Design Guide for Campus Wi-Fi Networks in the Wi-Fi 6 Era

HUAWEI

Executive Summary

Traditional campus Wi-Fi networks are built based on Key Performance Indicators (KPIs) to meet coverage and access capacity requirements. However, this traditional approach is ineffective as bandwidth-hungry and latency-sensitive services proliferate, such as Virtual Reality (VR), Augmented Reality (AR), and 4K services. Instead, the user-oriented Key Quality Indicators (KQIs) make a difference, as they can better reflect real user experience and facilitate more accurate network quality evaluation and management.

To keep up, this document defines the service models, Wi-Fi 6 network construction criteria (including KQI levels), network planning, and AP selection in different scenarios and more importantly, based on actual verification results. This document is the first in the industry to guide through campus Wi-Fi 6 network construction tailored to all scenarios based on KQIs and KPIs.

Contents

1 Development History of Campus Wi-Fi Networks

The campus network is the most basic carrier to provide teaching, research, life, and social networking services for teachers and students. On the one hand, the campus network needs to provide teaching-related network services, such as research information sharing, multimedia teaching, electronic reading, and teaching material storage. On the other hand, the campus network must offer office work, campus forum, campus life, social networking, and other services to administration and teaching staff.

The wireless network was initially deployed on a campus network as the auxiliary of the wired network. With the advent of the mobile Internet era, the wireless network brings great convenience to people's work, learning, and life. It also provides them with Internet access anytime, and anywhere. These have become basic requirements for people in the modern era. At present, wireless network access has become an important part of the campus network. Consequently, wireless reconstruction of the campus network is in demand.

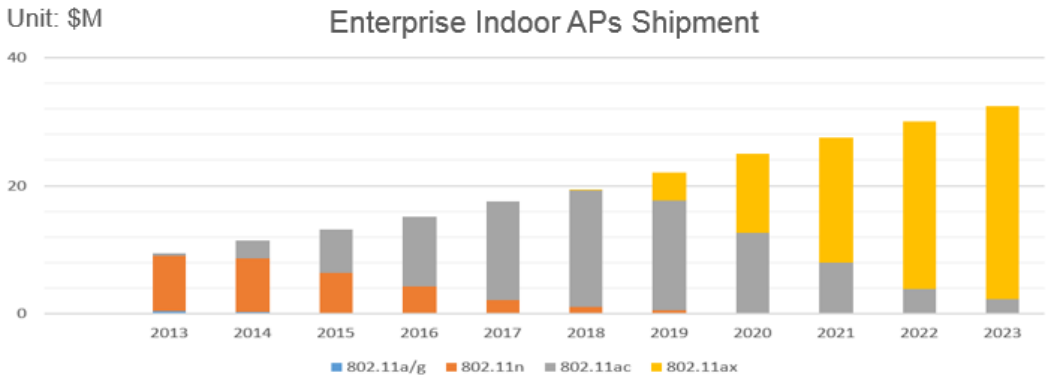
With the development of digital transformation, smart network terminals and innovative applications are changing the education industry. As the number of smart mobile terminals rapidly increases, the proportion of terminals — such as tablets, PCs, and smartphones — increases. Students and teachers expect to get better wireless network services and more rich multimedia experiences, including online learning, social entertainment, office, research, and teaching. In addition, they hope to obtain consistent network experiences anytime, and anywhere, including public areas, classrooms, libraries, auditoriums, conference rooms, and dormitories.

Generally, the number of teachers and students on a campus network ranges from thousands to tens of thousands. Teachers and students use different terminals — such as smart phones, tablets, and laptops — to log on to the campus website, campus public platforms, and Internet. They use different terminals to browse network content and perform online learning through the Virtual Desktop Infrastructure (VDI).

Different fields of study have varying requirements for network bandwidth. For example, medical schools and life sciences schools need to upload and download HD videos and pictures. They expect the wireless network to provide stable and smooth network experience. The access of wireless terminals has regularities. For example, a small number of wireless terminals access the network during class time. After classes, a large number of wireless terminals access the network, and many users watch online videos concurrently. In this case, the wireless network must be able to support high concurrency and provide high bandwidth.

Additionally, various mobile users are able to access areas throughout a campus, including classrooms, lecture halls, office buildings, outdoors, and in dormitories. Different areas have different building structures and different user-access characteristics. For example, lecture halls feature high ceilings and packed user density. In student dormitories, there are many wall partitions and four to eight persons live in each dormitory room. The volume of online video traffic is large and the concurrent rate is high. Generally, Wi-Fi is prone to signal attenuation and the bandwidth cannot meet requirements. Customized Wi-Fi products are required to meet Wi-Fi network coverage requirements in different scenarios, including classrooms, conference rooms, student dormitories, and stadiums.

In addition, research and innovative teaching applications impose higher requirements on Wi-Fi concurrency, bandwidth, and latency. At present, mainly 802.11ac Wave 2 wireless access devices are delivered. According to Dell'Oro Group, with the official release of the innovative Wi-Fi 6 standard, the shipment of enterprise-class indoor Access Points (APs) that support 802.11ax (Wi-Fi 6) will exceed 4 million in 2019. The market share of 802.11ax products will increase rapidly after 2020, according to Dell'Oro Group. With its increasing popularity, Wi-Fi 6 will become the mainstream in the market. Wi-Fi 6 will be the first choice for campus wireless coverage in the next few years.



2 Challenges Faced by Campus Wi-Fi Networks

With the widespread development of campus network informatization, more teachers and students have smart terminals, including laptops, tablets, and smart phones. Teachers and students need to access internal teaching resources and the Internet in scenarios such as classrooms, labs, libraries, academic lecture halls, conference rooms, and outdoor areas. In many scenarios, it is difficult to access the wired network. Therefore, building a campus Wi-Fi network can extend the network coverage scope to the greatest extent, enabling the network to cover every corner of the campus.

After nearly 20 years of development, enterprise-grade Wi-Fi has achieved great success. The biggest contribution of Wi-Fi is to liberate people from traditional wired networks and to provide convenient network services for individual users and social organizations.

Globally, Wi-Fi is carrying more than half of the total data traffic. Additionally, higher requirements are imposed on the network performance, as the number of mobile terminals rapidly increases and new services emerge. For example, immersive teaching needs to leverage HD VR glasses to demonstrate teaching content for students. Immersive teaching requires that the Wi-Fi network latency be less than 10 milliseconds, Wi-Fi bandwidth be greater than 100 Mbps, and the supported number of concurrent users be greater than 50. However, the current 802.11ac network cannot meet such requirements. Therefore, the campus Wi-Fi network faces great challenges from the demands of new services.

2.1 How to Measure the Quality of a Wi-Fi Network

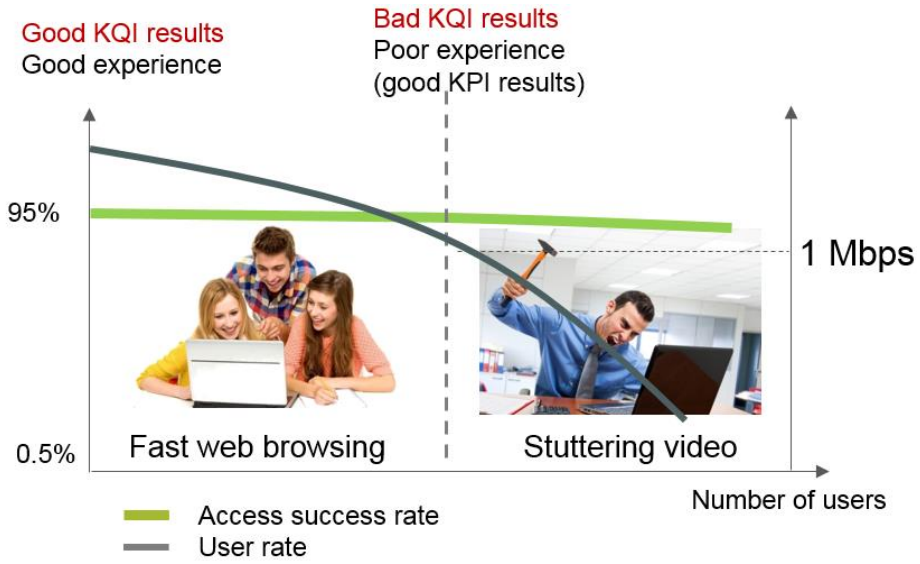
Huawei believes user experience is the most important criteria for determining Wi-Fi network quality.

Generally, network O&M personnel extract network Key Performance Indicators (KPIs) based on network devices. They then determine the network quality and health status of the entire network based on the KPIs. As shown in the following figure, the access success rate is an important KPI for measuring Wi-Fi network quality. As the number of network access users increases, the access success rate decreases. When the access success rate falls below 95%, the network experience is considered poor.

Figure 2-1 Relationship between KPIs and network quality

It is true that the KPI information obtained from network devices or the network management system server may indicate user experience to a certain degree. However, the KPI information cannot accurately reflect network quality and user experience. As shown in the following figure, when the number of users accessing the Wi-Fi network increases — but has not exceeded the specified threshold — and the access success rate remains above 95%, it is regarded as a good user experience based on KPI information, specifically, access success rate. However, the actual network access rate of users falls below 1 Mbps, which indicates a negative user experience. Therefore, only Key Quality Indicators (KQIs) oriented to users can reflect the actual user experience.

Figure 2-2 Relationship between KQIs and network quality



2.2 Problems Faced by Campus Wi-Fi Networks

The construction of wireless campus networks becomes essential, as more wireless terminals access the campus network, and as teachers and students require network access anytime, anywhere.

The physical areas of the campus are scattered and diversified, including classrooms, offices, conference rooms, lecture halls, libraries, labs, canteens, outdoor areas, and other areas for learning, office work, and living. Traditional solutions cannot implement wireless-access coverage anywhere throughout the campus and network.

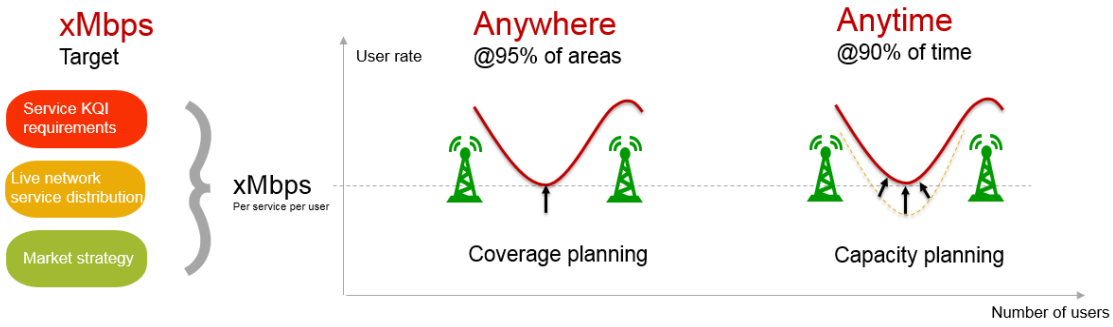
Additionally, some older campus Wi-Fi networks use 802.11n-compliant wireless APs. Network applications require increasingly high bandwidth and the number of wireless terminals increases significantly. In some areas — such as conference rooms, lecture halls, and other high-density access scenarios — user access is difficult, or the network speed is low after it is accessed. The planned capacity cannot meet the requirements for good access experience anytime of teachers and students.

Traditional solutions build campus Wi-Fi networks based on KPIs. From the preceding analysis, we can see the disadvantage of KPI-based network construction. In short, good KPI results do not necessarily indicate good user experiences.

2.3 Both KPIs and KQIs Are Required for Campus Wi-Fi Network Construction

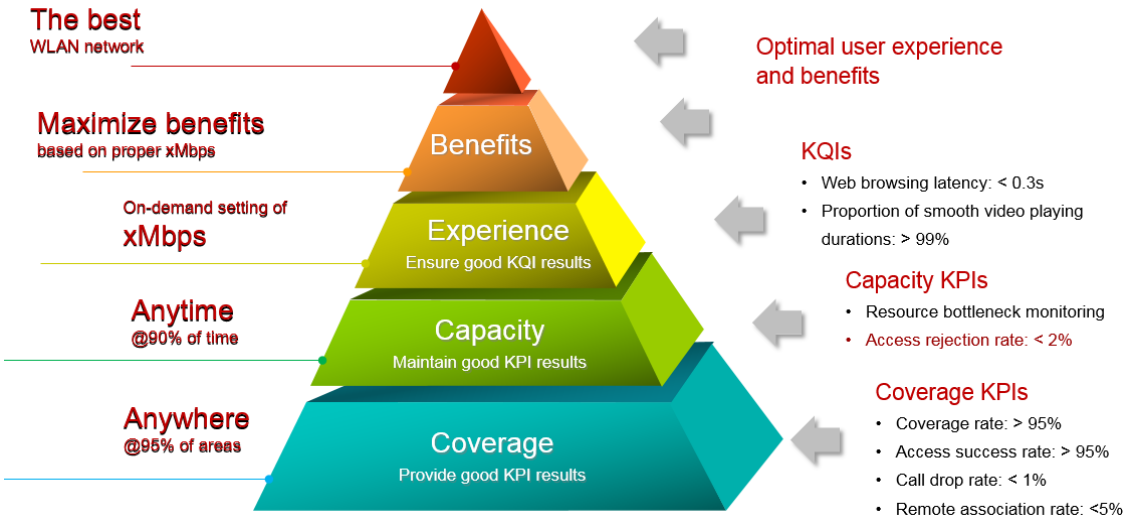
To solve the preceding problems, we need to build a high-quality campus Wi-Fi network. The ultimate goal is to enable teachers and students who access the Wi-Fi network to obtain good experience. To achieve the goal, the network built must allow teachers and students to access the Wi-Fi network anytime, anywhere and are allocated satisfied bandwidth. Different campus areas, access users, and service types have different bandwidth requirements. A Wi-Fi network oriented to good service experience needs to be built based on providing different bandwidth requirements.

Figure 2-3 Standards for building a high-quality network



According to the preceding analysis, both network-oriented KPIs and user-oriented KQIs are required for building a high-quality Wi-Fi network. As shown in the following figure, the KPI-based network construction can meet the coverage scope and access capacity requirements. With KQIs, the completed network can achieve good user experience. We expect to build a network with perfect access experience anytime, and anywhere. To achieve this objective, high costs are required because the Wi-Fi network itself is susceptible to impact, and it is open. Therefore, in actual network construction, the relationship between investment and benefits will be considered. It is recommended that the campus Wi-Fi network be able to provide good bandwidth experience within 95% of areas and 90% of time.

Figure 2-4 Standards for building a high-quality Wi-Fi network



According to iLab analysis, xMbps rate baselines when users' WLAN network access experience is good or excellent are provided.

Service Type	Single-Service Rate Baseline (kbps)	
	Excellent	Good
Web	2500	1200
Streaming (480p)	4000	3200
Streaming (720p)	8000	6400
Streaming (1080p)	16000	12000
Streaming (4K)	50000	22500
VoIP (voice)	128	64
VoIP (video)	300	256
Email	16000	8000
File transfer	16000	8000
SNS	2500	1200
IM	256	128
Gaming	2000	1000
Other	300	128

3 Construction Standards for High-Quality Campus Wi-Fi Networks

Wireless network requirements vary according to campus scenarios and service demands. You need to determine wireless network construction standards in different scenarios based on these differences, and then select different Wireless Local Area Network (WLAN) devices for deployment to achieve the best use effect and construction costs. Wireless coverage on campus can fall into the following scenarios: classrooms, offices, conference rooms/auditoriums, libraries, labs, canteens, playgrounds, and dormitories. The following sections describe the service differences, wireless network construction standards, and recommended solutions in various scenarios.

3.1 Classroom Scenarios

Classrooms are among the most important teaching areas on campus. They feature large user density and high-quality network requirements. In the peak hours of class and self-learning, the wireless network access user density in the classroom is about two users per square meter. The Wi-Fi network carries important teaching services such as Internet access, teaching video, and instant academic exchange. Building a high-quality wireless network is an effective way to improve teaching efficiency.

3.1.1 Service Model

In the classroom scenario, the wireless network carries the following types of services: Web, video, voice, email, and Instant Messaging (IM). The KQIs of web and video services are high in such a scenario.

Item	Web	Video (720p)	Video (1080p)	Voice	Email	Desktop Sharing	IM	Gaming
Proportion of users of each service	45%	10%	10%	5%	5%	5%	10%	10%
KQI	Excellent	Excellent	Excellent	Good	Good	Good	Good	Good
Bandwidth required by each service (kbps)	2,500	8,000	16,000	128	16,000	2,500	256	2,000

3.1.2 Network Construction Standards

Based on the service model and KQI in the classroom scenario, you are advised to plan and design the wireless network according to the following standards:

Bandwidth design

16 Mbps @ everywhere. That is, in 95% of the wireless coverage area, the user access bandwidth reaches up to 16 Mbps.

Capacity design

Wi-Fi 5: The Wi-Fi 5 compliant STA supports dual spatial streams, and the AP works in HT40 mode. When the concurrency rate is 50%, the number of STAs supported by an AP is 32.

Wi-Fi 6*: The Wi-Fi 6 compliant STA supports dual or more spatial streams, and the AP works in HE40 mode. When the concurrency rate is 50%, the number of STAs supported by an AP is 48.

Coverage design

RSSI @ 95% area: $\geqslant$ –67 dBm

3.1.3 Network Planning

There are two types of teaching venues: ordinary classrooms and lecture halls. Generally, the area of an ordinary classroom is less than 100 square meters. It is recommended that one AP be mounted on the beam or ceiling. For a lecture hall, the area is large and has a large number of users. In such cases, multiple APs are required. It is recommended that APs be deployed in W-shaped mode, with a spacing of 15 meters (Figure 3-2).

Figure 3-1 AP location planning for ordinary classrooms

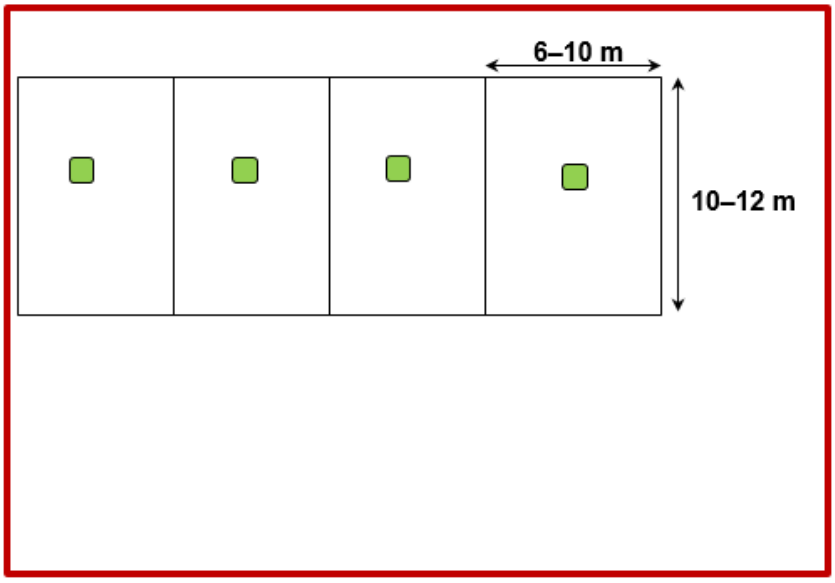
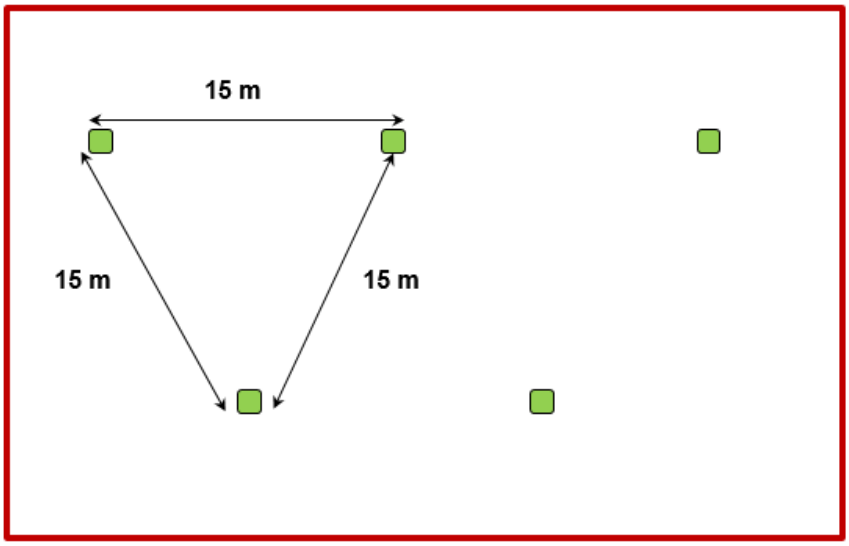


Figure 3-2 AP location planning for lecture halls



3.1.4 AP Selection

When selecting APs, you should consider both service performance and cost-effectiveness, including the following points:

AP Hardware Standards	Indoor settled AP
	802.11ac Wave 2/802.11ax
	4 or more spatial streams
	2-radio or 3-radio (recommended)
	Smart antennas
AP Software Standards	Smart radio calibration
	Dynamic load balancing
	Conflict optimization technology
	Dynamic frequency band adjustment technology
	Application identification and acceleration
	Smart roaming

3.2 VR Classroom Scenarios

Virtual Reality (VR) is now being applied more and more in the classroom. For VR classroom scenarios, users have high requirements on the network quality. The wireless network carries important teaching services, such as teaching video and instant academic exchanges. Building a high-quality wireless network is an effective way to improve teaching efficiency.

3.2.1 Service Model

The following table lists the VR teaching services carried by the wireless network in the VR classroom scenario.

Item	Web	Video (720p)	Video (1080p)	Voice	Email	Desktop Sharing	IM	VR
Proportion of users of each service	0%	0%	0%	0%	0%	0%	0%	100%
KQI	Excellent	Excellent	Excellent	Good	Good	Good	Good	Excellent
Bandwidth required by each service (kbps)	2,500	8,000	16,000	128	16,000	2,500	256	60,000

3.2.2 Network Construction Standards

Based on the service model and KQI in the VR classroom scenario, you are advised to plan and design the wireless network according to the following standards:

Bandwidth design

60 Mbps @ everywhere. That is, in 95% of the wireless coverage area, the user access bandwidth reaches up to 60 Mbps.

Capacity design

Wi-Fi 5: The Wi-Fi 5 compliant STA supports dual spatial streams, and the AP works in HT80 mode. When the concurrency rate is 100%, the number of STAs supported by an AP is 16.

Wi-Fi 6*: The Wi-Fi 6 compliant STA supports dual or more spatial streams, and the AP works in HE80 mode. When the concurrency rate is 100%, the number of STAs supported by an AP is 39.

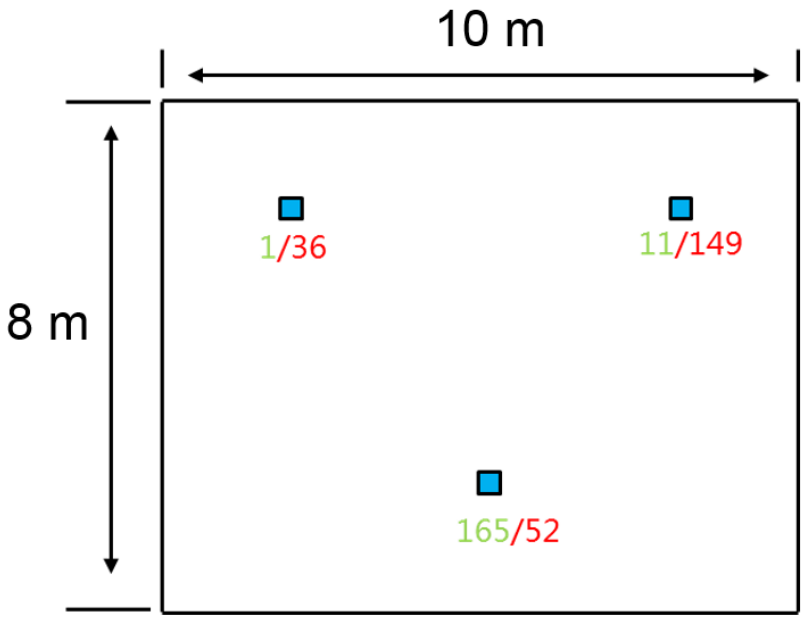
Coverage design

RSSI @ 95% area: ⩾ –55 dBm

3.2.3 Network Planning

Assume that a school classroom is 10 meters long and 8 meters wide. It is recommended that three APs be mounted on the beam or ceiling of the classroom in W-shaped mode at a spacing of 4 to 5 meters, as shown in the figure.

Figure 3-3 AP location planning for VR classrooms



3.2.4 AP Selection

During AP selection, you should consider both service performance and cost-effectiveness, including the points shown below.

AP Hardware Standards	Indoor settled AP
	802.11ac Wave 2/802.11ax
	4 or more spatial streams
	2-radio or 3-radio (recommended)
	Smart antennas
AP Software Standards	Smart radio calibration
	Dynamic load balancing

	Conflict optimization technology
	Dynamic frequency band adjustment technology
	Application identification and acceleration
	Smart roaming

3.3 Office Scenarios

Staff offices also have high wireless network usage. Currently, most teachers are equipped with laptops for office work, course preparation, and learning and communication through wireless networks. A high-quality wireless network helps improve office efficiency.

3.3.1 Service Model

The following table lists the categories of services carried by wireless networks in office scenarios. Office services require high KQIs for web, video, voice, email, desktop sharing, and IM.

Item	Web	Video (720p)	Video (1080p)	Voice	Email	Desktop Sharing	IM	Gaming
Proportion of users of each service	40%	10%	10%	5%	10%	5%	10%	10%
KQI	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Good
Bandwidth required by each service (kbps)	2,500	8,000	16,000	128	16,000	2,500	256	2,000

3.3.2 Network Construction Standards

Based on the service model and KQI in the office scenario, you are advised to plan and design the wireless network according to the following standards:

Bandwidth design

16 Mbps @ everywhere. That is, in 95% of the wireless coverage area, the user access bandwidth reaches up to 16 Mbps.

Capacity design

Wi-Fi 5: The Wi-Fi 5 compliant STA supports dual spatial streams, and the AP works in HT40 mode. When the concurrency rate is 40%, the number of STAs supported by an AP is 40.

Wi-Fi 6*: The Wi-Fi 6 compliant STA supports dual or more spatial streams, and the AP works in HE40 mode. When the concurrency rate is 40%, the number of STAs supported by an AP is 60.

Coverage design

RSSI @ 95% area: ⩾ –67 dBm

3.3.3 Network Planning

The office can be divided into two types: small and large. The area of a small office is about 15 to 40 square meters and the number of people is fewer than 10. For small offices, it is recommended that wall plate APs be deployed on the ceiling, wall, or junction boxes. One AP is installed in each office. Remember to avoid metal obstacles. A large office comprises a sizeable area and accommodates many people. Typically, multiple APs are needed. It is recommended that APs be deployed in W-shaped mode, with a distance of 15 meters, as shown in Figure 3-5. Each AP covers 30 to 40 users.

Figure 3-4 AP location planning for small offices

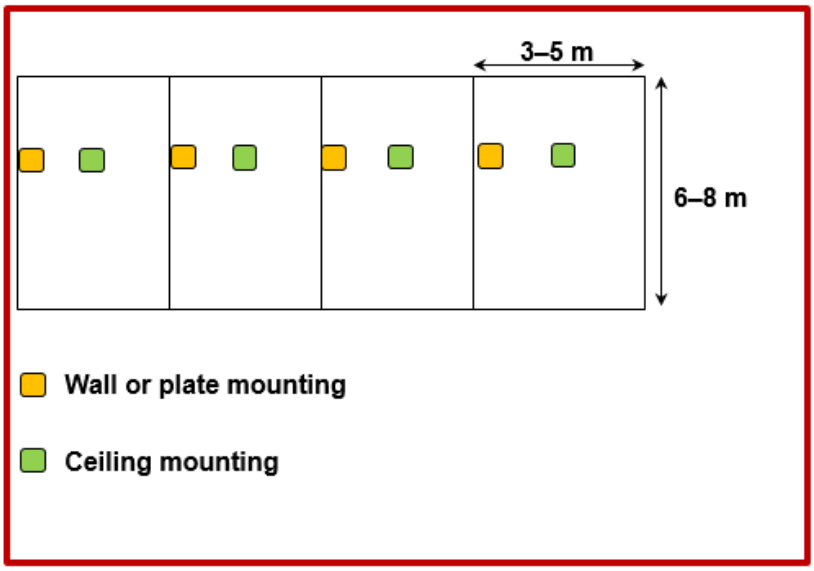
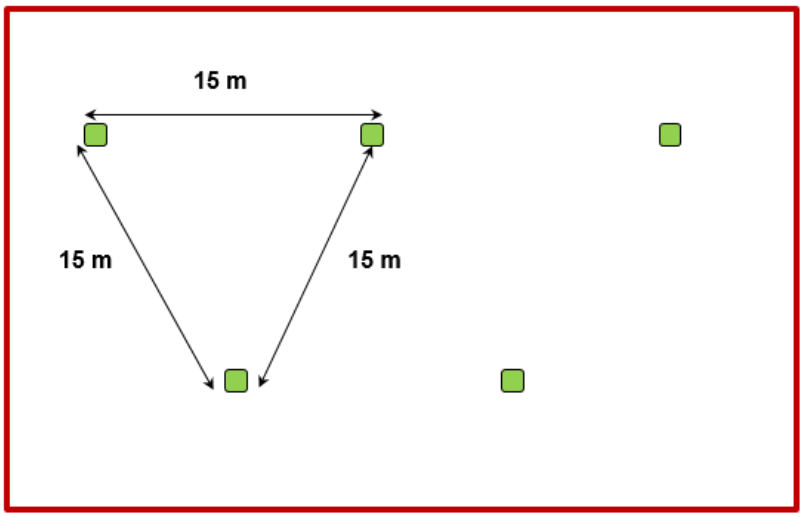


Figure 3-5 AP location planning for large offices



3.3.4 AP Selection

When selecting APs, you should take into account service performance and cost-effectiveness, including the following:

Small offices

AP Hardware Standards	Wall plate AP

	802.11ac Wave 2
	Dual-band; 2 or more spatial streams
	Smart antennas
AP Software Standards	Smart radio calibration
	Dynamic load balancing
	Conflict optimization technology
	Dynamic frequency band adjustment technology
	Application identification and acceleration
	Smart roaming

Large offices

AP Hardware Standards	Indoor settled AP
	802.11ac Wave 2
	Dual-band; 2 or more spatial streams
	Smart antennas
AP Software Standards	Smart radio calibration
	Dynamic load balancing
	Application identification and acceleration
	Smart roaming

3.4 Conference Room/Auditorium Scenarios

Conference rooms and auditoriums are scenarios with traffic bursts. When there are activities such as large conferences and academic reports, the number of users will reach its peak. That is, 2 users per square meter on average, or even higher. In such scenarios, you need to consider factors like AP capacity, channel planning, and

interference suppression so the wireless network can provide good access experience in high-density scenarios.

3.4.1 Service Model

The following table lists the categories of services carried by wireless networks in conference room and auditorium scenarios, where the KQI requirements for web, video, voice, email, desktop sharing, and IM services are high.

Item	Web	Video (720p)	Video (1080p)	Voice	Email	Desktop Sharing	IM	Gaming
Proportion of users of each service	45%	10%	5%	5%	5%	5%	15%	10%
KQI	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Good
Bandwidth required by each service (kbps)	2,500	8,000	16,000	128	16,000	2,500	256	2,000

3.4.2 Network Construction Standards

According to the service model and KQI, it is recommended that the wireless network planning and design for conference room and auditorium scenarios be performed according to the following standards:

Bandwidth design

16 Mbps @ everywhere. That is, in 95% of the wireless coverage area, the user access bandwidth reaches up to 16 Mbps.

Capacity design

Wi-Fi 5: The Wi-Fi 5 compliant STA supports dual spatial streams, and the AP works in HT40 mode. When the concurrency rate is 35%, the number of STAs supported by an AP is 45.

Wi-Fi 6*: The Wi-Fi 6 compliant STA supports dual or more spatial streams, and the AP works in HE40 mode. When the concurrency rate is 35%, the number of STAs supported by an AP is 68.

Coverage design

RSSI @ 95% area: ⩾ –67 dBm

3.4.3 Network Planning

In the conference room scenario, the area is about 30 to 60 square meters and the number of people is fewer than 50. It is recommended that one settled AP be mounted on the ceiling of each conference room. Remember to avoid metal obstacles. In high-density scenarios such as large auditoriums, high-density APs with directional antennas are recommended. The APs are planned in W-shaped mode, with intervals of 10 meters, and each accommodating 30 to 40 persons, as shown in Figure 3-7.

Figure 3-6 AP location planning for conference rooms

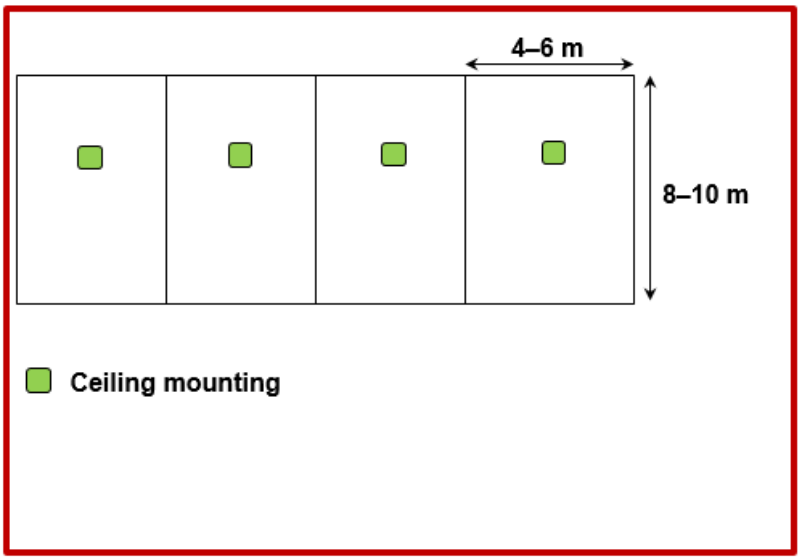
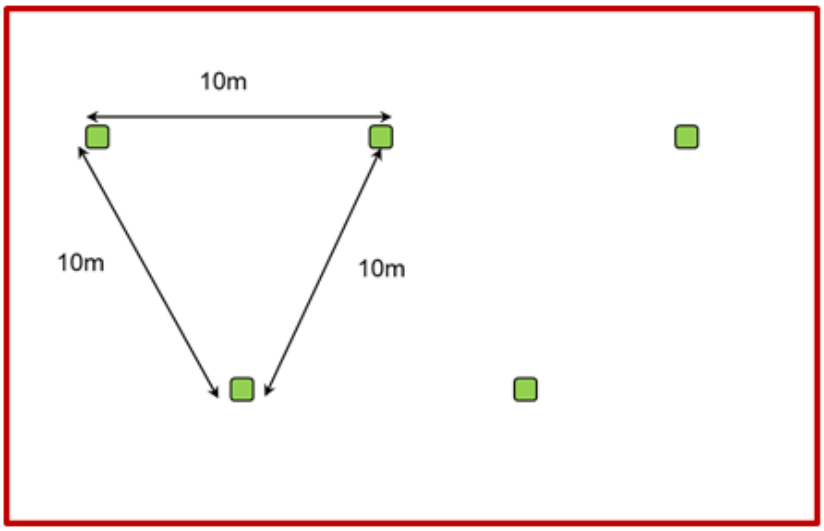


Figure 3-7 AP location planning for large auditoriums



3.4.4 AP Selection

For conference room and auditorium scenarios, you can select high-performance APs or high-density APs to offer good user experience in traffic-burst situations. You are advised to consider the following points when selecting APs:

Conference rooms

AP Hardware Standards	Indoor settled AP
	802.11ac Wave 2/802.11ax
	Dual-band; 4 or more spatial streams
	Smart antennas
AP Software Standards	Smart radio calibration
	Dynamic load balancing
	Conflict optimization technology
	Dynamic frequency band adjustment technology
	Application identification and acceleration
	Smart roaming

Large auditoriums

AP Hardware Standards	Indoor settled AP
	802.11ac Wave 2/802.11ax
	Dual-band; 2 or more spatial streams
	Directional antennas
AP Software Standards	Smart radio calibration
	Dynamic load balancing
	Conflict optimization technology
	Dynamic frequency band adjustment technology
	Application identification and acceleration
	Smart roaming

3.5 Library Scenarios

The library is an important area for students to study independently. With the popularization of the Internet, online learning through mobile terminals in the library is very common. During peak hours (after class or during self-study in the evening), the user density and the concurrent rate of wireless network users in the library are relatively high. Therefore, the wireless network of the library also needs to be planned and designed according to corresponding standards.

3.5.1 Service Model

The following table lists the categories of services carried by wireless networks in library scenarios, where the KQI requirements for web, video, and IM services are high.

Item	Web	Video (720p)	Video (1080p)	Voice	Email	Desktop Sharing	IM	Gaming
Proportion of users of each service	45%	10%	5%	5%	5%	5%	15%	10%
KQI	Excellent	Excellent	Excellent	Good	Good	Good	Excellent	Good
Bandwidth required by each service (kbps)	2,500	8,000	16,000	128	16,000	2,500	256	2,000

3.5.2 Network Construction Standards

Based on the service model and KQI in the library scenario, you are advised to plan and design the wireless network according to the following standards:

Bandwidth design

8 Mbps @ everywhere. That is, in 95% of the wireless coverage area, the user access bandwidth reaches up to 8 Mbps.

Capacity design

Wi-Fi 5: The Wi-Fi 5 compliant STA supports dual spatial streams, and the AP works in HT40 mode. When the concurrency rate is 25%, the number of STAs supported by an AP is 64.

Wi-Fi 6*: The Wi-Fi 6 compliant STA supports four or more spatial streams, and the AP works in HE40 mode. When the concurrency rate is 25%, the number of STAs supported by an AP is 96.

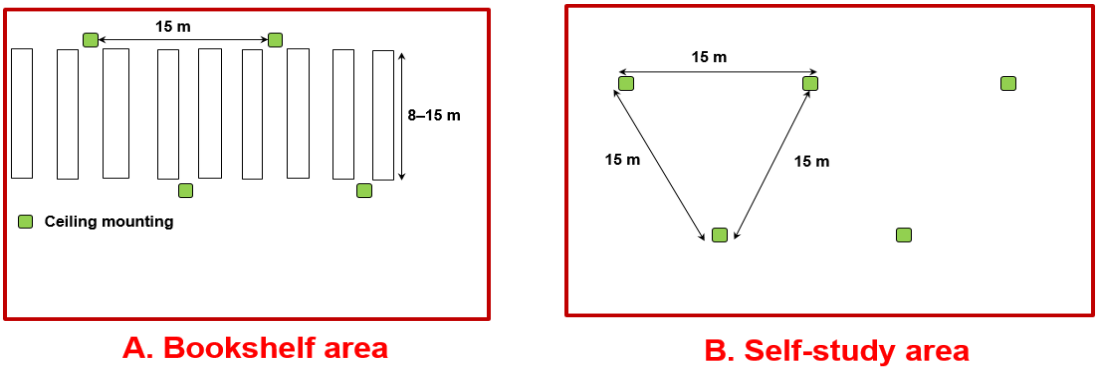
Coverage design

RSSI @ 95% area: $\geqslant$ –67 dBm

3.5.3 Network Planning

If the library area is less than 100 square meters, you are advised to deploy one settled indoor AP on the ceiling. Remember to avoid metal obstacles. If the area measures more than 100 square meters, deploy the AP in W-shaped mode. The AP coverage radius is 8 meters and the AP distance is 15 meters, as shown below.

Figure 3-8 AP location planning for libraries



3.5.4 AP Selection

For the library scenario, you need to take into consideration the experience of a large number of concurrent users. Therefore, high-performance APs are recommended. You are advised to consider the following points when selecting APs:

AP Hardware Standards	Indoor settled AP
	802.11ac Wave 2/802.11ax
	Dual-band; 4 or more spatial streams
	Smart antennas
AP Software Standards	Smart radio calibration
	Dynamic load balancing
	Conflict optimization technology
	Dynamic frequency band adjustment technology
	Application identification and acceleration
	Smart roaming

3.6 Lab Scenarios

The lab is one of the most important teaching areas in the campus. It features medium user density and high network coverage-quality requirements. During peak hours, the wireless network access density in the lab is about one user per 4 square meters. In such a scenario, the Wi-Fi network carries important teaching services, such as web, email, gaming, HD video, and IM. Building a high-quality wireless network is an effective way to improve teaching efficiency.

3.6.1 Service Model

After sampling and analyzing the network traffic in lab scenarios, the wireless network carries the following types of services: web, email, gaming, HD video, and IM. In addition, the KQIs of web and video services are high.

Item	Web	Video (720p)	Video (1080p)	Voice	Email	Desktop Sharing	IM	Gaming
Proportion of users of each service	45%	10%	5%	5%	5%	5%	15%	10%
KQI	Excellent	Excellent	Good	Good	Good	Good	Good	Good
Bandwidth required by each service (kbps)	2,500	8,000	16,000	128	16,000	2,500	256	2,000

3.6.2 Network Construction Standards

Based on the service model and KQI level in the lab scenario, you are advised to perform wireless network planning and design according to the following standards:

Bandwidth design

8 Mbps @ everywhere. That is, in 95% of the wireless coverage area, the user access bandwidth reaches up to 8 Mbps.

Capacity design

Wi-Fi 5: The Wi-Fi 5 compliant STA supports dual spatial streams, and the AP works in HT80 mode. When the concurrency rate is 50%, the number of STAs supported by an AP is 70.

Wi-Fi 6*: The Wi-Fi 6 compliant STA supports four or more spatial streams, and the AP works in HE80 mode. When the concurrency rate is 50%, the number of STAs supported by an AP is 91.

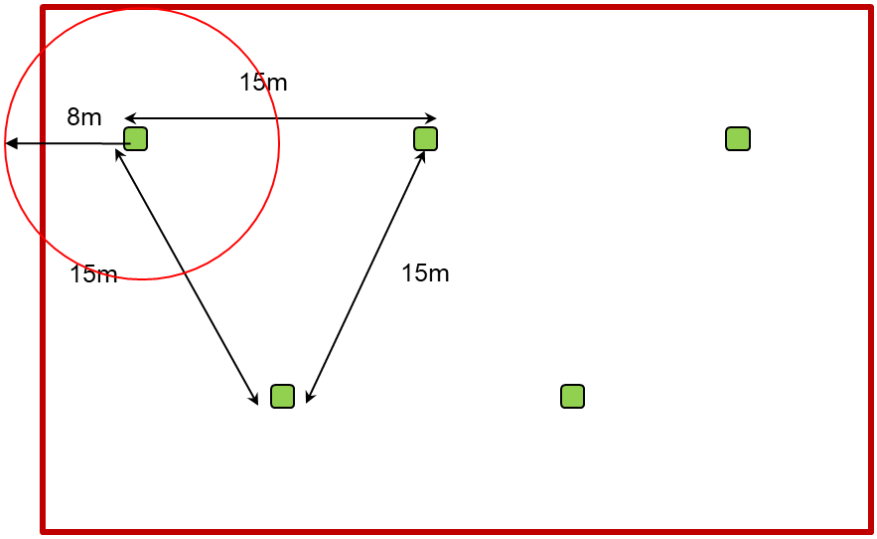
Coverage design

RSSI @ 95% area: ⩾ –70 dBm

3.6.3 Network Planning

In normal cases, the area of a lab is less than 100 square meters, with no more than 100 persons. It is recommended that one AP be deployed on the ceiling. Provided there are more than 100 persons, deploy APs in W-shaped mode at a spacing of 15 meters, shown in the following figure. The APs must be installed away from metal obstacles.

Figure 3-9 AP location planning for labs



3.6.4 AP Selection

During AP selection, you should consider both service performance and cost-effectiveness. In lab scenarios, it is recommended that you consider the following points when selecting APs:

AP Hardware Standards	802.11ac Wave 2/802.11ax
	Dual-band; 4 or more spatial streams
	Smart antennas
AP Software Standards	Smart radio calibration
	Dynamic load balancing
	Application identification and acceleration
	Smart roaming

3.7 Canteen Scenarios

The canteen is one of the high-density areas in the campus and has high requirements on network quality. During peak hours, the wireless network access user density in the canteen is about one user per 2 square meters. The wireless network carries important services such as web, email, gaming, HD video, and IM.

3.7.1 Service Model

After the network traffic is sampled and analyzed, the wireless network in canteen scenarios carries the following types of services: web, email, gaming, HD video, and IM. In addition, the KQIs of web and video services are high.

Item	Web	Video (720p)	Video (1080p)	Voice	Email	Desktop Sharing	IM	Gaming
Proportion of users of each service	45%	10%	5%	5%	10%	5%	10%	10%
KQI	Excellent	Excellent	Good	Good	Good	Good	Good	Good

Item	Web	Video (720p)	Video (1080p)	Voice	Email	Desktop Sharing	IM	Gaming
Bandwidth required by each service (kbps)	2,500	8,000	16,000	128	16,000	2,500	256	2,000

3.7.2 Network Construction Standards

Based on the service model and KQI in the canteen scenario, you are advised to plan and design the wireless network according to the following standards:

Bandwidth design

8 Mbps @ everywhere. That is, in 95% of the wireless coverage area, the user access bandwidth reaches up to 8 Mbps.

Capacity design

Wi-Fi 5: The Wi-Fi 5 compliant STA supports dual spatial streams, and the AP works in HT20 mode. When the concurrency rate is 35%, the number of STAs supported by an AP is 60.

Wi-Fi 6*: The Wi-Fi 6 compliant STA supports four or more spatial streams, and the AP works in HE20 mode. When the concurrency rate is 35%, the number of STAs supported by an AP is 84.

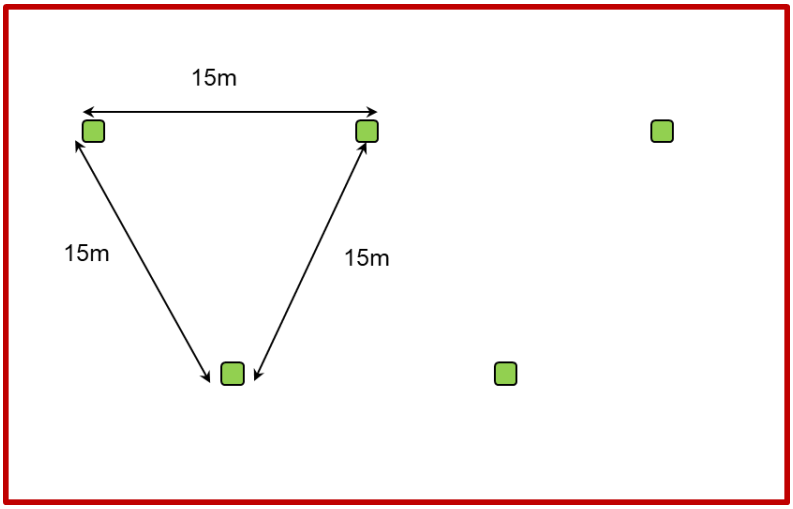
Coverage design

RSSI @ 95% area: ⩾ –70 dBm

3.7.3 Network Planning

It is recommended that APs be installed on the ceiling in W-shaped mode at intervals of 12 meters to 15 meters. Do not install APs within 2 meters from load-bearing pillars.

Figure 3-10 AP location planning for canteens



3.7.4 AP Selection

You should consider both service performance and cost-effectiveness when selecting APs, including the following points:

AP Hardware Standards	802.11ac Wave 2/802.11ax
	Dual-band; 4 or more spatial streams
	Omnidirectional antennas
AP Software Standards	Smart radio calibration
	Dynamic load balancing
	Application identification and acceleration
	Smart roaming

3.8 Playground Scenarios

The playground is an outdoor area on the campus. It features medium user density, normal requirements on network quality, and high requirements for the seating area of the stands. In normal cases, the wireless network access user density is about one user per 10 to 20 square meters. The wireless network carries important services such as web, email, gaming, HD video, and IM.

3.8.1 Service Model

After the network traffic in the playground scenario is sampled and analyzed, the main services carried by the wireless network include web, gaming, HD video, and IM. Additionally, the KQIs of web and video services are high.

Item	Web	Video (720p)	Video (1080p)	Voice	Email	Desktop Sharing	IM	Gaming
Proportion of users of each service	50%	10%	5%	10%	0%	0%	10%	15%
KQI	Excellent	Excellent	Good	Good	Good	Good	Good	Good
Bandwidth required by each service (kbps)	2,500	8,000	16,000	128	16,000	2,500	256	2,000

3.8.2 Network Construction Standards

Based on the service model and KQI in the playground scenario, you are advised to perform wireless network planning and design by following the standards below:

Bandwidth design

4 Mbps @ everywhere. That is, in 95% of the wireless coverage area, the user access bandwidth reaches up to 4 Mbps.

Capacity design

Wi-Fi 5: The Wi-Fi 5 compliant STA supports dual spatial streams, and the AP works in HT20 mode. When the concurrency rate is 40%, the number of STAs supported by an AP is 80.

Wi-Fi 6*: The Wi-Fi 6 compliant STA supports four or more spatial streams, and the AP works in HE20 mode. When the concurrency rate is 40%, the number of STAs supported by an AP is 112.

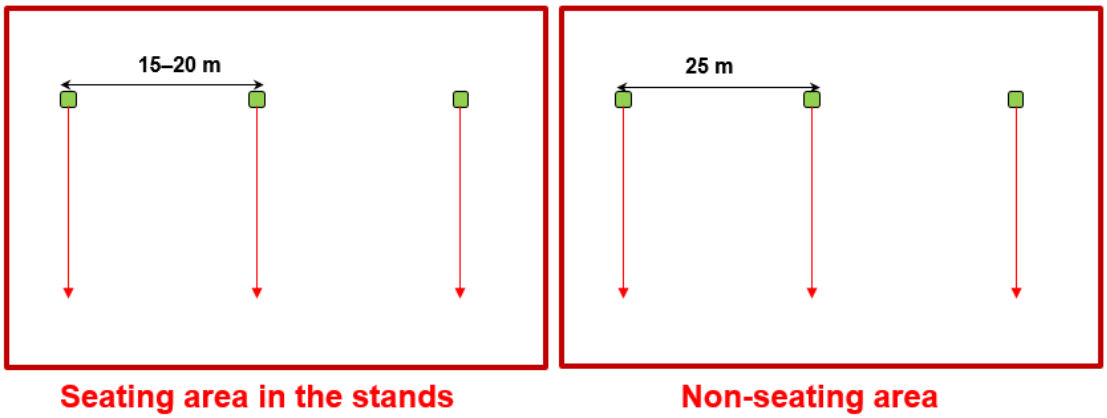
Coverage design

RSSI @ 95% area: ⩾ –75 dBm

3.8.3 Network Planning

In the playground scenario, there are generally seating areas in the stands and non-seating areas. It is recommended that APs with built-in directional antennas be mounted on the wall or a pole. For the seating area in the stands, APs are deployed in straight line mode at intervals of 15 meters to 20 meters. For the non-seating area, APs are deployed in straight line mode at intervals of about 25 meters. Do not make the coverage direction of outdoor APs face structures such as teaching buildings. This serves to reduce interference from indoor coverage areas. If only thin coverage is required for the playground, and the concurrency requirement is not considered, outdoor APs with external omnidirectional antennas can be used.

Figure 3-11 AP position planning for playgrounds



3.8.4 AP Selection

When selecting APs, you should consider the service performance, cost-effectiveness, and aesthetics. For the playground scenario, you should take into account the following points:

AP Hardware Standards	802.11ac Wave 2/802.11ax
	Dual-band; 4 or more spatial streams
	Built-in directional antennas

AP Software Standards	Smart radio calibration
	Dynamic load balancing
	Application identification and acceleration
	Smart roaming

3.9 Dormitory Scenarios

The dormitory area is a living area on the campus. Although it features medium user density, it places high requirements on network quality. In the peak hours of the evening, the wireless network access user-density in the dormitory is about one user per 2 square meters. The wireless network carries services, such as web, email, gaming, HD video, and IM.

3.9.1 Service Model

After the network traffic in dormitory scenarios is sampled and analyzed, the main services carried by the wireless network are typically classified into the following categories: web, email, gaming, HD video, and IM. In addition, the KQI requirements for web and video services are high.

Item	Web	Video (720p)	Video (1080p)	Voice	Email	Desktop Sharing	IM	Gaming
Proportion of users of each service	40%	10%	5%	5%	5%	5%	10%	20%
KQI	Excellent	Excellent	Good	Good	Good	Good	Good	Good
Bandwidth required by each service (kbps)	2,500	8,000	16,000	128	16,000	2,500	256	2,000

3.9.2 Network Construction Standards

Based on the service model and KQI in the dormitory scenario, you are advised to plan and design the wireless network according to the following standards:

Bandwidth design

16 Mbps @ everywhere. That is, in 95% of the wireless coverage area, the user access bandwidth reaches up to 16 Mbps.

Capacity design

Wi-Fi 5: The Wi-Fi 5 compliant STA supports dual spatial streams, and the AP works in HT40 mode. When the concurrency rate is 75%, the number of STAs supported by an AP is 21.

Wi-Fi 6*: The Wi-Fi 6 compliant STA supports four or more spatial streams, and the AP works in HE40 mode. When the concurrency rate is 75%, the number of STAs supported by an AP is 34.

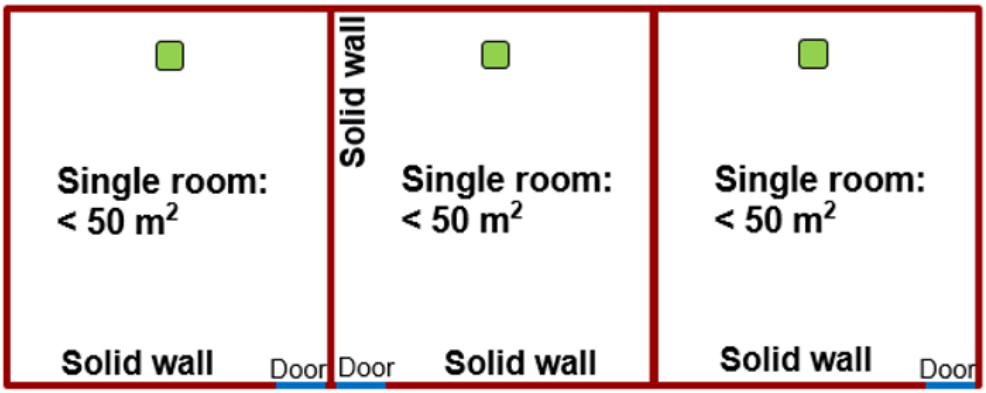
Coverage design

RSSI @ 95% area: ⩾ –65 dBm

3.9.3 Network Planning

In scenarios with a high concentration of rooms — such as dormitories — walls or other indoor objects may cause severe signal attenuation. Common indoor settled APs or distributed APs cannot meet the requirements of high-performance wireless coverage at low costs. In this case, you can use the agile distributed WLAN architecture. Generally, Remote Units (RUs) or wall plate APs are deployed indoors to ensure no coverage holes are present.

Figure 3-12 AP location planning for dormitories



3.9.4 AP Selection

You should consider both service performance and cost-effectiveness. In dormitory scenarios, when selecting APs, consider the following points:

AP Hardware Standards	802.11ac Wave 2/802.11ax
	Dual-band; 4 or more spatial streams
	Smart antennas
AP Software Standards	Smart radio calibration
	Dynamic load balancing
	Application identification and acceleration
	Smart roaming

4 Summary

Driven by the rapid development of standards and the explosive growth of application scenarios, the campus Wi-Fi network has developed into a complete solution. The campus Wi-Fi network includes wireless APs, Access Controllers (ACs), network management systems, and authentication systems. Services carried on the network are no longer simple requirements such as accessing the mobile Internet.

Enterprise-grade WLAN networks have become full-scale infrastructures that support digital transformation of various industries, and improve production and work efficiency. A good Wi-Fi network can greatly improve campus operation efficiency, meet the stringent demands of teachers, satisfy all students, and support schools to deploy more digital and intelligent services.

If you have not deployed a campus Wi-Fi network, or your existing Wi-Fi network cannot meet the requirements for current and future-ready digital service developments, you should consider upgrading. Based on the preceding scenarios, you are advised to deploy the latest Wi-Fi network to build a high-quality solution for teachers and students, and campus administrators.

A Acronyms and Abbreviations

A	
AC	Access Point
AP	Access Controller
I	
IM	Instant Message
K	
KPI	Key Performance Indicator
KQI	Key Quality Indicator
V	
VDI	Virtual Desktop Infrastructure
W	
WLAN	Wireless Local Area Network

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