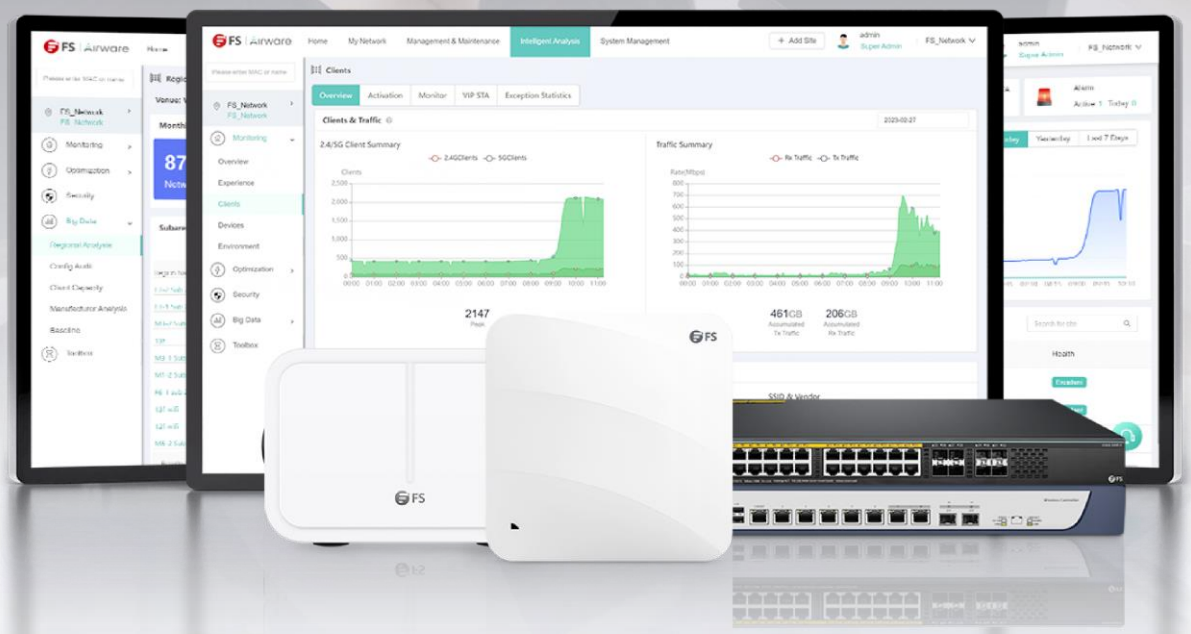


Wireless Network Solution

Network Planning Guide

V1.0.2307A

Innovation · Expertise · Agility

Introduction

Overview

This document provides methods, precautions, and suggestions for WLAN network planning, so that readers can learn more about WLAN network planning.

Intended Audience

This is applicable to network planning engineers, hardware installation engineers, commissioning engineers, on-site maintenance engineers, and system maintenance engineers. You should be familiar with WLAN basics.

Matching Products

This document introduces how to carry out network planning design based on the related product components of the wireless network solution. The applicable product models are shown in the following table.

Product Categories	Product Model
AP	Indoor Access Points: AP-W6D2400C / AP-W6T6817C / AP-N505 / AP-N515 / AP-N515H FS-AP733C / FS-AP1167C / FS-AP3000C
	Outdoor Access Points: AP-T565 / AP-T567
AC	AC-1004 / AC-224AP / AC-7072 / FS-AC32
Airware Cloud	Airware

Contents

01

WLAN Planning Procedure

The basic flow of WLAN network planning is shown in the following figure.

Steps		Instruction
01	Requirements collection	Collect complete and comprehensive project information and requirements to reduce the number of redesigns caused by insufficient information.
02	Site survey	Conduct site survey and collect more detailed informationfor network planning, such as interference sources, obstacles, etc.
03	WLAN planning design	According to the results of requirements collection and site survey, determine which coverage method to use, such as indoor or outdoor coverage, and then design the network coverage, network capacity and AP deployment.
04	Device Installation	Layout and installation of AC, AP and other network equipment are carried out according to the results of the network regulation scheme.
05	Check & acceptance	To test whether the coverage, signal strength and network speed of the wireless signal meet the acceptance criteria, it is recommended to use FS Airbox APP for acceptance test and output the acceptance report.

02

Requirements collection

In order to design a WLAN network solution that meets user needs, complete and effective information needs to be obtained during the requirements collection phase. Failure to obtain accurate information can lead to subsequent planning difficulties and even redesigns. The following is a list of common and important WLAN network planning information.

Table 1: Requirements collection checklist

Requirement Category	Key Point of Requirement Analysis
Legal and regulatory restrictions	Confirm the laws and regulations that the network location complies with, and which country code needs to be used.
Management Type	Confirm what type of management method is needed, Fit AP Mode (FS AC Controller management), Fat AP Mode (FS AP stand-alone management), and FS Airware cloud management.
Architectural drawings of the network deployment site	Drawings are used to design network planning solutions. Obtain the drawings with scale information and confirm the completeness of the drawings, and know the total number of buildings, how many floors each building has, the total construction area and other information through the drawings. Support CAD/PDF/PNG/JPG format drawing import. If there is no drawing, it is necessary to go to the site for actual measurement and redraw the drawing with scale information.
Wireless network coverage area	Confirm the required VIP areas, common areas, and simple areas. • VIP areas: The network area used by VIP users, which requires high network quality. • Common areas: The main coverage area of the network with many usage needs, such as office area, classroom, dormitory, hotel room, etc. • Simple areas: areas with less demand for network usage, such as aisles, storage rooms, kitchens, etc.
Field strength of wireless signals	The signal field strength requirements in the coverage area may be required when the user has strong technical capabilities. For example, the key area is -40 dBm--65 dBm, and the general area is >-75 dBm.
Number of access users	The total number of access terminals in the current coverage area, and how many users plan to access at the same time in the coverage area. In the wireless office scenario, it is generally considered that each person has a mobile phone and a compter, then the number of access terminals = number of access users x 2.
Terminal type	Confirm the type and quantity of terminals, common terminals such as mobile phones, tablets, and laptops, and special terminals such as barcode scanners and cash registers.
Bandwidth requirements	Confirm the main service types carried by the network and the bandwidth requirements of each user.
Coverage	Whether there is a clear requirement, it should be placed indoors or covered outdoors.
Power supply	Whether there are clear requirements for the power supply method, and what power supply facilities and areas are available on site.
Switch location	The position on the AP connected to the switch on the wired side.
Special needs	Are there any other special needs.

03

Site survey

The main purpose of the site survey is to obtain the actual environmental information on the site, such as floor height, building materials, interference sources, obstacles, and weak current wells telecommunications room. Site survey is an essential link in WLAN networking, which directly determines the feasibility and actual performance of the networking scheme, and also provides the original reference for later scheme design and engineering implementation.

The tools used in site survey and site survey information collection items can be referred to below.

3.1 Tool preparation

In order to complete the site survey tasks, it is necessary to use a variety of tools for assistance. The following are common tools.

Table 2: Site survey tools

Tool Type	Tool Name	Tool Instructions
Software	FS Airware	FS Airware supports the cloud geological survey function, allowing users to simulate the real environment online before the official deployment of the project, judge the impact of obstacles on the signal strength of the equipment, and finally give a reasonable equipment pre-deployment plan, and support wireless signal simulation and Output of engineering geological survey report. For more information about FS Airware, please refer to the webpage information.
	FS Airbox	FS Airbox is a one-click detection tool that can perform comprehensive Wi-Fi detection and generate a detection report. According to the final detection results, you can understand whether the WiFi network is good or bad and how to solve the problem. For more information about FS Airbox, please refer to the user manual.
	Google Earth	Used when deploying outdoor network scenarios, it is used to mark the latitude and longitude of APs, check obstacles, and confirm the project site environment.
Hardware	Indoor Rangefinder	Used when deploying indoor network scenarios, it is used to measure the height of AP installation locations, the distance between APs and obstacles, and the length, width, and height information of venues, etc.
	Camera	Record the site environment, such as the AP installation environment, and return information about site obstacles in the scene.
	Testing AP (including matching power supply and bracket)	Indoor scene with FS Airbox APP for obstacle attenuation test, it is recommended to carry test FAT AP: Battery: Used to power the test AP. Ground-mounted support: The support is required to be able to 6.56 feet (2m), which is used to simulate the installation scene of the AP ceiling.

Other	Architectural Plan Drawings	Print architectural drawings in advance to facilitate on-site site surveys and use them to verify whether the drawings are consistent with the on-site environment and to record the use of information.
	Lift	If the ceiling height exceeds 20 feet (6.1m), a lift and certified operator are required.

3.2 Site Survey Information to Be Collected

In order to ensure that site survey personnel can collect information more comprehensively and accurately, the following table lists the site survey information that needs to be collected for their reference. When conducting site surveys, site surveyors should collect information based on the table, and record the collected information in detail at the corresponding positions on the architectural drawings.

Table 3: Site survey information collection items

Survey information	Sample information record	Description
Floor height	Common indoor floor height 9.8 feet (3m)	It is very important to obtain the floor height information of areas such as hollow areas, halls or lecture halls. Can be measured with a rangefinder.
Building materials and attenuation	240 mm brick wall (2.4 GHz 15 d, 5 GHz 25 dB attenuation), 80 mm thick colored glass (2.4 GHz 8 dB, 5 GHz 10 dB attenuation)	Obtain the thickness and attenuation of on-site building materials, and test the attenuation on-site if conditions permit. If it is impossible to test, you can refer to the preset common obstacle attenuation in the site survey tool.
Source of interference	Other Wi-Fi interference is detected, and the interference source information has been additionally marked on the drawing	Detect whether there is interference on site, including mobile phone hotspots, Wi-Fi from other manufacturers, and non-Wi-Fi interference (such as Bluetooth, microwave ovens, etc.) can use the FS Airbox APP to record interference source information.
New obstacles	There is a new partition on site, which has been additionally marked on the drawing	Confirm whether the site is completely consistent with the architectural drawings, highlight the inconsistent areas, and take photos to record as much as possible.
Live photos	Take photos and record global photos	Take as many photos as possible on site, and take photos of the site as comprehensively as possible to record the environment and transmit survey information.
AP selection	Ordinary AP	Choose indoor APs, outdoor APs, or high-density APs based on the scenario.

Installation method and location	Ceiling installed under the ceiling, wall mounted on the wall	Determine whether it can be installed on the ceiling. When ceiling installation is not possible, consider wall or panel installation.
Telecommunications room location	The location of the telecommunications room has been marked on the drawing	Mark the location of the weak current well telecommunications room on the drawing for placement of the switch.
Power supply wiring	Network cables to be routed have been drawn on paper	Mark the power supply wiring of POE on the drawing. It is recommended that the length of the POE network cable does not exceed 262 feet (80m).
Construction feasibility	Whether the AP can be deployed, the distance to the switch, the distance to the power supply point, and whether the wiring between them is feasible	Whether there are fire doors or concrete load-bearing walls that are difficult to drill.
Outdoor site	Observe the main buildings and the heights of the available sites	Tall buildings, street lamps, and iron towers in or near the coverage area can be used as the main buildings of the AP site to visually measure their heights.
Outdoor propagation environment	Signal propagation environment in the coverage area	Understand the general outline of the on-site coverage area, observe whether there are tall buildings, trees and other obstacles around the coverage area, and if possible, take some photos of the area for later use or archiving.
Special Requirements	Roaming packet loss rate less than 1%, latency less than 20ms	Special requirements, such as roaming packet loss rate, delay, etc.

3.3 Site survey skills

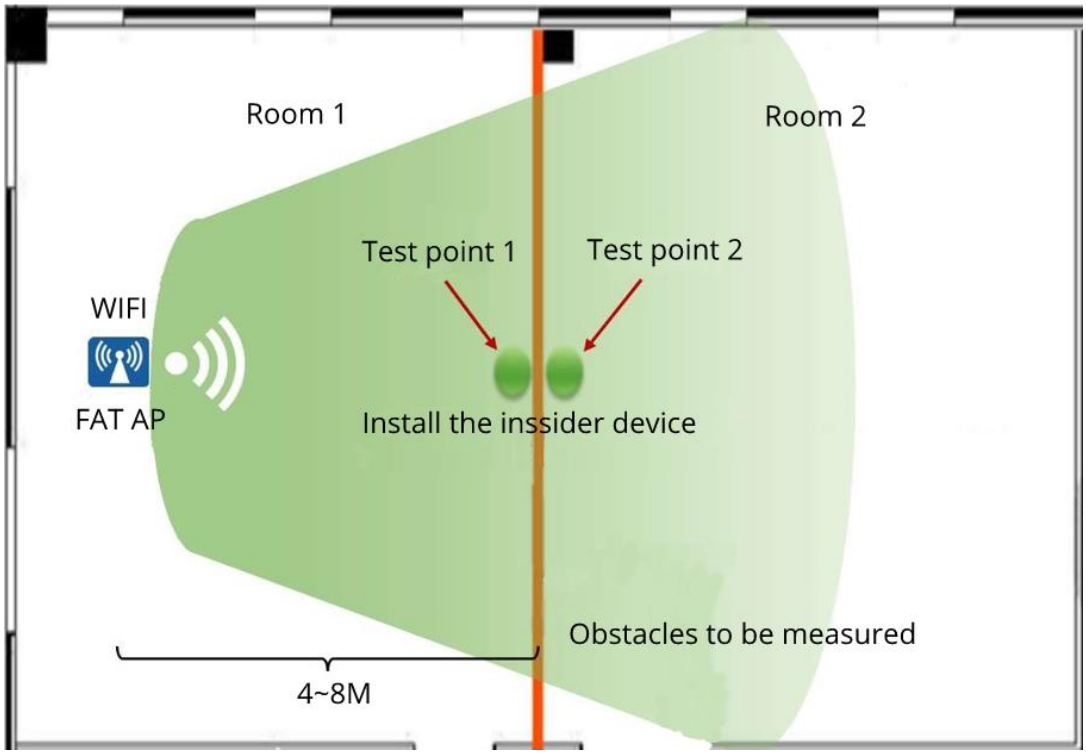
Because obstacles have strong attenuation on wireless signals, which greatly affects the design and deployment of network planning, so in the process of site survey, special attention should be paid to and master the test method of obstacle attenuation in order to obtain real 2.4G and 5G attenuation, and provide accurate input for subsequent network planning.

The test method of obstacle attenuation is introduced as follows:

1. Fat AP (recommended)/Mobile phone hotspot: There is no other obstruction between the AP and the obstacle to be tested, and the distance between the AP and the obstacle is 4~8 meters. If the AP is too close to the obstacle, the measured RSSI value fluctuates greatly with the distance, which will make the obstacle attenuation value obtained in the test much larger than the actual value.
2. Test points 1 and 2: Install the inSSIDer frequency scanning software (recommended) on the laptop, and perform 5 RSSI measurements at test points 1 and 2 respectively according to the diagram and record them.

3. Attenuation calculation: target obstacle attenuation = average RSSI point 1- average RSSI overshoot point 24.2.4G and 5G.

Follow steps 1-3 to test the obstacle attenuation values of 24G and 5G respectively.



04

WLAN Planning Design

Based on the collected requirements and site survey results, start detailed network planning and design. Network planning is mainly based on network coverage, capacity, and AP deployment.The tools used in site survey and site survey information collection items can be referred to below.

4.1 Network coverage design

In order to complete the site survey tasks, it is necessary to use a variety of tools for assistance. The following are common tools.

4.1 .1 Coverage Calculation

- Indoor semi-open scene

  In order to provide high-quality wireless services, all rooms (except panel APs) are required to have wireless signal strengths of 2.4G and 5G not lower than -65dBm in any indoor space, and a packet loss rate of less than 1%.

  Signal quality: In more than 95% of the target coverage area, the S/N value of the downlink signal received by the user terminal is >10dB.

  Rate index: In the target coverage area, the maximum downlink service rate for single user access ≥ 90% of the AP uplink relay bandwidth.

  Signal leakage: The intensity of indoor WLAN signal leakage to 10m outdoors is not higher than -75dBm.

  1. Basic indicators: the main types of STAs - the indicators for mobile phones are -65dBm, for notebooks -70dBm, and the coverage is 100%.
  2. Extended indicators (business type): confirmed by importance
     - Office applications, real-time charging applications, business applications (such as wireless ward rounds), or other applications that must meet the recommended indicators.
     - For mobile entertainment applications and non-real-time charging items, the recommended index can be reduced by 5dBm.
  3. Extended index (customer type): Whether it is VIP, if yes, it is recommended that the index should be increased by 5dBm.

- Outdoor coverage scenarios

  The wireless signal strength in the outdoor environment is not lower than -75dBm at the edge of wireless cellular coverage at 2.4G and 5G. At the same time, in order to achieve signal stability, the interference signal strength of the same frequency and channel should not be higher than -75dBm.

- Multi-level Point-to-Point Wireless Bridge scene

  Taking Multi-level Point-to-Point Wireless Bridge scenario as an example, the bridging link between the root bridge and the non-root bridge is called the main link and needs to ensure stable uplink RSSI ≥ 30. If the signal strength cannot reach the above value, it is necessary to adjust or replace the point as soon as

possible to avoid the bridge performance being too low due to insufficient signal strength and unable to meet the transmission requirements.

Multi-hop refers to AP1 (root bridge)<---->wireless bridge<---->AP2(non-root bridge)<---->wired connection<---->AP3(root bridge)< ---->Wireless Bridge<---->AP4 (non-root bridge)

AP1(root bridge) AP2(Non-root bridge) AP3(root bridge) AP4(Non-root bridge)

4.1 .2 Link budget

After the wireless network is deployed, the coverage area will show obvious signal attenuation characteristics due to the structural characteristics of the building, resulting in signal blind spots. The attenuation of signals by building materials in common scenarios is shown in the figure.

Table 4: Signal Attenuation Caused by Common Obstacles

Material Type	Thickness/ mm	2.4G attenuation value/ db	5G attenuation value/ db
Brick wall	120.0	4.0	7.0
Brick wall	240.0	15.0	25.0
Wooden door	40.0	3.0	4.0
Synthetic material	20.0	2.0	3.0
Asbestos	8.0	3.0	4.0
Glass window	50.0	4.0	7.0
Colored thick glass	80.0	8.0	10.0
Concrete	240.0	25.0	30.0
Bullet-proof glass	120.0	25.0	30.0
Metal	8.0	30.0	35.0

Combined with the above common signal loss experience values, the following loss calculation formula can be used to judge:

Pr[dB]= Pt[dB]+Gt[dB]-Pl[dB]=Gr[dB]

Pr[dB] is the signal strength of the receiving end; Pt[dB] is the transmission power; Gt[dB] is the gain of the transmitting antenna; Pl[dB] is the path loss (including space propagation loss, feeder propagation loss, wall/glass blocking loss etc.); Gr[dB] is the receiving antenna gain;

Table 5: Signal Attenuation Caused by Common Obstacles

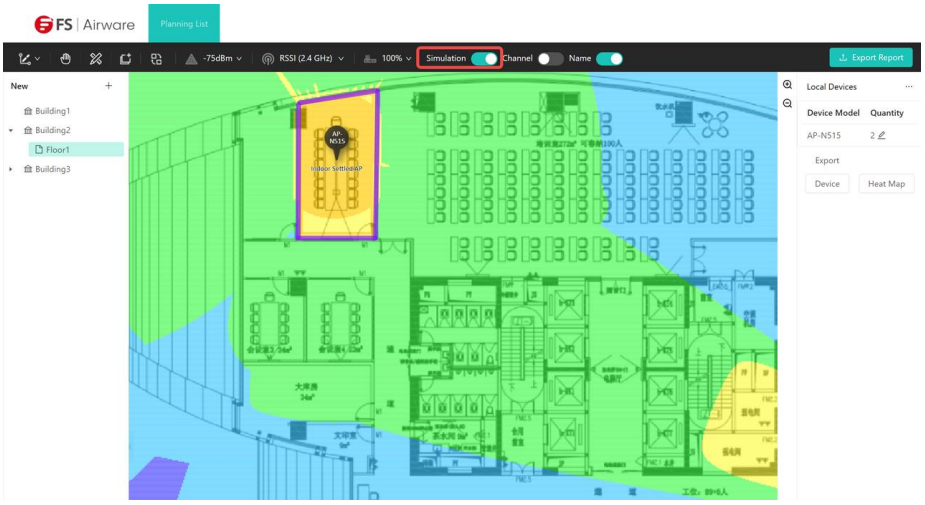
Path loss table for unobstructed propagation								
Distance	1 m	2m	5m	1 0m	20m	40m	80m	1 00m
2.4G	43dB	52.8dB	63.2dB	71dB	78.8dB	86.4dB	94.1dB	97.5dB
5.8G	54dB	61.8dB	72.2dB	81dB	88.8dB	96.3dB	103.9dB	106.9dB

For example: It is known that the 5G RF transmission power of an AP is 20dBm, the 5G antenna gain is 6dB, the 10m transmission distance attenuation is 81dB, and the obstacle attenuation is 5dB. Assume that the receiving terminal is a mobile phone (usually the antenna gain is 0), and substitute the data into the formula:
Signal Strength=20+6-81-5+0=-59dB
It meets the signal field strength requirements of most projects.

4.1 .3 Coverage Design

It is recommended to use FS Airware for network coverage design. Collect the information in the list according to the requirements, set the coverage area, network terminal capacity and other information in FS Airware, and FS Airware can directly design the network planning scheme, simulate the signal strength in the coverage area, and output the simulation diagram. After the simulation is completed, the number and deployment positions of required APs can be preliminarily calculated.

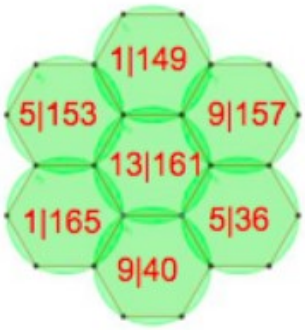
For specific steps, please refer to ‹Airware Cloud Site Survey User Manual›

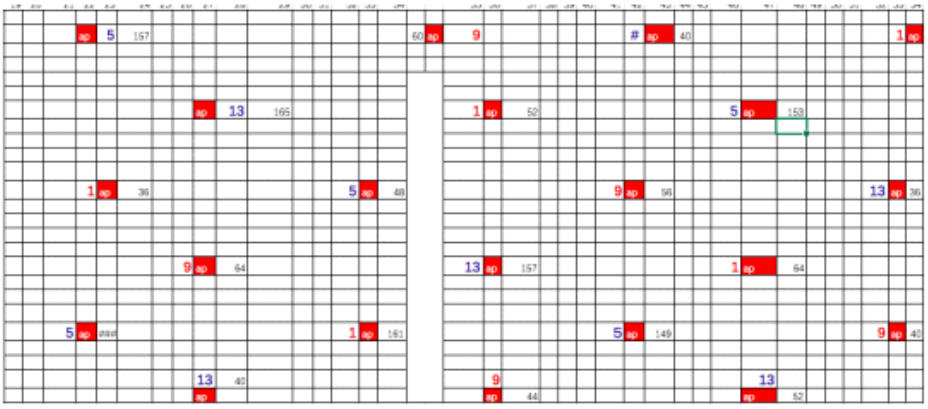


4.1 .4 Channel Design

Recommend to query 2.4G/5G channels via ‹Country Code Channel Compliance Table› to obtain the best channel planning scheme, AP point planning adopts cellular deployment to increase the same-frequency spacing as much as possible.

For example, the AP point and channel planning in a high-density environment is as follows:





4.2 Network capacity design

4.2.1 Parameters for capacity design

Table 6: Bandwidth requirements of a single user (office scenario as an example)

Business type	Single service baseline rate (Mbps)		The proportion of each business in the office scene							
	Excellent	Good	Meeting room	High-density office area	General office area	Recreation area	Exhibition hall	Dining room	Parking lot	Toilet
4K video	50	30	10%	10%	10%	10%	10%	10%	10%	10%
1 080P video	16	12	10%	10%	10%	10%	10%	10%	10%	10%
720P video	8	4	10%	10%	10%	10%	10%	10%	10%	10%

Electronic whiteboard wireless projection	32	16	10%	20%	0%	0%	0%	0%	0%	0%
Email	32	16	10%	10%	10%	0%	0%	0%	0%	0%
Web browsing	8	4	30%	20%	20%	30%	30%	30%	10%	30%
Game	2	1	0%	5%	10%	10%	0%	10%	10%	10%
Instant messaging	0.512	0.256	10%	5%	20%	20%	30%	20%	30%	20%
VoIP (Voice)	0.256	0.128	10%	10%	10%	10%	10%	10%	20%	10%
Average bandwidth per user(Mbps) - Excellent			16	19	13	10	10	10	9	10

If the bandwidth requirement in a specific scenario is not specified, the scenario-based bandwidth requirement assessment can be performed according to the above table.
The average bandwidth requirement for a single user in different scenarios is: the sum of the products of the baseline rate and the proportion of a single service.

Table 7: Number of concurrent users of a single AP

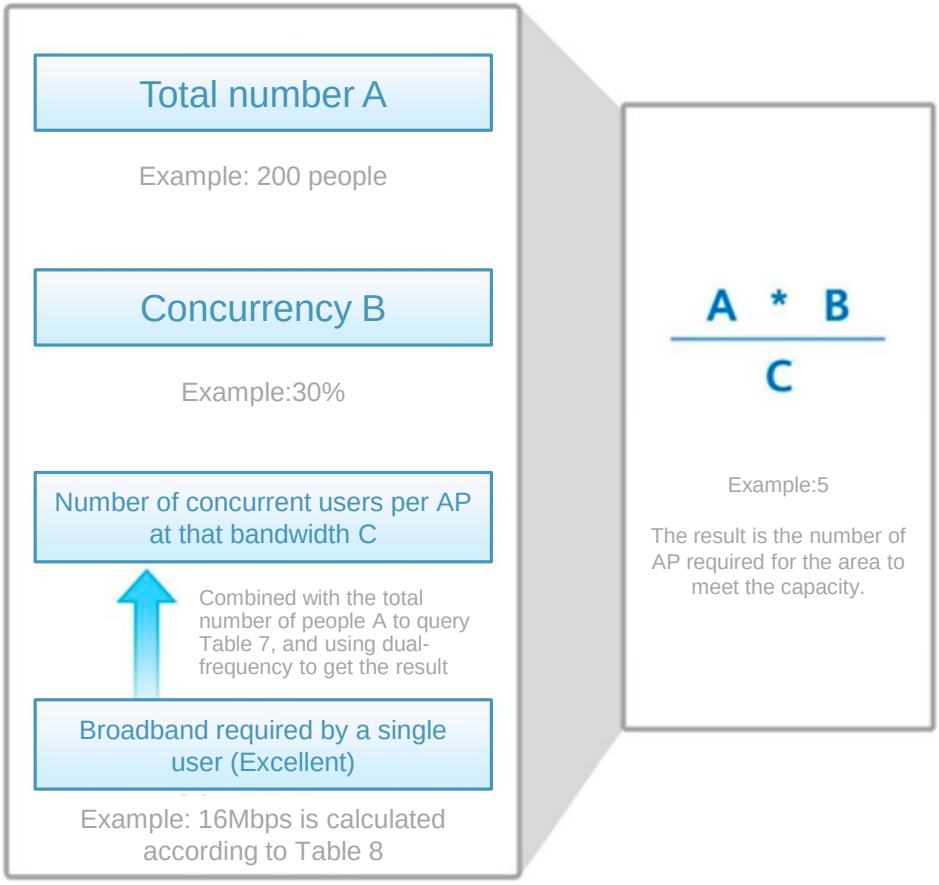
The maximum number of concurrent terminals for Wi-Fi 6 APs under different user access bandwidths (2.4G@20MHz, 5G@40MHz, all terminals support Wi-Fi 6, dual spatial streams)				
Serial number	User access bandwidth	Single radio (5G) maximum number of concurrent terminals	Dual radio (2.4G+5G) maximum number of concurrent terminals	Tri-band (2.4G+5G1 +5G2) maximum number of concurrent terminals
1	2Mbps	56	85	141
2	4Mbps	39	56	95
3	6Mbps	27	38	65
4	8Mbps	21	30	51
5	16Mbps	12	18	30

The physical rate of WLAN refers to the rate of the physical layer of the air interface. That is the rate that can be achieved by the physical layer sent by the air interface. The rate presented in the product documentation is the rate of the physical layer.
The rate shown in the above table is the rate of the application layer, and the rate of the application layer is the actual effective rate after removing various overheads on the air interface, so the actual rate of the application layer is lower than the rate of the physical layer.

4.2.2 Parameters for capacity design

Table 8: WLAN Capacity Design Example

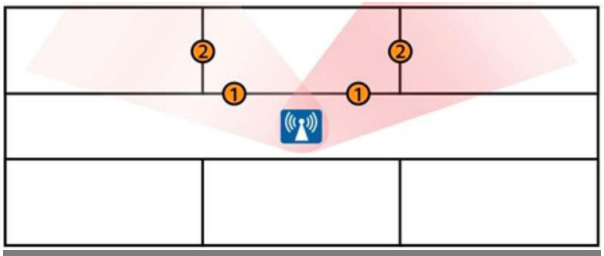
Business type	Single service baseline rate(Mbps)		Proportion
	Excellent	Good	Meeting room
4K video	50	30	10%
1 080P video	16	12	10%
720P video	8	4	10%
Electronic whiteboard wireless projection	32	16	10%
Email	32	16	10%
Web browsing	8	4	30%
Game	2	1	0%
Instant messaging	0.512	0.256	10%
VoIP (Voice)	0.256	0.128	10%
Average bandwidth per user(Mbps)-Excellent			16Mbps



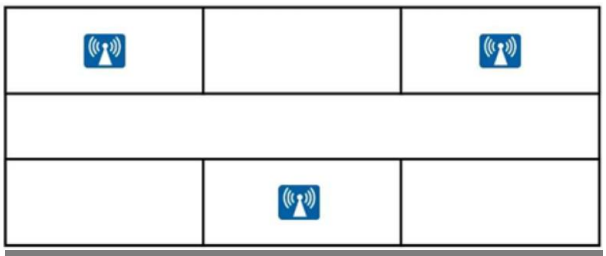
4.3 AP deployment design

4.3.1 AP laying principle

- Indoor AP layout design
  1. Indoor AP supports ceiling mounting (recommended, top height is not more than 6 meters) or wall Mounting (installation height is about 3 meters)
  2. Reduce the number of obstacles through the signal. Generally, it is recommended to penetrate the single layer wall (typical 120mm brick wall) at most, and some special scenes (such as gypsum wall, glass wall, etc.) can be considered to pass through the two layers of wall.
  3. 240mm thick brick wall, concrete wall and metal wall are not recommended to penetrate cover, if the AP penetration coverage solution is still adopted when the constraints are not met, it will cause the problem of weak signals and roaming discontinuity after crossing the wall. For this case, if you need to ensure good coverage and roaming, network planning needs to add deployment AP points based on wall structure.
  4. Key areas and VIP areas should try to ensure AP deployment separately to ensure user experience.
  5. Separate AP is deployed at intersections or corners to ensure signal overcover, continuity of cover (greater than-65 dBm), adjacent AP can establish a neighboring relationship table to ensure good roaming experience.
  6. The installation position is more than 3 meters away from the load-bearing column.

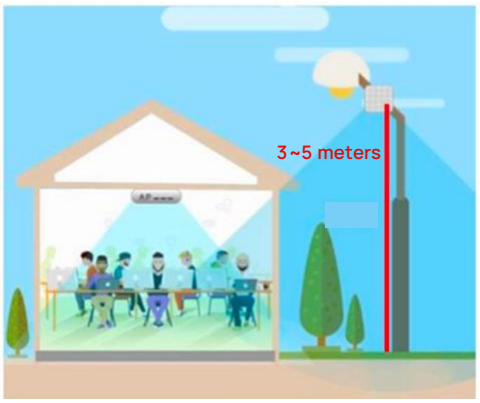


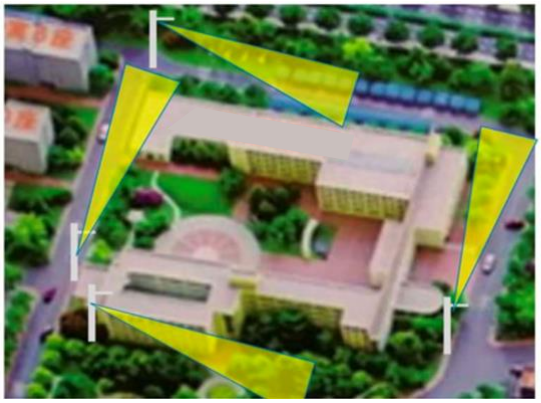
The location is unreasonable, the signal penetrates multiple walls

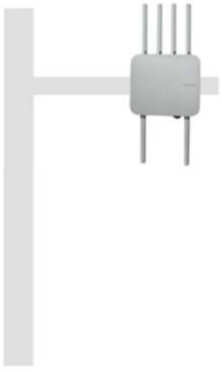


The location is reasonable, and the signal penetrates the single-layer wall

- Indoor AP layout design







1. Omni-directional antenna coverage is recommended for open scenes such as squares and parks. Built-in directional antenna AP hunting cover is recommended for narrow and long roads and other scenes. External small-angle directional antenna coverage is recommended for high-density, backhaul, and ultra-long-distance coverage scenarios.
2. The recommended installation height of the outdoor directional and antenna is 3~5 meters.
3. Outdoor AP only covers the outdoor area, while indoor AP only covers the indoor area. Directed AP or antenna is recommended for the roads around the building to reduce the interference to indoor signals and cover in the same direction as far as possible.
4. Due to the influence of trees, it is usually recommended to stick with the monitoring pole and install the holding pole.
5. Outdoor omodirectional antenna should be installed vertically.
6. Avoid interference from strong electricity, magnetism and other signals near the site.

4.3.2 Power supply & Cabling principles

- Power over Ethernet (PoE)

  In indoor scenarios, AP can use PoE in most cases, with the advantages of using PoE:
  - Multiplex data transmission network cable can supply power, without additional wiring, reduce the construction cost.
  - No need to buy additional power adapter, save economic investment.
  - Using a power adapter for power supply requires a power supply near the AP, which is not required for the PoE power supply. Usually, only one PoE access switch is required to provide PoE input for the AP.

  Pay attention to the following when deploying PoE power supply:
  - The longer the network cable is, the weaker the power supply is. Generally, the length of the network cable should not exceed 80m. The specific actual network cable maximum length depends on the network cable type and AP type.
  - Network cable involves going through the wall, pipe distribution and cabling, which takes a long time for installation and construction. Therefore, if the network needs to upgrade in the future, it is recommended to choose a higher standard network cable, and the subsequent upgrade requires no need for re-construction.

- Cabling principles

  When arranging network cabling, pay attention to the following:
  - The length of network cable is reserved for 5m so that AP position can be fine-tuned to reduce interference or optimize signal coverage.
  - The network cable is deployed far away from the strong electric and strong magnetic position.
  - Confirm the network cable deployment plan with the user in advance to avoid the user not agreeing to the construction due to other reasons such as property and beauty.

  The AP layout principles may be slightly different in different sub-scenarios. Usually, after the AP layout design is completed, the network planning scheme is also designed.

05

Installation & implementation

According to the results of the network regulation design, install the equipment in the planned position.

5.1 Installation Video

Video instructions for installing the AP refer to the installation video.

AP Type	Installation Method	Video Link
Indoor AP	Ceiling Mounting	https://resource.fs.com/video/20220727144557c7rzcb.mp4
	Wall Mounting	https://resource.fs.com/video/products/2022/0/2/20220216424709221 55-KVOBQHhD.mp4

5.2 Notes for installation

AP installation and precautions documentation refer to the AP Quick Installation Guide.

AP Type		Product Model	Video Link
Wi-Fi6	Indoor AP	AP-N505	AP-N505 Access Point Quick Start Guide
		AP-W6T6817C	AP-W6T6817C and AP-W6D2400C Quick Start Guide
		AP-W6D2400C	
		AP-N515	AP-N515 Access Point Quick Start Guide
		AP-N515H	
	Outdoor AP	AP-T565	AP-T565 and AP-T567 Quick Start Guide
		AP-T567	

Wi-Fi5	Indoor AP	FS-AP733C	
		FS-AP1167C	Wi-Fi 5 Access Point Quick Start Guide
		FS-AP3000C	

5.3 Site installation record form

After the installation is complete, record the installation location information of the AP by referring to the table below.

Table 9： AP installation records

Site	AP Number	Alias	Antenna Type	MAC Address	SN	Installation Method	Uplink ONU/LSW port

Check & acceptance

6.1 Introduction of acceptance tools

Airbox is an application software for testing Wi-Fi running on the mobile terminal. Comprehensive Wi-Fi detection is conducted through the one-click detection tool. Users can complete the wireless acceptance work alone and generate the test report.

6.2 Acceptance steps

Use the FS Airbox APP installed on the mobile machine for project acceptance. Please refer to the FS Airbox user manual for the acceptance operation.

FS has invested resources in product R&D, quality control, intelligent manufacturing, industry-leading experts, professional technical support, and networking solutions. All is to provide customers with higher-performance, lower-power consumption, and the most cost-effective products, promoting clients' network upgrades.

For more information and technical support, welcome to contact us at www.fs.com/contact_us