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Wi-Fi 6

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Preface

Author Introduction

Xia Zhou: Serves as documentation engineer for Huawei wireless local area network (WLAN) products. Since joining Huawei in 2010, Ms. Zhou has been dedicated to documentation development for Huawei data center switches, WLAN products, and campus network solutions. She has made significant contributions to developing the book *Enterprise Wireless Local Area Network Architectures and Technologies*.

About This Book

The Wi-Fi standard was first developed more than 20 years ago. Earlier Wi-Fi standards focused merely on increasing speeds, while the latest-generation Wi-Fi 6 extends to improving user performance in high-density scenarios. To this end, Wi-Fi 6 introduces various new technologies, such as orthogonal frequency division multiple access (OFDMA), uplink multi-user multiple-input multiple-output (UL MU-MIMO), basic service set coloring (BSS coloring), and target wake time (TWT). Such technologies allow Wi-Fi 6 to promise four times higher bandwidth and concurrency than Wi-Fi 5, as well as lower latency and better energy-saving capabilities.

This book describes the evolution of Wi-Fi standards, service challenges faced by Wi-Fi networks, and new technologies introduced in Wi-Fi 6. In this book, you will also find some frequently asked questions during the network upgrade to Wi-Fi 6, typical applications of Wi-Fi 6, and Huawei's next-generation Wi-Fi 6 access point (AP) products. Finally, this book will introduce you to the enhanced version of Wi-Fi 6 — Wi-Fi 6E.

Intended Audience

This book is intended for information and communications technology (ICT) practitioners, such as network engineers with a basic knowledge of Wi-Fi and operation experience. It is also worth reading for anyone with Wi-Fi service requirements or with a general interest in the next-generation Wi-Fi standard.

Symbol Conventions

Note Supplements important information in the main text. **Note** is used to address information not related to personal injury, equipment damage, or environment deterioration.

Caution Indicates a low-risk hazard that, if not avoided, could result in minor or moderate injury.

Table of Contents

Chapter 1

What Is Wi-Fi 6?

Abstract

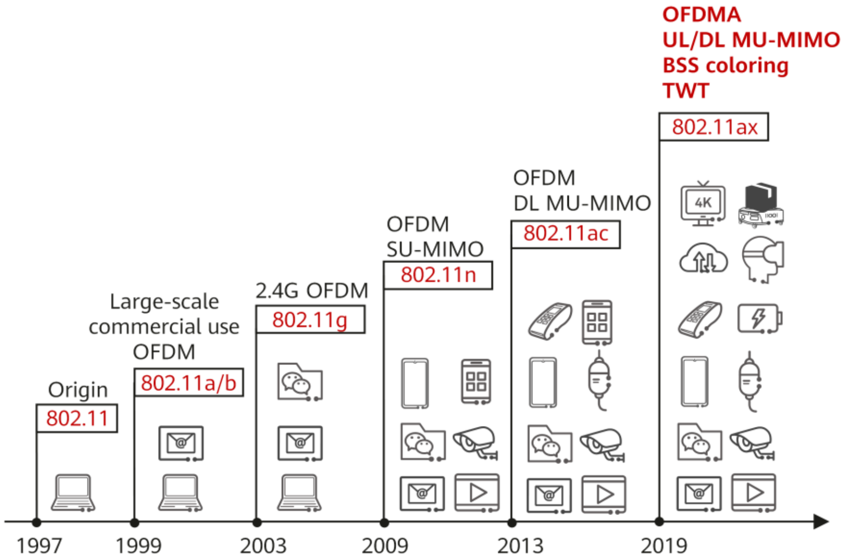
This chapter describes the evolution of Wi-Fi standards, the differences between the standards, and the Wi-Fi naming conventions.

1.1 802.11: Each Generation Is Better Than the Last

802.11ax is the latest-generation wireless local area network (WLAN) standard launched by the Institute of Electrical and Electronics Engineers (IEEE), a global standards developer. One of its best known standards is IEEE 802.3 (Ethernet), while IEEE 802.11 defines WLAN technology.

In as early as 1990, the IEEE set up a dedicated 802.11 Working Group to study and formulate WLAN standards. In 1997, the world's first 802.11 standard (802.11-1997) for WLAN was launched. Since then, the IEEE has released a new standard every four to five years, the latest being the 6th-generation 802.11ax standard, as shown in Figure 1-1.

Figure 1-1 802.11 standard evolution



- Standard origin: 802.11-1997 defeats other standards and is the first widely used WLAN standard in the industry.
- Standard enhancement: 802.11b makes the large-scale commercial use of WLAN possible by delivering speeds of 11 Mbit/s. 802.11a further increases the speed to 54 Mbit/s by applying orthogonal frequency division multiplexing (OFDM) technology to the 5 GHz frequency band.
- Standard extension and compatibility: 802.11g extends the use of OFDM technology to the 2.4 GHz frequency band and is backward compatible with 802.11b.
- High throughput (HT) standard based on multiple-input multiple-output (MIMO) and OFDM: 802.11n supports single-user MIMO (SU-MIMO) and OFDM, and delivers speeds of up to 600 Mbit/s.
- Very high throughput (VHT) standard: 802.11ac supports downlink multi-user MIMO (DL MU-MIMO), provides channel bandwidth of up to 160 MHz, and delivers speeds of up to 6933.33 Mbit/s.

- High efficiency WLAN (HEW) standard: 802.11ax introduces technologies such as orthogonal frequency division multiple access (OFDMA), uplink MU-MIMO (UL MU-MIMO), basic service set coloring (BSS coloring), and target wake time (TWT), further improving the throughput in high-density scenarios and increasing the speed to up to 9607.8 Mbit/s.

Table 1-1 compares capabilities of different 802.11 standards.

Table 1-1 802.11 standards comparison

Standard Version	Frequency Band (GHz)	PHY Technology	Modulation	Spatial Streams	Channel Bandwidth (MHz)	Data Rate (Mbit/s)
802.11	2.4	IR, FHSS, and DSSS	-	-	20	1 and 2
802.11b	2.4	DSSS/CCK	-	-	20	5.5 and 11
802.11a	5	OFDM	64-QAM	-	20	6 – 54
802.11g	2.4	OFDM DSSS/CCK	64-QAM	-	20	1 – 54
802.11n	2.4 and 5	OFDM SU-MIMO	64-QAM	4	20 and 40	6 – 600
802.11ac	5	OFDM Downlink MU-MIMO	256-QAM	8	20, 40, 80, 160, and 80+80	6 – 6933.33
802.11ax	2.4, 5, and 6	OFDMA UL/DL MU-MIMO	1024-QAM	8	20, 40, 80, 160, and 80+80	6 – 9607.8

Note

IR: Infrared

FHSS: frequency hopping spread spectrum

DSSS: direct sequence spread spectrum

CCK: complementary code keying

QAM: quadrature amplitude modulation

1.2 802.11ax = Wi-Fi 6

Wi-Fi 6 is the name of IEEE 802.11ax, as defined in the naming conventions released by the Wi-Fi Alliance for IEEE 802.11 standards. The Wi-Fi Alliance is a commercial organization that promotes and markets 802.11 standards as well as certifies interoperability of 802.11 products worldwide. Through rigorous testing, it checks the interoperability of products with other Wi-Fi certified products in various configurations. Its members include most producers of 802.11 equipment and some carriers, who are permitted to use the Wi-Fi trademark owned by the Wi-Fi Alliance to brand their certified products.

Figure 1-2 Wi-Fi generations

The Wi-Fi Alliance certifies 802.11-compliant technologies under the Wi-Fi CERTIFIED logo.

In 2018, the Wi-Fi Alliance decided to make WLAN standards easier to understand and remember. To this end, the organization renamed the standards in a manner similar to the different generations of mobile communications, which are called 3G, 4G, and 5G. Earlier 802.11 versions were also renamed in retrospect to align with this new naming convention, as shown in Figure 1-2.

Chapter 2

How Does Wi-Fi 6 Stand Out?

Abstract

This chapter describes challenges faced by Wi-Fi networks and how Wi-Fi 6 addresses these challenges by improving performance in high-density scenarios.

2.1 Challenges Faced by Wi-Fi

In the early stages of Wi-Fi technology development, Wi-Fi networks were used only as a supplement to wired networks and were only applied in certain scenarios, such as cafeterias, airports, and hotels, for guests to browse web pages and send emails. With the upgrade of Wi-Fi technologies and proliferation of mobile terminals, both common consumers and enterprise users are beginning to see the great potential of Wi-Fi technologies.

Specifically, mobile office is taking the lead in improving working efficiency for enterprises. Today, centering on fully wireless office, Wi-Fi networks have evolved from supplementing wired networks to being as essential as wired networks. In the future, more bandwidth-intensive services — such as enterprise cloud desktop office, videoconferencing, 4K video, virtual reality (VR), and augmented reality (AR) — will be migrated from wired networks to Wi-Fi networks.

These emerging services are usually bandwidth-hungry and latency-sensitive. For example, 4K video requires around 30 Mbit/s bandwidth for each terminal; latency-sensitive voice applications require less than 30 ms latency; VR service requires 50 Mbit/s bandwidth for each terminal and less than 15 ms latency.

Facing such challenges, a question that is often asked is, "is our existing Wi-Fi network ready for this?"

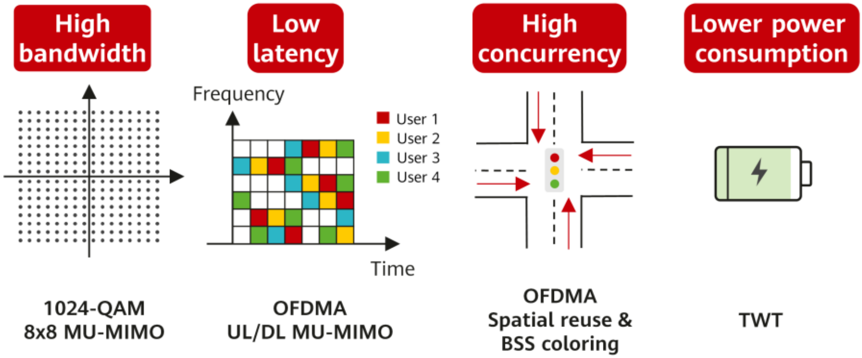
The answer is no. The existing Wi-Fi 5 network can provide high bandwidth. However, as more users access the network, throughput becomes a bottleneck. If the transmission delay occurs due to network congestion or retransmission, user experience will be greatly affected, with obvious deterioration to video quality.

Another obvious trend is the rapid growth and wide application of the Internet of Things (IoT). As the industry looks for ways to converge IoT and Wi-Fi, the two are evolving from coexistence to convergence, and ultimately normalization. How to best achieve this is a major area of research in the Wi-Fi field.

2.2 Key Technologies of Wi-Fi 6

Compared with Wi-Fi 5, Wi-Fi 6 stands out not only in its higher speeds but also in better user performance in high-density scenarios. Figure 2-1 shows various technologies adopted in Wi-Fi 6 to improve performance.

Figure 2-1 Wi-Fi 6 performance improvement



High Bandwidth

Over the last 20 years, Wi-Fi has become exponentially faster. Wi-Fi 6 leverages various "speed boosters", such as higher-order 1024-QAM, more subcarriers and spatial streams, and longer symbol duration. The end result is a theoretical speed of 9.6 Gbit/s at 160 MHz channel bandwidth, nearly 900 times faster than the first generation of Wi-Fi (802.11b).

Low Latency

OFDMA and BSS coloring technologies introduced in Wi-Fi 6 reduce latency to as low as **20 ms**, much lower than that in Wi-Fi 5 (30 ms latency). OFDMA reduces channel conflicts and improves spectrum utilization, and BSS coloring reduces co-channel interference. This makes Wi-Fi 6 ideal for latency-sensitive applications such as VR/AR, panoramic live broadcast, interactive gaming, immersive conferencing, and HD wireless projection.

High Concurrency

Wi-Fi 6 introduces multi-user technologies, such as OFDMA and UL MU-MIMO, to improve spectrum utilization. Compared with Wi-Fi 5, Wi-Fi 6 achieves a **four-fold** increase in the concurrent connections.

Energy-Saving

As the number of IoT terminals increases, so too does their power consumption. In addition to improving user experience, Wi-Fi 6 focuses on power consumption of terminals in addition to the speed improvement.

Wi-Fi 6 uses TWT technology to save power by waking terminals up on demand. TWT, together with 20 MHz-only technology, improves the battery life of terminals by **30%**.

Chapter 3
OFDMA

Abstract

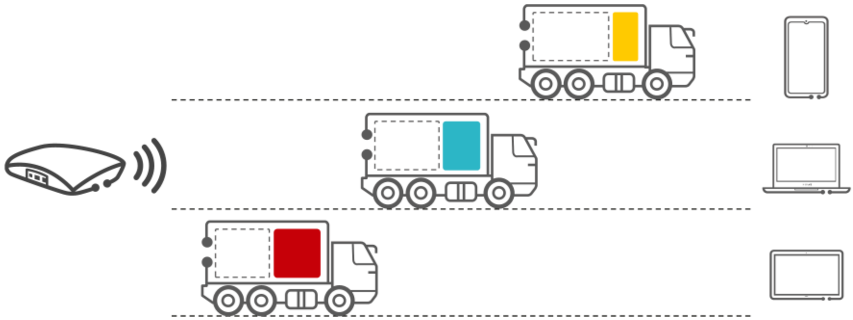
This chapter describes how Wi-Fi 6 introduces OFDMA, the differences between OFDMA and OFDM, and the resource unit (RU) — the minimum transmission unit in OFDMA.

3.1 OFDMA Fundamentals

One of the key differences between Wi-Fi 6 and Wi-Fi 5 is that the former introduces the multi-user technology — OFDMA, which makes it possible for users to improve spectrum utilization by sharing channel resources.

We can view OFDMA as a multi-user version of OFDM, which is a single-user transmission technology. This means that each time data is sent, one user occupies the entire channel regardless of the user data amount. Let's imagine Wi-Fi communication is express delivery, and information represents the goods to be transported to the receiver. In OFDM, the van delivers one package per trip, regardless of its size. As a consequence, some of the space in the van is usually wasted, as shown in Figure 3-1.

Figure 3-1 Multi-user transmission in Wi-Fi 5



To make better use of the van's space, Wi-Fi 6 introduces OFDMA, which is essentially a multiple access technique. Put differently, it divides channel resources into multiple RUs. Different users are allocated these RUs, which carry their respective data. In this way, the data of multiple users can be sent on one channel simultaneously.

Let's revisit the delivery van analogy. With OFDMA, the van is divided into several compartments to simultaneously carry different packages. As such, it can deliver several packages to different receivers on a single trip, as shown in Figure 3-2.

Figure 3-2 Multi-user transmission in Wi-Fi 6

To sum up, OFDMA is a multi-user technology that allows an AP to communicate with multiple users during one transmission period. For instance, if an AP needs to communicate with three users, three transmission periods are needed with OFDM, whereas only one is required with OFDMA.

3.2 Minimum Transmission Unit: RU

As previously mentioned, the RU is the minimum transmission unit in OFDMA. The next section delves into how RUs are divided.

Tone

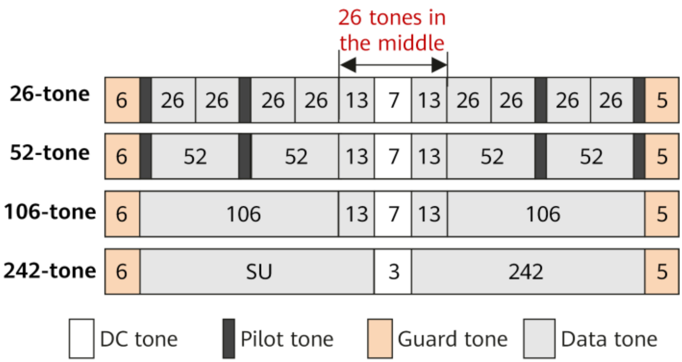
Before we discuss how RUs are divided, we first need to describe the concept of tone. Wireless signals are transmitted on fixed frequencies, which are also known as carriers, and the 802.11 standard further divides these frequencies into subcarriers (tones). For example, a 20 MHz channel in Wi-Fi 6 is divided into 256 tones, with 78.125 kHz spacing, which represents only one quarter compared to Wi-Fi 5 (312.5 kHz). Among these tones, 234 data tones are used for transmission, 7 direct current (DC) tones (located at the spectrum center) are used for identification only, 4 pilot tones are used for functions such as channel estimation, and 11 guard tones are used to provide guard intervals (GIs).

RU Division

To simplify OFDMA-based scheduling, Wi-Fi 6 defines seven types of RUs: 26-tone RU, 52-tone RU, 106-tone RU, 242-tone RU, 484-tone RU, 996-tone RUs, and 2x996-tone RUs.

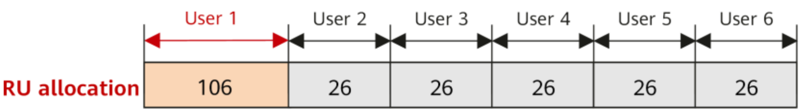
Figure 3-3 shows the different types of RUs supported by a 20 MHz channel.

Figure 3-3 RU division for a 20 MHz channel



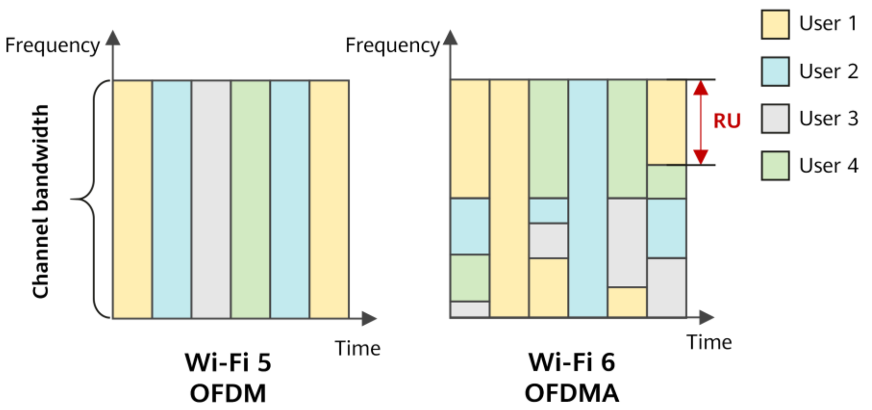
In practice, different types of RUs can be used together. For example, a 20 MHz channel is allocated to users 1 to 6, as shown in Figure 3-4. A 106-tone RU is allocated to user 1 and 26-tone RUs are allocated to the other users.

Figure 3-4 Multi-user RU allocation



Only one user can occupy a channel in Wi-Fi 5 at a time, while RU allocation allows multiple users to share a Wi-Fi 6 channel, as shown in Figure 3-5.

Figure 3-5 Channel occupation comparison in OFDM and OFDMA modes



In addition to the 20 MHz channel, the 40 MHz, 80 MHz, and even 160 MHz channels can also be divided into various RU combinations, as listed in Table 3-1. If a 160 MHz channel is only divided into 26-tone RUs, then theoretically, it allows an AP to communicate with a maximum of 74 terminals simultaneously.

Table 3-1 RU allocation for channels with different bandwidths

RU Type	20 MHz Channel	40 MHz Channel	80 MHz Channel	160 MHz Channel	80+80 MHz Channel
26-tone	9	18	37	74	74
52-tone	4	8	16	32	32
106-tone	2	4	8	16	16
242-tone	1	2	4	8	8
484-tone	-	1	2	4	4
996-tone	-	-	1	2	2
2x996-tone	-	-	-	1	1

Chapter 4

MU-MIMO

Abstract

This chapter describes the selling points of MU-MIMO, defines *M*x*N* MIMO, and details the relationship between OFDMA and MU-MIMO.

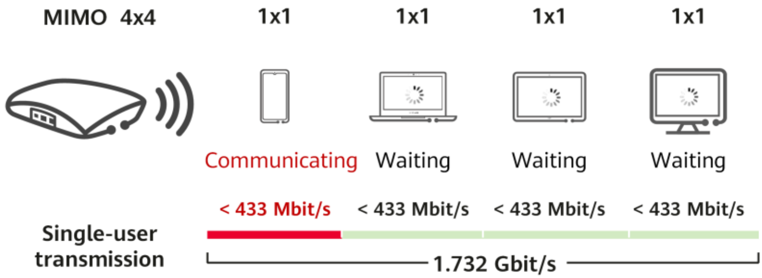
4.1 MU-MIMO Fundamentals

What Is MU-MIMO?

MU-MIMO is another multi-user technology utilized by Wi-Fi 6, and it was first introduced in Wi-Fi 5.

Practically speaking, we cannot require the APs and terminals on a Wi-Fi network to have the same number of antennas. This is because APs typically have three or four antennas, whereas most terminals (such as mobile phones) have only one or two. As a result, the APs and terminals are unable to make the most of channel resources. Case in point is a Wi-Fi 5 Wave 2 AP that supports 4x4 MIMO and provides a maximum theoretical speed of 1.732 Gbit/s (theoretical speed of each spatial stream: 433 Mbit/s). When it communicates with a mobile phone (1x1 MIMO), the maximum theoretical speed is only 433 Mbit/s as just one spatial stream is available between them, meaning a speed of 1.3 Gbit/s is unused. On top of that, an AP can only communicate with one user at a time, further decreasing the single-user rate. Figure 4-1 demonstrates the preceding single-user transmission.

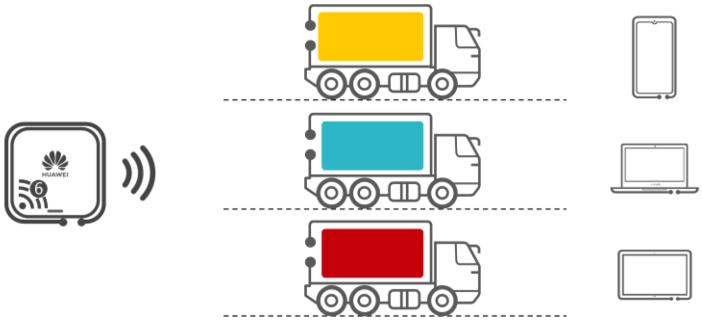
Figure 4-1 Single-user transmission



Wi-Fi 5 introduced MU-MIMO to bridge the MIMO gap. This technology enables an AP to communicate with multiple terminals simultaneously, thereby fully utilizing the AP's capacity.

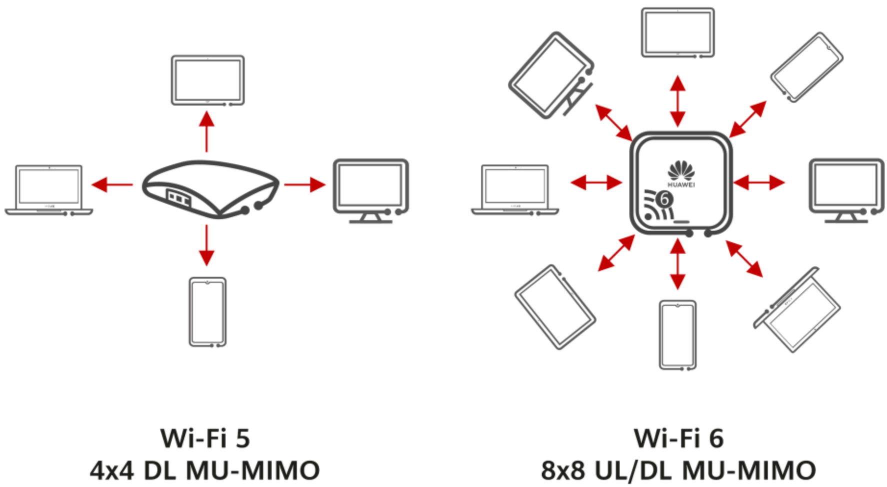
Let's reuse the delivery van analogy. Imagine that Wi-Fi 4 is a single van that only delivers goods to one receiver per trip. Wi-Fi 5 and Wi-Fi 6 are an upgraded fleet of vans, which an AP can now use to deliver goods to multiple receivers, as shown in Figure 4-2.

Figure 4-2 Multi-user transmission in MU-MIMO



As shown in Figure 4-3, in Wi-Fi 5, an AP can simultaneously communicate with a maximum of four terminals in the downlink, whereas Wi-Fi 6 allows simultaneous communication with up to eight terminals in both the downlink and uplink, further increasing the transmission rate.

Figure 4-3 MU-MIMO of Wi-Fi 5 and Wi-Fi 6



What Is *M*x*N* MIMO?

A WLAN device's MIMO capabilities are typically represented by *M*x*N* MIMO, where *M* represents the transmit (Tx) antennas and *N* represents the receive (Rx) antennas in a MIMO system. Signals are transmitted between the Tx and Rx antennas over spatial streams; however, the number of available spatial streams depends on the number of Tx or Rx antennas (whichever is lower). For example, a 4x4 (4T4R) MIMO system supports a maximum of four spatial streams, whereas a 3x2 (3T2R) MIMO system supports only one or two spatial streams (as only two Rx antennas are available).

A three-number syntax is sometimes used when describing MU-MIMO capabilities, with the third number after the colon indicating the number of users in an MU group. For instance, in a 4x4:4 MU-MIMO system, four spatial streams are destined to four MU-MIMO-capable users.

4.2 MU-MIMO and OFDMA: Competitive or Complementary?

Differences Between OFDMA and MU-MIMO

Both MU-MIMO and OFDMA can perform serial-to-parallel conversion to enable more efficient connectivity in multi-user scenarios, and they complement each other while also exhibiting unique characteristics.

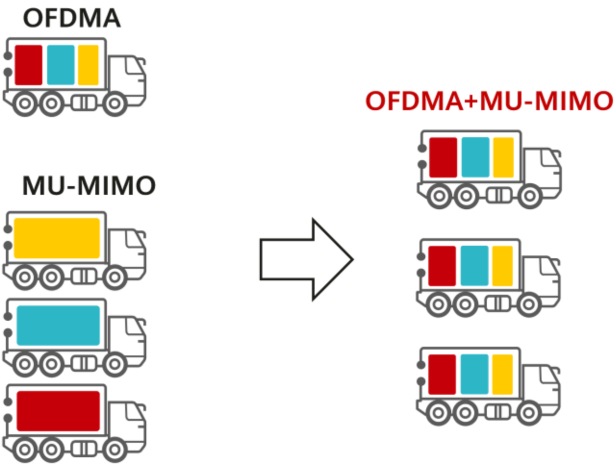
- **MU-MIMO**: **physically** divides network resources to increase capacity and efficiency in high-bandwidth applications such as video streaming and download. This technology increases spatial stream utilization and effective bandwidth while also lowering latency. That said, the MU-MIMO system is not sufficiently stable and is prone to impact from terminals.
- **OFDMA**: supports multi-channel transmission in the **frequency domain** and is ideal for low-bandwidth, small-packet applications such as web browsing and instant messaging. It increases spatial stream utilization and transmission efficiency while also reducing application latency and queuing

time. Unlike MU-MIMO, this technology is stable and resilient to impact from terminals.

Relationship Between MU-MIMO and OFDMA

Can MU-MIMO and OFDMA be used together?

Figure 4-4 OFDMA + MU-MIMO joint scheduling



Yes, they can. MU-MIMO and OFDMA are not mutually exclusive; on the contrary, they complement each other. Phrased differently, OFDMA + MU-MIMO joint scheduling optimally allocates resources based on services (such as web browsing, video streaming, download, and instant messaging). With a proper algorithm design, this joint scheduling mode reduces the conflicts caused by random uplink/downlink access and enhances user experience in densely populated scenarios, as shown in Figure 4-4.

Chapter 5

BSS Coloring and Spatial Reuse

Abstract

This chapter describes why an overlapping basic service set (OBSS) is generated and how BSS coloring addresses medium contention overhead caused by OBSSs, thereby implementing spatial reuse.

5.1 OBSS

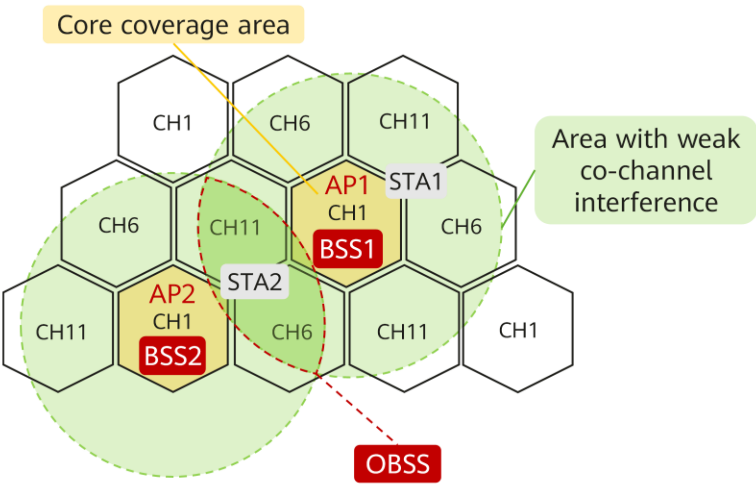
Unlike wired communication, wireless communication is inherently prone to **interference**. In wired communication, signal collision between transmitters can be detected using high and low levels on cables. However, it goes without saying that we cannot do this in wireless communication. To mitigate interference in wireless communication, 802.11 has introduced a MAC-layer detection mechanism — carrier sense multiple access with collision avoidance (CSMA/CA).

Conceptually, CSMA/CA views all stations on the **same channel** as participants in a "radio transmission roundtable." Stations must listen first, wait their turn, and then transmit data, ensuring they do not cause interruption in their radio environment before starting transmission. Contention overhead refers to the valuable airtime consumed by this transmission delay.

As the number of terminals on Wi-Fi networks skyrockets, high-density AP deployments have become the norm. Unfortunately, we can only work with a limited number of channels, and many of these APs may end up working on the same channel. For this reason, too many APs and terminals hear each other on the same channel, causing unnecessary medium contention overhead. Let's return to the roundtable example. Even when two participants are just whispering, everyone has to wait for them to finish. In other words, within a specific period of time, only one terminal or AP can transmit data, regardless of whether they are located in the same physical area.

In Figure 5-1, AP1 and AP2 are on the same channel and can listen to each other. This means that they cannot communicate with their associated terminals simultaneously, even though they are in different BSSs. In this case, an OBSS is generated between BSS1 and BSS2. To address co-channel interference generated by the OBSS, Wi-Fi 6 improves spatial reuse by introducing BSS coloring.

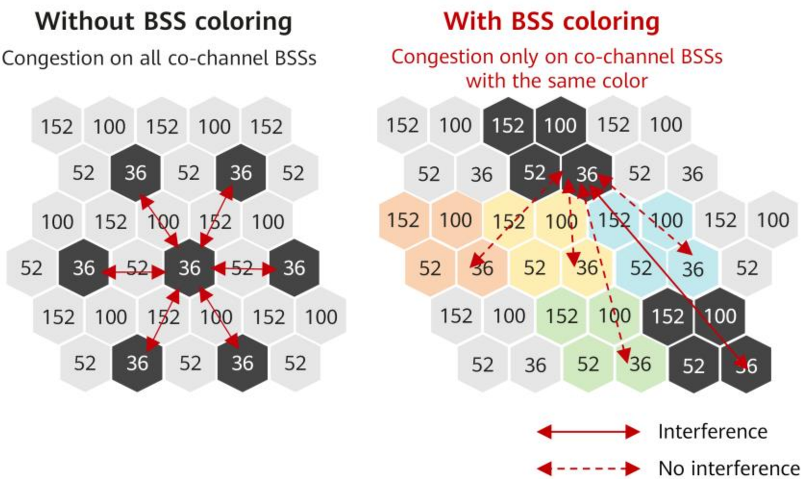
Figure 5-1 OBSS



5.2 BSS Coloring

BSS coloring allows a Wi-Fi 6 network to tag channels with colors, which is like sealing frames from different APs in envelopes of different colors. Upon receiving a frame in such an envelope, a receiver can directly determine whether it is from the same BSS, without opening the envelope. If it is from the same BSS, the receiver can process the frame as required; otherwise, it does not initiate a new transmission, significantly reducing unnecessary backoffs and achieving spatial reuse.

Figure 5-2 Co-channel BSS congestion before and after BSS coloring is performed



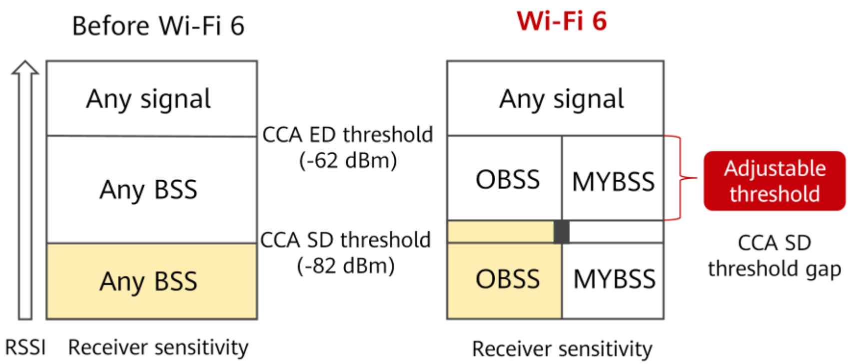
APs on the same channel will not interfere with each other provided that their channels are marked with different colors. For example, as shown in Figure 5-2, APs on black channel 36 and gray channel 36 can transmit data simultaneously.

Implementing BSS coloring on a Wi-Fi network is easier said than done. A wireless access controller (WAC) allocates color flags to APs, which then place a 6-bit BSS color field in the PHY and MAC headers of frames, enabling them to distinguish intra-BSS (also known as MYBSS) frames from inter-OBSS (that is, OBSS) frames.

Before Wi-Fi 6 arrived on the scene, CSMA/CA used a clear channel assessment (CCA) mechanism to detect whether a channel is idle. CCA defines two thresholds: **signal detection (SD)** and **energy detection (ED)** thresholds. The **SD threshold** is used to detect whether any station is transmitting data, and the **ED threshold** is used to detect whether the radio environment is noisy.

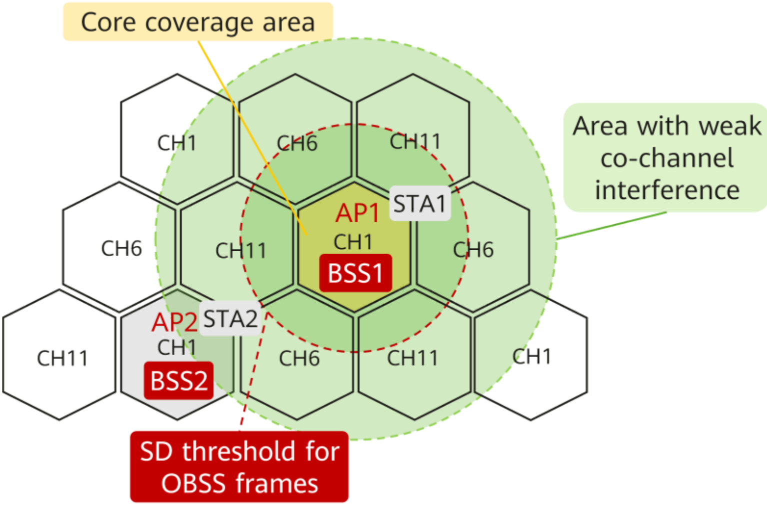
Wi-Fi 6 has introduced two SD thresholds for MYBSS and OBSS frames, as shown in Figure 5-3.

Figure 5-3 Dynamic CCA thresholds



- For MYBSS frames, the SD threshold should be set as low as possible to ensure MYBSS frames are received without loss.
- For OBSS frames, the SD threshold should be set higher. A terminal considers a channel to be interference-free and open for communication provided that the signal RSSI is within the specified SD threshold. This makes it possible for the terminal and AP to continue communicating with each other, as shown in Figure 5-4, thereby achieving spatial reuse.

Figure 5-4 Adjusting the SD threshold for OBSS frames



Chapter 6

Energy Saving

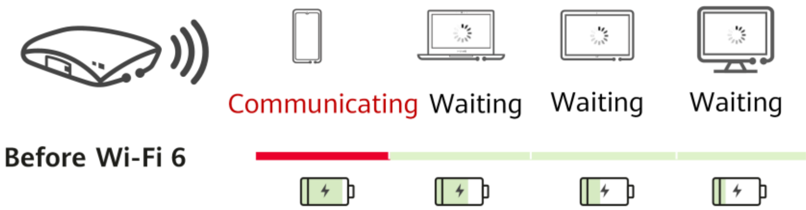
Abstract

This chapter describes the main energy-saving technologies of Wi-Fi 6: TWT for reducing the service period (SP) of terminals and operating mode indication (OMI) for reducing the power consumption of terminals during the SP.

6.1 TWT

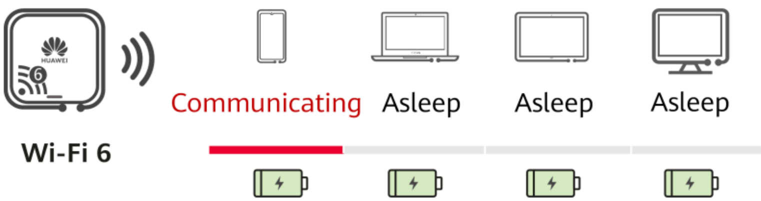
Energy-saving for terminals is another important concern of Wi-Fi 6.

Figure 6-1 Energy-saving mode before Wi-Fi 6



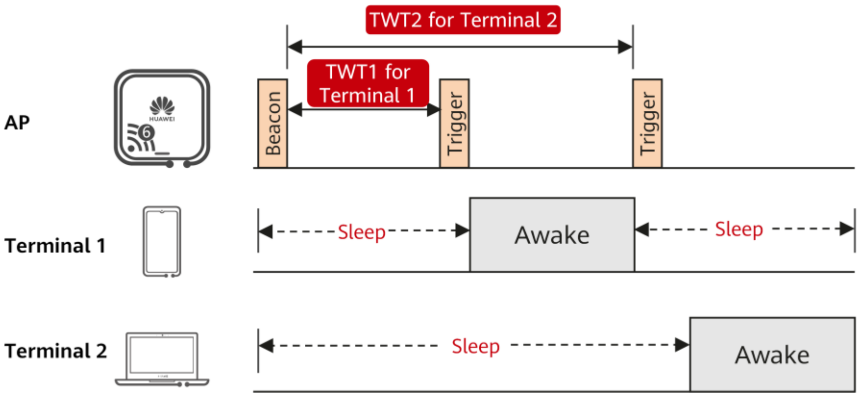
Energy saving mechanisms have existed since Wi-Fi 4. As shown in Figure 6-1, within a beacon period, a terminal checks whether any data is sent from an AP. If so, the terminal stays awake until it receives all the data, and then it enters the sleep mode. That said, some terminals with low traffic volume (such as smart meters) might waste energy while waiting for communication.

Figure 6-2 Energy-saving mode in Wi-Fi 6



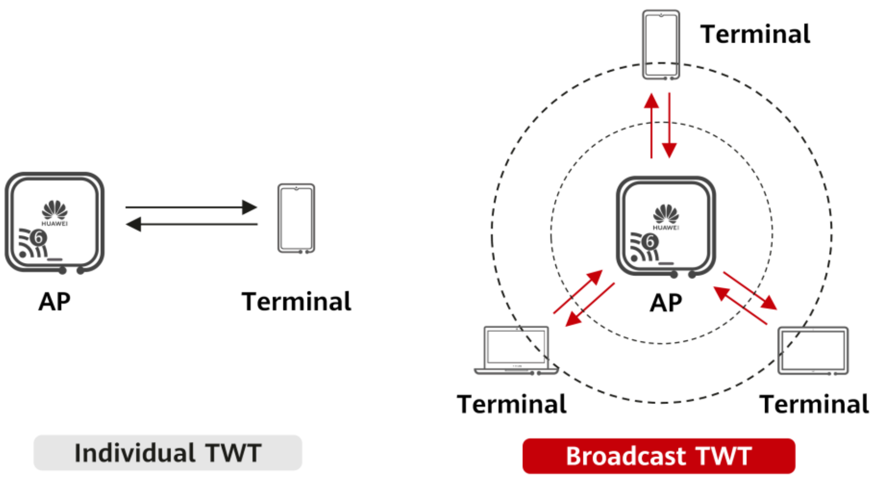
To save energy, Wi-Fi 6 introduces the TWT mechanism, which was originally designed in 802.11ah for terminals with low traffic volumes (especially IoT terminals). TWT enables an AP and terminal to establish a TWT agreement and negotiate the TWT SP. This ensures that the terminal is awake only within the SP. Figure 6-3 shows the working process of the TWT mechanism.

Figure 6-3 TWT mechanism



Two TWT modes are defined in Wi-Fi 6: individual TWT and broadcast TWT, as shown in Figure 6-4.

Figure 6-4 Individual TWT and broadcast TWT



Individual TWT requires a corresponding agreement between an AP and terminal, where the terminal only recognizes the TWT it negotiates with the AP.

To simplify this negotiation, Wi-Fi 6 defines the broadcast TWT mode, which does not require an individual TWT agreement. Instead, terminals request to participate in the broadcast TWT operation to obtain the TWT SP announced by the AP.

6.2 OMI

Before introducing OMI, we need to understand the differences between legacy Wi-Fi 4 or Wi-Fi 5 terminals and Wi-Fi 6 terminals in obtaining the uplink transmit opportunity (TXOP).

- Legacy terminals: Contend for the uplink TXOP.
- Wi-Fi 6 terminals: Obtain the TXOP based on the synchronization and control by APs, thanks to OFDMA's support for multi-user transmission.

Can Wi-Fi 6 terminals also contend for the TXOP, just like legacy terminals? The answer to this question is yes. Wi-Fi 6 defines an OMI procedure for this very purpose. When a terminal communicates with an AP, the terminal proactively reports its capabilities, such as UL OFDMA support, maximum bandwidth, and the number of spatial streams.

How does the OMI procedure save energy?

When a terminal has sufficient battery power, it communicates with its maximum capability; if the battery power is insufficient, the terminal may compromise its capability (for example, by reducing bandwidth or the number of spatial streams) and notify the AP through OMI. The AP then communicates with the terminal by using the transmit parameters recommended by the terminal.

To save energy, TWT minimizes the SPs of terminals, while OMI reduces the power consumption within the SP as much as possible.

Chapter 7
Other Wi-Fi 6 Enhancements

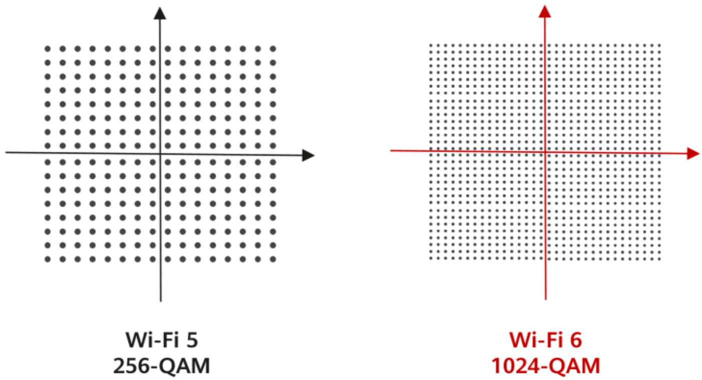
Abstract

This chapter describes several other key technologies leveraged by Wi-Fi 6: 1024-QAM, long OFDM symbol, four new physical layer (PHY) protocol data unit (PPDU) formats, preamble puncturing, and 20 MHz-only mode.

7.1 1024-QAM

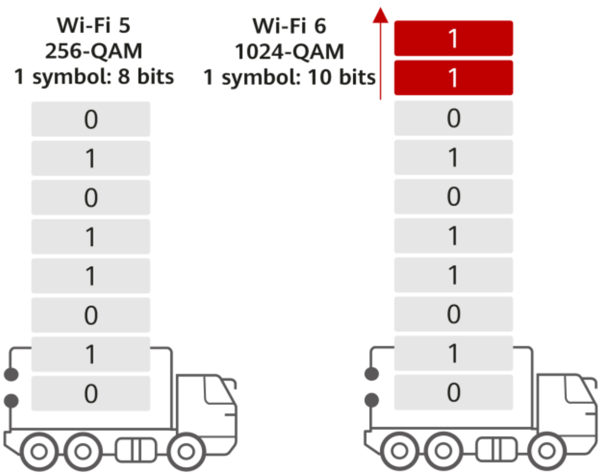
Wi-Fi 6 aims to increase the system capacity, reduce latency, and improve efficiency in multi-user high-density scenarios. However, high efficiency does not necessarily compromise the speed. Within this context, Figure 7-1 compares the QAM modes adopted in Wi-Fi 5 and Wi-Fi 6. The former uses 256-QAM (which represents 1 symbol with 8 bits), whereas the latter uses 1024-QAM (which represents 1 symbol with up to 10 bits — 25% higher). With more bits carried per symbol, the data throughput per spatial stream also improves by 25% in Wi-Fi 6.

Figure 7-1 QAM modes adopted in Wi-Fi 5 and Wi-Fi 6



Let's imagine each symbol is a truck shown in Figure 7-2. A higher-order QAM mode allows us to carry even more information on each truck, which translates to faster data transmission.

Figure 7-2 Data carried per symbol in Wi-Fi 5 and Wi-Fi 6



Channel conditions play an important role in the successful implementation of 1024-QAM. As the carrier bandwidth used for sending a symbol and the transmission duration are both fixed, a higher order leads to a smaller difference between two symbols. This poses high requirements on the environment and components of the receiver and transmitter.

If the environment is noisy with a small signal-to-noise ratio (SNR), symbols are difficult to demodulate and become prone to demodulation errors. This means that a lower-order QAM scheme is the only option in these "noisy" environments.

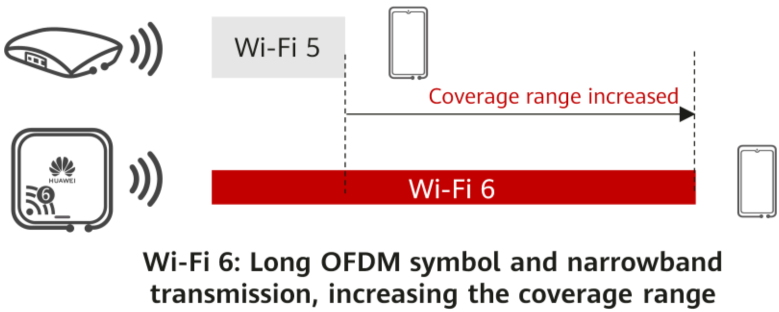
Put differently, if we speak too fast in a noisy environment, individual words may be drowned out.

7.2 Extended Range

Wi-Fi 6 uses the long OFDM symbol transmission mechanism, which increases the data transmission duration from 3.2 μs to 12.8 μs. On top of that, Wi-Fi 6 defines GIs 0.8 μs, 1.6 μs, and 3.2 μs, which are longer than 0.4 μs and 0.8 μs in Wi-Fi 5. In outdoor environments or environments with a severe multipath effect, a longer GI can better prevent multipath interference. Furthermore, narrowband transmission can effectively reduce the noise interference on a frequency band. In this regard, it is worth pointing out that Wi-Fi 6 can use only 2 MHz bandwidth for narrowband transmission, which increases the coverage range.

Compared with Wi-Fi 5, Wi-Fi 6 transmits signals on narrower bandwidth, supports longer symbol duration, reduces transmission interference, and increases the coverage range.

Figure 7-3 Coverage range increase brought by Wi-Fi 6 compared with Wi-Fi 5

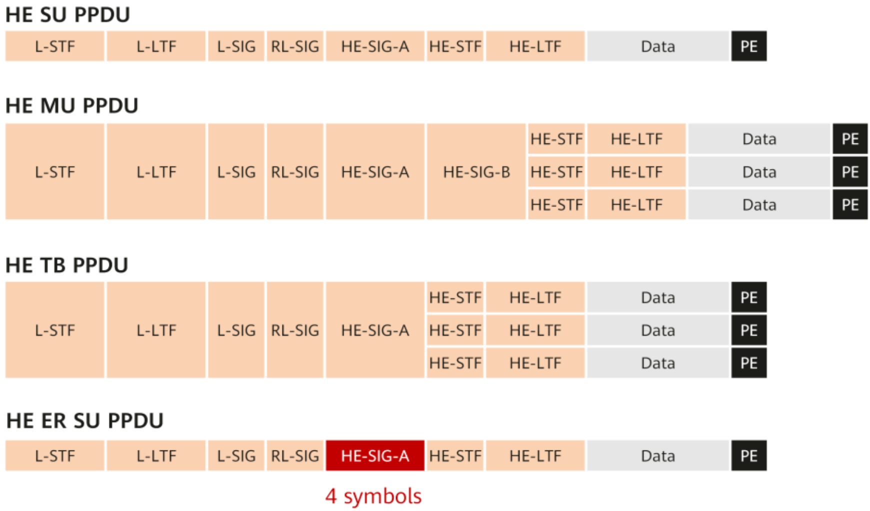


7.3 Four New PPDU Formats

In OFDMA, PPDUs are used to transmit data to different terminals. In this context, Wi-Fi 6 defines four new PPDU formats (as shown in Figure 7-4), enabling terminals to know the specific RUs allocated to them. These four PPDU formats provide different functions and are compatible with earlier Wi-Fi standards.

- HE SU PPDU: applies to single-user packet transmission.
- HE MU PPDU: applies to simultaneous multi-user transmission.
- HE Trigger-based PPDU (HE TB PPDU): applies to UL OFDMA and UL/DL MU-MIMO scenarios. The Trigger frame in the HE TB PPDU format a terminal receives from an AP contains resource allocation information used for concurrent multi-user uplink transmission.
- HE extended range SU PPDU (HE ER SU PPDU): applies to outdoor long-range scenarios.

Figure 7-4 Four new PPDU formats introduced in Wi-Fi 6



A PPDU consists of the preambles, data field, and packet extension (PE). A preamble is a string for carrying information (such as clock information) exchanged between a transmitter and receiver, so as to transmit data fields. The preambles of a PPDU include:

- Legacy preambles: achieve compatibility with non-Wi-Fi 6 terminals.
- HE preambles: transmit information related to OFDMA, MU-MIMO, and BSS coloring.

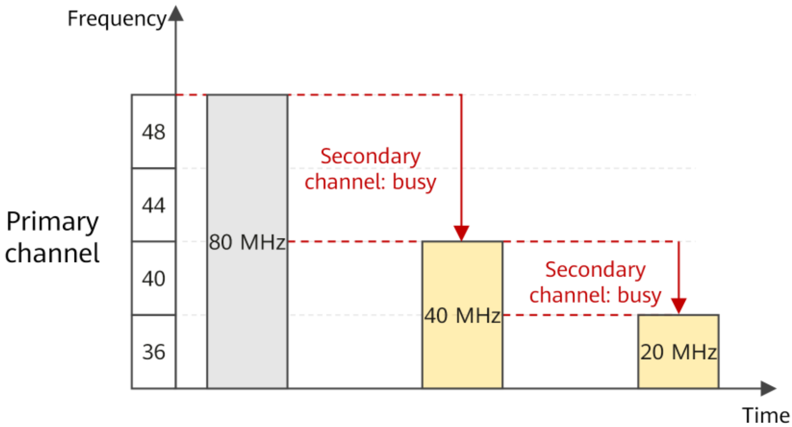
7.4 Preamble Puncturing

What Is Channel Bonding?

Wi-Fi radio waves are carried on high-frequency signals with 20 MHz bandwidth regulated by Wi-Fi standards.

If we imagine a 20 MHz channel as a single-lane road, then it goes without saying that bottlenecks occur when traffic is heavy. By adding additional lanes, we can allow for increased traffic, and as such, Wi-Fi 4 introduced **channel bonding**. This technology bonds two adjacent 20 MHz channels into a single 40 MHz channel, thereby doubling the data transmission rate. Then, a 20 MHz channel becomes the primary channel while the other is designated as the secondary one. The primary channel remains dominant and transmits management frames (such as beacon frames), whereas the secondary channel carries only data frames.

Figure 7-5 How channel conflicts affect channel bonding



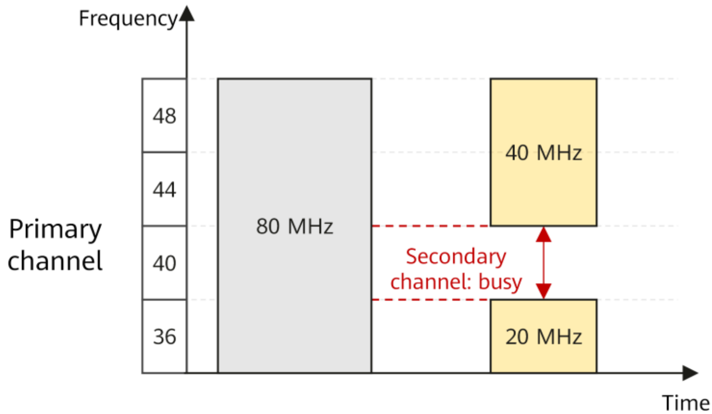
The downside to bonding contiguous channels is that bandwidth will be halved when the secondary channel becomes busy due to conflicts. Let's use a bonded 80 MHz channel shown in Figure 7-5 as an example. If the secondary 40 MHz channel is busy, the channel bandwidth is halved to 40 MHz; if the secondary 20 MHz channel is busy, only the primary 20 MHz channel is in effect.

Such bandwidth reduction is detrimental to high-density Wi-Fi services. Some channels may become extremely busy in high-density deployments, resulting in Wi-Fi devices becoming capped at 20 MHz channel bandwidth.

How Does Wi-Fi 6 Improve Channel Bonding?

To resolve the preceding issue, Wi-Fi 6 defines the preamble puncturing mechanism. As shown in Figure 7-6, by bonding non-contiguous available channels (excluding the busy secondary channel), preamble puncturing prevents bandwidth from being halved. For instance, if a secondary 20 MHz channel is occupied, the primary 20 MHz and the secondary 40 MHz channel are still available for data transmission. This improves spectrum efficiency by up to 300% compared with conventional channel bonding, where only the primary 20 MHz channel continues to work.

Figure 7-6 Preamble puncturing mechanism

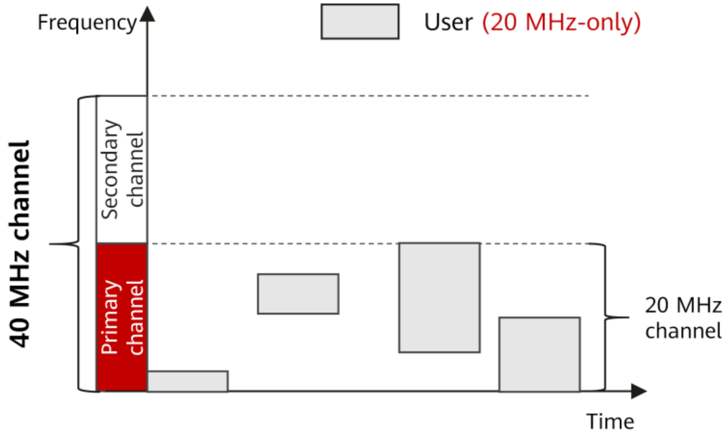


This mechanism is fittingly called preamble puncturing because information is carried in preambles from a transmitter to receiver, and a skipped busy channel appears to be punctured.

7.5 20 MHz-Only Mode

Some terminals, such as wearable or IoT devices, have low power consumption and data volumes. These terminals typically support only 20 MHz channel bandwidth and therefore are also referred to as 20 MHz-only terminals. They work only on the primary channel even if 40 MHz or 80 MHz bandwidth is available, wasting the bandwidth of secondary channels, as shown in Figure 7-7.

Figure 7-7 20 MHz-only terminals working only on the primary channel



To resolve this issue, Wi-Fi 6 schedules 20 MHz-only terminals to secondary channels by utilizing TWT, thereby saving energy and improving channel utilization.

Chapter 8
Are You Ready for Wi-Fi 6?

Abstract

This chapter addresses several frequently asked questions during the network upgrade to Wi-Fi 6, including the Wi-Fi 6 device compatibility, multi-GE rate achievement, and power over Ethernet (PoE).

8.1 Compatibility

Wi-Fi 6 stands out based on its high bandwidth, low latency, high concurrency, and low power consumption. To fully utilize features of a Wi-Fi 6 network, APs and terminals must be upgraded to Wi-Fi 6 to properly work together. Currently, only a few terminals support Wi-Fi 6, including mobile phones and PCs.

Many people may think that there is no need to deploy Wi-Fi 6 APs as most current terminals do not support it. This is actually a common misunderstanding.

Wi-Fi 6 APs are typically backward compatible with earlier Wi-Fi standards and can communicate with non-Wi-Fi 6 terminals. Thanks to 8x8 MU-MIMO introduced in Wi-Fi 6, a Wi-Fi 6 AP can communicate with a maximum of eight terminals at the same time, which is twice that supported in Wi-Fi 5.

Additionally, the multi-antenna gain of Wi-Fi 6 APs can improve the receiver sensitivity and coverage range, which are also effective for non-Wi-Fi 6 terminals.

The Wi-Fi Alliance predicts that nearly 2 billion Wi-Fi 6 devices will be delivered in 2021. In the global enterprise, residential, and public service fields, Wi-Fi 6 will be widely used by PCs, APs, smartphones, and IoT terminals.

Therefore, it is strongly recommended that Wi-Fi 6 be directly deployed if you want to construct new Wi-Fi networks or upgrade your legacy Wi-Fi 4 or Wi-Fi 5 network for access capacity and investment considerations.

8.2 Multi-GE Rate

The theoretical transmission rate per spatial stream on a Wi-Fi 6 AP has exceeded 1 Gbit/s. As such, the transmission rate of access switches may become a bottleneck. In recent years, the access layer bandwidth has gradually evolved to 2.5 Gbit/s, 5 Gbit/s, and even 10 Gbit/s.

A question that is often asked here is, "If the bandwidth becomes insufficient, why not directly upgrade the bandwidth to 10 Gbit/s? How come 2.5 Gbit/s and 5 Gbit/s bandwidths also exist?" This is because although 10 Gbit/s bandwidth meets requirements, such a high bandwidth is costly and requires re-cabling.

- Typically, Category 5e (Cat5e) shielded twisted-pair cables have been deployed at the early stages of building construction, and these cables cannot handle 10 Gbit/s traffic flows.
- If Category 6 (Cat6) or higher cables or even optical fibers are used, re-cabling is required, greatly increasing construction complexity and costs.

Given this, the entire industry urgently needed a new solution to improve network bandwidth without having to reroute cables. A feasible way was to build an Ethernet that flexibly works at speeds between 1 Gbit/s and 10 Gbit/s. It is in this context that the IEEE 802.3bz-compliant multi-GE Ethernet was unveiled.

In particular, Huawei's hybrid optical-electrical switch S5732-H48XUM2CC is ideal for building such an Ethernet thanks to its support of multi-GE Ethernet, with 100M/1000M/2.5GE/5GE/10GE port rates for flexible choices on demand. This switch is also well suited for the bandwidth requirements of Wi-Fi 6 APs.

This one-off investment will pave the way for evolution over the next 10 years, even supporting the future release of Wi-Fi 7 with possible data rates of up to 25 Gbit/s. This eliminates the need to re-cable and significantly reduces costs.

8.3 PoE Power Supply

In most cases, APs are powered by PoE, which allows for easier AP deployment. To achieve better performance, many vendors add antennas (4x4 or 8x8) or three radios to Wi-Fi 6 APs. Therefore, Wi-Fi 6 APs consume far higher power than APs in compliance with previous Wi-Fi standards.

For example, a 4x4 AP can work at sufficient power only in 802.3at (PoE+), 802.3bt (PoE++), or a higher power supply standard. The 802.3af (PoE) standard is not suitable. As for 8x8 APs that require even more power, even though some of them can use 802.3at (PoE+) power supply, their functions are compromised, for example, the USB or BLE function is unavailable. Table 8-1 compares capabilities of different PoE power supply standards.

Table 8-1 PoE power supply standards comparison

Standard	DC Resistance of a 100 m Network Cable (Ω)	Output Power (W)
802.3af (PoE)	20	⩽ 15.4
802.3at (PoE+)	12.5	⩽ 30
802.3bt (PoE++)	12.5	⩽ 90

This poses higher requirements on the PoE power supply capability of access switches, which means that some access switches may need to be upgraded.

Another possible circumstance worth mentioning is that an 802.3at-capable switch is used to supply power to APs. If all APs are replaced with Wi-Fi 6 APs that consume higher power, the overall power consumption of the APs will exceed the output power of the switch. This will lead to each single AP being insufficiently powered. In this case, an AP may restart unexpectedly. This explains why Wi-Fi maintenance personnel often receive calls from customers complaining about random, unexpected AP restarts. Therefore, after you upgrade you network with Wi-Fi 6 APs, verify that the output power of switches meets the total power consumption of the APs.

Chapter 9

Wi-Fi 6 Typical Applications

Abstract

This chapter describes typical applications of Wi-Fi 6 in enterprises, such as workspaces, manufacturing and production, and services.

Wi-Fi 6 achieves a four-fold increase in network bandwidth and concurrency compared with Wi-Fi 5. Powered by Smart Antenna, Huawei AirEngine Wi-Fi 6 products further reduce average network latency from 30 ms to 10 ms. This ensures 4K HD conferences in wireless offices, smooth VR/AR teaching without dizziness, and zero packet loss during automated guided vehicle (AGV) roaming in industrial manufacturing, accelerating the digital transformation of enterprises in various industries.tur The following will introduce you to some typical applications of Huawei AirEngine Wi-Fi 6 products in enterprises.

9.1 Wi-Fi 6 Transforms Workspaces

Digital transformation has become the top priority of almost all enterprises today. However, according to a survey conducted by a consulting firm, more than 80% of enterprises have failed in digital transformation (*source: Forbes*). The main reason for this is that enterprises still work in a top-down mode. This mode was suitable during the traditional mechanized production era. In the intelligent mobile Internet era, enterprises are required to build digital office space to promote the transformation from traditional organizations to learning-oriented, collaborative organizations.

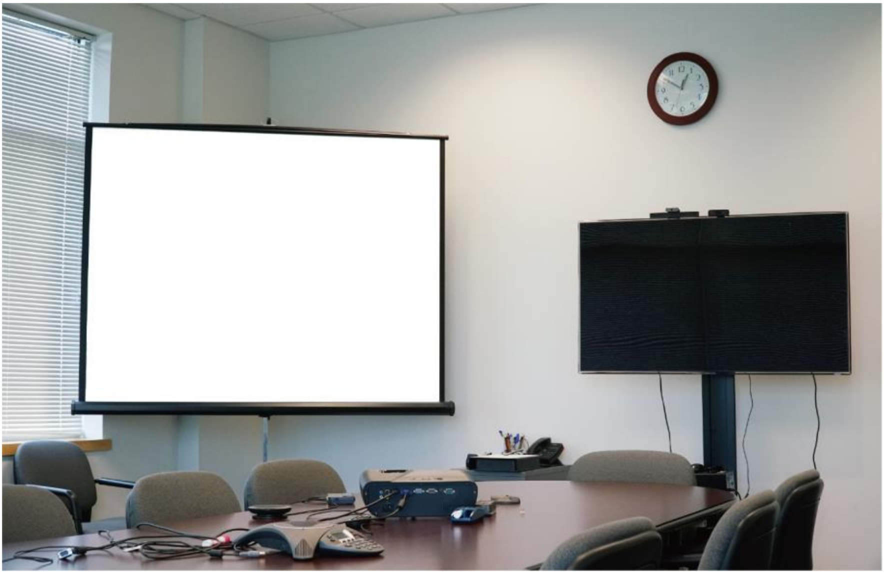
In the digital workspace, employees need to interact and communicate with each other anytime and anywhere so as to improve work efficiency, stimulate creativity, and quickly respond to market requirements. To build a digital workspace, wireless networks are essential. For example, Huawei Digital Office serves more than 320,000 users across more than 170 countries and regions, and provides wireless network access for videoconferencing systems, intelligent conference rooms, cameras, and other IoT terminals. These applications have varying requirements on wireless networks. For example, 4K HD videoconferencing requires high bandwidth; collaborative office requires low latency; and smart asset tracking requires a large number of connections.

The most common office application is the intelligent conference room shown in Figure 9-1. More than 15 million conferences are held in Huawei every year. Conference room management is a great challenge as there are such a large number conference rooms and wireless HD screens.

Wi-Fi 6 technology enables intelligent transformation for traditional conference rooms. Wi-Fi 6 provides wireless access to wireless projectors, wireless HD screens, electronic whiteboards, laptops, mobile phones, and even room temperature and lighting sensors. When a project team holds a meeting, participants may need to project the content on their laptops to the wireless projector for real-time demonstration. At times, devices such as wireless HD screens are also used, which poses a great challenge to network bandwidth and latency. In addition, there are a large number of terminals in densely populated conference rooms.

Traditional Wi-Fi 5 networks can no longer meet the bandwidth and latency requirements in such high-concurrency scenarios. In contrast, Wi-Fi 6 can easily cope with these bandwidth-hungry and latency-sensitive applications by increasing both network bandwidth and concurrency by four times, based on technologies such as OFDMA, 8x8 MU-MIMO, and 1024-QAM.

Figure 9-1 Intelligent conference room



In mobile office scenarios, employees can access the network wirelessly from any location. In particular, employees may work while on the move, making seamless coverage and roaming critical. For example, when an employee makes a video call while moving in the office, Wi-Fi 6 intelligently eliminates blind spots at corners and near windows and optimizes wireless coverage, delivering consistent service experiences.

9.2 Wi-Fi 6 Transforms Manufacturing and Production

Industrial manufacturing is one of the first industries that undergo IT transformation, and has a wide range of requirements for networks, such as VR/AR-based planning and design, automated assembly and inspection, smart logistics, and robot and asset management. Each phase has specific requirements on the bandwidth, number of connections, and latency.

For example, 8K HD video has been applied to monitoring and quality inspection in industrial manufacturing. Typically, surveillance cameras with high resolution and flexible deployment can achieve higher detection and recognition accuracy. However, such high resolution requires a bandwidth guarantee. Wi-Fi 6 can easily meet the ultra-high bandwidth requirement of 8K videos.

Figure 9-2 Smart factory

In the Huawei Songshan Lake smart factory, Wi-Fi networks are not only used to carry voice and data services, but also used for positioning and navigation of AGVs in unmanned warehouses. AGVs have high requirements on network latency and packet loss, which may directly affect warehousing services. This improves the coordination, safety, and overall efficiency of warehouse management while also reducing costs.

As shown in Figure 9-2, Huawei's Wi-Fi 6 network provides seamless coverage and as low as 10 ms latency, ensuring secure and efficient continuous production in unmanned warehouses. Wi-Fi 6 also lays a solid foundation for Huawei's smart logistics and supports end-to-end "One Flow" operation. In collaboration with Huawei Smart Cloud, Wi-Fi 6 can automate 80% of raw material management, supply chain management, and fleet management, and digitize all storage, send, receive, and assembly processes, improving efficiency by 40%.

9.3 Wi-Fi 6 Transforms Services

Besides office and manufacturing, Wi-Fi 6 brings great transformation to enterprises in terms of campus services.

Huawei's smart asset management system manages up to 280,000 valuable assets worldwide. Through mobile applications, asset management personnel can scan asset labels to identify and obtain asset data. Once these assets are recorded in the system, they can be monitored and tracked throughout the campus and audited through one click within minutes. All these can be achieved by installing low-power IoT modules on Huawei AirEngine Wi-Fi 6 APs, improving service rollout efficiency and reducing IT operation costs.

Another typical service example occurs in an airport scenario. As shown in Figure 9-3, an airport provides free Wi-Fi services for passengers. With the development and expansion of the scale and services of airports, there are increasingly higher requirements on Wi-Fi networks. The airport provides passengers with all-round Wi-Fi services based on Wi-Fi 6, covering the check-in hall, waiting hall, and VIP lounge. In addition to passengers' terminals, other devices, such as digital signage and intelligent sensors, are also connected to the Wi-Fi network. Wi-Fi 6 and intelligent applications together help shorten passenger queuing time by 15% and reduce operation manpower by up to 20%. The high-bandwidth and low-latency Wi-Fi 6 network allows passengers to easily plan trips, make HD video calls, and process important service files.

Figure 9-3 Smart airport

Chapter 10

Huawei Wi-Fi 6 APs

Abstract

This chapter describes Huawei enterprise Wi-Fi 6 APs, including indoor and outdoor Wi-Fi 6 APs.

Huawei launched its first Wi-Fi 6 AP in October 2017. Soon after, Huawei launched a full portfolio of AirEngine series Wi-Fi 6 products for various sectors, including enterprise, education, finance, healthcare, government, manufacturing, and business.

AirEngine 8700 Series Indoor APs

Huawei AirEngine 8760-X1-PRO is Huawei's next-generation flagship Wi-Fi 6 AP for indoor scenarios. This high-performance AP can flexibly switch between three radio modes: dual-radio, triple-radio, and dual-radio + independent scanning radio*, achieving a device rate of up to 10.75 Gbit/s.

The AP uses built-in smart antennas to ensure always-on Wi-Fi signals for users, significantly enhancing users' wireless network experience. It also provides 10GE uplink optical and electrical ports. These strengths make AirEngine 8760-X1-PRO ideal for various scenarios such as enterprise office, government, and education. Figure 10-1 shows the AirEngine 8760-X1-PRO appearance.

Figure 10-1 AirEngine 8760-X1-PRO

- Flexible switching between radio modes, providing a device rate of up to 10.75 Gbit/s (1.15 Gbit/s on the 2.4 GHz frequency band and 9.6 Gbit/s on the 5 GHz frequency band)
  - Dual-radio mode: 2.4 GHz (4x4) + 5 GHz (12x12)
  - Triple-radio mode: 2.4 GHz (4x4) + 5 GHz (8x8) + 5 GHz (4x4)
  - Dual-radio + independent scanning radio mode: 2.4 GHz (4x4) + 5 GHz (8x8)
- 2 x 10GE electrical ports + 1 x 10GE SFP+ optical port
- USB interface for external power supply, external IoT expansion, and storage
- Built-in smart antennas that automatically adjust the coverage direction and signal strength based on the intelligent switchover algorithm to adapt to the application environment change, in addition to providing accurate and stable coverage as terminals move
- Built-in IoT slots (PCIe), supporting IoT expansion such as BLE 5.0, ZigBee, radio frequency identification (RFID), and Thread
- Built-in independent radio scanning module, achieving real-time detection for interference and rogue devices and timely radio calibration*
- Bluetooth serial port-based O&M through collaboration between the built-in Bluetooth module and CloudCampus APP; and accurate positioning for Bluetooth terminals and tags through collaboration with a positioning server
- Working modes: Fit, Fat, and cloud management

Note

The two 10GE electrical ports work in PoE_IN hot backup mode.

The 10GE electrical ports support 100M/1000M/2.5GE/5GE auto-sensing.

Features marked with the asterisk (*) are available only in V200R020C00 or later.

AirEngine 6700 Series Indoor APs

Huawei AirEngine 6700 series indoor APs are Wi-Fi 6 APs ideal for midsize and large enterprises requiring high density access. AirEngine 6700 series include various models, such as the AirEngine 6760-X1, AirEngine 6760-X1E, and AirEngine 6761-21T, as shown in Figure 10-2.

Figure 10-2 Mainstream AirEngine 6700 series models

Table 10-1 AirEngine 6700 series indoor APs

Item	AirEngine 6760-X1	AirEngine 6760-X1E	AirEngine 6761-21T
Device rate	10.75 Gbit/s*	10.75 Gbit/s*	6.58 Gbit/s
Spatial streams	4+8, 4+4+4, or 4+6+independent scanning radio*	4+8, 4+4+4, or 4+6+independent scanning radio*	2+2+4
Antenna	Built-in smart antenna	External antenna	Built-in smart antenna
IoT	BLE 5.0, with two built-in IoT slots	BLE 5.0, with two built-in IoT slots	BLE 5.0
Ethernet ports	1 x 10GE electrical port + 1 x GE electrical port + 1 x 10GE optical port	1 x 10GE electrical port + 1 x GE electrical port + 1 x 10GE optical port	2 x GE electrical ports

Note

Specifications marked with the asterisk (*) can be implemented through RTU licenses.

AirEngine 5700 Series Indoor APs

Huawei AirEngine 5700 series indoor APs are Wi-Fi 6 APs ideal for office of small- and medium-sized enterprises, business, retail, and education scenarios. AirEngine 5700 series include various models, such as the AirEngine 5760-51, AirEngine 5761-21, and AirEngine 5761-11, as shown in Figure 10-3.

Figure 10-3 Mainstream AirEngine 5700 series models

Table 10-2 AirEngine 5700 series indoor APs

Item	AirEngine 5760-51	AirEngine 5761-21	AirEngine 5761-11
Device rate	5.95 Gbit/s*	5.38 Gbit/s	1.77 Gbit/s
Spatial streams	4+4, 2+2+4, or 2+4+independent scanning radio*	2+4	2+2
Antenna	Built-in smart antenna	Built-in smart antenna	Built-in smart antenna
IoT	BLE 5.0, with two built-in IoT slots	BLE 5.0	BLE 5.0
Ethernet ports	1 x 5GE electrical port + 1 x GE electrical port	2 x GE electrical ports	1 x GE electrical port

Note

Specifications marked with the asterisk (*) can be implemented through RTU licenses.

AirEngine 8760R Series Outdoor APs

Huawei AirEngine 8760R series outdoor APs are flagship Wi-Fi 6 APs suitable for high-density scenarios such as large enterprises, stadiums, and public venues. Figure 10-4 shows the appearances of AirEngine 8760R series outdoor APs.

Figure 10-4 AirEngine 8760R series outdoor APs

Table 10-3 AirEngine 8760R series outdoor APs

Item	AirEngine 8760R-X1	AirEngine 8760R-X1E
Device rate	10.75 Gbit/s	10.75 Gbit/s
Spatial streams	8+8 or 4+12	8+8 or 4+4+4
Antenna	Built-in outdoor smart antenna	External antenna
IoT	BLE 5.0	BLE 5.0
PoE	PoE out	PoE out
Ethernet ports	1 x 10GE electrical port + 1 x GE electrical port + 1 x 10GE optical port	1 x 10GE electrical port + 1 x GE electrical port + 1 x 10GE optical port

AirEngine 6760R Series Outdoor APs

Huawei AirEngine 6760R is a series of high-performance Wi-Fi 6 APs ideal for outdoor scenarios such as squares, parks, and pedestrian streets. Figure 10-5 shows the appearances of AirEngine 6760R series outdoor APs.

Figure 10-5 AirEngine 6760R series outdoor APs

Table 10-4 AirEngine 6760R series outdoor APs

Item	AirEngine 6760R-51	AirEngine 6760R-51E
Device rate	5.95 Gbit/s	5.95 Gbit/s
Spatial streams	4+4	4+4
Antenna	Built-in smart antenna	External antenna
IoT	BLE 5.0	BLE 5.0
Ethernet ports	1 x 5GE electrical port + 1 x GE electrical port + 1 x 10GE optical port	1 x 5GE electrical port + 1 x GE electrical port + 1 x 10GE optical port

More Product Information

In addition to the preceding Wi-Fi 6 APs, Huawei WLAN products include WACs, more indoor APs, and scenario-specific products (such as wall plate APs and agile distributed APs). For more information about Huawei WLAN products, visit http://e.huawei.com or contact Huawei's local sales office.

Chapter 11

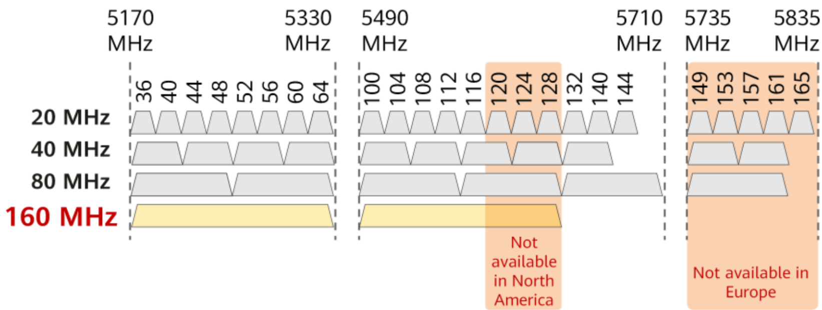
Wi-Fi 6E: Extended Version of Wi-Fi 6

Abstract

This chapter describes the extended version of Wi-Fi 6 (Wi-Fi 6E), the differences between Wi-Fi 6E and Wi-Fi 6, and Wi-Fi 6E compatibility.

Previous generations of Wi-Fi were mostly focused on improving speeds. For example, in Wi-Fi 5, 160 MHz channel bandwidth was proposed. Wi-Fi mainly leverages 2.4 GHz and 5 GHz frequency bands, on which the available spectrum ranges differ between countries. Nevertheless, it is difficult to provide sufficient 160 MHz channels on these two frequency bands.

Figure 11-1 Support for 160 MHz channels on the 5 GHz frequency band in different regions



As shown in Figure 11-1, only one 160 MHz channel is available in North America, and only two in Europe. This means that 160 MHz channels are basically unavailable.

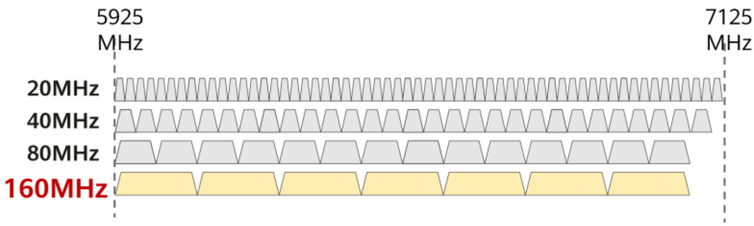
One solution given in Wi-Fi 5 is to replace 160 MHz with noncontiguous 80 MHz, that is, 80+80 MHz. However, this mode will undoubtedly complicate the Wi-Fi network design.

Another solution is proposed by Wi-Fi 6E (E stands for "Extended"), which extends Wi-Fi 6 to the 6 GHz frequency band.

What Is the 6 GHz Frequency Band?

The 6 GHz frequency band provides contiguous spectrum blocks that are globally unified, operating in the range of 5925 MHz to 7125 MHz, as shown in Figure 11-2. With this 1200 MHz spectrum available, Wi-Fi 6E devices will be able to work on 7 additional 160 MHz channels, 14 additional 80 MHz channels, 29 additional 40 MHz channels, or 59 additional 20 MHz channels.

Figure 11-2 6 GHz frequency band



Regulators in many countries and regions now are opening up the 6 GHz unlicensed spectrum to their citizens, including Brazil, Chile, the European Union, Japan, Mexico, South Korea, Taiwan (China), the United Arab Emirates, the United Kingdom, and the United States.

Wi-Fi 6E vs Wi-Fi 6

Wi-Fi 6E extends the functions of Wi-Fi 6 to the 6 GHz frequency band, as shown in Figure 11-3. Other Wi-Fi 6 features are still available in Wi-Fi 6E.

Figure 11-3 Wi-Fi 6E vs Wi-Fi 6

	Wi-Fi 6	Wi-Fi 6E
Frequency	2.4 GHz and 5 GHz	6 GHz
PHY technology	1024-QAM	1024-QAM
Modulation mode	OFDMA UL/DL MU-MIMO	OFDMA UL/DL MU-MIMO
Number of spatial streams	8	8
Channel bandwidth	20 MHz, 40 MHz, 80 MHz, 160 MHz, 80+80 MHz	20 MHz, 40 MHz, 80 MHz, 160 MHz, 80+80 MHz
BSS coloring	Supported	Supported
TWT	Supported	Supported

The 6 GHz frequency band will address various challenges by providing the following:

- High concurrency

  Wi-Fi 6E can work on the 6 GHz frequency band, providing an additional 1200 MHz in spectrum resources, even more than the combined resources of the 2.4 GHz and 5 GHz frequency bands. These new spectrum resources alleviate channel congestion and improve the concurrency rate.

- High bandwidth

  The 6 GHz frequency band provides additional 160 MHz channels so that the use of 160 MHz bandwidth is made practical. This easily meets high bandwidth requirements.

- Low latency

  Conventional Wi-Fi devices support only the 2.4 GHz and 5 GHz frequency bands. The 6 GHz frequency band is supported only by Wi-Fi 6E devices. Such separation eliminates interference and meets the latency requirements of latency-sensitive applications.

As such, the 6 GHz frequency band is more suitable for applications that require higher bandwidth and lower latency, such as unified communications, cloud computing, and AR/VR.

As with anything, the 6 GHz frequency band is not perfect. It uses short waves, which adapt to high-speed transmission but are not suitable for long-distance transmission due to high attenuation.

Wi-Fi 6E Compatibility

Wi-Fi 6E devices will be backward compatible with Wi-Fi 6 and earlier Wi-Fi standards. However, to leverage new 6 GHz channels available in Wi-Fi 6E, devices must support the 6 GHz frequency band. That is, Wi-Fi 6E features are available only when Wi-Fi 6E-capable terminals (such as PCs or smartphones) work with Wi-Fi 6E-capable APs.

Do You Need to Upgrade Your Network to Wi-Fi 6E?

Regarding the 6 GHz frequency band for Wi-Fi use, most countries and regions are still in the research or wait-and-see phase. Currently, only a few terminals support the 6 GHz frequency band. And even in the next three to five years, most Wi-Fi terminals will only support 2.4 GHz and 5 GHz frequency bands. According to the technology evolution cycles of previous Wi-Fi generations, it usually takes three to four years for a new Wi-Fi standard to reach a 50% penetration rate. Considering the varying timelines for 6 GHz frequency band availability in different countries and regions, it may be some time before Wi-Fi 6E becomes mainstream. Given this, unless you have some specific needs, you can continue to use your Wi-Fi 6 products to enjoy optimal Wi-Fi 6 network experience, without having to wait for 6 GHz-capable devices.

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