP dial peer, you must use the **destination-pattern** command and **session target** command. The **destination-pattern** command defines the phone number associated with the dial peer. The **Session target** command specifies the destination IP address of the dial peer.

To configure the VoIP dial peer, first enter dial peer configuration mode. In global configuration mode, use the following commands to enter dial peer configuration mode.

Command	Function
Ruijie(config)# **dial-peer voice** *number* **voip**	Enters VoIP dial peer configuration mode.
Ruijie(config)# **no dial-peer voice** *number*	Deletes the specified VoIP dial peer.

The *number* parameter is a valid dial peer ID ranging from 1 to 2147483647. The dial peer ID should be unique.

After you enter peer configuration mode, you can use the following commands to configure the features of the VoIP dial peer.

Command	Function
Ruijie(config-dial-peer)# **destination-pattern** *string*	Configures the phone number of the peer voice port (the wild card '.' can be used).
Ruijie(config-dial-peer)# **no destination-pattern**	Deletes the peer phone number.
Ruijie(config-dial-peer)# **description** *string*	Uses a short character string to describe the VoIP dial peer.
Ruijie(config-dial-peer)# **no description**	Cancels the description of the VoIP dial peer.
H323: Ruijie(config-dial-peer)# **session target** {**ipv4:** *a.b.c.d* | **ras**} SIP: Ruijie(config-dial-peer)# **session target** {**ipv4:** *a.b.c.d* | **sip-server**}	a.b.c.d is the dotted notation of the destination IP address of the dial peer. *ras* indicates that the destination address bound with the dial peer needs to be obtained through the dynamic resolution of the RAS process. *sip-server* specifies a SIP server.
Ruijie(config-dial-peer)# **no session target**	Deletes the peer IP address configured.
Ruijie(config-dial-peer)# **no shutdown**	Enables the VoIP dial peer.
Ruijie(config-dial-peer)# **shutdown**	Shuts down the VoIP dial peer.
Ruijie(config-dial-peer)# **codec** {*g711ulaw* | *g711alaw*|*g723r53*|*g723r63*|| *g729r8*|*g729a*}[**bytes** *payload_size*]	Specifies the voice coding format and payload size.
Ruijie(config-dial-peer)# **vad**	Enables the voice activity detection function.
Ruijie(config-dial-peer)# **no vad**	Disables the voice activity detection function.
Ruijie(config-dial-peer)# **dtmf-relay h245-alphanumeric**	Enables the dtmf-relay function.
Ruijie(config-dial-peer)# **no dtmf-relay h245-alphanumeric**	Disables the dtmf-relay function.
Ruijie(config-dial-peer)#**voice-class codec** *tag*	Applies the codec list to the VoIP dial peer.
Ruijie(config-dial-peer)#no **voice-class codec**	Does not apply the codec list to the VoIP dial peer.
Ruijie(config-dial-peer)#**preference** ***value***	Specifies a preference for the dial peer. *value*: specifies the value of the preference, in the range of 0 to 9. The smaller the value is, the higher the preference is.
Ruijie(config-dial-peer)#no **preference**	Cancels the preference setting.

When you configure the phone number of the VoIP dial peer, you can use the wildcard to reduce the configuration work. For example, if the peer device has eight voice ports, and their phone numbers consist of seven digits starting with 1234, you can use the following command:

```
Ruijie(config-dial-peer)# destination-pattern 1234…
```

The above command represents all the 7-digit phone numbers starting with 1234.

By default, RGOS uses the G729 coding format, and enables the voice activity detection function and enables the dtmf-relay function.

Note

The commands for configuring the dial peer configure the outgoing and incoming functions of the devices, and are defined from the perspective of the configured devices. Therefore, the POTS dial peer uses the **destination-pattern** command to define the number of the phone connected to the voice port of the local device, while the VoIP dial peer uses the **destination pattern** command to define the phone number of the callee.

Configuring Abbreviated Dialing

Within an enterprise, the phone numbers all start with the same digits in most cases. It is troublesome to use the full numbers for internal calls. For convenience, our products provide the abbreviated dialing function, by which the users only need to dial the last few digits. The VoIP processing software can enable the abbreviated dialing function by using the **num-exp** command. The last few digits dialed are automatically expanded by the device into the complete E.164 numbers.

To configure the abbreviated dialing function, use the following commands in global configuration mode.

Command	Function
Ruijie(config)# **num-exp** extension-number expanded-number	Enables the abbreviated dialing function.
Ruijie(config)# **no num-exp** extension-number	Disables the abbreviated dialing function.

extension-number and expanded-number are both character strings composed of the characters such as 0 to 9 and a dot.

For example, if an enterprise uses 7-digit phone numbers starting with 3703, you can use the following command:

```
Ruijie(config)# num-exp 3… 3703…
```

This means that when users dial 3…, the number is automatically expanded to 3703…. This makes dialing easy.

Configuring the Voice Port

To implement the VoIP function on the device, you must install the VoIP module on the device in order to provide the analog voice ports. The signaling types of these analog voice ports depend on the installed voice interface (VI) board. The **voice-port** command is used to configure the physical features of the voice ports installed on the device. Usually, the physical feature parameters of the voice ports can use the default values, without needing additional configuration.

The voice port supports the following two basic voice signaling types:

- **FXS**: The FXS interface is a standard RJ-11 interface, which is directly connected to the devices such as a POTS phone and PBX via a telephone line to provide a ringing voltage and a dial tone.
- **FXO**: The 2-wire loop trunk FXO interface uses the RJ-11 telephone line to connect the local calls to the PSTN central office or the PBX that does not support E&M signaling. The devices with the FXO interface can only be connected to the devices with the FXS interface. This interface is particularly useful for remote expansion applications.

To configure the voice port, enter voice port configuration mode. In global configuration mode, use the following commands to enter voice port configuration mode.

Command	Function
Ruijie(config)# **voice-port** *slot-number/port-number*	Enters voice port configuration mode.

The *solt_number* parameter specifies the expanded slot number of the voice card.

The *port-number* parameter specifies the voice port number of the voice card.

After you enter voice port configuration mode, you can use the following commands to configure the features of the voice port.

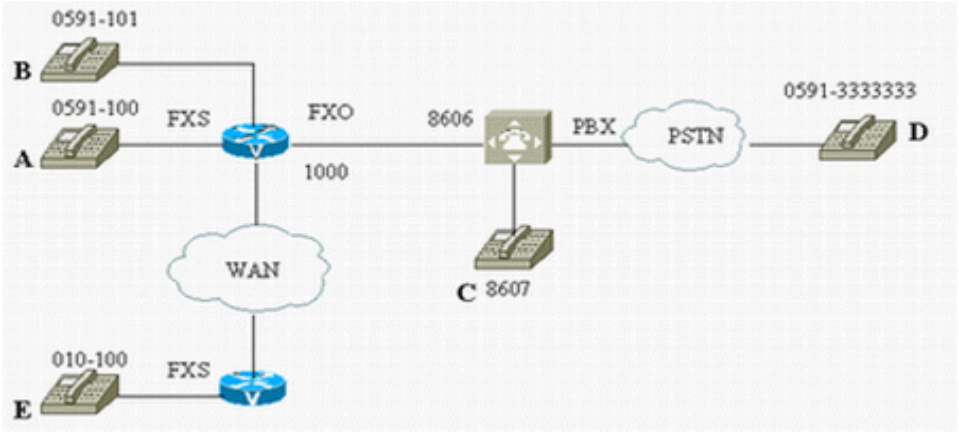
Command	Function
Ruijie(config-voice-port)# **connection plar** *String*	Specifies the E.164 phone number of the destination end.
Ruijie(config-voice-port)# **no connection plar**	Deletes the E.164 phone number of the destination end.
Ruijie(config-voice-port)# **input gain** *value*	Configures the voice input gain.
Ruijie(config-voice-port)# **no input gain**	Restores the default value of the voice input gain.
Ruijie(config-voice-port)# **output attenuation** *Value*	Configures the voice output attenuation.
Ruijie(config-voice-port)# **no output Attenuation**	Restores the default value of the voice output attenuation.
Ruijie(config-voice-port)# **caller-id enable** [**first** | **second** | **all**]	Enables the caller ID display.
Ruijie(config-voice-port)# **caller-id type [bellore|** etsi**|dtmf**]	Configures the caller ID display type.
Ruijie(config-voice-port)# **no caller-id enable**	Cancels the caller ID display.

The input gain and the output attenuation are 0 by default.

If the voice port is configured with the **connection plar** command, the user only needs to pick up the phone connected to the port, without dialing any number, and the device will automatically dial a phone number. This function is very convenient for the call center with a unified access number.

The caller ID display function is disabled by default. After you use the **caller-id enable [first |second |all]** command to configure the voice port (**first** by default if no parameter is selected), the port will display the caller number when it is called. The scheme is shown below:

Figure 4 Schematic diagram of the caller ID display



The following table describes the command parameters of the above scheme.

Scheme No.	Caller	Callee	Parameter			
			Default	Fisrt	Second	All
1	A	B	0591100	0591100	0591100	0591100
2	A	E	0591100	0591100	0591100	0591100
3	C	A	1000	1000	8607	10008607
4	D	A	1000	1000	3333333	10003333333
5	C	E	1000	1000	8607	10008607
6	D	E	1000	1000	3333333	10003333333

Note

For schemes 3, 4, 5 and 6, the information will be correctly displayed according to the above table only when the device of the FXO is a 36 series product and the caller ID display function is correctly configured for the port of the FXO. If the caller ID display is disabled for the FXO (or not supported), the caller number cannot be displayed when the **second** parameter is selected; and only 1000 is displayed when the **all** parameter is selected.

For schemes 5 and 6, when the device of the FXO is a 36 series product and the caller ID display function is correctly configured for the port of the FXO, if the device of the FXO is configured with H323-id, the caller number cannot be displayed when the device of phone E selects the **second** parameter; and only 1000 is displayed when the **all** parameter is selected.

Configuring the IP Address of the Voice Interface

As users are increasingly concerned about network security, they use firewalls in the network to only allow IP addresses within a special range to traverse the firewalls. For example, when there are multiple IP addresses on the device, only a particular IP address is allowed to traverse the firewall. You can specify the IP address of an interface that initiates VoIP call requests to improve network security.

To configure the IP address of the voice interface, use the following commands in global configuration mode.

Command	Function
Ruijie(config)# **voip ip address** *a.b.c.d*	Specifies the IP address of the interface that initiates VoIP calls.
Ruijie(config)# **no voip ip address** *a.b.c.d*	Restores the default value.

Configuring the Maximum Number of Concurrent Voice Communication Channels

When the network bandwidth is small, you can set the maximum number of concurrent voice channels for the voice gateway. There is no limit on the maximum number of concurrent voice channels by default. If the bandwidth is narrow, the communication of each channel will have poor quality. Now you can use this **max connection** command to configure the maximum number of concurrent voice channels according to the network condition to ensure high communication quality. When the existing number of voice channels reaches the *number* value, the voice gateway will give the busy tone prompt no matter whether the other party or local party dials the number.

To configure the maximum number of concurrent voice channels of the voice gateway, use the following commands in voice service voip configuration mode.

Command	Function
Ruijie(config)# **voice service voip**	Enters voice service voip configuration mode.
Ruijie(config-voice-service-voip)# **max connection** *number*	Configures the maximum number of concurrent voice channels.

Configuring the Caller ID Display Function Globally

The caller ID display function is disabled by default. To enable this function, you must enable it for every port and this is rather troublesome. For ease of use, a global switch is provided to enable the caller ID display function on all ports (according to the default parameters).

Once the caller ID display function is enabled on a port, the global configuration is not effective on the port.

To configure the caller ID display function globally, use the following commands in voice service voip configuration mode.

Command	Function
Ruijie(config)# **voice service voip**	Enters voice service voip configuration mode.
Ruijie(config-voice-service-voip)# **caller-id enable**	Enables the caller ID display function globally.
Ruijie(config-voice-service-voip)# **no caller-id enable**	Disables the caller ID display function globally.

Configuring Hunt Groups

The RGOS access gateway supports hunt groups and preferences. That is, you can configure the same destination pattern (number) for multiple dial peers. Because each POTS dial peer number is a voice port connected with a phone, hunt groups can ensure that the call is connected even when one special voice port is busy or does not answer. If the router is configured with hunt groups, it can forward the call to another voice port when one voice port is busy or does not answer. If a peer is down, the router will select another peer with a higher preference according to the preferences of peers to reinitiate a call.

For example, Router A configures different destination patterns for four POTS dial peers. Because each dial peer has a different number, when one voice port is busy, the router does not have the backup port for this voice port.

In one hunt group, if one voice port is busy, the voice access gateway will find another available voice port. In the following Router B configuration, each dial peer is configured with the same destination pattern, 3000, which forms a dial pool corresponding to the pattern 3000.

Router A (Without Hunt Groups)	Router B (With Hunt Groups and Preferences)
dial-peer voice 1 pots destination-pattern 3001 port 1/1 ! dial-peer voice 2 pots destination-pattern 3002 port 1/2 !	dial-peer voice 1 pots destination-pattern 3000 port 1/1 preference 0 ! dial-peer voice 2 pots destination-pattern 3000 port 1/2

dial-peer voice 3 pots destination-pattern 3003 port 1/3 ! dial-peer voice 4 pots destination-pattern 3004 port 1/4	preference 1 ! dial-peer voice 3 pots destination-pattern 3000 port 1/3 preference 2 ! dial-peer voice 4 pots destination-pattern 3000 port 1/4 preference 3

You can set preferences for multiple dial peers in one hunt group by running the **preference** command. The router will try placing calls in the dial peer with the highest preference. As shown in the preceding Router B configuration, all dial peers have the same destination pattern but have different preferences.

The smaller the preference value is, the higher the preference is. The number 0 stands for the highest preference. If multiple dial peers in one hunt group have the same preference, a dial peer will be selected randomly during a call.

For a dial peer selection rule in one hunt group, the default sequence is shown below:

1) The longest phone number is matched: If one dial peer's phone number is 345… and another dial peer's phone number is 3456789, the router will select the dial peer 3456789 first, because it has long accurate matching.
2) Specify preferences: Specify preferences for dial peers by using the **preference** command.
3) Random selection: Weights of all destination patterns are equal.

You can combine POTS and VoIP dial peers to create hunt groups, which is quite useful. When a user wants to send a call to a packet network, if the packet network fails to be connected, the call can be rerouted to the PSTN via a PBX. The configuration below shows if the IP network fails to be connected, the router sends the call to the PSTN.

```
dial-peer voice 101 voip
destination-pattern 472....
session target ipv4:192.168.100.1
preference 0
!
dial-peer voice 102 pots
destination-pattern 472....
prefix 472
port 1/0
preference 1
```

You cannot use the same preference for POTS and VoIP dial peers in one hunt group.

You can configure separate preference sequences for each dial peer, but those preference sequences do not work at the same time. For example, you can configure the preference sequence 0, 1, 2 for POTS dial peers, and then configure the preference sequence 0, 1, 2 for VoIP dial peers, but those two preference sequences are separated. The system will resolve the preference sequence of POTS dial peers first.

To set preferences, see the "Configuring the POTS Dial Peer" and "Configuring the VoIP Dial Peer" sections.

Hunt groups are disabled on the RGOS access gateway by default. In global configuration mode, run the following command to enable hunt groups.

Command	Function
Ruijie(config)# **voice hunt** {**user-busy**| **no-answer**| **no-channel** |**all**}	Enables hunt groups in different cases. **all**: enables hunt groups in case of any connection failure. **no-answer**: enables hunt groups if the peer does not answer. **user-busy**: enables hunt groups if the peer is busy. **no-channel**: enables hunt groups if the peer is down.

Configuring the Fast Call Function

To configure the fast call function, use the following commands in voice service voip configuration mode.

Command	Function
Ruijie(config)# **voice service voip**	Enters voice service voip configuration mode.
Ruijie(config-voice-service-voip)# **h323 call start fast**	Enables the caller fast call function.
Ruijie(config-voice-service-voip)# **h323 call start calledfast**	Enables the callee fast call function.
Ruijie(config-voice-service-voip)# **no h323 call start fast**	Disables the fast call function.

Note

The fast call function includes the caller fast call function and callee fast call function. To enable the callee fast call function, you must first enable the caller fast call function. If you disable the caller fast call function, the callee fast call function will be automatically disabled.

With GK management and fast call enabled, DTMF cannot be transmitted through an H.245 channel in out-band mode, and can be transmitted in in-band mode only.

VoIP Configuration Examples

This section provides four typical VoIP configuration examples:

- Configuring Interconnection Between the Router and the FXS Port
- Configuring Interconnection Between the Router and the PBX Trunk Port
- Configuring the Auto Dialing Function
- Configuring Route Reselection in Case of Router Breakdown

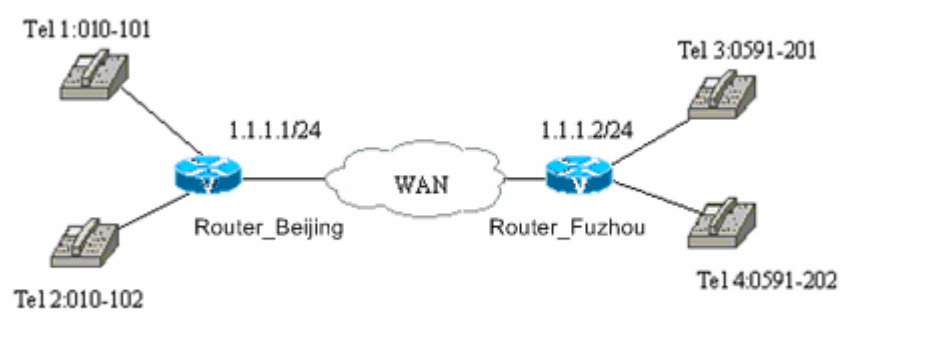
Configuring Interconnection Between the Router and the FXS Port

Networking Requirements

VoIP communication needs to be implemented between Beijing and Fuzhou. One router with the VoIP module is installed in these two cities, and VoIP communication is achieved directly via the WAN, on which voice and data services can be transmitted at the same time.

The specific connection is shown in the following figure. This connection method has a simple network structure, and you can directly connect phones to the router for telephone communication. Users that have built the network can enjoy zero charges for toll calls. The disadvantage is that its capacity is small, not enough for communication of the entire group. This scheme is suitable for small office systems.

Figure 5 FXS directly connected with the telephones to build the VoIP network



Configuration Steps

Configuration of Router_Beijing:

#Configure the router name.

```
hostname "Router_Beijing"
```

Configure the WAN port.

```
interface Serial0
 ip address 1.1.1.1 255.255.255.0
 encapsulation ppp
 clock rate 2000000
```

Configure the phone number of the local voice port 1/0.

```
dial-peer voice 1 pots
 destination-pattern 010101
 port 1/0
```

Configure the phone number of the local voice port 1/1.

```
dial-peer voice 2 pots
 destination-pattern 010102
 port 1/1
```

Configure the peer phone number and IP address (a wildcard is used).

```
dial-peer voice 3 voip
 destination-pattern 059120.
 session target ipv4: 1.1.1.2
```

Configuration of Router_Fuzhou:

#Configure the router name.

```
hostname "Router_Fuzhou"
```

Configure the IP address of the WAN port.

```
interface Serial0
 ip address 1.1.1.2 255.255.255.0
 encapsulation ppp
```

Configure the phone number of the local voice port 1/0.

```
dial-peer voice 11 pots
 destination-pattern 0591201
 port 1/0
```

Configure the phone number of the local voice port 1/1.

```
dial-peer voice 12 pots
 destination-pattern 0591202
 port 1/1
```

Configure the peer phone number and IP address (a wildcard is used).

```
dial-peer voice 13 voip
 destination-pattern 01010.
 session target ipv4: 1.1.1.1
```

Configuring Interconnection Between the Router and the PBX Trunk Port

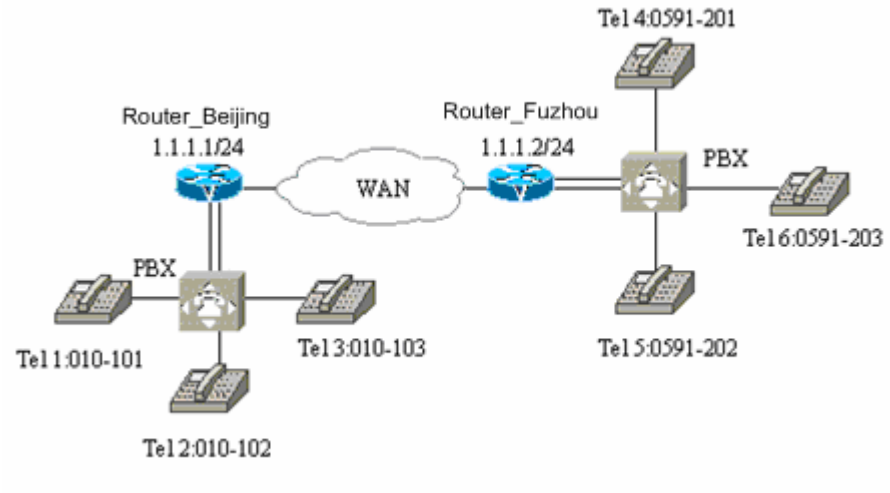
Networking Requirements

A company has its head office in Beijing and a branch in Fuzhou. The requirement is that a PBX should be used to build a VoIP network and allow the two places to make common internal calls over the IP network.

For the voice gateway to connect to the PBX, the following mode can be used:

- Install the FXS voice module on the router and connect the 2-wire loop trunk interface FXO on the PBX.
- Install the FXO voice module on the router and connect the POTS interface FXS on the PBX.

Figure 6 Building the VoIP Network via the PBX



As shown in the above figure, the Beijing head office has its own telephone network built by using a PBX. This is also the case in the Fuzhou Branch. There are two lines from the router to the PBX. The specific connection method can be one of the above two methods. The number of connections capable of simultaneous communication is equal to the number of the voice gateway connections or the number of PBX connections, whichever is smaller.

When users in the two places make IP phone calls, they must first dial 9 to connect to the line through which the PBX and voice gateway are connected. For example, if extension 3 in Fuzhou (with the internal phone number of 203) is to call extension 2 in Beijing (with the internal phone number of 102), the operation procedure is as follows:

First, extension 3 in Fuzhou goes off hook and dials 9 to connect to the voice gateway. Then, the access number 010-101 of the voice gateway of Beijing is dialed. When the voice gateway is connected, the call directly reaches the PBX in Beijing, which provides the prompt tone (for example, “please dial the extension number”). In this example, the hunting function (forwarding on busy) is configured, so the user only needs to dial 010-101. If the number is busy, the call will be automatically forwarded to the next port. This is also the case from Beijing to Fuzhou, where only 0591-201 needs to be dialed.

Then, the internal extension 102 in Beijing is dialed. In this way, the two places can communicate with each other through VoIP.

The operation procedure for dialing the extension in Fuzhou from Beijing is the same, and the configuration of the router is also the same. The only difference lies in the connection mode of the entire network. In this way, the two places can make common calls to each other via VoIP.

Configuration Steps

Configuration of Router_Beijing:

Configure the router name.

```
hostname "Router_Beijing"
```

Configure the WAN port.

```
interface Serial0
 ip address 1.1.1.1 255.255.255.0
 encapsulation ppp
 clock rate 2000000
```

Configure the phone number of the local voice port 1/0.

```
dial-peer voice 1 pots
 destination-pattern 010101
 port 1/0
```

Configure the phone number of the local voice port 1/1, and set call forwarding on busy.

```
dial-peer voice 2 pots
 destination-pattern 010102
 group 1/0
 port 1/1
```

Configure the peer phone number and IP address (a wildcard is used).

```
dial-peer voice 3 voip
 destination-pattern 059120.
 session target ipv4: 1.1.1.2
```

Configuration of Router_Fuzhou:

#Configure the router name.

```
hostname "Router_Fuzhou"
```

Configure the IP address of the WAN port.

```
interface Serial0
 ip address 1.1.1.2 255.255.255.0
 encapsulation ppp
```

Configure the phone number of the local voice port 1/0.

```
dial-peer voice 11 pots
 destination-pattern 0591201
 port 1/0
```

Configure the phone number of the local voice port 1/1, and set call forwarding on busy.

```
dial-peer voice 12 pots
 destination-pattern 0591202
 group 1/0
 port 1/1
```

Configure the peer phone number and IP address (a wildcard is used).

```
dial-peer voice 13 voip
 destination-pattern 01010.
 session target ipv4: 1.1.1.1
```

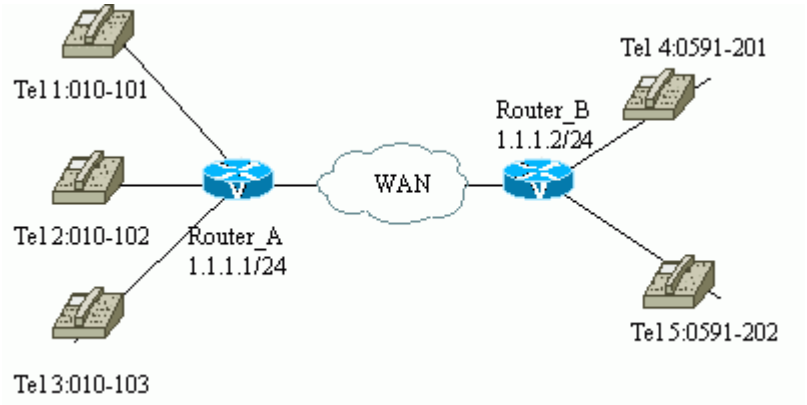
Configuring the Auto Dialing Function

Networking Requirements

An enterprise builds an IP call center, and users in the branches can dial the unified call center access number. The requirement is that once the IP phone of the branches goes off-hook, the unified call center access number is dialed automatically, and that transmission of voice and data is implemented at the same time on the WAN line.

As shown in the following figure, Router B is the voice gateway in the branch. Once the phone connected to Router B goes off-hook, the unified call center access number 010101 should be dialed automatically.

Figure 7 FXS directly connected with the telephones to build the VoIP network



Configuration Steps

Configuration of Router_A:

Configure the router name.

```
hostname "Router_A"
```

Configure the WAN port.

```
interface Serial0
 ip address 1.1.1.1 255.255.255.0
 encapsulation ppp
clock rate 2000000
```

Configure the phone number of the local voice port 1/0.

```
dial-peer voice 1 pots
 destination-pattern 010101
 port 1/0
```

Configure the phone number of the local voice port 1/1, and set call forwarding on busy.

```
dial-peer voice 2 pots
 destination-pattern 010102
 group 1/0
 port 1/1
```

Configure the phone number of the local voice port 1/2, and set call forwarding on busy.

```
dial-peer voice 10 pots
 destination-pattern 010103
 group 1/0
```

```
 port 1/2
```

Configure the peer phone number and IP address (a wildcard is used).

```
dial-peer voice 3 voip
 destination-pattern 059120.
 session target ipv4: 1.1.1.2
```

Configuration of Router_B:

Configure the router name.

```
hostname "Router_B"
```

Configure the IP address of the WAN port.

```
interface Serial0
 ip address 1.1.1.2 255.255.255.0
 encapsulation ppp
```

Configure the phone number of the local voice port 1/0.

```
dial-peer voice 11 pots
 destination-pattern 0591201
 port 1/0
```

Configure the phone number of the local voice port 1/1.

```
dial-peer voice 12 pots
 destination-pattern 0591202
 port 1/1
```

Configure the peer phone number and IP address (a wildcard is used).

```
dial-peer voice 13 voip
 destination-pattern 01010.
 session target ipv4: 1.1.1.1
```

Set the auto dialing of the port 1/0 and specify the dialed number.

```
voice-port 1/0
 connection plar 010101
```

Set the auto dialing of the port 1/1 and specify the dialed number.

```
voice-port 1/1
 connection plar 010101
```

Configuring Route Reselection in Case of Router Breakdown

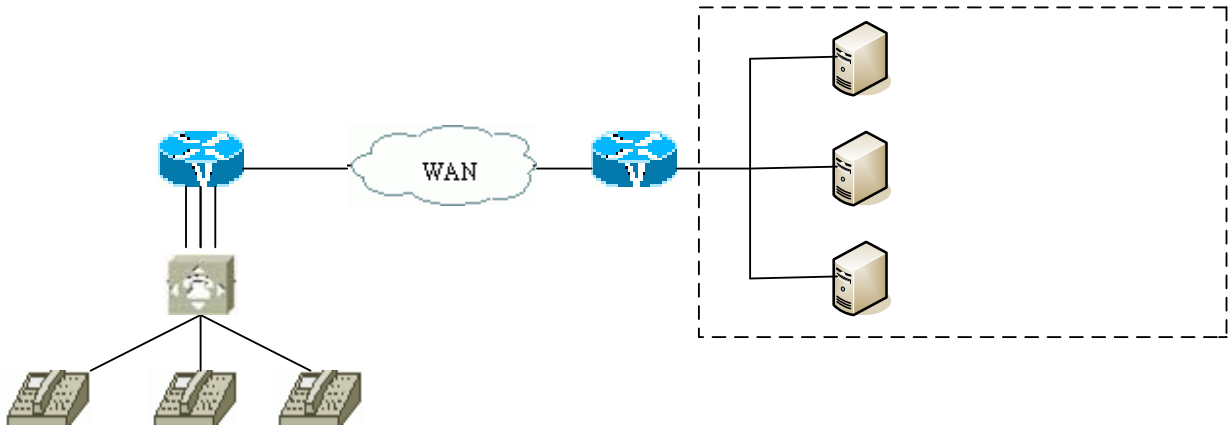
Networking Requirements

China Life Insurance Co., Ltd. uses a voice access gateway as a VoIP gateway to receive calls directed to its customer service number 95519 from the PSTN of each city. Then other advanced functions similar to GK addressing are

implemented by the main system of the company's three CallManager systems to connect the calls to the PBX of its Shandong Branch and complete the 95519 call process.

As shown in the following figure, the company has three CallManager systems, which are respectively used as the main system and backup systems. It is required that the VoIP gateways in the city branches and provincial branches of the company should be able to set VoIP dial peers with different preferences for the same destination number prefix in order to implement redundant hot backup of the CallManager systems. Three telephones are connected to Router A through a PBX. The H.323 voice gateway interface is Ethernet interface 1/0, which is connected to Router B through a WAN line. The IP address of Router A is 1.1.1.1. The phone numbers are 010-101, 010-102, and 010-103. The IP address of Router B is 1.1.1.2.

Figure 8 Configuring route reselection in case of router breakdown



Configuration Steps

Configuration of Router A:

Configure the WAN port.

```
interface Serial0
ip address 1.1.1.1 255.255.255.0
encapsulation ppp
clock rate 2000000
```

Configure the phone number of the local voice port 1/0.

```
dial-peer voice 1 pots
destination-pattern 010101
port 1/0
```

Configure the phone number of the local voice port 1/1.

```
dial-peer voice 2 pots
destination-pattern 010102
port 1/1
```

Configure the phone number of the local voice port 1/2.

```
dial-peer voice 3 pots
```

```
destination-pattern 010103
port 1/2
```

Configure the peer phone number and IP address (a wildcard is used).

```
dial-peer voice 20 voip
codec g711ulaw
destination-pattern 9551.
session target ipv4: 100.3.2.3
preference 1
session protocol H.323
```

Configure the peer phone number and IP address (a wildcard is used).

```
dial-peer voice 21 voip
codec g711ulaw
destination-pattern 9551.
session target ipv4: 100.3.2.4
preference 2
session protocol H.323
```

Configure the peer phone number and IP address (a wildcard is used).

```
dial-peer voice 22 voip
codec g711ulaw
destination-pattern 9551.
session target ipv4: 100.3.2.5
preference 3
session protocol H.323
```

Enable hunt groups.

```
voice hunt no-channel
```

Configuring the GK Client

Overview

When you make a VoIP call, the voice gateway needs to check the IP address of the voice gateway according to the number dialed, and then establishes a connection to the voice gateway of the other party. Therefore, the router needs to maintain a table of relationship between the phone number and the IP address of the voice gateway. In a small VoIP network, this relationship can be statically configured inside the router by using a command. However, in a large VoIP network, because such relationship may change constantly, it is difficult to maintain this relationship within the router by using a static mapping method. For this reason, the gatekeeper is introduced.

As defined in ITU-T specifications, the gatekeeper (GK) is an H.323 entity that provides address translation, access admission, bandwidth control and management, zone management, security check, call control signaling, and call management for the H323 terminal, GW, or some MCUs in the LAN or WAN. Sometimes, it also provides route control and billing functions. In a zone managed by the GK, the GK not only provides call service control but also acts as the center control point for all calls.

The entities that implement the complete GK function can be classified into clients and servers. The GK client usually uses the router as the hardware carrier and configures IP voice gateway functions by using the command line interface, and interacts with the GK server through the RAS signaling. This allows the GK server to provide the router IP voice gateway with address translation, access admission, bandwidth management and router IP voice gateway management. The GK server can be implemented on workstations or routers.

Our products implement the functions of both the GK client and GK server.

Configuring the GK Client

The GK client configuration includes:

- Configuring the H.323 Voice Gateway Interface (mandatory)
- Configuring the Local Voice Gateway Alias (mandatory)
- Configuring the GK Server Alias and IP Address (mandatory)
- Configuring the Technical Prefix (optional)
- Activating and Disabling the GK Client Function (mandatory)

Configuring the H.323 Voice Gateway Interface

When the router acting as the voice gateway is configured as the GK client for management, it needs to communicate with the GK server on the network to register the information of the router on the GK server and obtain the information of other voice gateways from the GK server. Therefore, an interface must be specified to communicate with the GK server. This interface is an H.323 gateway interface. The Ethernet interfaces, asynchronous serial interfaces, and synchronous interfaces can all become H.323 gateway interfaces. The GK client function is activated only when an H.323 gateway interface has been specified.

To configure the H.323 voice gateway interface, run the following commands in specified interface configuration mode.

Command	Function
Ruijie(config-if)# **h323-gateway voip Interface**	Specifies the interface as the H.323 voice gateway interface.
Ruijie(config-if)# **no h323-gateway voip interface**	Removes the configuration.

No interface is specified as the voice gateway interface by default.

Configuring the Local Voice Gateway Alias

Every voice gateway in a network has a unique name used to register with the GK server for identification. One voice gateway can have only one alias.

To configure the local voice gateway alias, run the following commands in H.323 voice gateway interface configuration mode.

Command	Function
Ruijie(config-if)# **h323-gateway voip h323-id** *name*	Configures the local voice gateway alias.
Ruijie(config-if)# **no h323-gateway voip h323-id** *name*	Removes the configuration.

No local voice gateway alias is configured by default, that is, the local voice gateway alias is empty.

Configuring the GK Server Alias and IP Address

The GK server is used for discovery, node registration, call management and other management & control functions for the voice gateways in the network. On the GK client, you must specify the name and IP address of the GK server so that the local voice gateway and the GK server can communicate with each other.

To configure the alias and IP address of the GK server, run the following commands in H.323 voice gateway interface configuration mode.

Command	Function
Ruijie(config-if)# **h323-gateway voip id** *gk-name* **ipaddr** *a.b.c.d* [*ras-port*]	Configures the name and IP address of the GK server.
Ruijie(config-if)# **no h323-gateway voip id** *gk-name* **ipaddr** *a.b.c.d* [*ras-port*]	Removes the configuration.

The *gk-name* parameter specifies the alias of the GK server, and *a.b.c.d* specifies the IP address of the GK server. The *ras-port* parameter specifies the management port, which is 1718 by default. You should obtain such information from the administrator of the GK server.

Configuring the Technical Prefix

The technical prefix is used to identify the voice gateway type by the GK server. The default technical prefix of the H323 voice gateway is 1#, which usually does not need to be configured.

To configure the technical prefix, run the following commands in H.323 voice gateway interface configuration mode.

Command	Function
Ruijie(config-if)# **h323-gateway voip tech-prefix** *string*	Configures the technical prefix of the voice gateway.
Ruijie(config-if)# **no h323-gateway voip tech-prefix** *string*	Removes the configuration.

Activating and Disabling the GK Client Function

After you configure the H.323 voice gateway interface and the name and IP address of the GK server, you can activate the GK client function. When another H.323 gateway interface is specified, or the related parameters of the voice gateway (for example, gateway alias, corresponding GK alias, and GK IP address) are modified, you should activate the GK client function again so that the related GK client information stored on the GK server can be updated timely.

To activate or disable the GK client function, use the following commands in global configuration mode:

Command	Function
Ruijie(config)# **gateway**	Activates the GK client function of the voice gateway.
Ruijie(config)# **no gateway**	Disables the GK client function of the voice gateway.

The GK client function of the voice gateway is not activated by default.

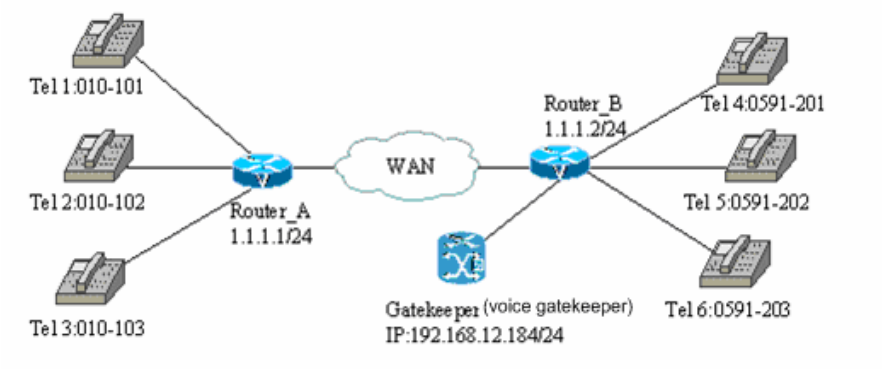
Example of Configuring the GK Client

Networking Requirements

An enterprise builds a VoIP network. The GK server is used to resolve the dynamic phone number and IP address.

As shown in the following figure, Router A is connected with three phones. The H.323 voice gateway interface is synchronous port 0, and is connected to Router B via the WAN line. Router B is connected with three phones. The H.323 voice gateway interface is ynchronous port 0. The voice GK and Router B are in the same LAN (as long as the voice GK and Router B are capable of interworking on the network, the GK can be at any physical location).

Figure 9 FXS directly connected with the telephones to build the VoIP network



Configuration Steps

Configuration of Router_A:

#Configure the router name.

```
hostname "Router_A"
```

Configure the WAN port.

```
interface Serial0
 ip address 1.1.1.1 255.255.255.0
 encapsulation ppp
 h323-gateway voip interface          //Configure the interface as the H.323 voice gateway
interface.
 h323-gateway voip h323-id Router_A//Configure the local voice gateway alias.
 h323-gateway voip id GKServer ipaddr 192.168.12.184 1718
//Configure the GK alias and IP address and the TCP port.
 clock rate 2000000
```

Configure the phone number of the local voice port 1/0.

```
dial-peer voice 1 pots
 destination-pattern 010101
 port 1/0
```

Configure the phone number of the local voice port 1/1.

```
dial-peer voice 2 pots
 destination-pattern 010102
 port 1/1
```

Configure the phone number of the local voice port 1/2.

```
dial-peer voice 3 pots
 destination-pattern 010103
```

```
 port 1/2
```

Configure the peer phone number and the resolution method as RAS.

```
dial-peer voice 10 voip
 destination-pattern 059120.
 session target ras                    //Configure the resolution method as RAS.
```

Enable the GK client function.

```
gateway
```

Configure the static default route (for communication only).

```
ip route 0.0.0.0 0.0.0.0 Serial0
```

Configuration of Router_B:

Configure the router name.

```
hostname "Router_B"
```

Configure Ethernet port 0.

```
interface FastEthernet0
 ip address 192.168.12.183 255.255.255.0
```

Configure the WAN port.

```
interface Serial0
 ip address 1.1.1.2 255.255.255.0
 encapsulation ppp
 h323-gateway voip interface
 h323-gateway voip h323-id Router_B
 h323-gateway voip id GKServer ipaddr 192.168.12.184 1718
```

Configure the phone number of the local voice port 1/0.

```
 dial-peer voice 11 pots
 destination-pattern 0591201
 port 1/0
```

Configure the phone number of the local voice port 1/1.

```
dial-peer voice 12 pots
 destination-pattern 0591202
 port 1/1
```

Configure the phone number of the local voice port 1/2.

```
dial-peer voice 13 pots
 destination-pattern 0591203
 port 1/2
```

Configure the peer phone number and the resolution method.

```
dial-peer voice 20 voip
 destination-pattern 01010.
 session target ras
```

Enable the GK client function.

```
gateway
```

Troubleshooting the GK Client

Fault: The GK client is not successfully registered with the GK server.

You can troubleshoot the GK client by performing the following steps:

First use the **ping** command to check whether the GK server is communicating normally.

Use the **show running-config** command to check whether the GK client configuration is correct and whether the gateway command is effective.

Check whether the gatekeeper is activated on the GK server.

Check whether the zone has been set on the GK server.

Configuring the GK Server

Overview

When the VoIP network is large and distributed across multiple zones, the voice gateway IP address and corresponding phone numbers on the VoIP network may also change frequently. In this case, it is nearly impossible to directly configure the relationship between the phone numbers and IP addresses of the voice gateways. Therefore, the gatekeeper is needed for address translation and call control.

The H.323 system has four logical components: H.323 terminal, H.323 gateway, H.323 gatekeeper and MCU. The gatekeeper is an H.323 entity that is used as the soft switch of the VoIP network for phone number and address resolution and call control. The advantage of the gatekeeper is that it makes centralized management of the VoIP network easier.

The gatekeeper function is integrated with the device, which can be directly configured as a GK server to provide the GK function. The gatekeeper is a service provided by the RGOS. The device can be configured as both the GK server and the GK client, which are logically a whole but run separately without mutual interference.

Modes Supported by the GK Server

Single GK for a single zone: On some small VoIP networks, there is only one GK server, with which all the voice gateways register. The GK is responsible for maintaining and resolving the voice gateways already registered with the GK and their phone numbers.

Multiple GKs for multiple zones: In this mode, the gateways interconnected may belong to different zones. The gateway registers with the GK in the local zone and the GK is responsible for not only maintaining the gateways and phone numbers in the local zone but also resolving the phone numbers of other zones by sending address resolution requests to the GKs in the adjacent zones for interconnection between multiple zones.

Configuring the GK Server

The GK server configuration includes:

- Configuring the GK Server for a Single GK in a Single
- Configuring the GK Server for Multiple GKs in Multiple Zones
- When the prefix of the numbers processed by the GK is configured, the gatekeeper_name can be the local or remote GK name. Before you configure the zone prefix, you must first configure the GK specified by *gatekeeper_name* (the local or remote GK). When the GK resolves an address, the GK first checks whether any gateway has registered with it. If no gateway has registered with it, it uses the zone prefix to search for a GK that can resolve the number, and sends an address resolution request to the GK. The gatekeeper_name can be any visible characters and is case-sensitive.
- Monitoring and Maintaining the GK Server

Configuring the GK Server for a Single GK in a Single Zone

On some small VoIP networks, there is only one GK server, with which all the voice gateways register. The GK is responsible for maintaining and resolving the voice gateways already registered with the GK and their phone numbers.

To configure the GK server for the single GK in a single zone, use the following commands in global configuration mode.

Command	Function
Ruijie(config)# **gatekeeper**	Enters GK server configuration mode.
Ruijie(config-gk)# **zone local** *gatekeeper_name domain_name* [*ras_ip_address*]	Configures the local GK server information.
Ruijie(config-gk)# **no shutdown**	Enables the GK server service.

Parameters of the local GK server:

- The *gatekeeper_name* parameter specifies the name of the local GK, which can consist of any visible characters and is case-sensitive.
- The *domain_name* parameter specifies the domain name of the local GK, which can consist of any visible characters and is case-sensitive.
- The *ras_ip_address* parameter specifies the RAS address of the local GK server. You can configure the IP address of one interface of the device as the RAS address. After the configuration takes effect, the GK server uses this IP address for information exchange with other voice gateways.

After the local GK server is configured for the first time, the GK server will be started automatically. One router can be configured with only one local GK. To cancel the local GK server configuration, add **no** before the command. If any voice gateway has already registered with the GK server, the configuration cannot be cancelled. First run **shutdown** to shut down the GK server service before you can cancel the local GK server configuration.

Configuring the GK Server for Multiple GKs in Multiple Zones

For some medium- and large-sized VoIP networks, there may be multiple GK servers, each of which is responsible for maintaining and resolving the phone numbers and addresses, and registration of the voice gateways in a zone.

In this mode, the gateways interconnected may belong to different zones. The gateway registers with the GK server in the local zone and the GK server is responsible for not only maintaining the gateways and phone numbers in the local zone

but also resolving the phone numbers of other zones by sending address resolution requests to the GK servers in the adjacent zones, for interconnection between multiple zones.

To configure the GK server for the multiple GKs in multiple zones, use the following commands in global configuration mode.

Command	Function
Ruijie(config)# **gatekeeper**	Enters GK server configuration mode.
Ruijie(config-gk)# **zone local** *gatekeeper_name domain_name* [*ras_ip_address*]	Configures the local GK server information.
Ruijie(config-gk)# **no shutdown**	Enables the local GK server.
Ruijie(config-gk)# **zone remote** *remote_gk_name remote_domain_name remote_ras_ip_address* [*port*]	Configures the remote GK server information.
Ruijie(config-gk)# **zone prefix** *gatekeeper_name prefix*	Configures the prefix of the number processed by the GK.

Parameters of the local GK server:

- The *gatekeeper_name* parameter specifies the name of the local GK, which can consist of any visible characters and is case-sensitive.
- The *domain_name* parameter specifies the domain name of the local GK, which can consist of any visible characters and is case-sensitive.
- The *ras_ip_address* parameter specifies the RAS address of the local GK server. You can configure the IP address of one interface of the device as the RAS address. After the configuration takes effect, the GK server uses this IP address for information exchange with other voice gateways.

Parameters of the remote GK server:

- The *remote_gatekeeper_name* parameter specifies the name of the remote GK, which can consist of any visible characters and is case-sensitive.
- The *remote_domain_name* parameter specifies the domain name of the remote GK, which can consist of any visible characters and is case-sensitive.
- The *remote_ras_ip_address* parameter specifies the RAS address of the remote GK server, and you can specify the IP address of an interface of the remote device as the RAS address. However, the IP address should be the IP address that the local router can access. After the configuration takes effect, the local GK server communicates with the remote GK server by using this IP address.

Prefix of the numbers processed by the GK server:

- The *gatekeeper_name* parameter specifies the name of the GK (local or remote), which is case-sensitive.
- The *prefix* parameter specifies the prefix of the numbers processed by the GK server, which consists of 0 to 9, a dot, and an asterisk. For example, zone prefix Router_A 1.. indicates that the GK of Router_A processes the phone numbers starting with 1 and having the length of 3 digits. The zone prefix Router_A 2.. indicates that the GK of Router_B processes all the phone numbers starting with 2.

Note

When the prefix of the numbers processed by the GK is configured, the gatekeeper_name can be the local or remote GK name. Before you configure the zone prefix, you must first configure the GK specified by *gatekeeper_name* (the local or remote GK). When the GK resolves an address, the GK first checks whether any gateway has registered with it. If no gateway has registered with it, it uses the zone prefix to search for a GK that can resolve the number, and sends an address resolution request to the GK. The gatekeeper_name can be any visible characters and is case-sensitive.

Monitoring and Maintaining the GK Server

Our products provide a broad range of GK server monitoring and debugging means. To debug and monitor the GK server, run the **show** commands in privileged user mode.

Command	Function
Ruijie# **show gatekeeper calls**	Displays the calls of the GK.
Ruijie# **show gatekeeper endpoints**	Displays the information of the voice gateway that has already registered with the GK, including the RAS address, call address, gateway name, and the phone numbers managed by the gateway.
Ruijie# **show gatekeeper gw_type_prefix**	Displays the techical prefix of the gateway.
Ruijie# **show gatekeeper servers**	Displays the gatekeeper server information.
Ruijie# **show gatekeeper status**	Displays the status of the GK: enable/disable.
Ruijie# **show gatekeeper zone prefix**	Displays the prefix of the phone numbers processed in all zones.
Ruijie# **show gatekeeper zone status**	Displays the status of all zones.

1) Display the information of all the voice gateways that have registered with the GK server.

```
Ruijie# show gatekeeper endpoints
              GATEKEEPER ENDPOINT REGISTRATION
              ================================
CallSignalAddr  Port  RASSignalAddr   Port  Zone Name        Type    F
--------------- ----- --------------- ----- ---------       ----    --
1.1.1.1        1720   1.1.1.1         4419  GKServer         VoIP-GW
   E164-ID:  010101
   E164-ID:  010102
   E164-ID:  010103
   E164-ID:  010104
   H323-ID:  Router_A
192.168.12.183  1720  192.168.12.183  416   GKServer        VoIP-GW
   E164-ID:  0591201
   E164-ID:  0591202
   E164-ID:  0591203
```

```
   E164-ID:  0591204
   E164-ID:  0591205
   E164-ID:  0591206
   H323-ID:  Router_B
Total number of active registrations = 2
```

As shown in the above information, you can see two voice gateways that have registered with the GK server, their respective RAS IP addresses, phone numbers, and GK zones.

2) Display the information of the ongoing calls.

```
Ruijie# show gatekeeper calls
Total number of active calls = 1.
                    GATEKEEPER CALL INFO
                    ====================
Endpt(s): Alias      E.164Addr    CallSignalAddr  Port  RASSignalAddr   Port
   src EP:Router_A   010101       1.1.1.1         1720  1.1.1.1         4419
   dst EP: Router_B  0591201      192.168.12.183  1720  192.168.12.183  416
================================================================================
```

As shown in the above information, there is an ongoing call, whose caller is Router_A and called number is 010101, callee is Router_B, and called number is 0591201.

Examples of Configuring the GK Server

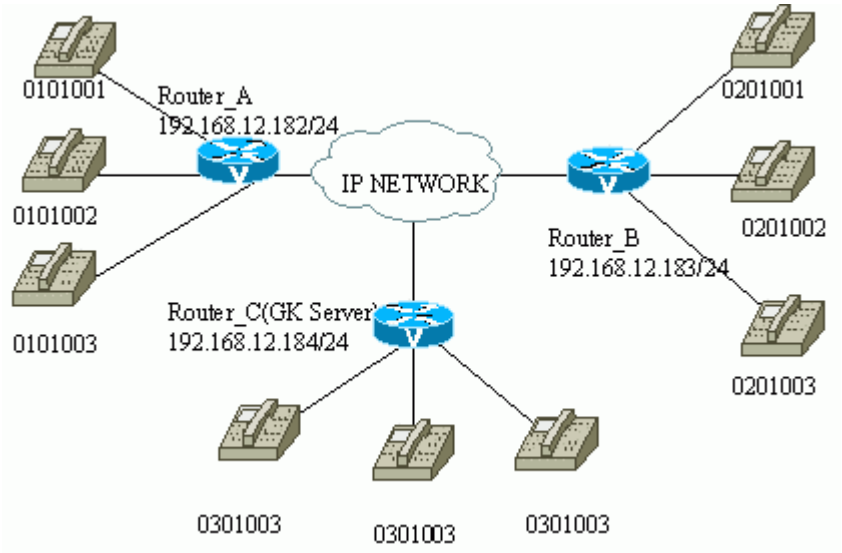
Example of Configuring the GK Server for a Single GK in a Single Zone

Networking Requirements

An enterprise builds a VoIP network. The GK server is used to dynamically resolve phone numbers and IP addresses. In the entire VoIP network, there is only one GK server. The phone numbers and addresses of all the voice gateways are resolved by the only GK server.

An shown in the following figure, Routers A, B and C are connected via the LAN. Each of the three routers is connected with three phones. Router C has enabled the GK server service. Routers A, B and C have all enabled the GK client function. The phone numbers and addresses are resolved by the RAS.

Figure 10 Building the VoIP network with a single GK in a single zone



Configuration Steps

Configuration of Router_A:

#Configure the router name.

```
hostname "Router_A"
```

Configure the LAN port.

```
interface FastEthernet0
 ip address 192.168.12.182 255.255.255.0
 h323-gateway voip interface           //Configure the interface as the H.323 voice gateway interface.
 h323-gateway voip h323-id Router_A//Configure the local voice gateway alias.
 h323-gateway voip id GKServer ipaddr 192.168.12.184 1718
                                       //Configure the GK alias and IP address and the TCP port.
```

Configure the phone number of the local voice port 1/0.

```
dial-peer voice 1 pots
 destination-pattern 0101001           //Configure the phone number of the interface to
0101001.
 port 1/0
```

Configure the phone number of the local voice port 1/1.

```
dial-peer voice 2 pots
 destination-pattern 0101002
 group 1/0
 port 1/1
```

Configure the phone number of the local voice port 1/2.

```
dial-peer voice 3 pots
 destination-pattern 0101003
 port 1/2
```

Configure the peer phone number and the resolution method.

```
dial-peer voice 10 voip
 destination-pattern 0......           //Configure the RAS resolution method for the 7-digit
numbers starting with 0.
 session target ras                //The address resolution mode is RAS.
```

Enable the GK client function.

```
gateway
```

Configuration of Router_B:

#Configure the router name.

```
hostname "Router_B"
```

Configure the LAN port.

```
interface FastEthernet0
 ip address 192.168.12.183 255.255.255.0
 h323-gateway voip interface           //Configure the interface as the H.323 voice gateway
interface.
 h323-gateway voip h323-id Router_B//Configure the local voice gateway alias.
 h323-gateway voip id GKServer ipaddr 192.168.12.184 1718
                                    //Configure the GK alias and IP address and the TCP port.
```

Configure the phone number of the local voice port.

```
dial-peer voice 11 pots
 destination-pattern 0201001
 port 1/0
!
dial-peer voice 12 pots
 destination-pattern 0201002
 port 1/1
!
dial-peer voice 13 pots
 destination-pattern 0201003
 port 1/2
!
dial-peer voice 20 voip
 destination-pattern 0......
 session target ras
```

Enable the GK client function.

```
gateway
```

Configuration of Router_C:

#Configure the router name.

```
hostname "Router_C"
```

Configure the LAN interface.

```
interface FastEthernet0
 ip address 192.168.12.184 255.255.255.0
 h323-gateway voip interface           //Configure the interface as the H.323 voice gateway
interface.
 h323-gateway voip h323-id Router_C//Configure the local voice gateway alias.
 h323-gateway voip id GKServer ipaddr 192.168.12.184 1718
                                    //Configure the GK alias and IP address and the TCP port.
```

Configure the phone number of the local voice port.

```
dial-peer voice 10 pots
 destination-pattern 0301001
 port 1/0
!
dial-peer voice 11 pots
 destination-pattern 0301002
 port 1/1
!
dial-peer voice 12 pots
 destination-pattern 0301003
 port 1/2
!
dial-peer voice 20 voip
 destination-pattern 0......
 session target ras                //Configure the address resolution mode as RAS.
```

Enable the GK client function.

```
gateway
```

Enable the GK server function.

```
gatekeeper
  zone local GKServer my_domain 192.168.12.184 //Configure the local GK server information.
```

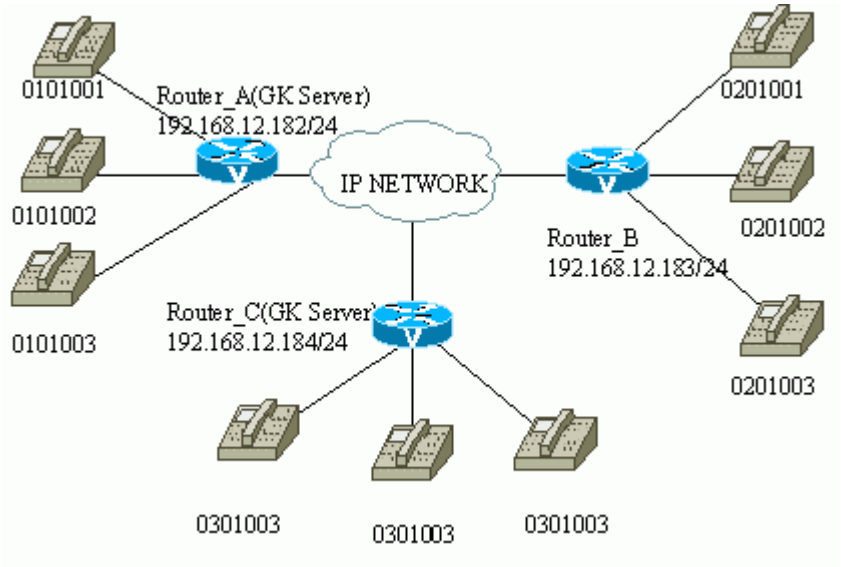
Example of Configuring the GK Server for Multiple GKs in Multiple Zones

Networking Requirements

A VoIP network is to be built. The GK server is used to dynamically resolve phone numbers and IP addresses. In the entire VoIP network, there are multiple GK servers. Each GK server is responsible for resolving the phone numbers and addresses of the voice gateway in a specific zone.

An shown in the following figure, Routers A, B and C are connected via the LAN. Each of the three routers is connected with three phones. Router A and Router C have enabled the GK server service. Routers A, B and C have all enabled the GK client function. The phone numbers and addresses are resolved by the RAS.

Figure 11 Building the VoIP network with multiple GKs in multiple zones



Configuration Steps

Configuration of Router_A:

#Configure the router name.

```
hostname "Router_A"
!
interface FastEthernet0
 ip address 192.168.12.182 255.255.255.0
 h323-gateway voip interface
 h323-gateway voip h323-id Router_A
 h323-gateway voip id GK2 ipaddr 192.168.12.182 1718
!
dial-peer voice 1 pots
 destination-pattern 0101001
 port 1/0
!
dial-peer voice 2 pots
 destination-pattern 0101002
 group 1/0
 port 1/1
!
dial-peer voice 3 pots
 destination-pattern 0101003
 port 1/2
!
dial-peer voice 10 voip
 destination-pattern 0......
 session target ras
```

Enable the GK client function.

```
gateway
```

Configure the GK server function.

```
gatekeeper
  zone local GK2 domain.com 192.168.12.182 //Configure the local GK server information.
  zone prefix GKServer 020....             //The 7-digit numbers starting with 020 are
submitted to the GK server with the GKServer name for resolution.
  zone prefix GKServer 030....             //The 7-digit numbers starting with 030 are
submitted to the GK server with the GKServer name for resolution.
  zone remote GKServer my_domain 192.168.12.184 1718   //Configure the remote GK server
information.
```

Configuration of Router_B:

Configure the router name.

```
hostname "Router_B"
!
interface FastEthernet0
 ip address 192.168.12.183 255.255.255.0
 h323-gateway voip interface
 h323-gateway voip h323-id Router_B
 h323-gateway voip id GKServer ipaddr 192.168.12.184 1718
!
dial-peer voice 11 pots
 destination-pattern 0201001
 port 1/0
!
dial-peer voice 12 pots
 destination-pattern 0201002
 port 1/1
!
dial-peer voice 13 pots
 destination-pattern 0201003
 port 1/2
!
dial-peer voice 20 voip
 destination-pattern 0......
 session target ras
```

Enable the GK client function.

```
gateway
```

Configuration of Router_C:

Configure the router name.

```
hostname "Router_C"
!
interface FastEthernet0
```

```
 ip address 192.168.12.184 255.255.255.0
 h323-gateway voip interface
 h323-gateway voip h323-id Router_C
 h323-gateway voip id GKServer ipaddr 192.168.12.184 1718
!
dial-peer voice 10 pots
 destination-pattern 0301001
 port 1/0
!
dial-peer voice 11 pots
 destination-pattern 0301002
 port 1/1
!
dial-peer voice 12 pots
 destination-pattern 0301003
 port1/ 2
!
dial-peer voice 20 voip
 destination-pattern 0......
 session target ras
```

Enable the GK client function.

```
gateway
```

Configure the GK server function.

```
gatekeeper
  zone local GKServer my_domain 192.168.12.184     //Configure the local GK server
information.
  zone prefix GK2 010....                          //The 7-digit numbers starting with 010
are submitted to the GK Server with the GK name for resolution.
  zone remote GK2 domain.com 192.168.12.182 1718       //Configure the remote GK server
information.
```

Configuring the E1 Voice Card

Introduction to the E1 Voice Card

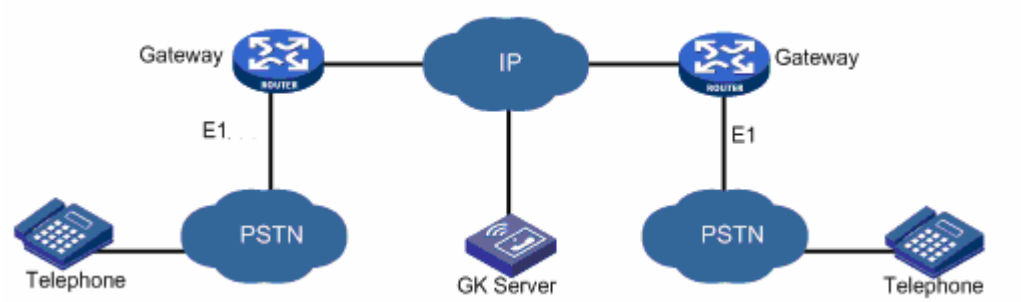
The plesiochronous digital hierarchy (PDH) includes two major communication systems: E1 system and T1 system. The E1 system recommended by the ITU-T is mainly applied in Europe and Mainland China. The T1 system recommended by the ANSI is mainly applied in America, Canada, and Japan.

E1 and T1 use the same sampling frequency (8 kHz), PCM frame length (125 seconds), number of bits per code (8 bits), and timeslot bit rate (64 kbit/s). E1 and T1 different in the following aspects: E1 uses 13-segment A-law coding/decoding, while T1 uses 15-segment μ-law coding/decoding; each PCM primary frame of E1 includes 32 timeslots, while each PCM primary frame of T1 includes 24 timeslots; each PCM primary frame of E1 includes 256 bits, while each PCM primary frame of T1 includes 193 bits. Therefore, E1 provides 2.048 Mbit/s bandwidth, while T1 provides 1.544 Mbit/s bandwidth. Currently, Ruijie routers support only the E1 system and does not support the T1 system.

Introduction to the E1 Voice Function

E1 serves as a trunk to exchange voice and signaling with the PSTN side. To implement this function, the router must be provided with the corresponding E1 voice interface and a series of functions suitable for voice transmission on the E1 and T1 lines. The physical interface of Ruijie E1 voice interface is an E1VI interface. When the E1 line is used in networking of voice transmission, the PSTN switch and the router are connected through an E1 trunk line. The basic networking is shown in FIG. 12.

Figure 12 E1 voice system networking



Using E1 voice mode, the router can provide more voice channels for communication, which greatly improves the utilization of the router and supported service ranges.

Method for Using the E1 Interface

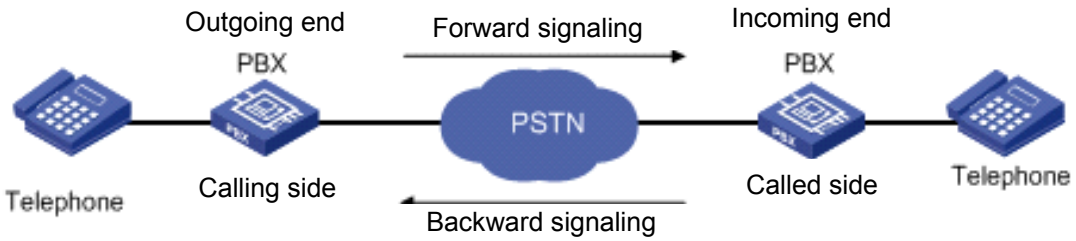
The E1 interface is divided into timeslots logically. Timeslot 16 is used as a signaling channel. A timeslot group can be created on the E1 interface. When the E1 interface is used as a CE1 interface having a signaling channel, if R2 (SS1) signaling is used, every 32 timeslots make up a primary frame (such as a PCM30 frame structure), where timeslot 0 is used for frame alignment, timeslot 16 is used for transmitting digital line signaling control information, and the other 30 timeslots are used for transmitting voice information. Every 16 primary frames make up a multiframe. In each multiframe, timeslot 0 of even primary frames is used for transmitting frame alignment signals (FASs), and timeslot 0 of odd primary frames is used for transmitting non frame alignment signals (NFASs), and the information transmitted thereon is status information of the link which provides control signaling for primary rate multiplexing. In timeslot 16 of the first primary frame (frame 0) of each multiframe, the first 4 bits are used for transmitting multiframe alignment signals (MFASs), and the last 4 bits are used for transmitting non multiframe alignment signals (NMFASs). Timeslot 16 of the other 15 primary frames is used for transmitting line status of two timeslots respectively. For example, timeslot 16 of the second primary frame (frame 1) is used for transmitting digital line signaling status of timeslot 1 and timeslot 17, and timeslot 16 of the third primary frame (frame2) is used for transmitting digital line signaling status of timeslot 2 and timeslot18, and so on.

Introduction to SS1 Signaling

Q.400 to Q.490 series protocols of the ITU-T define R2 signaling standards. However, R2 signaling has different standards in different regions and countries during implementation, and R2 signaling of each country is a variant of the ITU-T standard (SS1 signaling is a subset of R2 signaling).

SS1 signaling is classified into digital line signaling and register signaling. The digital line signaling is mainly used for monitoring the seizure, release, and blocking of a trunk line. The register signaling uses multi-frequency control mode to transmit information such as address. Usually, the calling side acts as an outgoing end, and the called side acts as an incoming end. The signaling from the outgoing end to the incoming end is forward signaling, and the signaling from the incoming end to the outgoing end is backward signaling, as shown in Figure 13.

Figure 13 SS1 signaling related elements



1) Digital line signaling

The digital line signaling is mainly used to change the call status and condition on the line, and its main functions include identifying and detecting four scenarios: seizure by caller off-hook, answer by callee off-hook, caller on-hook, and callee on-hook, and accordingly setting the line status to seized or idle. The signaling is transmitted in the timeslots of the sixteenth multiframe in the PCM system. In the two directions of each voice channel, there are four bits, that is, a, b, c, and d, as the flag bits, where the value of cd is fixed to 01 (cd of SS1 signaling is 11). Therefore, a_f and b_f bits are used for forward signaling, and a_b and b_b bits are used for backward signaling. In the digital line signaling, meanings of a_f, b_f, a_b, and b_b are as follows:

The following table describes the signal bits of the line signaling.

Signal Bit	Meaning	Value = 0	Value = 1
a_f	Identifies the working status of the outgoing device and reflects the calling subscriber line status.	Seizure by off-hook	On-hook clear (idle)
b_f	Indicates the forward failure status from the outgoing end to the incoming end.	Normal	Failed
a_b	Indicates the called subscriber line status (on-hook or off-hook).	Callee off-hook	Callee on-hook
b_b	Indicates the idle or seized status of the incoming device.	Idle	Seized or blocked

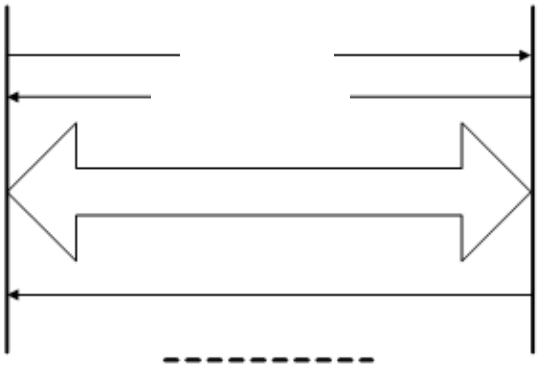
The following table shows the status codes of the line signaling:

Line Status	Signaling Code			
	Forward (Forward)		Backward (Back)	
	a_f	b_f	a_b	b_b
Idle (idle)	1	0	1	0
Seized (seize)	0	0	1	0
Seizure acknowledgement (seizure-ack)	0	0	1	1
Answer (answer)	0	0	0	1
Backward clear (clear-back)	0	0	1	1
Forward clear (clear-forward)	1	0	0/1	1
Blocked (block)	1	0	1	1
Unblocked (unblock)	1	0	1	0

The typical process of exchanging SS1 digital line signaling is as follows:

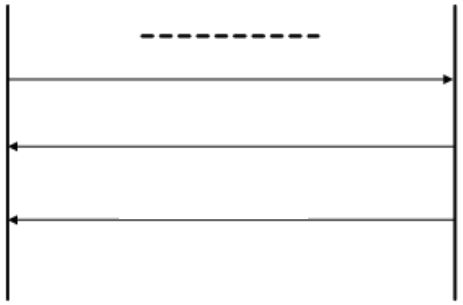
Call setup: When the trunk line is idle, the outgoing end sends a forward seizure signal to the incoming end. The incoming end returns a seizure ACK signal after identifying the seizure signal. In this case, the lines on both sides are in the seized state, and the process of exchanging register signaling is started. When the callee goes off-hook to answer the call, the incoming end should send a backward answer signal. After the outgoing end identifies the backward answer signal, the call is set up.

Figure 14 Digital line signaling — call setup



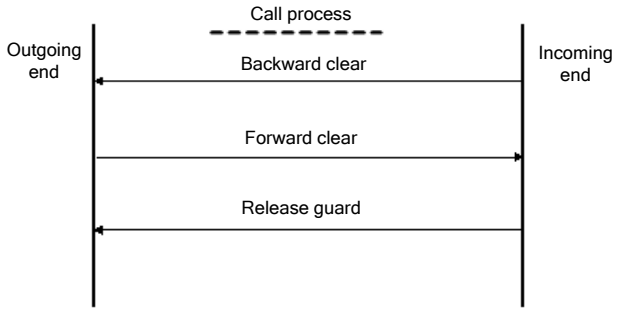
Outgoing end on-hook first: The outgoing end sends a forward clear signal 10. The incoming end should send a backward signal 10 (release guard or forward clear ACK signal) after identifying the forward clear signal. When the outgoing end identifies the backward signal 10, the corresponding trunk line is released.

Figure 15 Digital line signaling — outgoing end on-hook first



Incoming end on-hook first: The incoming end sends a backward clear signal 11. The outgoing end should send a forward clear signal 10 after receiving the backward clear signal. The incoming end should send a backward signal 10 when identifying the forward clear signal 10 of the outgoing end. When the outgoing end identifies the backward signal 10, the corresponding trunk line is released.

Figure 16 R2 digital line signaling — incoming end on-hook first



On-hook due to a forced release signal: When the incoming end supports a metering signal, to avoid the collision of the metering signal and the backward clear signal sent by the incoming-end user who goes on-hook first, a forced release signal 00 may be used to replace the backward clear signal 11.

Blocking in the idle or call state: When the outgoing end receives a block signal 11 from the incoming end when the trunk line is in the idle or call state, the outgoing end should send a forward signal 10, and the corresponding trunk line is blocked. When the incoming end unblocks the trunk line, the incoming end should send a backward idle indication signal 10 on the corresponding line. The outgoing end should keep the forward signal 10 unchanged, and unblock the corresponding local trunk line so that the line can be used for a next call.

Troubleshooting of the idle outgoing device: When the incoming end receives a forward signal 11 sent by the outgoing device due to failure when the trunk line is in the idle state, the incoming device should send a backward line signal 11 on the line, and the trunk line fails. After the outgoing device recovers from the failure, the outgoing device sends a forward signal 10 on the line. In this case, the incoming end should send a signal 10 on the line, and the trunk line is normal.

Troubleshooting of the outgoing device in a call: When the incoming end in a call receives a forward signal 11 sent by the outgoing device due to failure, the incoming device should release a voice channel backward, and at the same time send a backward line signal 11 on the line, and the trunk line fails. After the outgoing device recovers from the failure, the outgoing device sends a forward signal 10 on the line. In this case, the incoming end should send a signal 10 on the line, and the trunk line is normal.

2) ITU-T register signaling

The main function of register signaling is to control the automatic connection of a line. The register signaling uses multi-frequency control mode. The register signaling is classified into forward signaling and backward signaling. The forward signaling in the exchanging phase is divided into group I and group II, and the backward signaling in the exchanging phase is also divided into group A and group B. When the outgoing end identifies a seizure ACK line signal, the register starts to work, sends the first digit of the called number, and waits for the response of backward group A signaling from the incoming end.

Forward group I signaling consists of connection control signaling and digit signaling. The following table describes the forward group I signaling.

Signal	Basic Meaning
I-1…I-10	Digit signaling, corresponding to 1, 2, 3, 4, 5, 6, 7, 8, 9, and 0 in sequence, and responsible for sending specific number information to the incoming end
I-11	National reserved
I-12	The request being rejected
I-13	Connected to the test device

Signal	Basic Meaning
I-14	National reserved
I-15	Terminating address identification and pulse (used in an international call)

Backward group A signaling: control signaling of forward group I signaling, controlling and acknowledging the forward group I signaling. The following table describes the backward group A signaling.

Signal	Basic Meaning
A-1	"Send-digits" control signal, requesting to send a next digit
A-2	"Send-digits" control signal, requesting to resend from the previous digit
A-3	Number receiving completed, changing to the process of exchanging the forward group II signaling and the backward group B signaling
A-4	National network congested (sent by the national exchange), terminating the process of exchanging register signaling
A-5	Requesting caller group information
A-6	Number receiving completed, terminating the process of exchanging register signaling, starting to charge, and entering a call process
A-7	"Send-digits" control signal, requesting to resend from the previous two digits
A-8	"Send-digits" control signal, requesting to resend from the previous three digits
A-9	National reserved
A-10	National reserved
A-11	Send country code indicator
A-12	Send language or authentication bit
A-13	Requesting to send a line class
A-14	Requesting echo suppressor information
A-15	International network congested (sent by the international exchange), terminating the process of exchanging register signaling

Forward group II signaling: indicates the service nature of the outgoing end, and decides whether to allow forced release and break-in according to the nature of different services. The following table describes the forward group II signaling.

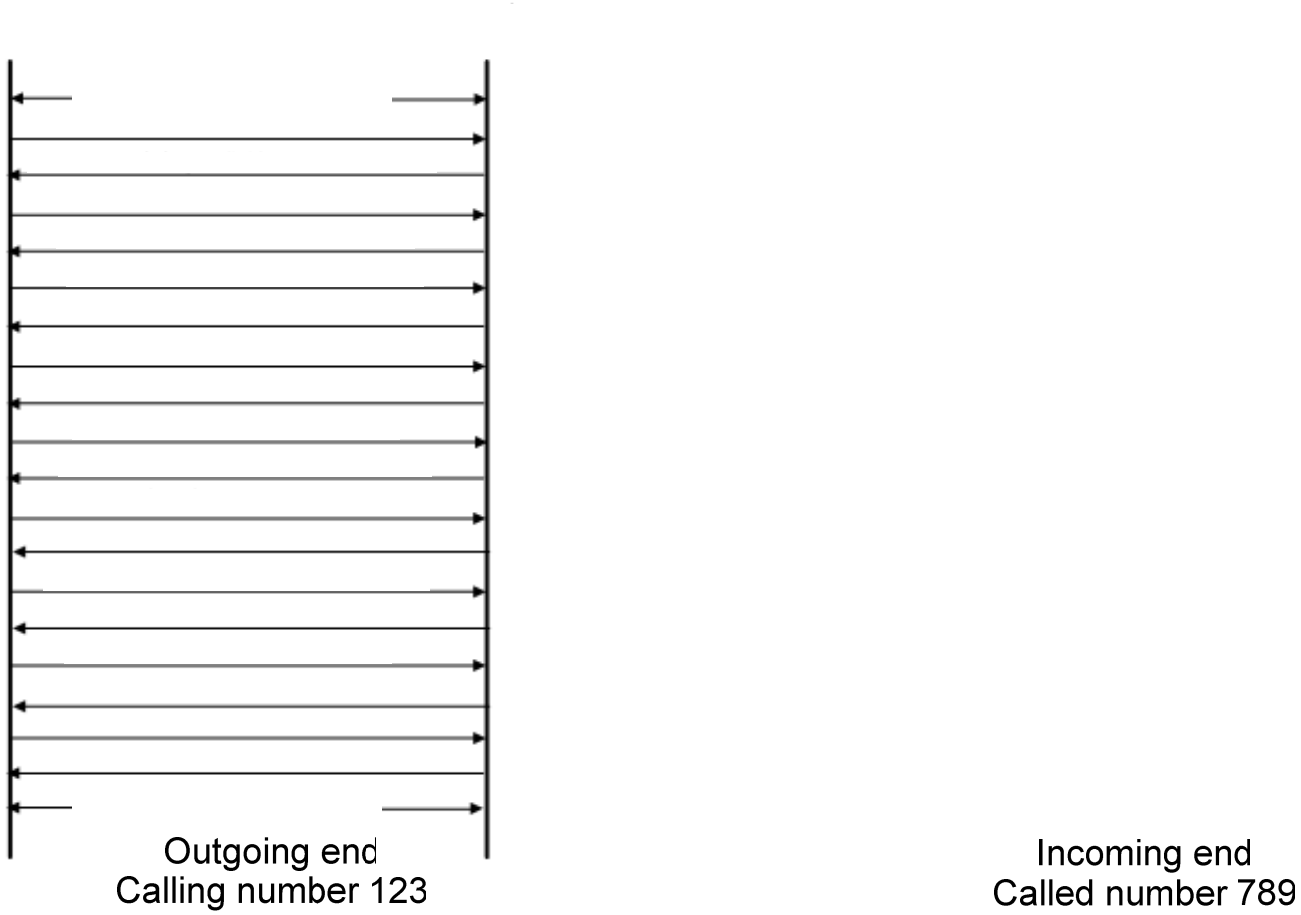
Signal	Basic Meaning
II-1	Non-priority user
II-2	Priority user
II-3	Maintained device
II-4	National reserved
II-5	Attendant
II-6	Data transmission
II-7	For international use: The caller does not support forwarding.
II-8	For international use: data transmission
II-9	For international use: The caller is a user with priority.
II-10	For international use: It is used in international aid, and the caller supports forwarding.
II-11…II-15	National reserved

Backward group B signaling: indicates the status of the callee, acknowledges group II signaling, and performs connection control. The following table shows the backward group B signaling.

Signal	Basic Meaning
B-1	National reserved
B-2	Requesting a special tone to be sent to the caller
B-3	The subscriber line is busy.
B-4	Congested
B-5	Unallocated number
B-6	The user is idle and charged.
B-7	The user is idle and not charged.
B-8	The subscriber line fails.
B-9…B-15	National reserved

The typical process of exchanging R2 register signaling is as follows (the following figure shows a process of requesting caller group information):

Figure 17 Register signaling exchanging process



Configuring the E1 Voice Card

The E1 voice card configuration includes:

- Configuring the DS0 Group (mandatory)
- Configuring the Voice Port (optional)
- Configuring the Dial Peer (mandatory)
- Configuring Basic Parameters of the E1 Interface (optional)
- Configuring Related Parameters of R2 Signaling (optional)

Configuring the DS0 Group

Command	Function
Ruijie(config)# **controller e1** *slot-number*/*port-number*	Enters configuration mode of the specified CE1 interface.
Ruijie(config-controller)# **ds0-group** *chan-num* **timeslots** *timeslot-range*	Allocates the specified timeslot range (timeslots 1 to 31, where timeslot 16 is reserved for transmitting line signaling, and the timeslots may be discontinuous) to the specified channel group (channel group numbers 0 to 30).
Ruijie(config-controller)# **no ds0-group** *chan-num*	Cancels timeslot allocation of the specified channel group.

Configuring the Voice Port

To configure the voice port, first enter voice port configuration mode.

In global configuration mode, run the following command to enter voice port configuration mode.

Command	Function
Ruijie(config)# **voice-port** *slot-number*/*port-number: chan-num*	Enters voice port configuration mode.

Other configurations are the same as the configuration of the VoIP voice port.

Configuring the Dial Peer

Configuring the POTS Dial Peer

This configuration is the same as the configuration of a common POTS dial peer except for the **port** command.

Command	Function
Ruijie(config-dial-peer)# **port** *slot-number*/*port-number: chan-num*	Specifies the dial port corresponding to the dial peer.
Ruijie(config-dial-peer)# **no port**	Cancels the local dial port number.

Configuring the VoIP Dial Peer

This configuration is the same as the configuration of a common VoIP dial peer.

Configuring Basic Parameters of the E1 Interface

Command	Function
Ruijie(config)# **controller e1** *slot-number*/*port-number*	Enters configuration mode of the specified CE1 interface.
Ruijie(config-controller)# **framing** {**crc4** | **no-crc4** }	Sets frame check mode of the CE1 interface.
Ruijie(config-controller)# **no framing**	Restores the default setting of frame check mode for the CE1 interface.

Command	Function
Ruijie(config-controller)# **linecode** {**ami** | **hdb3** }	Sets the line codec format of the CE1 interface.
Ruijie(config-controller)# **no linecode**	Restores the default setting of the line codec format for the CE1 interface.
Ruijie(config-controller)# **clock source** {**line** | **internal** }	Sets the synchronization clock source of the CE1 interface.
Ruijie(config-controller)# **no clock source**	Restores the default setting of the synchronization clock source of the CE1 interface.

Configuring Related Parameters of R2 Signaling

To configure the related parameters of R2 signaling, first enter cas configuration mode from controller e1 command mode.

Command	Function
Ruijie(config-controller)# **cas-custom** *channel*	Enters cas configuration mode.

You can configure related parameters of R2 signaling in cas configuration mode.

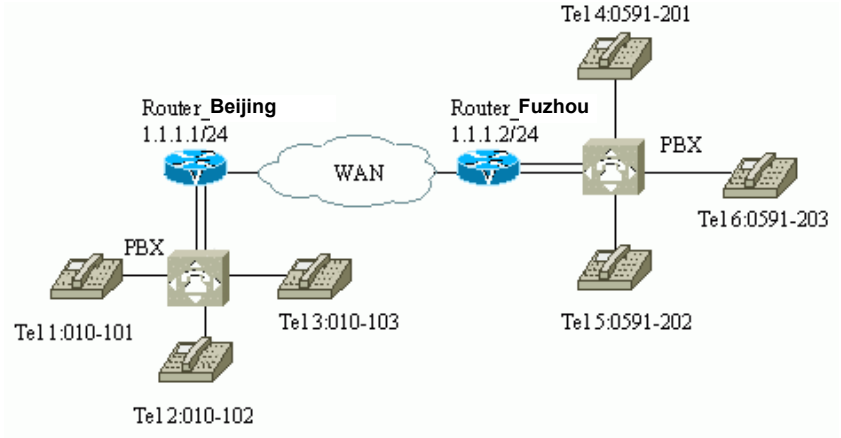
Command	Function
Ruijie(config-ctrl-cas)# **alert-wait-time** *time*	Configures a timeout interval for waiting for the end of the ringing tone.
Ruijie(config-ctrl-cas)# **ani-digits** *time*	Requests the caller to send the calling number when acting as a callee.
Ruijie(config-ctrl-cas)# ani-timeout *time*	Specifies the duration for the callee to request the caller to send the calling number.
Ruijie(config-ctrl-cas)# **caller-digits** *number*	Configures the number of digits that need to be collected before the caller ID or caller number is received.
Ruijie(config-ctrl-cas)# **end-of-callednum send**	Indicates that the called number is sent completely.
Ruijie(config-ctrl-cas)# **invert-abcd** *A-bit B-bit C-bit D-bit*	Configures line signaling inversion mode.
Ruijie(config-ctrl-cas)# **ka** *number*	Specifies the ka value.
Ruijie(config-ctrl-cas)# **kd** *number*	Specifies the kd value.
Ruijie(config-ctrl-cas)#kd-timeout *time*	Specifies the kd duration.
Ruijie(config-ctrl-cas)# **kb idle** *number*	Specifies the kb value if the callee is idle.
Ruijie(config-ctrl-cas)#kb-timeout *time*	Specifies the kb duration.
Ruijie(config-ctrl-cas)#release-guard-time *time*	Starts the timer after the device receives a forward release signal, and sets the line to idle when the timer expires.
Ruijie(config-ctrl-cas)# **seizure-ack-time** *time*	Configures the time interval for sending a backward seizure ACK signal after the router receives a forward seizure signal.

Command	Function
Ruijie(config-ctrl-cas)# send ring	Configures the ring back tone to be provided by the local end.
Ruijie(config-ctrl-cas)# **trunck-direction** *timeslots-list* {**in** | **out** | **dual**}	Configures the trunk direction of the timeslot specified by the E1 line. **in** means allowing incoming trunk calls only; **out** means allowing outgoing trunk calls only; and **dual** means allowing both incoming and outgoing trunk calls.
Ruijie(config-ctrl-cas)# **unused-abcd** *A-bit B-bit C-bit D-bit*	Specifies unused abcd bit values.
Ruijie(config-ctrl-cas)#wait-kd	Configures kd waiting to start a call.

Example of Configuring E1 Voice Card R2 Signaling

Configuring Interconnection Between the Router and the PBX Trunk Port

Figure 18 Building the VoIP network via the PBX



As shown in the above figure, the Beijing head office has its own telephone network built by using a PBX. This is also the case in the Fuzhou Branch. The router and the PBX are connected via an E1 line.

When users in the two places make IP phone calls, they must first dial 9 to connect to the line through which the PBX and voice gateway are connected. For example, if extension 3 in Fuzhou (with the internal phone number of 203) is to call extension 2 in Beijing (with the internal phone number of 102), the operation procedure is as follows:

First, extension 3 in Fuzhou goes off hook and dials 9 to connect to the voice gateway.

Then, the access number 010-101 of the voice gateway of Beijing is dialed. When the voice gateway is connected, the call directly reaches the PBX in Beijing, which provides the prompt tone (for example, “please dial the extension number”). In this example, the hunting function (forwarding on busy) is configured, so the user only needs to dial 010-101. If the number is busy, the call will be automatically forwarded to the next port. This is also the case from Beijing to Fuzhou, where only 0591-201 needs to be dialed.

Then, the internal extension 102 in Beijing is dialed. In this way, the two places can communicate with each other through VoIP.

The operation procedure for dialing the extension in Fuzhou from Beijing is the same, and the configuration of the router is also the same. The only difference lies in the connection mode of the entire network. In this way, the two places can make common calls to each other via VoIP.

Configuration Steps

Configuration of Router_Beijing:

Configure the router name.

```
hostname "Router_Beijing"
```

Configure the WAN port.

```
interface Serial0/0
ip address 1.1.1.1 255.255.255.0
encapsulation ppp
clock rate 2000000
```

Configure the ds0 group.

```
controller e1 1/0
ds0-group 1 timeslots 1-15
```

Configure the voice port.

```
voice-port 1/0:1
```

Configure the phone number of the local voice port 0.

```
dial-peer voice 1 pots
destination-pattern 010101
port 1/0:1
```

Configure the phone number of the local voice port 1.

```
dial-peer voice 2 pots
destination-pattern 010102
group 1/0:1
port 1/0:1
```

#Configure the phone number of the local voice port 2.

```
dial-peer voice 3 pots
destination-pattern 010103
group 1/0:1
port 1/0:1
```

Configure the peer phone number and IP address (a wildcard is used).

```
dial-peer voice 4 voip
destination-pattern 059120.
session target ipv4: 1.1.1.2
```

Configuration of Router_Fuzhou:

Configure the router name.

```
hostname "Router_Fuzhou"
```

Configure the IP address of the WAN port.

```
interface Serial0/0
ip address 1.1.1.2 255.255.255.0
encapsulation ppp
```

Configure the ds0 group.

```
controller e1 1/0
ds0-group 1 timeslots 1-15
```

Configure the phone number of the local voice port 0.

```
dial-peer voice 11 pots
destination-pattern 0591201
port 1/0:1
```

Configure the phone number of the local voice port 1, and set call forwarding on busy.

```
dial-peer voice 12 pots
destination-pattern 0591202
group 1/0:1
port 1/0:1
```

#Configure the phone number of the local voice port 2.

```
dial-peer voice 13 pots
destination-pattern 0591203
group 1/0:1
port 1/0:1
```

Configure the peer phone number and IP address (a wildcard is used).

```
dial-peer voice 14 voip
destination-pattern 01010.
session target ipv4: 1.1.1.1
```

The SIP Access Gateway Configuration

Understanding the SIP Protocol

The Session Initiation Protocol (SIP) is an application layer control protocol that can create, modify, and terminate multimedia sessions, including IP phone calls, multimedia distribution, and multimedia conferences. It is a core protocol in the IETF multimedia data and control architecture (the latest RFC document is RFC 3261), aiming to control signaling on IP networks and communicate with soft switch platforms. As a result, the protocol builds a next-generation value-added service platform, which will provide better value-added services to telecommunication carriers, banks, financial organizations, and other sectors.

SIP is used to initiate sessions, control the setup and termination of multi-party multimedia sessions, and dynamically adjust and modify session attributes, such as bandwidth requirements, transmission media types (voice, video, data, etc), media encoding/decoding formats, and multicast and unicast support. SIP, based on text encoding, with reference to the mature HTTP protocol, is extensible and easy to implement, so it is suitable for implementing an Internet-based multimedia conferencing system.

With using the client/server model, the SIP protocol completes the setup of a user's call via the communication with a proxy server.

A SIP terminal sends an INVITE message to a destination session terminal and the message contains its own description information.

The destination terminal can decide whether to accept or reject the request according to the INVITE message and its own capability. SIP can forward the INVITE message via the proxy server. The proxy server can confirm the location of the destination terminal, find a route, perform authentication and authorization according to requirements of session terminals, and provide the call routing policies of session terminals. SIP records each terminal's description information through a registrar, including the address, route, and number. Each SIP terminal sends a REGISTER message to the registrar to register or update description information. SIP, as an application layer protocol, can use TCP or UDP at the transmission layer. SIP can support IPv4 and IPv6.

SIP Networking Elements

SIP is a peer-to-peer protocol. Terminals participating in each session on the SIP network are known as user agents (UAs). Terminals are classified into two types according to their roles in a session.

- User agent client, UAC, session initiator
- User agent server, UAS, session receiver

Generally, each SIP terminal has two functions: UAC and UAS, depending on their locations in a session.

SIP Client

The SIP client includes the following networking elements:

- SIP phone: UAC and UAS, including SIP soft terminal and SIP phone terminal.

- SIP access gateway: It provides a call control function. The most important function of the SIP access gateway is to provide connection and forwarding from the SIP network to other networks. This function does not include control signaling conversion among different networks and possible audio/video transcoding.

SIP Client

The SIP server includes the following networking elements:

- **Proxy server:** Same as the relay device on the network. The SIP proxy server receives the messages from SIP terminals, and routes the messages to the next server on the network. The proxy server can provide the functions of authentication, authorization, network control, routing, reliable relay, encryption, and so on.
- **Redirect server:** The redirect server indicates the message next-hop address for SIP terminals. By querying the redirect server, a SIP client can obtain the message next-hop address.
- **Registrar:** The registrar provides registration services to the SIP client. The registrar, and its adjacent proxy server, or redirect server, are in the same physical location on the network.

Note

The SIP server can communicate with external servers, and introduce their functions into the SIP network. The typical external servers include a Lightweight Directory Access Protocol (LDAP) directory server, a location server, a database server, an XML server, and an AAA server. With those external servers, the location, authentication, billing functions can be provided for the SIP network.

SIP Working Principles

Registration

In the SIP system, all SIP terminals, as UAs, must register with the SIP server (registrar) to inform its location, session capability, call policy, and so on.

Users register their information by running registration commands. The UA sends a REGISTER message to the server, where the message contains all registration information. Then the registrar sends a reply after receiving REGISTER message. If registration succeeds, a success message will be sent to the terminal, as shown in the figure below:

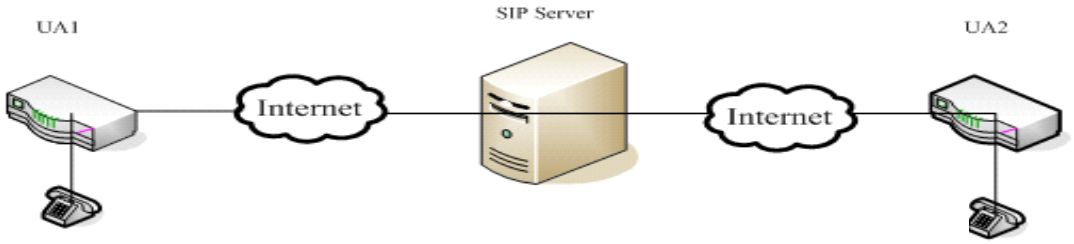
Figure 19 Message exchange when the UA registers with the registrar

Setting Up a Call

The SIP protocol uses the client/server model. Because each SIP terminal has UAC and UAS functions, there are two call modes: One is the end-to-end call between UAs, as shown in Figure 20, and the other is the call between UAs via a server, as shown in Figure 21.

Figure 20 Call setup between UAs

Figure 21 Call setup with server participation



For example, as shown in the preceding figure, phone 1 needs to call phone 2, and two voice gateways are used as SIP terminals (UAs). After phone 1 dials phone 2's number, the voice gateway sends a session request to the SIP server. The SIP server sends a session request to voice gateway 2 by searching for phone 2's number. After voice gateway 2 receives the request, if phone 2 is available, a reply will be sent to the SIP server, and phone 2 rings. After the SIP server receives the reply, a reply will be sent to voice gateway 1. The reply includes two messages, a temporary reply and a success reply. Phone 2's UA informs phone 2 that someone sends a session invitation. At this time, the UA's reply to the SIP server is a temporary reply, 180 ringing message. When phone 2 is picked up, phone 2's UA sends a success reply to the SIP server, indicating that the phone is connected. Then phone 1's UA sends an OK message to phone 2's UA, indicating that the session is available. Therefore, there are 3 hand-shaking processes: INVITE---REPLY-ACK. The message exchange process is shown in Figure 22.

Figure 22 Message exchange for call setup

Constraints for SIP Access Gateway Configuration

- The voice encoding formats supported by the SIP access gateway are G.711-ulaw, G.711-alaw, G.723, and G.729.
- Only UDP access is supported by the SIP access gateway.
- The INVITE message must contain one SDP message.
- In 180 ringing message and 200 OK message, the SDP message cannot be modified.
- Currently, the SIP access gateway supports POTS-TO-IP sessions and IP-TO-POTS sessions, but does not support IP-TO-IP sessions. That is, it is not possible to configure a VOIP dial peer to enable the SIP access gateway to initiate a SIP call and route the call to other SIP devices.

Configuring the SIP Access Gateway

Task List

The SIP access gateway configuration includes:

- Configuring a VoIP dial peer to support SIP
- Configuring a SIP UA

Configuring a VoIP Dial Peer to Support SIP

To configure the specified VoIP dial peer to support SIP, run the following commands in global configuration mode.

Command	Function
Ruijie(config)**#dial-peer voice** *number* **voip**	Enters configuration mode of the specified VoIP dial peer.
Ruijie(config-dial-peer)**#session protocol** { *h.323* | *sip* }	Specifies the protocol used by the VoIP outgoing call.

Command	Function
Ruijie(config-dial-peer)# **destination-pattern** *number*	Specifies the destination number of the VoIP dial peer. *number*: specifies the destination number.
Ruijie(config-dial-peer)#**session target** { **sip-server** | **ipv4**:*ip_addr*:[*port-num*]}	Specifies the network address that matches the dial peer: **sip-server**: uses the configured SIP server address as the matching address of the peer. This keyword can be used only after the SIP server is configured. **ipv4**: specifies an IPV4 address. *port-num*: (optional) specifies the UDP port of the matching address, and is 5060 by default.

Use the following commands to configure the SIP server in global configuration mode.

Command	Function
Ruijie(config)#**sip-ua**	Enters configuration mode of the SIP UA.
Ruijie(config-dial-peer)#**sip-server** **ipv4**:*ip_addr*:[*port-num*]	Specifies the service address of the SIP server. **ipv4**: specifies an IPv4 address. *port-num*: (optional) specifies the UDP port of the matching address, and is 5060 by default.

Configuring the SIP UA to Register with the Server

To set up a call through the server, a SIP UA must first register with the server. To register the SIP agent, run the following commands in global configuration mode.

Command	Function
Ruijie(config)#**sip-ua**	Enters configuration mode of the SIP UA.
Ruijie(config-sip-ua)# **sip-id** *id-num* **password** *pwd-num*	Specifies the ID and password of the gateway during registration. *id-num*: specifies the ID during gateway registration. *pwd-num*: specifies the password during gateway registration.
Ruijie(config-sip-ua)#**sip-server** **ipv4**:*ip_addr*:[*port-num*]	Specifies the service address of the SIP server. ipv4: specifies an IPV4 address. *port-num*: (optional) specifies the UDP port of the matching address, and is 5060 by default.
Ruijie(config-sip-ua)# **mode** { **phone** | **gateway** }	SIP UA registration modes: phone registration mode, and gateway registration mode. Currently, only phone registration mode is supported. phone: phone registration mode gateway: gateway registration mode
Ruijie(config-sip-ua)#**register-enable**	To register with the server, you must first configure the server address. **no register-enable**: cancels registration with the server.

Hunt Group and Preference of the SIP Access Gateway

The SIP access gateway supports hunt groups and preferences. That is, you can configure the same destination pattern (number) for multiple dial peers. Because each POTS dial peer number is a voice port connected with a phone, hunt groups can ensure that the call is connected even when one special voice port is busy. If the router is configured with hunt groups, it can forward the call to another voice port when one voice port is busy.

For example, router A configures different destination patterns for four POTS dial peers. Because each dial peer has a different number, when one voice port is busy, the router does not have the backup port for this voice port.

In one hunt group, if one voice port is busy, the SIP access gateway will find another available voice port. In the following router B configuration, each dial peer is configured with the same destination pattern, 3000, which forms a dial pool corresponding to the pattern 3000.

Router A (Without Hunt Groups)	Router B (With Hunt Groups and Preferences)
	dial-peer voice 1 pots destination-pattern 3000 port 1/1 preference 0 !
dial-peer voice 1 pots destination-pattern 3001 port 1/1 !	dial-peer voice 2 pots destination-pattern 3000 port 1/2 preference 1 !
dial-peer voice 2 pots destination-pattern 3002 port 1/2 !	dial-peer voice 3 pots destination-pattern 3000 port 1/3 preference 2 !
dial-peer voice 3 pots destination-pattern 3003 port 1/3 !	dial-peer voice 4 pots destination-pattern 3000 port 1/4 preference 3
dial-peer voice 4 pots destination-pattern 3004 port 1/4	

You can set preferences for multiple dial peers in one hunt group by running the **preference** command. The router will try placing calls in the dial peer with the highest preference. As shown in the preceding router B configuration, all dial peers have the same destination pattern but have different preferences.

The smaller the preference value is, the higher the preference is. The number 0 stands for the highest preference. If multiple dial peers in one hunt group have the same preference, a dial peer will be selected randomly during a call.

For a dial peer selection rule in one hunt group, the default sequence is shown below:

3) The longest phone number is matched: If one dial peer’s phone number is 345… and another dial peer's phone number is 3456789, the router will select the dial peer 3456789 first, because it has long accurate matching.
4) Specify preferences: Specify preferences for dial peers by using the **preference** command.
5) Random selection: Weights of all destination patterns are equal.

You can combine POTS and VoIP dial peers to create hunt groups, which is quite useful. When a user wants to send a call to a packet network, if the packet network fails to be connected, the call can be rerouted to the PSTN via a PBX. The configuration below shows if the IP network fails to be connected, the router sends the call to the PSTN.

```
dial-peer voice 101 voip
destination-pattern 472....
session target ipv4:192.168.100.1
preference 0
!
dial-peer voice 102 pots
destination-pattern 472....
prefix 472
port 1/0
preference 1
```

You cannot use the same preference for POTS and VoIP dial peers in one hunt group.

You can configure separate preference sequences for each dial peer, but those preference sequences do not work at the same time. For example, you can configure the preference sequence 0, 1, 2 for POTS dial peers, and then configure the preference sequence 0, 1, 2 for VoIP dial peers, but those two preference sequences are separated. The system will resolve the preference sequence of POTS dial peers first.

Therefore, in config-dial-peer mode, run the **preference** command to configure preferences for dial peers in a hunt group.

Command	Function
Ruijie(config-dial-peer)**#preference value**	Specifies a preference for a dial peer. *value*: specifies a reference value, in the range of 0 to 10; the smaller the value is, the higher the preference is.

Enabling Hunt Groups on the SIP Access Gateway

Hunt groups are disabled on the SIP access gateway by default. To enable hunt groups, run the following command in config-dial-peer mode.

Command	Function
Ruijie(config-dial-peer)# **voice hunt** {**user-busy**| **no-answer** | **all**}	Enables hunt groups in different situations. **all**: enables hunt groups if all connections fail. **no-answer**: enables hunt groups if there is no response from the peer. **user-busy**: enables hunt groups when the peer is busy.

Maintaining the SIP Access Gateway

Debugging Information on SIP Calls

If there is any problem during a SIP call, run the following command for debugging:

Command	Function
Ruijie**#debug voip {sip}**	Displays signaling debugging information during SIP registration and call.

Displaying Information on SIP Calls

Command	Function
Ruijie**#show calls**	Displays call status and information on the SIP access gateway.

Run the **show calls** command to display call status and information on the gateway:

```
Ruijie#show calls
Call 1
State of the call : STATE_ACTIVE (6)
Protocol: SIP
Calling Number : 1000
Called Number : 2000
Source IP Address (Sig ): 1.1.1.5
Destn SIP Req Addr:Port : 1.1.1.7:5060
Destn SIP Resp Addr:Port: 1.1.1.7:5060
Destination Name : 1.1.1.7.18

Call 2
State of the call: STATE_ACTIVE (6)
Protocol: SIP
Calling Number: 1001
Called Number: 2001
Source IP Address (Sig ): 1.1.1.5
Destn SIP Req Addr:Port : 1.1.1.7:5060
Destn SIP Resp Addr:Port: 1.1.1.7:5060
Destination Name: 1.1.1.7

Number of gateway calls: 2
```

Displaying Information on the SIP Access Gateway Registration Status

To check call status and information on the SIP access gateway, run the following command.

Command	Function
Ruijie(config-sip-ua)**#show sip-ua register status**	Displays the registration status on the SIP access gateway.

Run the **show ip-ua register status** command to display the gateway registration status:

```
Ruijie(config-sip-ua)# show sip-ua register status
phone number    register id         expires(sec)       registered
1000               1000        180            yes
1001               1001        180            yes
```

```
2000                2000        180             no
2001                2001        180             yes
```

Typical Configuration Examples

End-to-End Call of the SIP Access Gateway

During the end-to-end call process of the SIP access gateway, the SIP access gateway sends SIP signaling to the destination gateway to set up a call. For the networking, see Figure 2, which shows the simplest networking scheme. Assume that the caller is UA1 SIP access gateway, with the IP address of 1.1.1.1, and phone number of 1000, and that the callee is UA2 SIP access gateway, with the IP address of 1.1.1.2, and phone number of 2000. The configuration is shown below:

Configuration of SIP access gateway UA1, a caller:

```
!
interface FastEthernet 1/0
ip address 1.1.1.1 255.255.255.0
duplex auto
speed auto
!
dial-peer voice 10 pots
destination-pattern 1000
port 2/0
!
dial-peer voice 20 voip
codec g711ulaw
destination-pattern 2000
session target ipv4: 1.1.1.2
session protocol SIP
```

Configuration of SIP access gateway UA2, a callee:

```
!
interface FastEthernet 1/0
ip address 1.1.1.2 255.255.255.0
duplex auto
speed auto
!
dial-peer voice 20 pots
destination-pattern 2000
port 2/0
!
dial-peer voice 10 voip
codec g711ulaw
destination-pattern 1000
session target ipv4: 1.1.1.1
```

```
session protocol SIP
```

Call Setup of the SIP Access Gateway via a Server

The SIP access gateway can register with a server, and then the server will participate in the call setup process between SIP access gateways. For the networking, see Figure 3, which shows a common networking scheme, because the server can provide security and value-added services for the gateway. Assume that the server IP address is 1.1.1.10 and that the server is configured with numbers 1000 and 2000. Number 1000's password is 1000, and number 2000's password is 2000, for SIP access gateway registration. The caller is SIP access gateway UA1, with the IP address of 1.1.1.1, phone number of 1000, and registered ID and password of 1000. The callee is SIP access gateway UA2, with the IP address of 1.1.1.2, phone number of 2000, and registered ID and password of 2000. The configuration is shown below:

Configuration of SIP access gateway UA1, a caller:

```
!
sip-ua
mode phone
sip-id 1000 password 1000
register-enable
sip-server ipv4:1.1.1.10 port 5060

!
interface FastEthernet 1/0
ip address 1.1.1.1 255.255.255.0
duplex auto
speed auto
!
dial-peer voice 10 pots
destination-pattern 1000
port 2/0
!
dial-peer voice 20 voip
codec g711ulaw
destination-pattern 2000
session target sip-server
session protocol SIP
```

Configuration of SIP access gateway UA2, a callee:

```
!
sip-ua
mode phone
sip-id 2000 password 2000
register-enable
sip-server ipv4:1.1.1.10 port 5060

!
interface FastEthernet 1/0
```

```
ip address 1.1.1.2 255.255.255.0
duplex auto
speed auto
!
dial-peer voice 20 pots
destination-pattern 2000
port 2/0
!
dial-peer voice 10 voip
codec g711ulaw
destination-pattern 1000
session target sip-server
session protocol SIP
```