Alcatel-Lucent OmniAccess Stellar Access Point Configuration and Deployment Guide for Education

Technical Brief
OmniAccess Stellar Deployment Guide

Alcatel·Lucent
Enterprise

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Overview

This document offers best practices for the configuration and deployment of Alcatel-Lucent OmniAccess® Stellar WLAN Access Points with the Alcatel-Lucent OmniVista® 2500 Network Management System (NMS) in enterprise mode to help ease wireless network configurations and apply the Alcatel-Lucent Service Defined Network architecture for service provisioning within college and university environments.

It will provide guidelines for typical deployment models in the education environment including: dormitories, playgrounds, libraries, classrooms, and stadiums to ensure optimal network efficiency and best user experiences.

This document is intended for the: Project core team, Project SQA team, Technical Support team, Product Manager, Partners/Customers.

Wireless AP deployment in colleges and universities

WLAN coverage scenarios and characteristics

Almost every university student has a smart phone and PC, and every device has a Wi-Fi connection. The Wi-Fi penetration rate has already reached 100% and the concurrent rate will exceed 50%, creating higher requirements for wireless network performance.

There are different deployment scenarios for colleges and universities, including class rooms, dormitories, libraries, and stadiums. Each environment requires unique products and different wireless coverage scenarios.

Coverage	Dormitories, playground, library, classroom, stadium
Applications	Online video, online game, file download, Instant messaging, Web page, multimedia classrooms
Authentication	PSK\Portal\802.1x
Clients	Laptop, PAD, Smart phone, Smart TV
Capacity	10000+ Clients, 50%+ Concurrent clients, 10G+ Uplink bandwidth
AP devices	AP1201H, AP1101, AP1221, AP1231, AP1251, AP1321, AP1361

Principles of deployment

Site-survey and capacity planning: For the optimal placement of the APs throughout the building, facility or an outdoor space, a site survey is recommended.

A site survey can be carried out in a couple of different ways:

1. A virtual site survey uses special software to simulate the environment and the placement of the APs can be done freely, with the ability to move the AP placement, increase or decrease the output power.
2. A physical site survey allows for the exact reading of how an AP will perform, eliminating any guess work involved with regards to positioning due to walls, or materials used in the buildings construction. It also provides an opportunity to discover any hidden or unknown interference sources that might have been overlooked, and lets you plan accordingly.

Capacity planning a WLAN deployment involves knowing or anticipating how the network is going to be used. The most important part is providing for the expected number and mix of clients connecting to the network. There are industry standard capacity numbers, and maximum client numbers per AP that are known, but other factors need to be considered. Refer to the appropriate sections to determine the capacity planning based on the deployment options with regard to dormitories, classrooms, halls and high-density auditoriums and multi-level stadiums.

Performance: There is a higher bandwidth requirement for college deployments with traffic limitations for users to reduce the traffic burst of a single client and avoid affecting performance of other users on the WLAN.

Security: WLAN is an open network and more vulnerable to unauthorized access or security risks. Users may employ their knowledge and skills to attack the campus internal network. A unified security authentication policy and access control policy are necessary to ensure authorized access to the network and to guarantee the security of the entire network using VLAN and client isolation.

Reliability: When deploying the access points (AP) in close proximity to clients the AP should be installed at an appropriate height to reduce the interference caused by mobility issues. There should be isolation space between APs to improve the AP reuse rate, especially in a highly dense deployment where the overall capacity and load balancing among APs must be enforced.

Ease of use: The system should be easy to manage and maintain using automated system configuration and optimization. It should also have remote management, maintenance and troubleshooting capabilities.

Ease of Management: OmniVista 2500 NMS

The OmniVista 2500 NMS is recommended for OmniAccess Stellar wireless deployment best practices. OmniVista 2500 NMS is used to enable automatic provisioning services for the OmniAccess Stellar wireless and Alcatel-Lucent OmniSwitch® network. OmniVista 2500 NMS is a web-based management interface that provides cohesive management and network wide visibility and ease of configuration across an entire Stellar AP and the OmniSwitch wired network infrastructure. OmniVista 2500 NMS is integrated with the latest web techniques to allow access anytime, from anywhere. It has a customizable dashboard that can be tailored to the network administrator's needs of most used or critical management functions.

The Network Analytics application helps to monitor network bandwidth and key traffic patterns through advanced collection and reporting capabilities. This information can provide insights to the IT department and the CIO on how network resources are consumed, in order to proactively optimize the end-user's quality of experience.

OmniVista 2500 NMS enables network administrators to easily provision, manage and maintain the network infrastructure with its network elements, alarms, unified access security policies, and virtualization. It also provides advanced network analytics for full visibility into users, devices and applications, as well as predictive analysis for forward planning of application deployment and bandwidth provisioning policies. The OmniVista 2500 NMS is a scalable, resilient, secure network management system for unified access to provision both wired and wireless Alcatel-Lucent Enterprise network equipment.

Service Defined Network – Universal Network Profiles

When securing network access based on the ALE Service Defined Network, best practices recommend employing the Access Guardian role-based policies available through the Universal Network Profile (UNP) feature. A UNP profile defines the network access for one or more user devices. Each device that is assigned to a specific profile is granted network access based on the profile criteria instead of on an individual MAC address, IP address, or port/SSID basis.

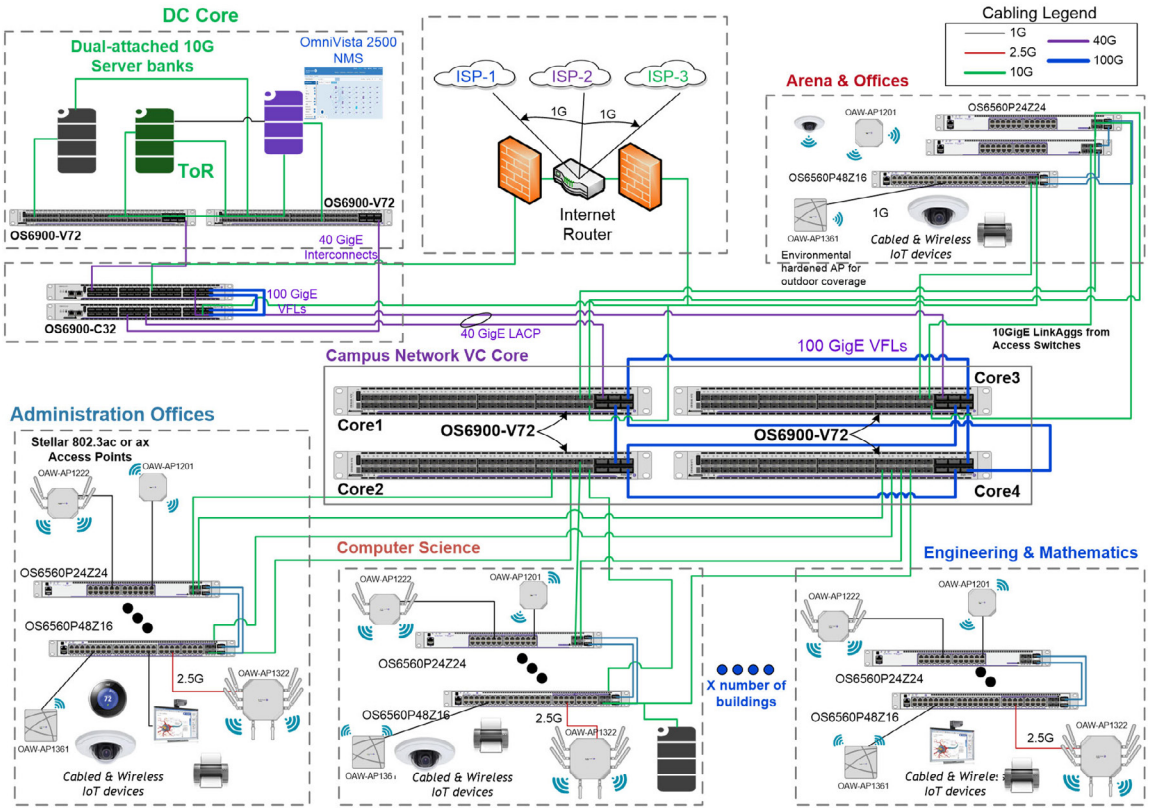
Assigning users to a profile provides greater flexibility and scalability across the network. Profiles can be used to group users according to function. All users assigned to the same UNP become members of that profile group. The UNP then determines what network access resources are available to a group of users, regardless of source subnet, VLAN, or other characteristics.

Network edge security services are provided through the solution and applied to each individual or device, rather than fixed to the switch port or SSID. Using role-based profiles, a user connecting to the network is authenticated and then a user profile is assigned that specifies all the network security behavior including access control lists (ACLs) and firewall rules. With this capability, wherever the user goes unique security rules will follow.

This solution provides tools for the administrator to create the policies just once, and then select both the OmniSwitch wired and OmniAccess Stellar wireless AP equipment and push the configuration to them at the same time. The OmniVista 2500 NMS backend workflow will translate the ACL requirements and issue the commands to all of the equipment. This eliminates the possibility of any errors being introduced (by having to repeat the process) and saves time and money by reducing the steps needed to provision the same network access rules to all equipment on the network.

Network topology

Figure 1: Network topology



AP deployment in dormitories

Student dormitories are independent, small spaces. Typically, there are 2-4 students in a room with approximately ten wireless clients. In this scenario the Alcatel-Lucent AP1201H is recommended for deployment. The AP1201H supports 2.4G and 5G dual radio frequencies, as well as the 802.11ac standard which meets the requirements to connect 32 clients concurrently.

AP quantity = M/2+N+(M+N)*5%

Explanation:

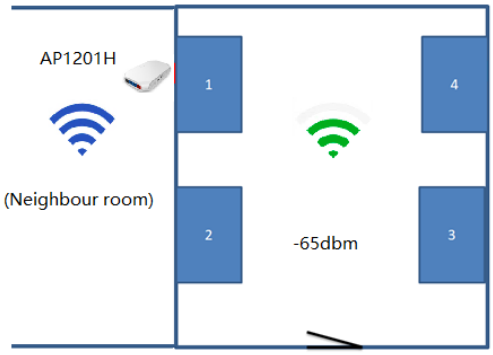
M is the number of dormitories with normal walls
N is the number of dormitories with a load-bearing wall
5% represents the redundant backup

Recommendations for deployment

The AP1201H maximum transmission power supported is 21 dBm for both the 2.4G and 5G bands and the gain of antenna is 4 dBm for 2.4G and 6 dBm for 5G frequency.

1. If the dormitory has a non-load-bearing wall where the attenuation of the wall is about 15 dBm, it is recommended that an AP be installed in every other room. A dormitory without an AP (as seen in the figure below) could result in the 5G band signal level reaching -65 dBm on position 2 and 3, which could meet the requirements for normal access.

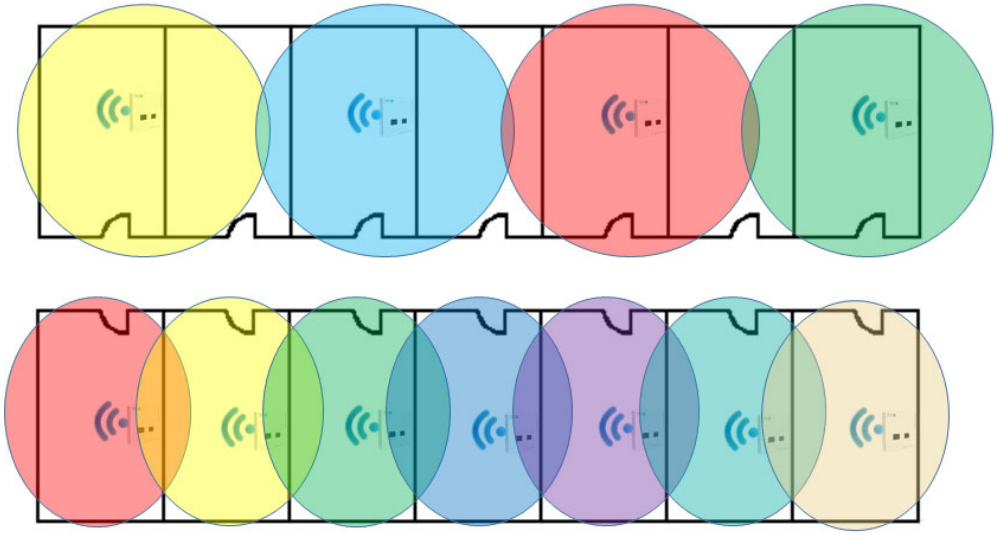
Figure 2: Dormitory without AP



2. If the dormitory has a load-bearing wall, such as in a tall building, the signal attenuation can reach more than 30 dBm which will reduce the 5G signal to -80 dBm in the neighboring room where there is no AP installed, making it not possible for the client to access the 5G signal. The 2.4G signal will also be below -70 dBm and while connection is possible the experience will be extremely poor, limited to web page access and instant messaging of text content, making is necessary to install APs in each dormitory room.

3. The AP should be mounted on the wall. The height should be 1.5 meters (5 feet) or higher, and should avoid signal attenuation caused by lockers, TVs and monitors.

Figure 3: Access point placement for visibility and proper RF planning



One of the key embedded technology features in the Stellar APs is called 'distributed intelligence' for optimal radio performance and ease of deployment. This feature is going to manage the radio optimization, the coordination among neighboring access points, the readings and the ability to select the right channel that avoids interference from other APs. It is going to manage the dynamic coverage adjustment to counteract AP failures informing the remaining access points to increase their power (always within the country emission limits) to try to cover the area previously covered by the failing AP.

Recommended configurations

Features	Configurations	Descriptions
RSSI threshold	2.4G RSSI :20 5G RSSI:15	The RSSI limit is configured to let clients connect to the closest AP
Roaming RSSI	2.4G RSSI :20 5G RSSI:15	The RSSI limit is configured to let clients to connect to the correct target AP
ACS	Enable	The AP performs dynamic monitoring and selects the best channel to reduce the workload as well as the network maintenance and optimization complexity
APC	Disable	In this relatively closed and independent environment, it is recommended that the APs transmission power be manually adjusted
Bandwidth setting	HT20 for 2.4G HT20 for 5G	When there are no requirements for mass clients and traffic it is recommended that the AP be configured to the HT20 mode in the 5G band to improve isolation between channels and reduce the interference between APs
Band steering	Enable	Band steering connects clients to 5G first and improves the user experience. It is recommended that this feature be enabled.
Traffic limitation	2mbps for upload 4mbps for download	Traffic limitation will prevent excessive use of bandwidth by a single client, and will improve the experience of the other wireless clients
BG-S	Disable	It is recommended that this feature be disabled unless there are special requirements for WIPS\ APC\fast roaming
Load balance	Enable	Load balancing can effectively balance the services between APs and improve network capacity
Voice/video awareness	Disable	Is not applicable as BG-S had been disabled
ATF	Disable	May reduce the user experience in dormitories where there is no AP installed

AP indoor stadium high density deployments

Colleges and university indoor sports stadiums require a medium-sized, high-density coverage deployment model. The typical capacity is approximately 1,500 users. The traffic mainly consists of instant messaging (such as Whatsapp, WeChat, Line, Facebook messenger, and Skype) and social applications (such as WeChat friends, Instagram, Facebook, and Twitter). There are no fixed high-traffic business requirements.

In this scenario, the concurrent rate of users usually does not exceed 50%, which means the number of concurrent users is about 750. It is recommended to use the Wi-Fi 5 AP, Alcatel-Lucent OmniAccess AP1231 or the Wi-Fi 6 AP, Alcatel-Lucent OmniAccess AP1321 for deployment. The AP1231 supports three RF cards working at the same time (2.4G 4x4 + 5G low band 4x4 + 5G High band 4x4) which is supported by a 2.5Gbps Ethernet port. The AP1321 supports three RF cards (2.4G 4x4 + 5G 4x4 + full band scanning) which is also supported by a 2.5G Ethernet port and mainly used in high-density enterprise-level indoor applications.

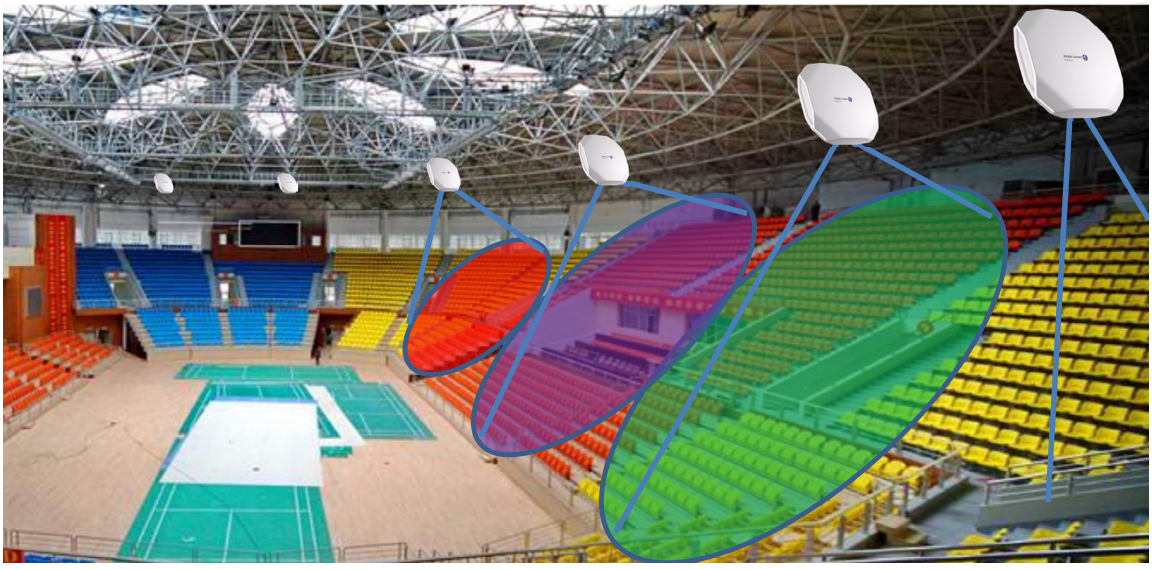
Number of APs: 8-10

Recommendations for deployment

The maximum transmission power supported for the AP1231 is 24 dBm both on 2.4G band and 5G bands, the gain of antenna is 4 dBm both on 2.4G and 5G band. The maximum transmission power supported for the AP1321 is 20 dBm/24 dBm on 2.4G/5G band, and the gain of antenna is 4 dBm both on 2.4G and 5G bands.

1. Based on the capacity and height of the stadium it is recommended that the AP be installed in the ceiling so that users in the front and rear rows will have a good experience. The second choice would be installation on a wall. See figure below.

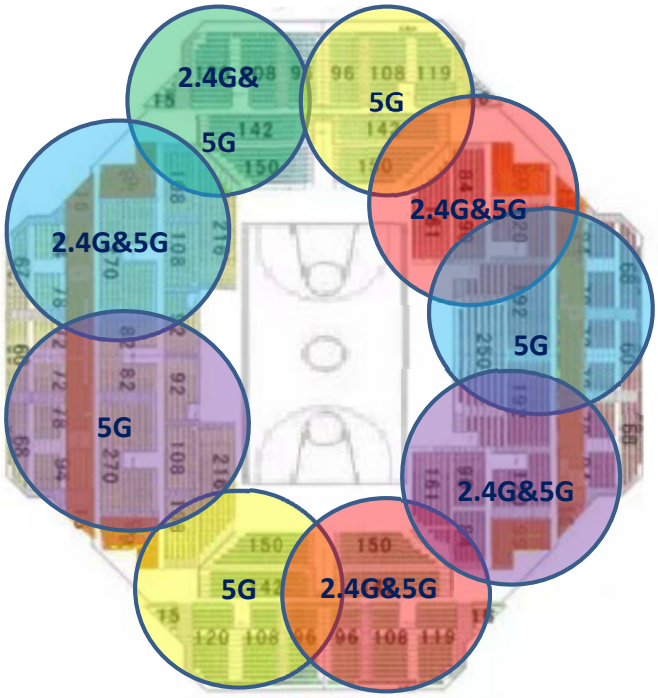
Figure 4: Access point installation recommendation for indoor stadium



2. The AP1231 and AP1321 support 1 Gbps and 2.5 Gbps Ethernet ports. It is recommended that the 2.5 Gbps be used as the uplink port in deployment. To achieve maximum AP1231 and AP1321 performance use a PoE switch that supports the 802.3 BT standards. Do not to use a 100Mbps network switch as an access switch to avoid bottlenecks on the wired side which will affect the overall network capacity and performance.

3. Since only three non-overlapping channels can be used for 2.4G band, use channels 1-6-11 to reduce internal interference at 2.4 GHz. It is recommended that the 2.4 G radio card be turned off on some APs in this deployment scenario to prevent co-channel interference. See figure below.

Figure 5: Site survey for RF coverage



Recommended configurations

Features	Configurations	Descriptions
RSSI threshold	2.4G RSSI :30 5G RSSI:30	The RSSI limit is configured to let clients connect to the AP, kick out clients with weak signals to avoid making a wrong connection, and improve the user experience for connected clients
Roaming RSSI	2.4G RSSI :30 5G RSSI:30	The RSSI limit is configured to let clients connect to the correct target AP to avoid making a wrong connection and ensure an improved user experience for connected clients
ACS	Disable	There will not be many APs in this closed, independent environment. It is recommended that the channel be manually configured to ensure best performance.
APC	Disable	There will not be many APs in this scenario, and the APs will be visible to each other. It is recommended that the AP's transmission power not be higher than 15 dBm.
Bandwidth setting	HT20 for 2.4G HT40 for 5G	It is recommended that the bandwidth setting be configured to HT40 mode in the 5G band to improve isolation between channels and reduce interference between APs
Band steering	Enable	Band steering connects clients to 5G first and improves the user experience. It is recommended that this feature be enabled.
Force to 5G	Enable	This feature will force clients to connect to 5G and will improve the user experience. Enabling this feature is recommended.
Traffic limitation	2mbps for upload 4mbps for download	Traffic limitation will prevent excessive use of bandwidth by a single client
BG-S	Disable	Disabling this feature is recommended unless there are special requirements for WIPS\APC\fast roaming
Load balance	Enable	Load balancing can effectively balance the traffic between APs and improve network capacity
Voice/video awareness	Disable	Not applicable when BG-S is disabled
Short Guard Interval (GI)	Disable	Short GI can increase the wireless transmission rate to a certain level. However, in an environment where there is an obvious multipath effect, the wireless signal will be delayed in the space due to multipath and other factors in the transmission. If the subsequent data block is sent too fast it will cause interference with the previous data block resulting in the signal not being correctly recognized by the receiving end and causing retransmission. This will reduce the transmission efficiency. In this scenario, it is recommended that the GI interval be configured to 0.8us for Wi-Fi 5 AP, and 1.6 us for Wi-Fi 6 AP.

AP deployment in classrooms

A medium-scale, high-density coverage deployment model is recommended in a classroom environment. The number of students may reach 40-60, 80-120, or 160-200 which corresponds to normal-sized classrooms, large-size classrooms and lecture halls, respectively.

Based on smart classroom requirements, the WLAN applications include local teaching, multi-screen collaboration and interaction, and audio and video applications, which involve unicast and multicast scenarios that require fixed high-traffic applications.

In this scenario, the number of concurrent wireless clients will reach 100%. The number of 2.4G and 5G clients is not proportionally fixed. Multimedia teaching requires that each client has at least 2Mbps of bandwidth. The AP1221 or AP1321 is recommended for this deployment. The AP1221 supports two RF cards (2.4G 2x2 + 5G 4x4). The AP1321 supports three RF cards (2.4G 4x4 + 5G 4x4 + full band scanning) which is supported by a 2.5G Ethernet port mainly used in medium-high-density enterprise-level indoor applications.

The number of APs required based on classroom size is as follows:

Room type	Number of clients	Recommended AP	Number of APs (PCS)
Lecture room_L1	40-60 clients	AP231/AP321	1
Lecture room_L2	80-120 clients	AP231/AP321	2
Lecture hall	160-200 clients	AP231/AP321	4

Recommendations for deployment

1. For any type of classroom, it is strongly recommended that the first option for mounting APs is to the ceiling. The second option is wall-mounting. See following figures:

Figure 6: AP ceiling mount in classroom deployments

Figure 7: AP wall mount in classroom deployments

2. In a wall-mounted installation the AP must be at the correct installation height and that it is visible to all wireless clients. Do not mount it too low or on the side of a load-bearing wall, which may cause rapid signal attenuation for some clients and will not offer the best performance. Incorrect installation methods are identified in the following figure.

Figure 8: Incorrect AP installation in classroom deployments

Recommended configurations

Features	Configurations	Descriptions
RSSI threshold	2.4G RSSI :30 5G RSSI:30	The RSSI limit is configured to let clients connect to the closest AP, make sure each client has a high RSSI value
Roaming RSSI	2.4G RSSI :30 5G RSSI:30	The RSSI limit is configured to let clients connect to the correct target AP to avoid making a wrong connection and ensure an improved user experience for connected clients
ACS	Enable	The AP performs dynamic monitoring and selects the best channel to reduce the workload and the complexity of network maintenance and optimization
APC	Disable	It is recommended that the AP transmission power be manually adjusted to not more than 10 dBm in order to reduce interference in the neighboring room
Bandwidth setting	HT20 for 2.4G HT80 for 5G	In a scenario of high concurrency and fixed high-traffic applications it is recommended that the 5G band be configured to HT80 mode to improve the AP capacity
Band steering	Enable	Band steering connects clients to 5G first and improves the user experience. It is recommended that this feature be enabled.
Force 5G	Enable	This will force clients connect to 5G and will improve the user experience Enabling this feature is recommended.
Traffic limitation	2mbps for upload 4mbps for download	Traffic limitation will prevent excessive use of bandwidth by a single client
BG-S	Disable	Disabling this feature is recommended unless there are special requirements for WIPS\APC\fast roaming
Load balance	Enable	Load balancing can effectively balance the traffic between APs and improve network capacity.
Voice/video awareness	Disable	Not applicable when BG-S is disabled

AP deployment for outdoor stadiums

A typical outdoor communication deployment model coverage area includes the stadium and field area platform and playgrounds. Traffic mainly includes instant messaging (such as Whatsapp, WeChat, Line, Facebook messenger, and Skype) and social applications (such as WeChat friends, Facebook, and Twitter). There are no fixed high-traffic business requirements.

In this scenario the concurrent rate of users does not usually exceed 20%, which means the number of concurrent clients is approximately 200. The Wi-Fi 5 AP, AP1251 or Wi-Fi 6 AP, AP1361 are recommended for deployment.

Number of APs: 6-8

Recommendations for deployment

1. For the stadium coverage, since the height of the ceiling from the seat is usually not more than 10 meters it is recommended that the AP be installed on the ceiling (the steel frame can be used for the installation). If there is a wall behind the stadium the AP may be installed on the wall for easy maintenance.

Figure 9: AP outdoor stadium installation

2. Usually 4-6 APs are required for coverage in the field area. Light poles around the field area can be used as installation points.

Figure 10: AP outdoor stadium

Figure 11: AP field area installation

3. Attention should be paid to waterproofing and lightning protection in outdoor environments

4. A PoE switch that supports the 802.3at standard should be used for the power supply.

Wi-Fi 6 for high density deployments

High-density coverage deployments and characteristics

In a high-density deployment the client capacity is very large and far exceeds a normal deployment scenario. High-density deployments include large-scale conference halls, stadiums, stations, and airport waiting areas. AP deployments are challenging in such scenarios.

Key Wi-Fi 6 feature benefits

Wi-Fi 6 inherits the advanced MIMO features of Wi-Fi 5 and offers some new features for high-density scenarios base on f Wi-Fi 5. These include the following key features:

- **Orthogonal frequency division multiple access (OFDMA)** which more efficiently shares channels to increase network efficiency and lower latency for both uplink and downlink traffic in high demand environments
- **Multi-user multiple input, multiple output (MU-MIMO)** which allows more downlink data to be transferred at once and enables an access point to handle a larger number of concurrent clients
- **160 MHz channel utilization capability** which increases bandwidth to deliver greater performance with low latency
- **1024-QAM** which enables throughput increases by encoding more data in the same amount of spectrum
- **Target wake time (TWT)** which enables scheduled sleep and wake times for better network efficiency and longer device battery life
- **Transmit beam forming** which improves signal power resulting in significantly higher rates at a given range

Key points for high-density coverage

High-density coverage is required to solve the issues of high performance and high interference between clients in a high-density environment. In this environment using ordinary APs can be a challenge. Using Wi-Fi 6 APs with related new features is a better solution. The main features are as follows:

- **Large-capacity AP which supports Wi-Fi 6 (802.11AX):** If users send data at 4Mbps each Wi-Fi 6 AP can provide the connections for more than 100 clients.
- **Channel reuse:** Visibility between wireless APs must be reduced when deploying Wi-Fi coverage in a high-density environment. Channel reuse and AP radio parameter adjustments can avoid weak signal interference on the same frequency from neighboring APs, reduce collisions and improve throughput. Experience suggests that in scenarios without fixed high-traffic, channel reuse provides greater benefits using HT20 bandwidth.
- **Optimize channel utilization:** One important factor affecting network capacity is channel utilization. If the channel utilization reaches 50% or greater before deployment the WLAN capacity will be significantly impacted. Channel utilization is driven by the following factors:
  - Interference from other WLAN systems such as ad-hoc personal Wi-Fi hotspots
  - Non-Wi-Fi signal interference such as Bluetooth or microwave ovens
  - Optimization of low transmission rate data frames and management frames

It is difficult to optimize AP configurations in the above first two points, which makes it very important to optimize the third point. In such a high-density scenario, it is recommended that the data frame and management frame be optimized separately, as well the data frame and management frame transmission rates must be increased appropriately.

- **Band Steering:** Although most clients now support 5GHz connection t there are still some clients that select the 2.4GHz channel when the 5GHz channel has not been used effectively. Band steering technology enables clients that support 5G to connect to 5G first. It can even force 5G clients to connect to the 5G channel using the 'Force 5G feature.
- **Airtime Fairness:** Airtime fairness lets all clients have same transmission timeslot and achieve higher wireless performance.

AP deployment principles in high-density scenarios

The AP deployment solution is very important in a high-density scenario. Following are the main deployment principles to be considered:

1. The wireless AP should be deployed as close to the clients as possible. When deploying an AP, visibility between wireless APs should be reduced to improve the signal strength between the AP and the clients. In scenarios where the height of buildings is much higher (such as railway stations), often exceeding 10 meters, it is not appropriate to install APs on the ceiling as there is no effective isolation between APs which means the signal strength from APs to clients will be poor. The AP should be deployed in a lowest place possible. Installing APs on the walls is a good choice.

2. Use fixed objects to isolate APs and improve channel reuse. For example, in a large conference hall people are better signal isolation objects. It is recommended to install the APs under the seat to meet the wireless access of the surrounding people and reduce interference with other APs. Load-bearing walls can also isolate APs.

3. If there are no isolated objects available in the scenario and there is an open environment for the clients, you can also choose directional antennas to improve the isolation between wireless APs and increase the signal strength for clients.

Note: Complete coverage for all areas is not required. It is important to ensure WLAN deployment in the main active areas. More APs will create more interference.

AP deployment in a large lecture hall

In a large lecture hall deployment, a stable and high standard Wi-Fi connection is required. In this scenario the concurrency rate is usually lower and there are no fixed high-traffic business requirements.

The Wi-Fi 6 AP, AP1321 is recommended for deployment. The AP1321 supports three RF cards (2.4G 4x4 + 5G 4x4 + full band scanning) which use 2.5G Ethernet ports. They are used mainly in high-density enterprise-level indoor applications. The number of APs depends on the size of the conference hall and the number of participants.

Recommendations for deployment

The AP deployment location should be as far away as possible from other equipment with a heavy current which would have a strong influence on the signal. AP deployment in a large conference hall can be handled in the following ways:

1. Ceiling installation is suitable for conference halls with a roof height that does not exceed 5m, as ceiling-mounted APs are not easy to maintain and calculating coverage ranges is difficult if the roof height is too high. Higher power settings will cause interference with other APs, and the lower power settings will lead to a poor negotiation rate which will affect the user experience. If aesthetics are an issue, the AP can be hidden and installed above the ceiling if installation conditions are met.

Figure 12: AP ceiling mount in conference hall

2. A wall-mounted installation is suitable for places with a width that does not exceed 30m. An appropriate AP installation height should be determined based on the distance to the coverage area.

Figure 13: AP wall mount in conference hall

3. Installation under or on the back of seats is suitable for wide conference halls. Wall-mounted APs will not provide full coverage and are not a good solution due to the RF signal being blocked by people in small coverage area of less than 5M. Since only three non-overlapping channels can be used for 2.4G band, channels 1-6-11 should be used to reduce internal interference. It is recommended that the 2.4 G radio card on some APs in this deployment scenario be turned off to prevent co-channel interference.

Recommended configurations

Feature	Configurations	Descriptions
RSSI Threshold	2.4G RSSI: 30 5G RSSI: 30	The RSSI limit is configured to let clients connect to the closest AP, kick out clients with weak signals to avoid making a wrong connection, and improve the user experience for connected clients
Roaming RSSI	2.4G RSSI: 30 5G RSSI: 30	The RSSI limit is configured to let clients connect to the correct target AP to avoid making a wrong connection and ensure an improved user experience for connected clients
ACS	Enable	The AP performs dynamic monitoring and selects the best channel to reduce the workload and the complexity of network maintenance and optimization
APC	Enable	If the AP is installed under, or on the back of the seat in this scenario, movement by the participants will lead to a signal change between APs. It is recommended that the APC function be enabled to allow the AP to dynamically adjust the transmission power to avoid coverage saturation.
Bandwidth setting	HT20 for 2.4G HT40 for 5G	It is recommended that the 5G band be configured to HT40 to improve the isolation between channels and reduce the interference between APs
Band steering	Enable	Band steering connects clients to 5G first and improves the user experience. It is recommended that this feature be enabled.
Force to 5G	Enable	This feature will force clients to connect to 5G and will improve the user experience. Enabling this feature is recommended.
Traffic limitation	2mbps/4mbps for upload/download	Traffic limitation prevents excessive use of bandwidth by a single client
BG-S	Enable	Background scanning is required to support ACS/APC. Recommended configurations are as follows: Scanning Interval: 900s Scanning Duration: 50ms

Feature	Configurations	Descriptions
Load balance	Enable	Load balancing can effectively balance the services between APs and improve network capacity
Voice/video awareness	Disable	Not applicable
Airtime Fairness	Enable	Airtime fairness lets all clients have the same transmission timeslot and achieve higher wireless performance
802.11b	Disable	Reject low-rate clients and improve 2.4G channel utilization
802.11g	Disable	Reject low-rate clients and improve 2.4G channel utilization
MGMT Rate control	24mbps	Increasing the MGMT rate will reduce the time taken by management frame transmission and improve the channel utilization
Client Rate Control	24mbps	Data frame rate control will reduce the time taken by low-rate date frame transmission and improve the channel utilization
Short Guard Interval (GI)	Disable	Short GI will increase the wireless transmission rate to a certain level. However, in an environment that has an obvious multipath effect the wireless signal will be delayed due to multipath and other factors in the space transmission. If the subsequent data block is sent too fast it will cause interference with the previous data block. This will result in the signal not being correctly recognized by the receiving end and causing retransmission, ultimately reducing transmission efficiency. In this scenario, it is recommended that the GI interval be configured to 1.6 us.

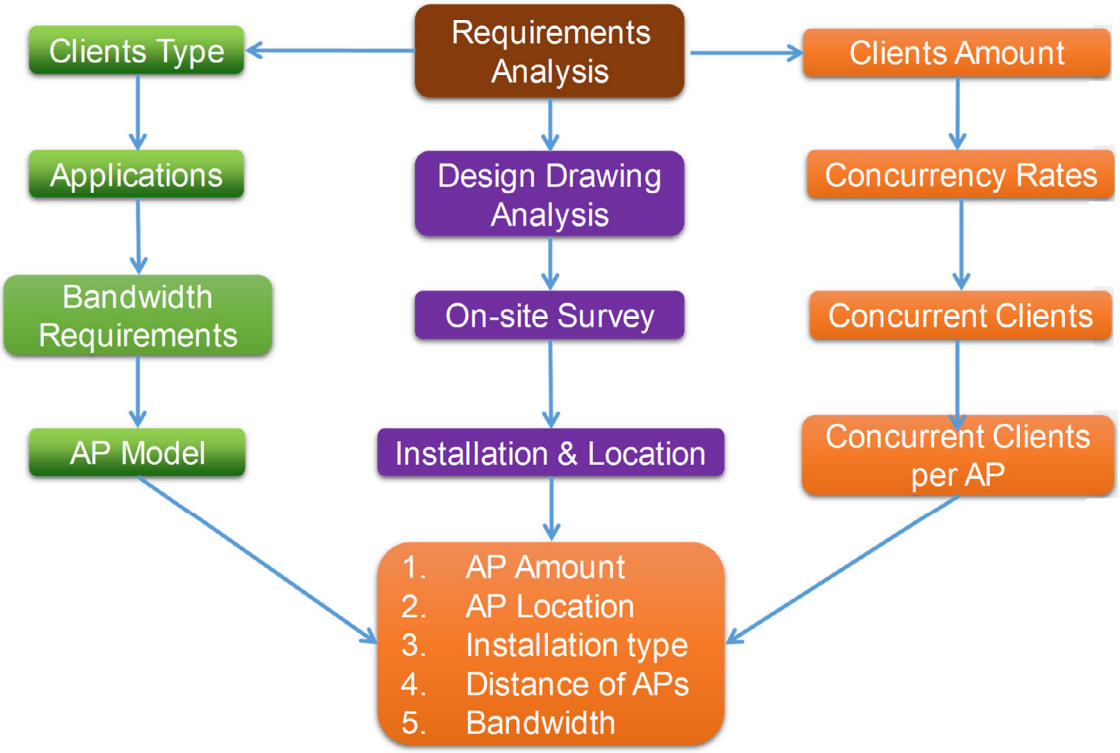
AP deployment in a large stadium

In a large professional sports stadium the number of visitors could exceed 50,000. The coverage area is required primarily in the spectator seating area. The application includes instant messaging (such as Whatsapp, WeChat, Line, Facebook messenger, and Skype) and social applications (such as WeChat friends, Facebook, and Twitter).

The Wi-Fi 6 AP, AP1321 and AP1361D are recommended for deployment. Both AP1321 and AP1361 support three RF cards (2.4G 4x4 + 5G 4x4 + full band scanning) which also provide a 2.5G Ethernet port. These are used mainly in high-density enterprise-level indoor/outdoor scenarios.

In large stadium deployments the concurrent rate of users usually does not exceed 30%, which means the number of concurrent users is approximately 15K. The number of APs required in this scenario is approximately 150-200.

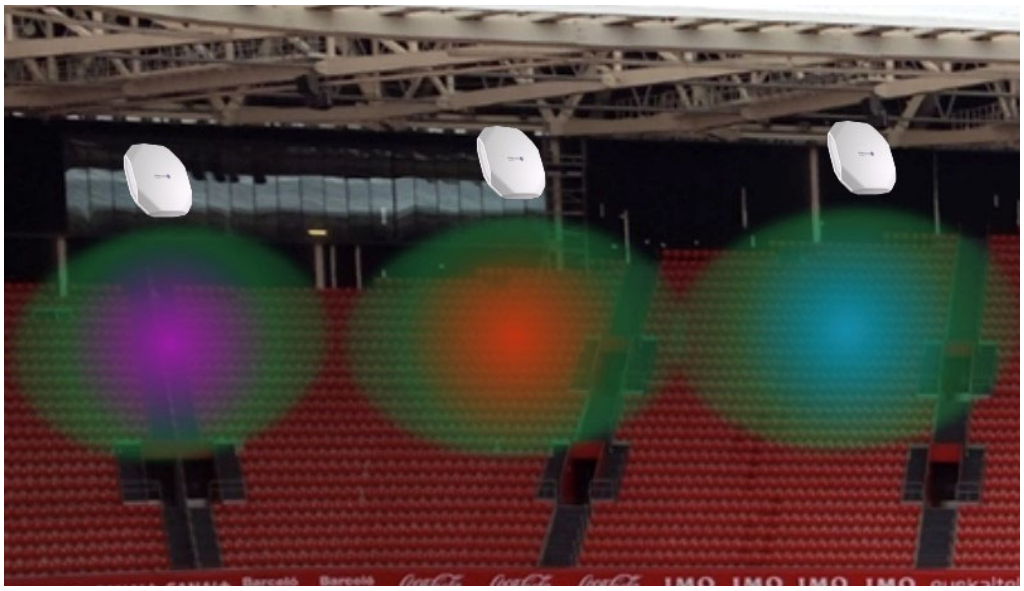
Figure 14: Capacity and deployment planning



Recommendations for deployment

1. Wall-mounted installation: APs should be installed in the wall near the last row of spectators. This will provide a wireless connection for clients at the back part of the stadium. APs installed in this location will be easy to maintain.

Figure 15: AP installation on the back wall of the stadium



2. Ceiling installation: APs installed on the ceiling above the last row on the first floor provide a wireless connection for the second half of the first floor.

Figure 16: AP installation on the ceiling of the stadium

3. APs installed under the seat: This deployment may be applied to the middle and front part of spectator area on each floor. APs must be protected from malicious destruction when they are installed in this location.

Figure 17: APs installation under spectator seating

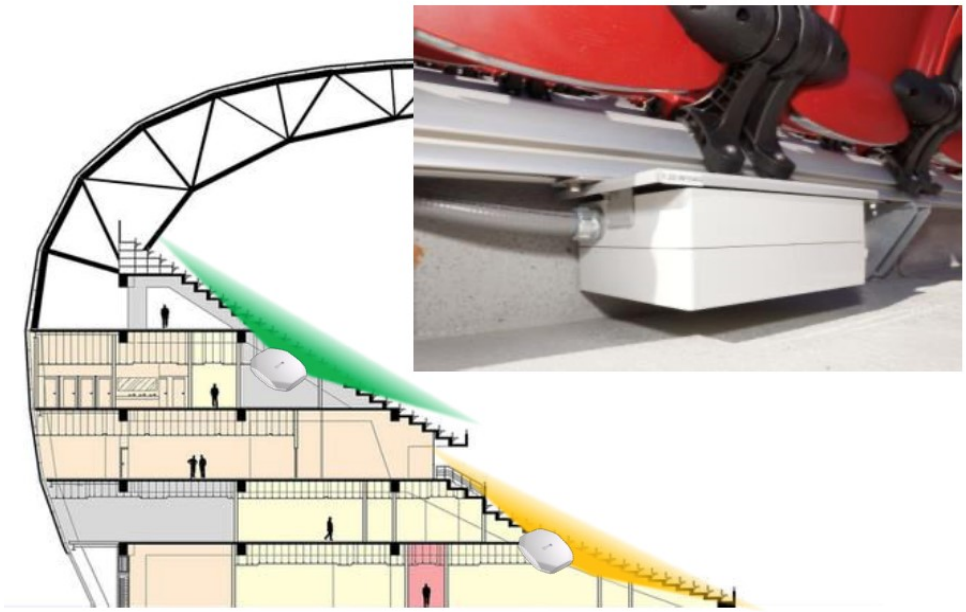
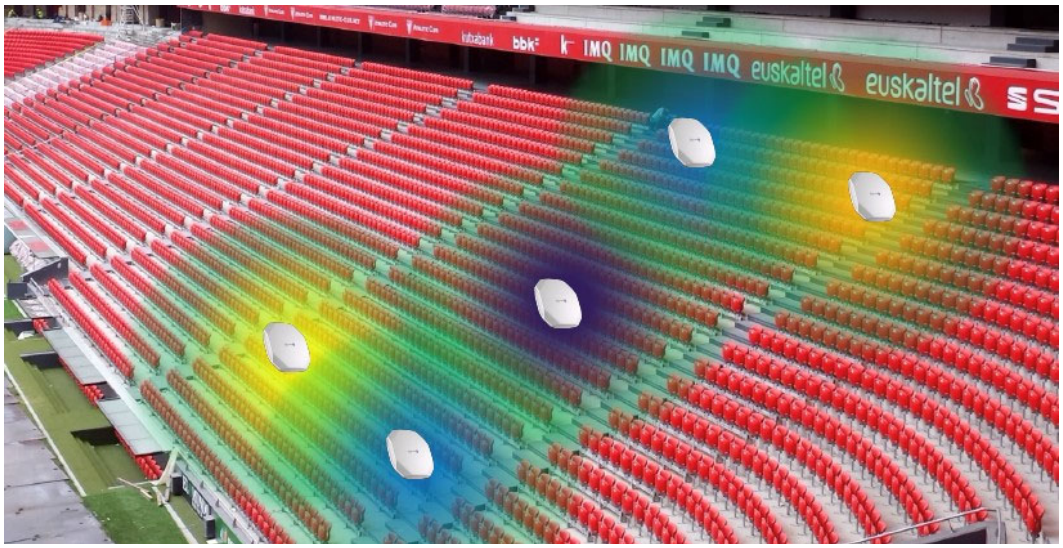


Figure 18: APs installation under spectator seating



4. APs installed on the steel frames on the stadium roof: This deployment provides network connection for clients in the middle and the front part on the upper floor. The AP1361 (D) is recommended for the deployment. The AP is not easy to maintain in this deployment.

Figure 19: AP installation on the steel frames on the stadium roof

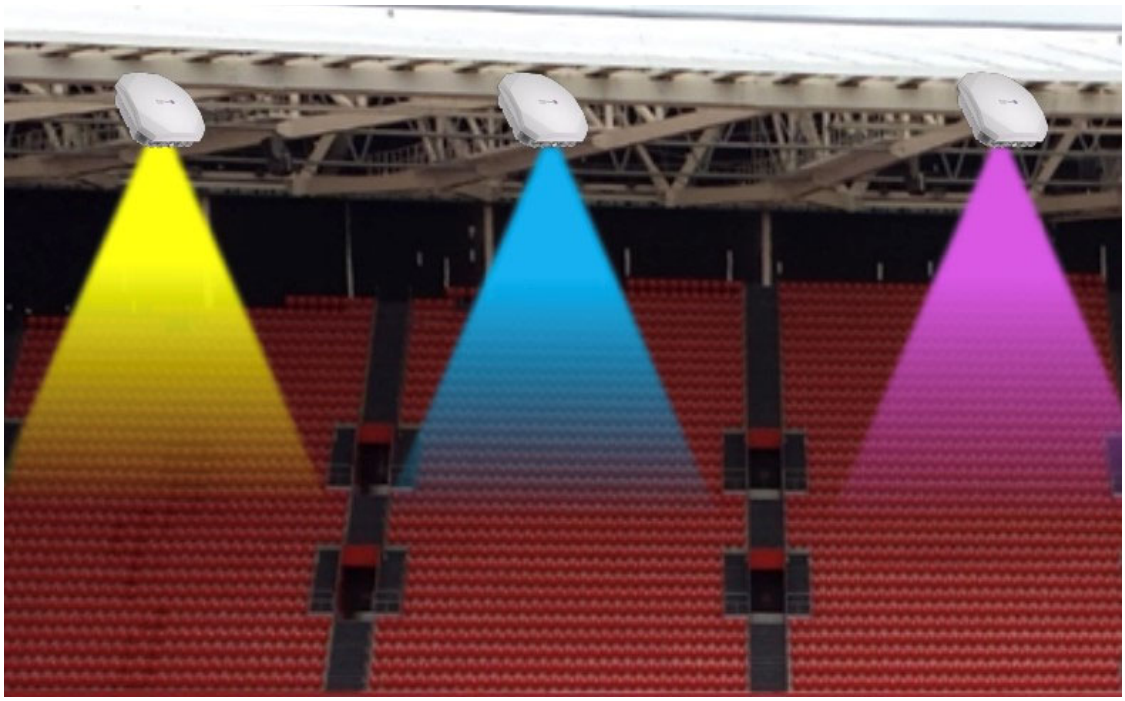
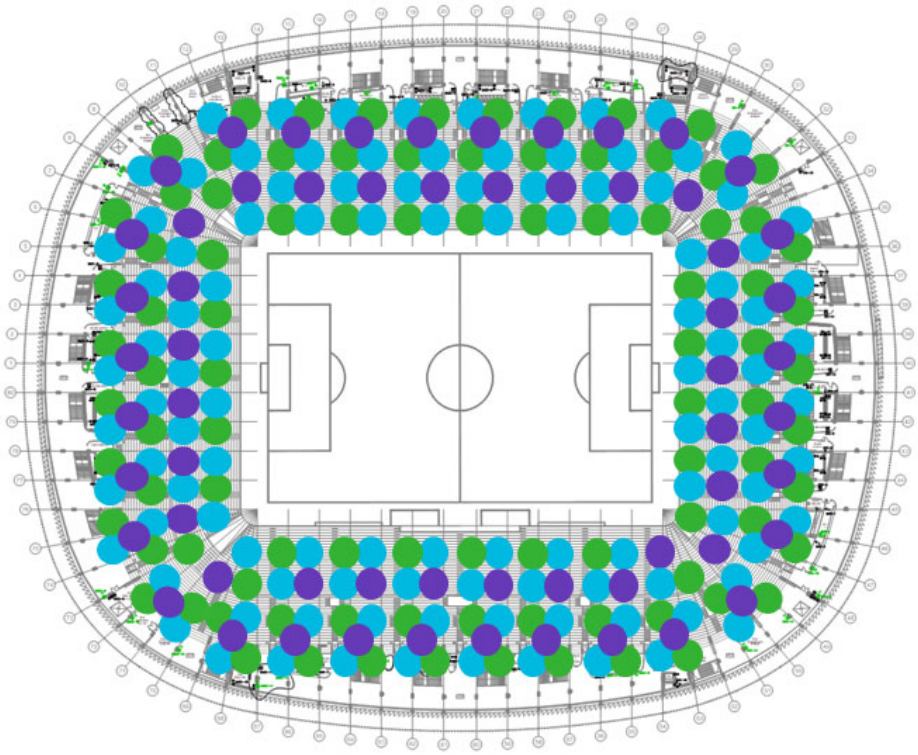


Figure 20: AP installation on the steel frames on the stadium roof

5. Since only three non-overlapping channels can be used for 2.4G band, use channels 1-6-11 to reduce internal interference at 2.4 GHz. It is recommended that the 2.4 G radio card on some APs be turned off in this deployment scenario to prevent co-channel interference.

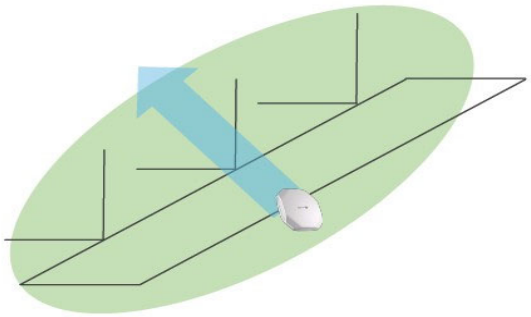
6. Please refer to the following schematic diagram for overall coverage.

Figure 21: Overall coverage



Note: AP installation in under-floor structures has been mentioned in some solutions, however, we do not recommend this deployment due to obstacles such as steel beams which can make deployment very complicated. In this scenario it is difficult to calculate the attenuation of wireless signals. The attenuation will be higher (> 30 dBm), which will cause a weak uplink signal and introduce a low transmission rate, reducing overall wireless performance.

Figure 22: AP under-floor installation (not recommended)



Recommended configurations

Feature	Configurations	Descriptions
RSSI Threshold	2.4G RSSI :30 5G RSSI:30	The RSSI limit is configured to let clients connect to the closest AP, kick out clients with weak signals to avoid making a wrong connection, and improving the user experience for connected clients
Roaming RSSI	2.4G RSSI :30 5G RSSI:30	The RSSI limit is configured to let clients connect to the correct target AP to avoid making a wrong connection and improving the user experience for connected clients
ACS	Enable	The AP performs dynamic monitoring and selects the best channel to reduce the workload and the complexity of network maintenance and optimization
APC	Enable	It is recommended that the APC function be enabled to allow the AP to dynamically adjust the transmission power to avoid coverage saturation
Bandwidth setting	HT20 for 2.4G HT40 for 5G	It is recommended that the 5G band be configured to HT40 to improve the isolation between channels and reduce the interference between APs
Band steering	enable	Band steering connects clients to 5G first and improves the user experience. It is recommended that this feature be enabled.
Force to 5G	Enable	This feature force clients to connect to the 5G radio, and will improve the user experience. Enabling this feature is recommended.
Traffic limitation	2mbps/4mbps for upload/download	Traffic limitation prevents excessive use of bandwidth by a single client which can reduce the experience of the other wireless clients
BG-S	Enable	Background scanning is required to support ACS/APC. Recommended configurations are as follows: Scanning Interval: 900s Scanning Duration: 50ms
Load balance	Enable	Load balancing can effectively balance the services between APs and improve network capacity
Voice/video awareness	Disable	Not applicable
Airtime Fairness	Enable	Airtime fairness lets all clients have the same transmission timeslot and achieve higher wireless performance

Feature	Configurations	Descriptions
802.11b	Disable	Reject low-rate clients and improve 2.4G channel utilization
802.11g	Disable	Reject low-rate clients and improve 2.4G channel utilization
MGMT Rate control	24mbps	Increasing MGMT rate will reduce the time taken by management frame transmission and improve the channel utilization
Client Rate Control	24mbps	Data frame rate control will reduce the time taken by low-rate date frame transmission and improve the channel utilization
Short GI	Disable	Although Short GI will increase the wireless transmission rate to a certain level, in an environment that has an obvious multipath effect, the wireless signal will be delayed due to multipath and other factors in the space transmission. If the subsequent data block is sent too fast it will cause interference with the previous data block. This will result in the signal not being correctly recognized by the receiving end and causing retransmission, ultimately reducing the transmission efficiency. In this scenario, it is recommended that the GI interval be configured to 1.6 us.

Glossary

1	AP	Access Point
2	SSID	Service Set Identifier
3	WLAN	Wireless Local Area Network
4	RSSI	Received Signal Strength Indicator
5	IGMP	Internet Group Management Protocol
7	ACS	Auto Channel Selection
8	APC	Auto Power Control
9	GI	Guard Interval
10	PSK	Pre-Shared Key

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