How Wi-Fi 6 and 5G Change Our Campus Network Design

Ruijie Networks Wi-Fi 6 Technology White Paper

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Introduction

What changes will be brought by Wi-Fi 6 and 5G to the wireless campus network construction? How to construct the wireless campus networks in the 5G era?

This document describes how Ruijie implements connection convergence and joint deployment for campus networks through mobile communications and Wi-Fi networks in the 3G, 4G, and the upcoming 5G eras. This document includes two parts: 1. comparing Wi-Fi 6 and 5G from technical perspectives, and analyzing the demand design behind the technologies; 2. analyzing the typical scenario models for campus networks to provide network construction suggestions.

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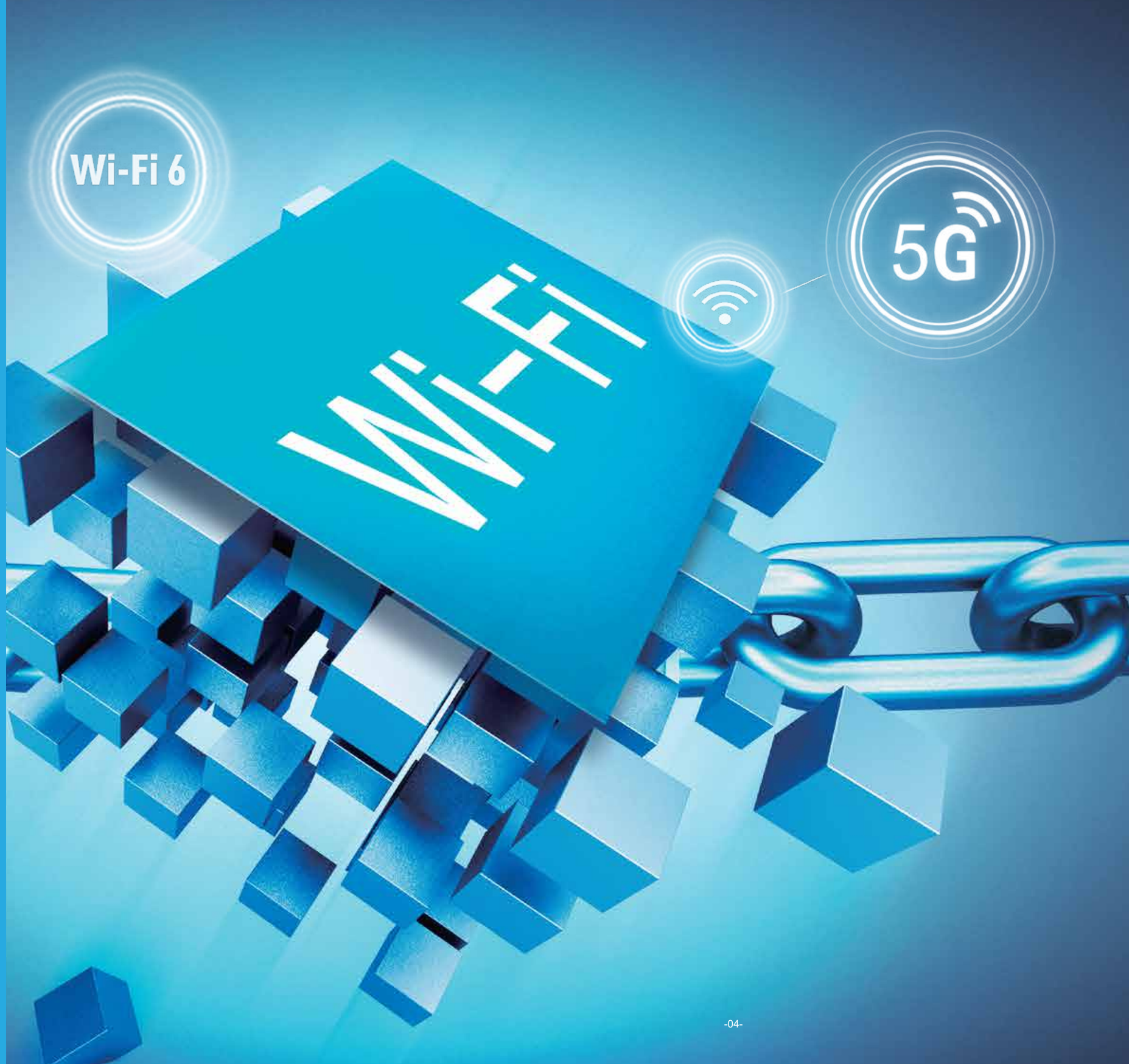
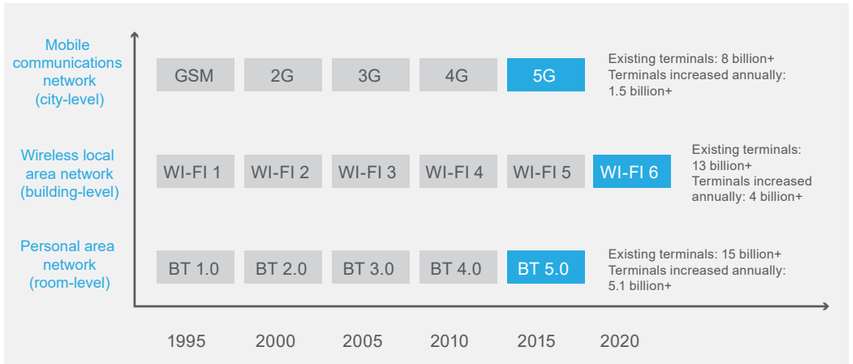
Technical Comparison



Big Three of Wireless Protocols

Three Most Successful Wireless Communications Modes

120 years has passed since Marconi invented radio, and plenty of radio communication technologies have been developed. Among dozens of radio communication technologies emerged in these years, the most successful three technologies are known as the big three: mobile communications network (city-level), wireless local area network (building-level), and wireless personal area network (room-level).



Big Three of Wireless Protocols

Mobile Communication

Mobile communication develops from the GSM in 1990s to the later 3G, 4G, and 5G. During this process, operators deployed wireless networks shared by users in cities. By the end of 2018, there had been more than 8 billion mobile communications network users, and there will be an increase of 1.5 billions terminals annually. Such an increase will be greater in the 5G era.

Wi-Fi Communication

The most successful technology for wireless local area networks is Wi-Fi. The first generation of Wi-Fi (Wi-Fi 1, 802.11b) was born in 1997. Wi-Fi protocols were referred to as 802.11b, 802.11a, 802.11g, 802.11n, and 802.11ac. In 2018, the Wi-Fi alliance renamed the protocols as Wi-Fi 1 to Wi-Fi 6. Wi-Fi 6 was commercially used in products in 2018 officially. By the end of 2018, there had been more than 13 billion Wi-Fi terminals, including mobile phones, tablets, PCs, and other intelligent devices. More than 4 billion new Wi-Fi terminals emerge each year, equaling 2/3 of the global population.

Bluetooth Communication

Bluetooth is the most successful technology applied to wireless personal area networks. The first generation of Bluetooth emerged in 1990s, which now has been developed to Bluetooth 5.0. By the end of 2018, the quantity of Bluetooth terminals had exceeded 15 billions, and there are more than 5 billion new Bluetooth terminals annually. These Bluetooth terminals mainly include Bluetooth earphones, Bluetooth speakers, mouses, and keyboards.

Future Widespread Big Three

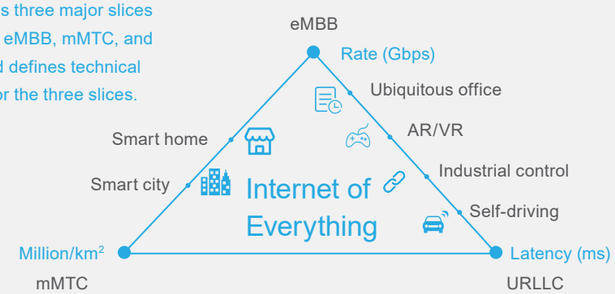
Numerous terminals employ the preceding three technologies. Basically, almost everyone in the world uses one of these terminals. Such popularity extends service life of the technologies, and terminals will be widely applied to people's life and production in the future for a long time. At present, these technologies have been developed to the fifth or sixth generation, proving that they are very successful and mature. These technologies will definitely coexist in the future.

5G Technologies

5G Features

5G provides various features, among which key features include Enhanced Mobile Broadband (eMBB), massive machine-type communications (mMTC), and ultra-reliable and low latency communications (URLLC). As an extension of 4G, 5G is neither pioneered nor ground-breaking, and its key technologies are basically improvements to 4G. For example, 4G provides a 20 MHz bandwidth with a 4x4 or 8x8 multiple-input multiple-output (MIMO) antenna solution, while 5G provides a 100 MHz bandwidth with a 64x64 MIMO antenna solution. Moreover, 5G supports a high-order modulation and demodulation technology.

5G promotes three major slices (scenarios): eMBB, mMTC, and URLLC, and defines technical indicators for the three slices.



5G Technical Features

	4G (Today, Before Further Development)	5G
Delay	10 ms	Less than 1 ms
Peak Data Rate	1 Gbps	20 Gbps
Number of Mobile Connections	8 billion (2016)	11 billion (2021)
Channel Bandwidth	20 MHz 200 MHz (applicable to Cat-NB1 IoT)	100 MHz (5 GHz below) 400 MHz (5 GHz above)
Band	600 MHz to 5.925 GHz	600 MHz millimeter waves (for example, 28 GHz, 39 GHz, or even 80 GHz)

Uplink Waveform	Single Carrier Frequency Division Multiple Access (SC-FDM)	Cyclic Prefix Orthogonal Frequency Division Multiplexing (CP-OFDM) Option
	+23 decibel-milliwatts (dBm) except 2.5 GHz time-division duplex (TDD) band 41 where +26 dBm HPUE is allowed. IoT has a lower power-class option at +20 dBm.	+26 dBm for less than 6 GHz 5G bands at and above 2.5 GHz

Comparison Between 5G and 4G Technologies

5G Vision

What makes 5G truly revolutionary lies not in its higher bandwidth or faster network access, but the following two technologies:

- mMTC: allows millions of IoT terminals to connect to networks, such as the global network, state network, and urban network. For example, mMTC can be applied to metering of water, electricity, and gas, as well as shared bicycles, smart manhole covers, and intelligent streetlights.
- URLCC: mainly used for production and self-driving applications. For example, the self-driving vehicle technology needs to be carried on URLCC networks, so as to meet various rapidly changing road statuses and emergencies and enable real-time responses. For example, automated devices for real-time control in the manufacturing workshops and those for harbor control, tower cranes, robots, and the like all need to be carried on URLCC networks.

5G State Strategy

5G is a state strategy and needs to be promoted. 5G not only provides faster network access, but also allows networks with massive connections and ultra-low latencies, which boost significant promotion and revolution to automation in the entire society.

5G Industry Chain Status and Prediction

From the Perspective of Standard

In 2019, the eMBB standard becomes mature, and is launched for pre-commercial trial. Operators successively test the eMBB performance in some cities to prepare for official commercial use. mMTC and URLLC standards will be completed after 2020.

From the Perspective of Terminal

It is expected that, by 2020, 5G networks will be launched for commercial use in a small scale, and mass-produced 5G mobile phones will appear on the market. By 2021, 5G-based Internet access services will be popularized and 5G mobile phones will appear on the market in a large scale. Moreover, 5G is mainly applied to some high-end mobile phones, and 5G mobile phones will possibly account for only 20% approximately. 5G mobile phones will become the mainstream after 2022.

Prediction of standards and product chains	Prediction of network construction of China operators
2019: Pre-commercial trial of eMBB, completion of URLLC and mMTC standards 2020: Small-scale commercial use of eMBB, mass production and launch-to-market of partial 5G smartphones 2021: Large-scale commercial use of eMBB, large-scale launch-to-market of 5G smartphones 2022–: 5G smartphones becoming mainstream	2018: Completion of band allocation 2019: Pre-commercial trial, licenses issued 2020: Small-scale commercial use, focusing on outdoor macro base stations 2021: Large-scale commercial use, focusing on outdoor macro base stations 2022–: All-around coverage, focusing on indoor small cells

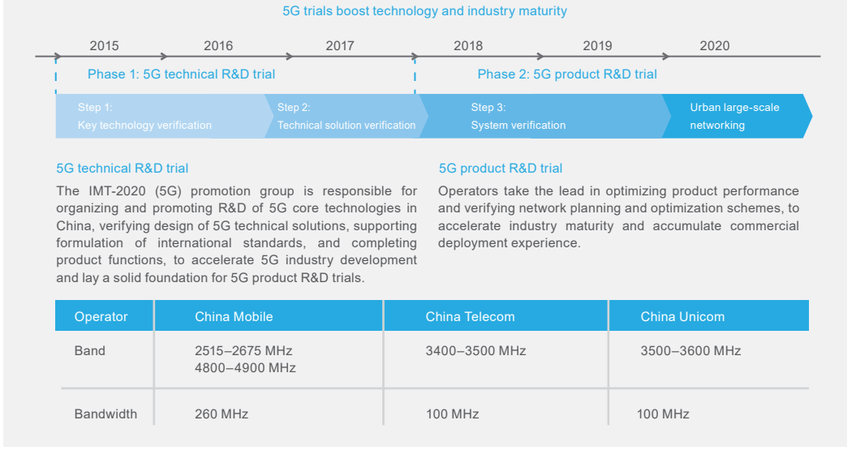
Current Status and Prediction of the 5G Industry Chain

Operators' 5G Deployment Progress

The three major operators in China are currently constructing 5G networks in response to the government's call. The Ministry of Industry and Information Technology allocated 5G frequencies to China Mobile, China Telecom, and China Unicom in 2018. In 2019, the three major operators started the pre-commercial trials and the Ministry of Industry and Information Technology released licenses to start the large-scale commercial deployment.

In 2020 and 2021, 5G focuses on application of outdoor macro base stations, to meet application requirements of an entire city. Operator networks will preferentially meet signal coverage requirements of streets and districts, mainly including public areas such as some airports and train stations. All-around indoor coverage will be implemented after 2022, and an indoor small cell will be used as the 5G indoor coverage solution.

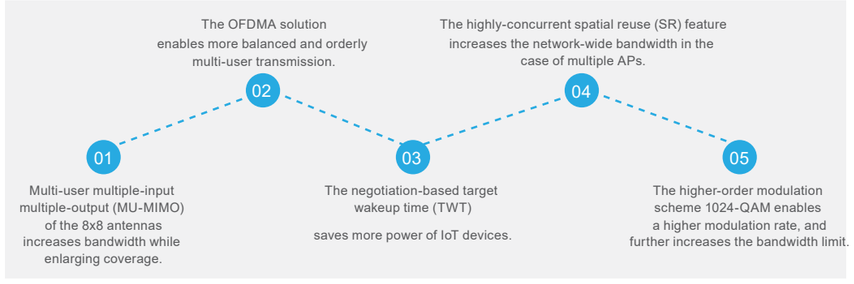
The preceding content describes the 5G industry chain and 5G network development progress. As known, trillions were invested in 4G base stations. As 5G supports higher frequencies and smaller coverage, investment in 5G base stations may be 3 to 5 times that of 4G base stations. Therefore, the operators implement 5G by phase.



Operator	China Mobile	China Telecom	China Unicom
Band	2515–2675 MHz 4800–4900 MHz	3400–3500 MHz	3500–3600 MHz
Bandwidth	260 MHz	100 MHz	100 MHz

Current Status and Prediction of the 5G Industry Chain

Wi-Fi 6 Key Technologies



Wi-Fi 6 Technical Features

Wi-Fi 6—New Generation of Wi-Fi, with Five New Key Technologies

- 1024-QAM (higher-rate modulation): further increases the bandwidth limit. Theoretically, Wi-Fi 4 offers up to 1.7 Gbps access rate, while Wi-Fi 6 offers up to 4.8 Gbps access rate.
- OFDMA: introduced from 4G to Wi-Fi, addressing a multi-user transmission balance issue for more orderly multi-user communication, thereby improving W-Fi experience and efficiency.
- UL/DL MU-MIMO of 8x8 antennas enable the AP to simultaneously communicate with more terminal users, thereby greatly increasing the concurrency bandwidth and system capacity.
- BSS color (spatial reuse technology): resolves the problem about how to reduce interference between APs and maximize channel spatial reuse rate in a high-density scenarios with multiple APs deployed, thereby increasing the network-wide bandwidth.
- TWT: used by various IoT terminals for power saving. Many IoT terminals are powered by batteries and encounter an energy consumption problem. The technical objective of TWT is to make a battery last for one year, two years, or even a longer time, so that various IoT devices can apply Wi-Fi for higher-rate communication.

Wi-Fi 6 Industry Chain Status and Prediction

From the Perspective of Standard

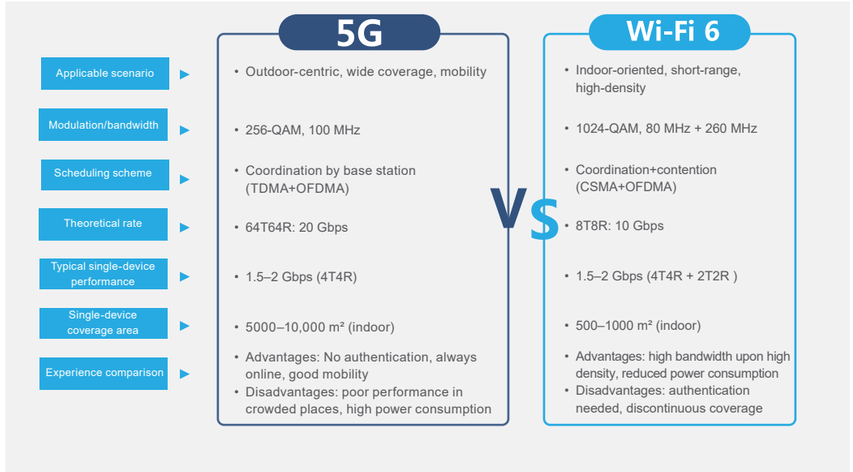
In 2018, Wi-Fi 6 became mature, and its products are first launched for commercial use. Some advanced universities/enterprises selected these leading products for commercial use in a small scale. In 2019, shipments of Wi-Fi 6 APs account for 20% of total AP shipments. Wi-Fi 6 APs become the mainstream choice in medium- and high-end customer scenarios, and large-scale commercial use starts. In 2020, Wi-Fi 6 will totally replace Wi-Fi 5, and become the mainstream of all enerprise network constructions. In addition, shipments of Wi-Fi 6 APs will account for more than 50%, and Wi-Fi 6 will become the standard for infrastructure network construction.

According to the development of Wi-Fi 5 (802.11ac), it took three years for Wi-Fi 5 to totally replace the previous Wi-Fi 4 (802.11n) in the education industry. The development progress of Wi-Fi 6 will be basically the same as that of Wi-Fi 5.

From the Perspective of Terminal

Generally, mobile phones are the first to comply with a new communication standard. In February 2019, Samsung released the world's first Wi-Fi 6 mobile phone, and Xiaomi released Mi 9 equipped with a Wi-Fi 6 chip. In September 2019, Apple announced that the new iPhone will be equipped with Wi-Fi 6. Mainstream chip vendors will all release Wi-Fi 6 mobile phone chipsets and introduce Wi-Fi 6 into their flagship models. Wi-Fi 6 will become the mainstream standard by 2020.

Comparison Between 5G and Wi-Fi 6 Features



Coverage and Performance Comparison

Applicable Scenarios

5G focuses on outdoor scenarios characterized by wide coverage, continuity, and mobility, while Wi-Fi 6 focuses on indoor scenarios characterized by short-range transmission, high-density coverage, and high performance.

Coverage and Performance

Signals and bandwidth

5G adopts the 256-QAM modulation scheme and 100 MHz single-carrier bandwidth, while Wi-Fi 6 adopts the 1024-QAM modulation scheme and up to 160 MHz single-carrier bandwidth. Wi-Fi 6 employs a modulation technology more advanced and a bandwidth higher than those of 5G. 5G focuses on long-range coverage, while Wi-Fi 6 mainly focuses on coverage within 10 m to 20 m, and such short-range transmission requires very high bandwidth.

Scheduling scheme

In 5G solutions, a base station is responsible for scheduling to direct a large quantity of terminals over the core network. Wi-Fi 5 and its precedents support only contention-based scheduling. Wireless APs are usually not enough, and therefore bandwidth becomes insufficient when there are many terminals. Consequently, abundant contention conflicts lead to a sharp decrease of transmission efficiency. This is why signal strength is strong but users cannot communicate in conferences with more than 10,000 participants. Wi-Fi 6 supports scheduling in the coordination + contention manner. Moreover, Wi-Fi 6 introduces OFDMA, which enables wireless APs to coordinate receiving and sending behavior of terminals for more orderly transmission on the entire network, thereby minimizing conflicts.

Throughput performance

Theoretically, the 5G rate can reach 20 Gbps, while the Wi-Fi 6 rate can reach 100 Gbps. This is because 5G supports up to 64 antennas, the 64x64 antennas have a large size and can be installed only outdoors. Typically, a single indoor 5G device supports a throughput from 1.5 Gbps to 2 Gbps, and cannot be equipped with antennas of such a size. Most indoor small cells use 4x4 antennas, and provide a bandwidth from 1.5 Gbps to 2 Gbps. Wi-Fi 6 adopts 4T4R antennas (4 transmit antennas and 4 receive antennas), and supports a throughput from 1.5 Gbps to 2 Gbps typically. Therefore, 5G and Wi-Fi 6 have similar single-device performance.

Coverage area

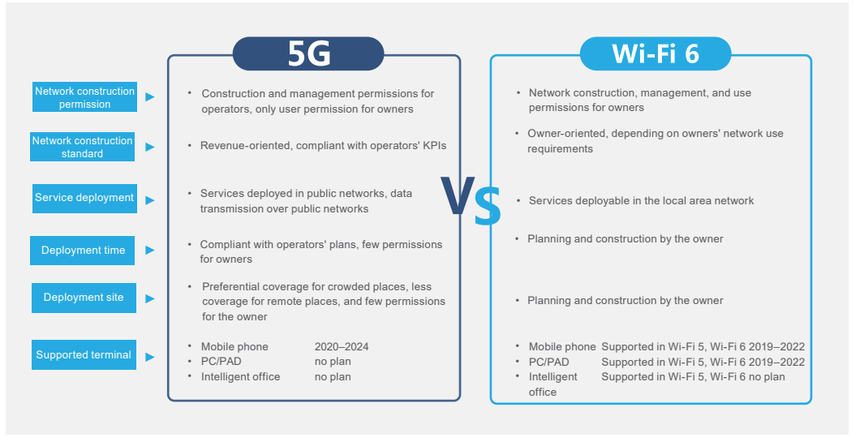
One 5G outdoor base station covers an area of kilometers, and therefore a small cell or an indoor building solution is generally deployed indoors. To reduce coverage costs, one 5G cell covers an area of 5000 m² to 10,000 m², that is, an area of about 1 or 2 floors. One Wi-Fi AP can cover a large conference hall, or several rooms in a large office. Each AP provides separate bandwidth and covers an area of about 500 m² to 1000 m². There is a 10 times difference between an indoor single-cell coverage area supported by 5G and that supported by Wi-Fi. Such deployment results in similar single-cell bandwidth but greatly different average bandwidth for each square meter or each user. Consequently, 5G bandwidth for each square meter or each user may be only 1/10 to 1/5 of Wi-Fi bandwidth. Therefore, 5G focuses on wide coverage but not high bandwidth.

User experience

Compared with 4G, 5G provides larger coverage and better mobility, and enables seamless roaming. 5G is disadvantageous in that when there are dense users, bandwidth allocated to each user is insufficient, because one base station is disposed in each 10,000 m². If more than 1000 users access the network concurrently, user experience significantly deteriorates.

Wi-Fi is complementary to 5G, and is advantageous in high bandwidth in the case of high density and reduced power consumption. When accessing a network via 4G for a slightly long time, a mobile phone's temperature increases and power consumption grows sharply. Conversely, a mobile phone accessing a network via Wi-Fi excels in power saving performance. However, Wi-Fi networks are private, require authentication, and provide discontinuous coverage. For example, when a user moves out of a campus, a Wi-Fi network deployed in the campus becomes unavailable as it is not as continuous as 5G networks.

Construction and Management



Construction and Management Comparison

Network management and control

Operators are responsible for 5G network construction and have the management permissions to the constructed 5G networks, and owners (universities) only have the use permission. Wi-Fi networks are private, and the owners have the construction, management, and use permissions.

Network construction standard

According the network construction standard, networks constructed by operators are preferentially revenue-oriented, and cannot ensure the investment return of owners. Comparatively, Wi-Fi networks set up by owners are service-oriented, and the owners can formulate their own network construction standards based on services.

Deployment mode

If 5G is used, services in a university basically need to be deployed on the public network or the cloud. Even if these services are deployed on an intranet, users need to access the services from public network addresses, and all data needs to be transmitted over the public network. If Wi-Fi is used, all services can be deployed and run on the intranet or LAN.

Deployment time

5G is deployed according to the operator' deployment plan and timeline. Operators first consider outdoor deployment and a campus network may not be covered by the operators' network construction plan. On the contrary, owners can deploy Wi-Fi any time they want.

Deployment site

Operators usually deploy devices in crowded places in consideration of revenue, and possibly deploy no devices in remote important replaces with few users, such as labs or research bases. In contrast, users can deploy Wi-Fi 6 as required.

Supported terminals

4G mobile phone applications have been popularized. It is expected that 5G will not gain its popularity until 2020 to 2024, and PCs and tablets will support operators' networks in much later time. For example, no more than 20% laptops are built in with the 4G features at present, and large mirroring screens and voice devices used for intelligent office do not support 4G or 5G. Instead, Wi-Fi is the standard configuration on these products. Therefore, Wi-Fi 6 will become the mainstream feature for these devices in next 2 or 3 years.

02

Scenario Analysis

Diversified Buildings and Scenarios in the Campus

One campus includes many distinctive buildings, such as dormitories, classrooms, libraries, office buildings, some outdoor stadiums, and scenic outdoor facilities. Users in these places have different service requirements.

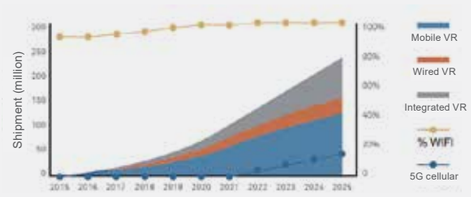
Universities have distinctive buildings and user behaviors,
and typical buildings include dormitories, classrooms, libraries, and office buildings.

Diversified university scenarios

Analysis and Suggestions for Classroom Scenario

Large Space, Dense Users, and Heavy Traffic

Typically, classrooms have large space and accommodate dense users with an average area of 2 m², and some lecture halls may even accommodate more than 100 users. In this scenario, mainly teaching services are used, and access to teaching resources means access to the intranet. According to the following figure, smart classroom and interactive teaching are major teaching trends, and interactive teaching inevitably involves mobile interaction. Moreover, some on-site teaching uses VR devices, for example, for medical and foreign language teaching. These all are applications requiring high bandwidth and are an inevitable trend of development.



VR/AR shipment and connection type prediction in the global market (Source: Wireless X Labs, ABI Research)

Image Quality	Single-eye Resolution	Frame Rate	Bandwidth	Wireless Network	Mobile Network
Basic smartphone VR	320x180	30 FPS	6 Mbps	Wi-Fi	LTE
4K VR	1200x1080	90 FPS	50 Mbps	802.11ax, WiGig	LTE-A Pro
8K VR	1920x1920	90 FPS	120–200 Mbps	802.11ax, WiGig	5G
12K VR (equivalent to high-definition TV)	3840x2160	120 FPS	0.6–1.4 Gbps	802.11ax, WiGig	5G

VR Video, Opportunity for Operators in the Flourishing Market

Wi-Fi-based and 5G-assisted Network Construction

It is recommended that network construction be Wi-Fi-based and 5G-assisted. One wireless AP (Wi-Fi 6 tri-radio AP is recommended) is deployed in one classroom, to provide a throughput of more than 1 Gpbs for use by 100 students. According to tests, when 30 users simutaneously watch VR videos in one room, the bandwidth allocated for watching each VR video exceeds 30 Mbps, which will be the future classroom service model. In contrast, when one 5G base station needs to cover more than ten classrooms on one floor, bandwidth provided by the 5G base station cannot support future smart classroom or interactive teaching. Therefore, it is recommended that 5G be used as a supplementary means to support access of common mobile phones to applications on the Internet, and Wi-Fi be used to support teaching applications.

One AP 850-I for 30 Users to Watch VR Videos Concurrently

Analysis and Suggestions for Library Scenario

Increasing Laptops and IoT Requirements

The library scenario features large space and dense users. Nowadays, students usually go to the library with their laptops, and use the laptops to query materials on the intranet, access teaching resources on the extranet, watch videos, ect. In addition, the library uses more IoT applications, such as book tracking and book borrowing management. Therefore, higher bandwidth requirements are imposed.

Wi-Fi-based and 5G-assisted Network Construction

In this scenario, both RAID and Wi-Fi are used. Therefore, it is recommended that network construction be Wi-Fi-based and 5G-assisted from perspectives of performance and new intelligent terminals. Wi-Fi 6 tri-radio APs are recommended with extended IoT plug-ins, to provide high-density and high-performance access for PCs and access to LANs for IoT devices, so that students can access the Internet and intelligent IoT applications. 5G provides relatively good performance in this scenario, but PCs are less compatible with IoT devices. Therefore, 5G supports Internet services for mainly mobile phones.

Analysis and Suggestions for Scientific Research and Office Building Scenario

High Independence and Security Requirements of Scientific Research and Office Buildings

In the scientific research and office building scenario, there are many rooms and scattered users, and services are mainly related to campus LAN resources, imposing certain confidentiality requirements, for example, requirements of access to confidential research or security resources. Besides, mainly desktop PCs are accessed. Other intelligent office devices such as projectors, printers, and conferencing devices will gradually increase, and office applications such as wireless screen mirroring and wireless conferences will also be supported.

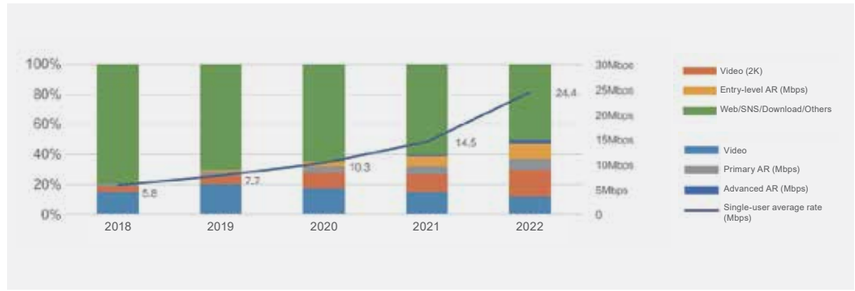
Wi-Fi-based and 5G-assisted Network Construction

It is recommended that Wi-Fi-based and 5G-assisted network construction be adopted. In this scenario, 5G enables basically sufficient bandwidth but cannot make PCs compatible with intelligent office devices. Therefore, confidentiality on public networks is compromised. In addition, office rooms have small sizes and accommodate only a small number of users. It is recommended that dual-stream dual-radio ceiling mounted or faceplate-mounted APs be deployed to ensure confidentiality of content access on LANs and enable network access for office devices.

Analysis and Suggestions for Dormitory Scenario

Dormitory—Special Network Scenario with Heavy and Isolated Traffic

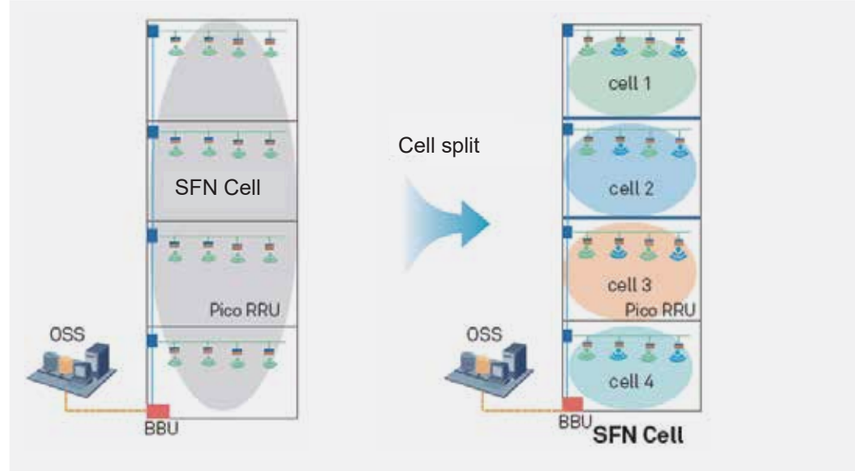
As a most distinctive feature in a campus, dormitories are dense and mutually isolated. Each dormitory serves 4 to 8 students and the students access the network mainly for entertainment. The network for dormitories has obvious network traffic tides and generates heavy traffic from 20:00 to 24:00 daily, imposing high service requirements at peak hours. According to wireless experience data from more than 2500 universities on Wireless Intelligent Service (WIS), network applications accessed by students are mostly mobile phone videos, and each student generates more than 20 GB Wi-Fi traffic monthly. Statistics from the Ministry of Industry and Information Technology in 2018 show that, 4G data of usage (DOU) (monthly average traffic per user) is about 5 GB, and the Wi-Fi DOU is four times that of 4G. The average bandwidth required by each user will reach 25 Mbps by 2022, which implies that each dormitory needs to be provided with more than 100 Mbps access bandwidth.



Limited Performance in 5G-only Deployment, Peak-hour Bandwidth Insufficiency

It is difficult for 5G to provide an access bandwidth of more than 100 Mbps, and meeting such a requirement with 5G-only deployment is challenging. In operators' typical deployment, a small cell is deployed for dormitories by installing one BBU (base station) in the extra-low voltage (ELV) room and one pRRU (radio) in the corridor. In this case, 20 to 30 rooms share one base station and bandwidth of one cell. One cell provides a throughput from 1 Gpbs to 1.5 Gpbs, and each room is assigned with only 30 Mbps bandwidth in the 4 peak hours, which is far from the approximate 100 Mbps requirement.

This conventional deployment obviously no longer can meet Internet access requirements in dormitories in the next 3 to 5 years. Certainly, operators can gradually improve deployment to increase the capacity by splitting cells and deploying one cell for 5 or 6 rooms. However, such improvement means an increase of construction costs by 4 times, and is unacceptable.

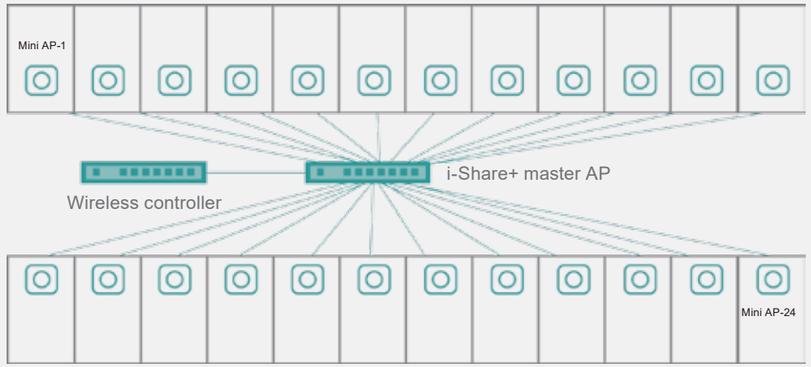


Limited Traffic

Traffic is severely limited in the dormitory scenario. It is estimated that DOU will grow by 5 to 10 times by 2024. However, the 5G user migration speed is insufficient. 5G users are expected to account for 40% and 4G users for 60% of the total quantity of users by 2024. The preceding DOU growth means that the capacity of 4G base stations will be increased by 60% x (5–10), that is, 3 to 6 times of the current capacity. In practice, this part of traffic cannot be carried over 4G or 5G. If no Wi-Fi is deployed, network traffic would still be limited.

5G and Wi-Fi as Mutual Supplements

Therefore, it is recommended that Wi-Fi and 5G both be used to deploy networks in dormitories with equal importance. Wi-Fi 6 faceplate-mounted APs can be deployed indoors, or the i-Share AP indoor solution for easy management can be used to enable low-cost large-bandwidth access to applications with heavy traffic. 5G meets students' requirements for using light-traffic applications, such as instant messaging applications, chatting applications, and Internet access applications. However, Wi-Fi is used to replace 5G during peak hours at night when 5G cannot support these services.



Suggestions for Network Construction in University Dormitories

Analysis and Suggestions for Public Facilities Scenario

Internet Access in Open Areas

Recreation and sports public facilities in universities include outdoor open activity areas and large-scale recreation and sports stadiums. In these scenarios, students and teachers mainly use mobile phones to access instant messaging and entertainment applications over the Internet. Users may need a slight bandwidth increase and the user requirements seem to remain basically the same in the short term.

Wi-Fi-based and 5G-assisted Network Construction

It is recommended that network construction be Wi-Fi-based and 5G-assisted in this scenario. 5G is advantageous in small-bandwidth low-latency instant communication and is born to meet entertainment needs. Moreover, 5G can also provide large continuous coverage without roaming to meet requirements of other applications, thereby enabling excellent user experience. Comparatively, Wi-Fi 6 is also feasible but result in higher construction costs, for example, due to roof-mounted installation of some APs. Certainly, hot spots can alternatively be deployed in key areas, to meet PC or conference requirements.

03

Construction Summary

Strength and Weakness of Wi-Fi and 5G

5G networks can be leased but not purchased. Although 5G traffic fee is required, service continuity is better. However, 5G networks are less personalized or private, and sometimes service traffic is heavy and services are unavailable. Besides, not all data can be carried over 5G networks and not all data can reach destinations, and extra fee may need to be paid based on the return gain or certain data may be rejected on 5G networks.

Users can autonomously set up networks via Wi-Fi 6. Although construction costs are higher, the networks can be used more freely than 5G networks. In addition, Wi-Fi 6 networks are locally available anytime, and can carry almost all types of data and send data to almost all destinations. However, service continuity is insufficient. If users go to other places, the networks are unavailable.

Double Show of Wi-Fi and 5G

In conclusion, the following suggestions are provided for constructing wireless campus networks:

- Consider the device capacity requirement, the service application requirement, and terminal support status to ensure performance and the loading capacity.
- Consider access control on campus network resources from a whole to ensure management and security.
- Consider expansion of services in the next two or three years.

According to the preceding aspects, it is recommended that a network supporting both Wi-Fi and 5G be constructed in a campus, and 5G and Wi-Fi be separately used for different scenarios and priorities, to eventually implement continuous, highly-efficient, and secure wireless coverage.