Trend Towards Stadium Wi-Fi

The Mobile Internet manifests itself by its ubiquitous high-speed Internet access and abundant types of mobile applications and services. Wi-Fi networks work as a supplement to 3G/LTE networks and balances the load of 3G/LTE networks. Due to their low cost and high bandwidth, Wi-Fi networks are widely popular and widely deployed in public places such as shopping malls, bars, hotels, and public squares.

A stadium is a typical high-density hotspot for a Wi-Fi network offering the following functions:

First, a Wi-Fi network facilitates communications between the stadium, fan club, and fans. With the help of a Wi-Fi network, the fans can access the local video server to relay the game and to interact with family members, friends, and other club members through social networking websites (microblog, WeChat, and Facebook). Through the stadium APP, the audience can query club or team member information, learn real-time game statistics, or obtain a schedule.

Second, a Wi-Fi network helps deliver business services by allowing an audience member to query and purchase game or concert tickets online or order food through a customized stadium APP during a game or concert. After the vendor receives the order, it will send the food directly to the fan. At the entrance or garage, the audience can use the indoor navigation system to find their seat or parking place.

Third, a Wi-Fi network increases stadium revenue by providing value-added services or by pushing advertising. Game reports and advertisements can be planted directly onto the Portal access page, stadium APP page, Wi-Fi SSID, or browser page, creating additional income for the stadium.

Last, a Wi-Fi network offers stadium employees a mobile office platform on which voice communications, mobile office applications, and other mobile communications are available for security personnel, sales staff, and game organizers, a great convenience for doing their job.

Unlike common office networks, the stadium Wi-Fi network is characterized by high-density, large capacity, and real-time service delivery, which makes its deployment complicated and demanding.

More specifically, the deployment of a Wi-Fi network in a stadium faces the following challenges:

First of all, the greatest challenge is the extremely high user density. Most stadiums have tens of thousands of seats; some world-renowned football stadiums are equipped with over 80,000 seats. Therefore, user density will be dozens or hundreds of times greater than in offices, dormitories, and hotels.

High user density requires that a Wi-Fi network provide large bandwidth and reliable core nodes, and be robust enough to defend against potential security threats from internal network terminals. Additionally, terminal behaviors must be effectively controlled on the Wi-Fi network.

Considering the enormous variety of users, terminals, services, and locations, a stadium Wi-Fi network must be able to recognize user identities, control user access, and deliver differentiated services.
Multi-user access scheduling

Multi-user Connection Access Control (CAC) controls user access based on the number of users connected to APs and channel usage. Such control is especially applicable to high-density scenarios. It can limit the number of users occupying the AP bandwidth and thus maximize user experience.

Control access of low-rate/weak-signal terminals

In a high-density scenario, some stations (STAs) may attempt to associate with distant APs; therefore, the APs may receive weak radio signals from the STAs. After associating with the APs, these STAs work at low rates, affecting overall network throughput. These weak-signal or low-rate STAs can be prevented from accessing the WLAN to reduce the impact of these STAs on the network as well as improve the overall WLAN performance.

Constructing a High-Density Wi-Fi Network

To fit well into a high-density stadium, a Wi-Fi network solution must offer end-to-end support capabilities and a comprehensive guarantee process that includes product capability, network planning, network deployment, configuration optimization, and testing and verification. Most importantly, the products and devices used must support high-density features and large bandwidth. In short, a Wi-Fi network plan must match stadium characteristics and access scenarios.

High-Density Wi-Fi Access Features

Huawei WLAN products integrate the latest 802.11 technologies, among which 802.11n, 802.11ac, MIMO, and implicit Beamforming greatly improve network throughput; also, a smart scheduling mechanism enables high-density access. The following paragraphs describe some of the scheduling technologies in detail:

Airtime scheduling: fair time scheduling

If low-rate terminals preempt the wireless channel ahead of high-rate terminals, high-rate terminals cannot operate at their maximum capacity. Airtime scheduling technology allows high-rate terminals to go first and periodically detects each terminal’s data sending time. It assigns equal time to all terminals, ensuring fairness in channel usage. With equal channel occupation time, high-rate terminals have more chances to transmit data.

APs implement cyclic scheduling of voice, video, and data services at low, medium, and high rates. The APs periodically detect terminal rates. A high-speed terminal is placed behind the low-rate ones if it works at a lower speed. Huawei products support the association between airtime scheduling and QoS scheduling. For wireless services, QoS scheduling (WMM) is implemented first, and then airtime scheduling.

Auto Radio: dynamic radio calibration

Movement of terminals within the stadium causes the radio environment to change frequently. Auto Radio adjusts the radio resources to ensure optimal access and high user bandwidth.

Auto Radio technologies include dynamic channel and power adjustment, dynamic load balancing, and automatic Clear Channel Assessment (CCA). Huawei’s CCA dynamically adjusts CCA threshold values based on the radio environment to improve channel efficiency and increase capacity.

High-Density Wi-Fi Network Plan

Proper network planning is the key to deploying a successful stadium high-density Wi-Fi network, but signal coverage where terminals are densely distributed is a not a deployment concern. A good network plan has to deal with the challenge of minimizing signal interference without compromising network capacity. A stadium has a complex structure, with stands of multiple layers in east, west, north, and south directions. The central lawn is sometimes used for concerts and also requires signal coverage. A massive number of APs must be deployed throughout the stadium, working on both 2.4 and 5 GHz channels. To avoid signal interference, the location of APs and channel design must meet deployment requirements.

A stadium Wi-Fi network plan involves the following aspects:

User bandwidth analysis

Video services require a bandwidth of 512 kbps and data services a bandwidth of 256 kbps. To ensure that mainstream applications run properly, the bandwidth must meet the following requirements:

<table>
<thead>
<tr>
<th>APP</th>
<th>Required Data Rate</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web</td>
<td>160-400 kbps</td>
<td>Size of a web page: 200 KB, delay: 4 to 10s</td>
</tr>
<tr>
<td>Video</td>
<td>280-560 kbps</td>
<td>Real-time services</td>
</tr>
<tr>
<td>Instant messaging</td>
<td>32-64 kbps</td>
<td>2 KB/Session, 0.5s.</td>
</tr>
<tr>
<td>Email</td>
<td>400 kbps</td>
<td>100 KB/Session, 2s</td>
</tr>
<tr>
<td>Social networking</td>
<td>200 kbps</td>
<td>50 KB/Session, 2s</td>
</tr>
<tr>
<td>VoIP</td>
<td>256 kbps</td>
<td>Real-time services, for example, 256 kbps GBR for Face Time</td>
</tr>
<tr>
<td>Game</td>
<td>200 kbps</td>
<td>25 KB, 1s</td>
</tr>
</tbody>
</table>
Capacity design

Usually, the number of APs is determined by two factors: coverage area and network capacity. A high-density scenario is capacity-limited but many APs need to be deployed in a high-density scenario. Therefore, the quantity of APs depends mainly on network capacity. The distance between APs must also be controlled to reduce interference.

To ensure good coverage, Huawei uses calculation rules for typical scenarios to calculate the number of APs and conducts comprehensive site surveys to create a detailed network design.

| Example: capacity design for the south stand |
|---------------------------------------------|-------------------|
| Average bandwidth required by each user     | 300 kbps          |
| Concurrent online users on a single AP      | 50                |
| Total number of users on the first layer of the south stand | 6,330 |
| Total number of users that concurrently use Wi-Fi services | 20% x 6,330 = 1,266 |
| AP quantity required                        | 1,266/50 = 25     |

AP deployment

AP deployment must match each stadium's unique structure. AP locations depend on the availability of acceptable locations and lack of signal interference and, each location needs to be approved by the customer. Three deployment modes are available: overhead, side, and floor.

- **Side mode:**
  - Advantages: The APs are easy to install and can be mounted in a line. Co-channel APs are far from each other, providing good anti-interference capability.
  - Disadvantages: The last row of seats is often near the ceiling and within reach of the APs, which must be protected from the fans.

- **Overhead mode:**
  - Advantages: APs are easy to install on bridleways. APs and terminals are mounted in line-of-sight of one another keeping penetration loss within the allowed range.
  - Disadvantages: It is difficult to install APs on high ceilings without bridleways or similar structures.

- **Floor mode:**
  - Advantages: AP signals attenuate due to obstacles. The AP coverage area can be controlled. Therefore, many APs can be deployed to connect more users.
  - Disadvantages: Obstacles between a terrace and terminals are complex; therefore, signal attenuation is hard to estimate.

Channel design

AP channels should be properly designed to prevent interference. When planning AP channels, avoid interference from other existing signals which can severely affect access quality.

Overall channel planning rules: Co-channel and adjacent-channel APs should be deployed far from each other to increase channel multiplexing efficiency. Additionally, interference between APs on the same layer or different layers should be considered.
Huawei Stadium High-Density Wi-Fi Solution

Deploying a Robust Network

Huawei recommends the agile campus network solution, which can build a high-bandwidth, reliable, and secure network for a stadium. Huawei’s agile campus network solution uses PoE switches as access switches to connect and provide power for APs, which simplifies AP installation. The access switches are enabled with 2 x GE uplinks to obtain the required access bandwidth. Agile switches function as the core switches and have Ethernet Network Processor (ENP) cards configured to offer native access controller (AC) functions. Next-generation USG6600 firewalls are utilized as the security resource center. Policy Center and Portal servers are deployed to implement unified policy control.

The agile campus solution features the following advantages:

- **Super large entry size:** ENP cards on Huawei’s agile switches support a large number of entries (including 1M MAC address, 256K ARP, 3M routing, and 128K multicast routing entries), supporting access for over 80,000 users.

- **Native AC:** Native AC provided by the agile switches enable customers to build wireless networks without additional AC hardware, reducing network construction costs. The agile switch is the first core switch in the industry that provides T-bit AC capabilities that avoid performance bottlenecks found on independent AC devices. The native T-bit AC capabilities achieve in-depth convergence of wired and wireless networks helping customers migrate their wireless networks to 802.11ac.

- **Security guarantee across the entire network:** The campus controller interoperates with the security resource center to provide security for the entire network. Security functions are not only implemented by egress firewalls. Additionally, the campus controller collects security events from the entire network, performs big data analysis, and automatically delivers security policies.

- **Ubiquitous services:** The campus controller associates with agile switches as well as the next-generation firewalls to realize multi-dimensional policy control, enabling provision of fine-grained rights and bandwidth policies for VIP users, employees, audience members, and VIP areas.

---

Designing a Smart Network with Flexible User Control

A Wi-Fi network covers both common and VIP areas in a stadium. In addition to delivering access to the fans, a Wi-Fi network has to deliver access services to VIPs and stadium staff members. Applications the audience may use include ordinary internet services, unique apps customized by stadiums and clubs, and video playback. Wireless terminals may include smartphones, customized devices, and laptops.

Through the association of network devices, Huawei agile campus network can identify users, their locations, service and terminal types in order to implement smart management and control accordingly:

- **Service guarantee for VIP users:** VIP users are assigned high priority, large bandwidth, and specific access rights.

- **Service guarantee for VIP areas:** Users in VIP areas are provided with high quality services, with high priority, bandwidth, and rights.

- **Policy control based on service type:** High priority and large bandwidth are allocated to URLs, services, or applications customized by the stadium. Malicious services or websites are assigned low priority, and related traffic is even blocked.

- **Portal page customization based on terminal type and location:** The stadium portal page displays the stadium map and/or game schedule and provides food and ticket information in the stand areas. The Portal page automatically adjusts to mobile phones, pads, and laptops, improving user experience.

- **Video service multicast design:** Video replay services are assigned high priority. Since multicast transmission across the entire network conserves network bandwidth, APs are configured to use a multicast-to-unicast conversion mechanism on wireless interfaces to transmit multicast data. This ensures high-quality video transmission on the wireless network.
Why Huawei

Huawei has 20 years of experience in the IP field and a full series of network products and solutions. As one of the world’s leading network solution providers, Huawei has an excellent long-term plan for network development and a firm determination to invest in the network field for the long run. Most importantly, Huawei has world-leading research capabilities, with world-class experts, and rich experience in setting pre-research network standards, and, Huawei’s chip development capabilities are growing leaps and bounds.