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Why Wi-Fi 6/6E?

Tech Brief

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INTRODUCTION

Is it time to upgrade your Wi-Fi network? The latest version of one of the most popular wireless networking technologies was at last fully ratified and published in May 2021. While Wi-Fi 6 access points and clients have been around for some time already, now 6GHz (6E) enterprise-grade APs are becoming widely available. Still, is Wi-Fi 6/6E much better than Wi-Fi 5? How is it different from older versions of Wi-Fi? More importantly, should someone that is a network owner rush out to upgrade?

Let's find out.

WHAT IS NEW WITH WI-FI 6/6E?

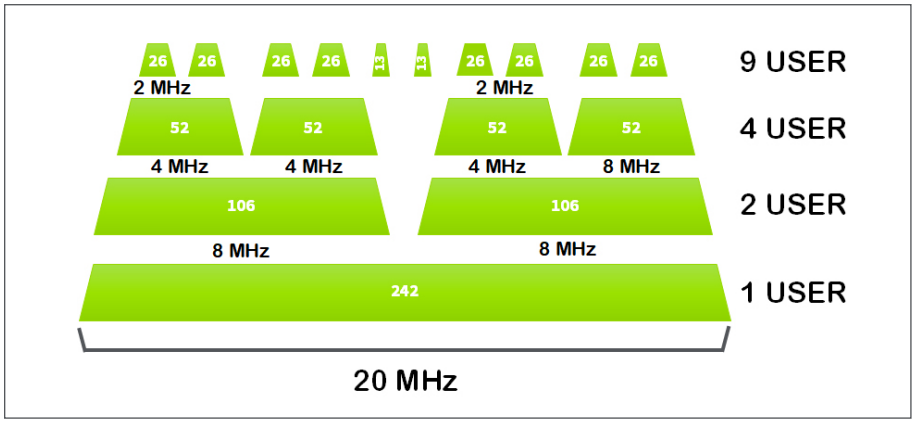
Multiple technology improvements were introduced with Wi-Fi 6/6E that not only help increase throughput, but greatly improve traffic management efficiency, allowing for better performance in environments where a high client capacity is required such as stadiums, conference centers, and smart buildings.

Orthogonal Frequency Division Multiple Access (OFDMA)

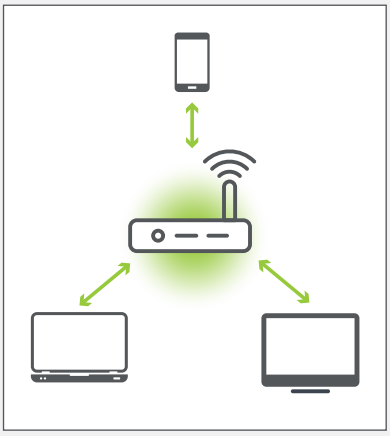
OFDMA is one of the biggest, if not the biggest, enhancement that was introduced with Wi-Fi 6/6E. This technology was designed to improve traffic management efficiency by enabling concurrent AP communication with multiple clients by dividing channels into "Resource Units" (smaller sub-channels). Based on client traffic needs, an AP can allocate a whole 20MHz channel to one single client or may partition the channel to serve multiple users simultaneously.

OFDMA is one of the biggest, if not the biggest, enhancement that was introduced with Wi-Fi 6/6E.

Why Wi-Fi 6/6E? It is like taking a wide single lane highway and converting it into a multi-lane one. Older versions of Wi-Fi only allowed for one device to talk at a time on a channel. OFDMA is ideal for low-bandwidth applications like IoT sensors since it allows for more Wi-Fi devices to talk at the same time on a single channel, which translates into better performance and higher speeds.



Example of how OFDMA can be used to divide a channel into Resource Units



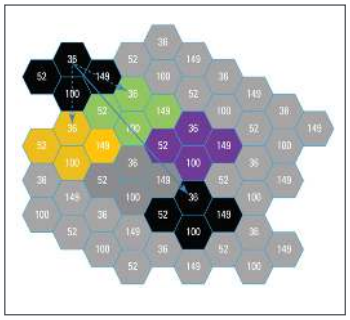
Example of an AP talking to multiple client devices at the same using MU-MIMO

Multi-User Multiple Input Multiple Output (MU-MIMO) Improvements

MU-MIMO was introduced with 802.11ac, but now it has been improved. Initially MU-MIMO allowed the simultaneous transmission of multiple frames to different clients on the same channel using up to four RF streams, and it was only supported for downlink. Wi-Fi 6/6E adds support for up to eight spatial stream and uplink transmissions.

Why Wi-Fi 6/6E? Similar as with OFDMA, think of it as moving from a four-lane highway on which you could only go in one direction to an eight lane one that allows for traffic to move in both directions. MU-MIMO increases capacity and efficiency by allowing more Wi-Fi devices to talk at the same time on a single channel, which translates into even better performance for mission-critical, high-bandwidth applications like voice calls and video streaming.

Overlapping Basic Service Set – OBSS



Graphical representation on how BSS Coloring Works

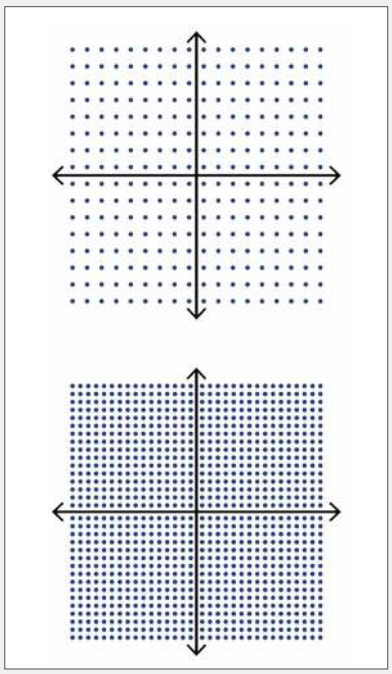
With older versions of Wi-Fi, devices trying to connect to a network used a "listen before talk" process, which meant they had to "listen" for any noise on a channel before transmitting. If there was any noise on the channel, even if it originated from a distant network, they would have to wait until the channel was clear before transmitting. This was done to avoid potential interference. OBSS enables the access point to use a "color" to uniquely identify a Wi-Fi network. If other traffic is detected on the channel, but it is not the same color of the local Wi-Fi network, devices can ignore it and continue transmission.

Why Wi-Fi 6/6E? When combined with other technologies like OFDMA, OBSS allows for more effective communication on crowded networks. As more and more devices utilize the Wi-Fi network, it can help increase reliability and lower latency.

Target Wake Time – TWT

The main purpose of TWT is to improve power management. It allows the AP to schedule a series of times for a station to 'wakeup' at scheduled intervals to exchange data frames. This allows the station to 'sleep' longer and reduces energy consumption.

Why Wi-Fi 6/6E? Longer client device battery life is essential for both mobile and IoT devices.



Graphical comparison of QAM-256 against QAM-1024

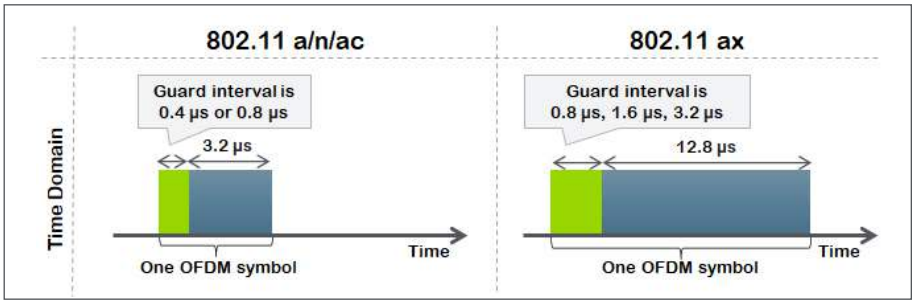
1024-QAM (Quadrature Amplitude Modulation)

QAM is a modulation scheme used in the communications industry to optimize throughput and range. For wireless communications, QAM is a signal in which two carriers shifted in phase by 90 degrees are modulated and the resultant output consists of both amplitude and phase variations. These variations form the basis for the transmitted binary "bits", that results in the information we see on our devices. By varying both the phase and the amplitude of the radio waves, the technology improves spectral efficiency by incorporating more data into each transmission.

Why Wi-Fi 6/6E? The previous version of Wi-Fi (802.11ac) uses 256-QAM, which allows for the transfer of 8 bits. 1024-QAM uses 10 bits to enable a 25% data rate increase in Wi-Fi 6/6E access points and devices.

Longer OFDM Symbols

OFDM is a technique for transmitting large amounts of digital data over a radio wave. This technology works by splitting the radio signal into multiple, smaller sub-signals that are then transmitted simultaneously at different frequencies to a receiver. Think of it this way, imagine you are a company shipping product via freight. You might only have two options: hiring a big truck or multiple smaller ones. Both methods can carry the same amount of product. Should a single truck get damaged or lost on the way, the whole shipment is affected, but with multiple smaller vehicles, that risk is minimized.



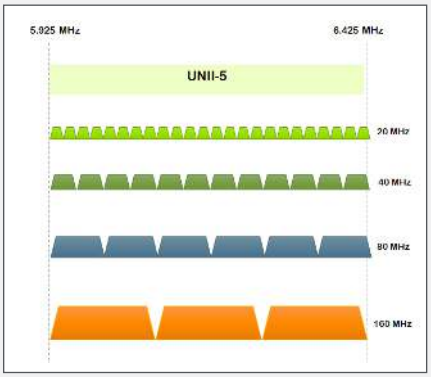
Comparison of OFDM Symbol used by older versions of Wi-Fi against Wi-Fi 6/6E

Why Wi-Fi 6/6E? Older versions of Wi-Fi allowed for the use of short guard intervals and OFDM symbols, Wi-Fi 6/6E introduces the use of longer guard intervals and four-times larger OFDM symbols. Going back to our analogy, it would be like making our small trucks a little bigger. Each of them would be able to carry more packages and improve delivery efficiency. In the case of Wi-Fi 6/6E longer OFDM symbols translates into increased frequency domain efficiency and capacity.

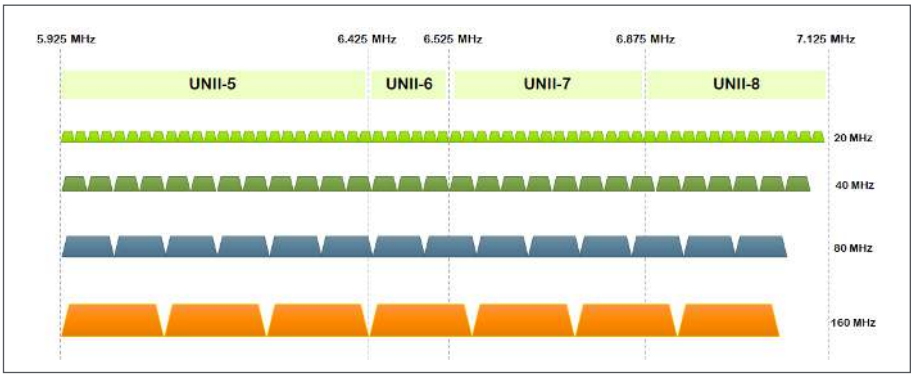
Tri-Band Support

You could consider this the second biggest enhancement introduced with Wi-Fi 6/6E, although some would say this is more important than OFDMA. Different from Wi-Fi 5 (802.11ac), which only supported the 5GHz band (when connecting to the 2.4GHz band you were using 802.11n), Wi-Fi 6/6E can operate in all 3 bands:

- **2.4GHz** – Provides access to fourteen 20MHz channels (only 3 non overlapping).
- **5.0GHz** – Provides access to twenty-five 20MHz channels.
- **6.0GHz** – Provides access to fifty-nine 20MHz channels.



6.0GHz band channels available in Europe



6.0GHz band channels available in the USA and Canada.

Why Wi-Fi 6/6E? This is a huge game changer! With 802.11ac you only had twenty-five 20MHz channels available, Wi-Fi 6/6E now provides access to ninety-eight 20MHz channels. Having many more channels available will help lower problems with co-channel and adjacent-channel interference and will allow increased usage of larger channel-widths (40MHz, 80MHz, and even 160MHz).

Note: The number of channels available will vary per regulatory region or country.

OTHER FUNCTIONALITY AVAILABLE IN THE 6.0GHZ BAND

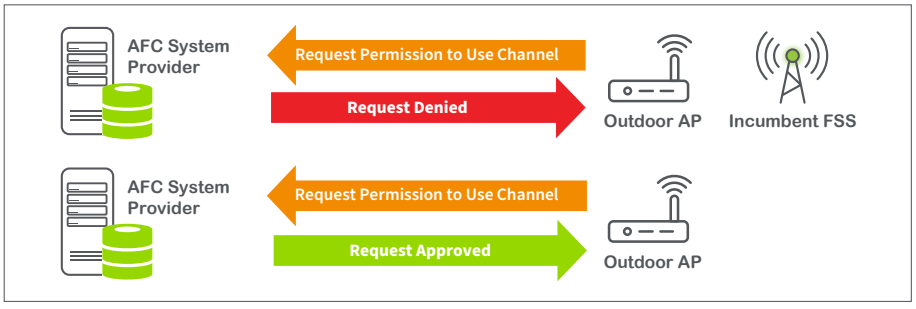
Another advantage of Wi-Fi 6/6E when compared to older versions of Wi-Fi is the exclusive use of the 6.0GHz band, that is, older versions of Wi-Fi are not supported in the new band. This provides the opportunity to introduce completely new functionality without having to worry about backwards compatibility to older Wi-Fi standards.

Automated Frequency Coordination (AFC)

Like the 5.0GHz band the new 6.0GHz band is a shared medium that is not only used for Wi-Fi, but also used for other services. Some examples of incumbent services include:

UNII Band	Service	Incumbents	Outdoor Wi-Fi
UNII-5	Fixed, FSS	Fixed Microwave, FSS (uplinks)	Yes - AFC required
UNII-6	Mobile, FSS	Broadcast, Cable TV, Relay, FSS (uplinks)	No
UNII-7	Fixed, FSS	Fixed Microwave, FSS (uplinks/downlinks)	Yes - AFC required
UNII-8	Fixed, Mobile, FSS	Broadcast, Fixed Microwave, Cable TV, Relay, FSS (uplinks/downlinks)	No

As a result, the FCC (and similar regulators around the world) introduced some restrictions to the use of the 6GHz band to prevent interference with incumbent services. The basic concept is that outdoor Wi-Fi AP's will need to consult a registered database (called an AFC system provider) to confirm its operation will not impact incumbent 6GHz band users. The AFC system provider will contain a database of existing 6GHz incumbents, including geolocation, frequencies used, power levels, antenna coverage, and more.



Graphical representation of the AFC process

The process works as follows:

- Before transmitting, an outdoor Wi-Fi 6/6E AP must consult a local AFC system provider to validate frequency availability. Communication can be directly from the AP to the AFC or through a management system, and the AP must provide all information about its location, coverage, and planned frequencies/power to be used.

- The AFC service provider will then either approve or deny the request and will provide a list of available frequencies to use plus other information.
- Only if approved to transmit on the requested frequency will the outdoor Wi-Fi 6/6E AP will be able to start transmitting.

Why Wi-Fi 6/6E? Like the DFS technology used in the 5GHz band, AFC is designed to prevent interference from incumbent technologies in the 6GHz band. Thus, it helps to increase Wi-Fi network stability and performance.

Preferred Scanning Channels and Reduced Neighbors Report

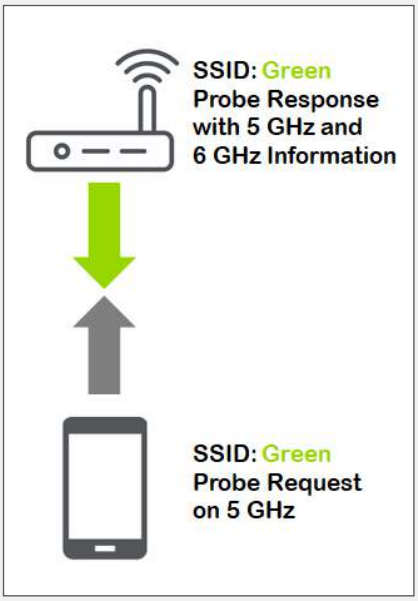
With so many new channels available in the 6GHz band, client devices could take more time to find an AP to connect or roam to. After all, not only will client devices have to scan through the 2.4GHz and 5.0GHz channels to find an AP to connect to, but they would now have to scan through all the fifty-nine channels available in the 6.0GHz band, too. This is a an issue since it could cause clients to lose connectivity while roaming between APs, or cause delays while trying to connect to a Wi-Fi network.

Multiple solutions have been suggested to work around this problem. One of them is through the use of "Preferred Scanning Channels" (PSC), which allows for the prioritization of a group of 20MHz channels within the 6GHz band. Instead of scanning the entire 6GHz band for an optimal channel, client devices would scan the preferred channels only.

Another solution that has been proposed and the most popular one, is "Reduced Neighbor Reports". Reduced neighbor reports allow for an AP to include a list of SSID's available on the 6.0GHz band in the 2.4GHz and 5.0GHz beacons or probe responses.

Why Wi-Fi 6/6E? These methodologies can accelerate network discovery since client devices can learn about network availability in the 6GHz band without having to scan through all the 6GHz channels, and then they can just go directly to the channel on which the SSID is being advertised to connect.

Note: Although Reduced Neighbor Reports are not part of the 802.11ax specification, many vendors are implementing the methodology.



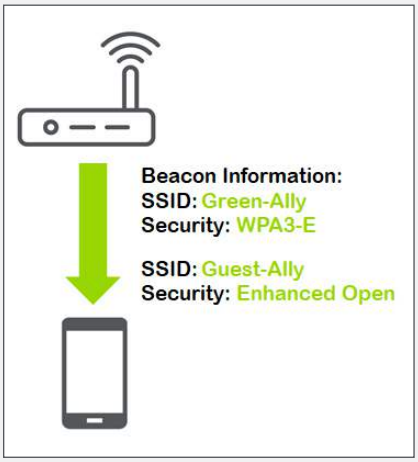
Example of Reduced Neighbor Reports process

Multiple BSSID per Beacon

Excessive beacon overhead is a common problem for Wi-Fi networks that can greatly impact performance. It happens when your APs are transmitting too many SSID's. For each SSID configured, AP's need to transmit a separate beacon frame, which are transmitted at the lowest data rates supported. All this traffic at low data rates increases airtime utilization, and thus lowers network performance and throughput.

To work around this limitation and take advantage of the fact that older Wi-Fi technologies cannot exist in the 6GHz band (no backwards compatibility required), Wi-Fi 6/6E introduces the ability to include information about multiple SSID's in a single beacon.

Why Wi-Fi 6/6E? Instead of requiring a separate beacon frame for each SSID configured on the AP, a single beacon frame is transmitted that includes information about all the APs SSID's. This helps lower beacon overhead and thus improves Wi-Fi network performance.



Example of a single Beacon frame with information about multiple SSID's

Enhanced Security with WPA3 and Management Frame Protection (MFP)

Network security is as important as it has ever been and because of that Wi-Fi 6/6E devices using the 6GHz band will now require you to move to the next level. Again, taking advantage of the fact that no backwards compatibility is required for Wi-Fi devices working on the 6GHz band, Wi-Fi 6/6E devices working in the 6GHz band will be required to use WPA3 or Enhanced Open (based on "opportunistic wireless encryption" or OWE). Older encryption methods like WEP, WPA, or WPA2 will not be supported in the 6GHz band.

Not only that, as Wi-Fi has been increasingly entrusted to carry mission critical enterprise data and voice communications, the impact of Wi-Fi Denial of Service (DoS) attacks has increased manyfold. To help prevent this type of attack, "Management Frame Protection" will now be required to for all Wi-Fi devices operating in the 6GHz band.

Why Wi-Fi 6/6E? The introduction of WPA3-Personal is a significant security enhancement as it replaces PSK authentication with Simultaneous Authentication of Equals (SAE). SAE is resistant to offline dictionary attacks and should make small business and home networks much more secure (enterprises should continue to use 802.1X and WPA3-Enterprise). Add to that the requirement for OWE, which is used to encrypt data on open networks without the use of a passphrase, plus MFP, and voilà, the result is a more secure Wi-Fi network.

Note: The use of older encryption methods will still be allowed in the 2.4GHz and 5.0GHz bands.

CONCLUSIONS

When you take into consideration all the new enhancements introduced with Wi-Fi 6/6E it is clear that all aspects of Wi-Fi operation can be enhanced by upgrading. If you are still using older versions of Wi-Fi like 802.11n you will see a significant performance boost by upgrading to Wi-Fi 6/6E, and if you are using Wi-Fi 5 (802.11ac) you will notice great efficiency improvements that will translate into better performance. Most importantly, because of new technologies like OFDMA, OBSS and 6GHz support you will notice performance improvements in very busy environments like apartment complexes (MDUs), stadiums, and conference centers as well.

If, despite repeated efforts to optimize your WLAN's architecture and configuration you are still struggling with coverage, capacity, and performance issues, then an upgrade to Wi-Fi6/6E may indeed be the solution you need.

To learn more about how NetAlly can help with your new Wi-Fi 6/6E deployment, visit **www.netally.com/products/etherscopenxg**.