Wi-Fi 6E New Technology

Features and Enhancements

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Introduction

In this article, I describe the latest WLAN technology, Wi-Fi 6 (802.11ax) and its extension, Wi-Fi 6E and the new 6 GHz frequency band used by Wi-Fi 6E. Additionally, I address the history and development of the new technology, challenges faced, features provided, and supported hardware.

The next generation of the Wi-Fi standard is Wi-Fi 6, also known as 802.11ax. Wi-Fi 6E is based on Wi-Fi 6 and extends the usage of WLANs to the 6 GHz frequency band. This paper provides a concise overview of these enhancements

Wi-Fi 6 Overview

- Sixth Generation for WLAN Standards.
- Marketing Name as per the Wi-Fi Alliance (Wi-Fi 6) and named 802.11ax as per the IEEE amendment or High Efficiency (HE) as per the PHY name in the standard.
- Wi-Fi Standards developed starting in 1997 and were enhanced in 1999 with support for both the 2.4 GHz and 5 GHz bands until the ratification of 802.11ax introduced support for the 6 GHz band as regulatory domains opened these frequencies for use with unlicensed hardware.
- The previous WLAN standards were primarily focused on increasing the maximum theoretical single client speed without solving the problem of high-density environments to provide good and stable connections to high numbers of concurrent devices served and with a high number of APs as most of smart offices deploy Wi-Fi now. Employee connections depend totally on wireless in many cases, not only used for Internet access but for other business applications as well. Additionally, Wi-Fi is often used as a backup for solution for wired network connections.
- While 802.11ac (Wi-Fi 5) used only the 5 GHz band, as it was not specified to be enabled over 2.4 GHz due to channel bonding and using 80 & 160 MHz channel widths, which is not feasible at 2.4 GHz with maximum of 40 MHz channel width (which is, itself, too wide for 2.4 GHz as well).
- Wi-Fi 6, however, specified usage of the 2.4 GHz band by using multiuser technologies as OFDMA, MU-MIMO UL/DL, and BSS Coloring to be able to serve multiple users simultaneously and provide suitable bandwidth and data rate to each user based on requirements and to provide more capacity of users, not only maximum theoretical speed.

- The table below shows the WLAN standards development history

Protocol	Released	Frequency	Channel Width	MIMO	Maximum data rate (theoretical)
802.11ac wave2	2016	5 GHz	80, 80+80, 160 MHz	Multi User (MU-MIMO)	1.73 Gbps
802.11ac wave1	2014	5 GHz	80 MHz	Single User (SU-MIMO)	866.7 Mbps
802.11n	2009	2.4 or 5 GHz	20, 40MHz	Single User (SU-MIMO)	450 Mbps
802.11g	2003	2.4 GHz	20 MHz	N/A	54 Mbps
802.11a	1999	5 GHz	20 MHz	N/A	54 Mbps
802.11b	1999	2.4 GHz	20 MHz	N/A	11 Mbps
Legacy 802.11	1997	2.4 GHz	20 MHz	N/A	2 Mbps

SOURCE: https://broadbandlibrary.com/the-history-of-wi-fi-and-emergence-of-wi-fi-6/

Wi-Fi 6 Features

Wi-Fi 6 provides multiple new technologies which help to provide more capacity for concurrent user connections without affecting per client data rate as significantly as earlier MAC/PHY implementations within 802.11.

- **OFDMA & Resource Unit (RU) Allocation**: Enables frequency splitting of the channels into small units (RUs) that can be allocated per concurrent users instead of reservation for the entire channel width for only one user transmission. Many times the traffic doesn't need the whole channel, particularly in high density deployments, and this model has proven more efficient in the cellular wireless space.
- **BSS Coloring**: Allows stations to have different rules for backoff mechanisms based on signal detection for intra-BSS signals as opposed to inter-BSS signals. Signals from other BSSs can be ignored with a higher signal level than those from the station's BSS.
- **1024 QAM** Modulation: Provides higher data rate transmission, but incorporates more complex modulation requiring a better signal.
- **MU-MIMO** DL/UL: Unlike 802.11ax, MU-MIMO is supported bi-directionally, both downlink (like 802.11ac) and uplink (new in 802.11ax).
- **Longer Symbol** rate provides more robust outdoor coverage.

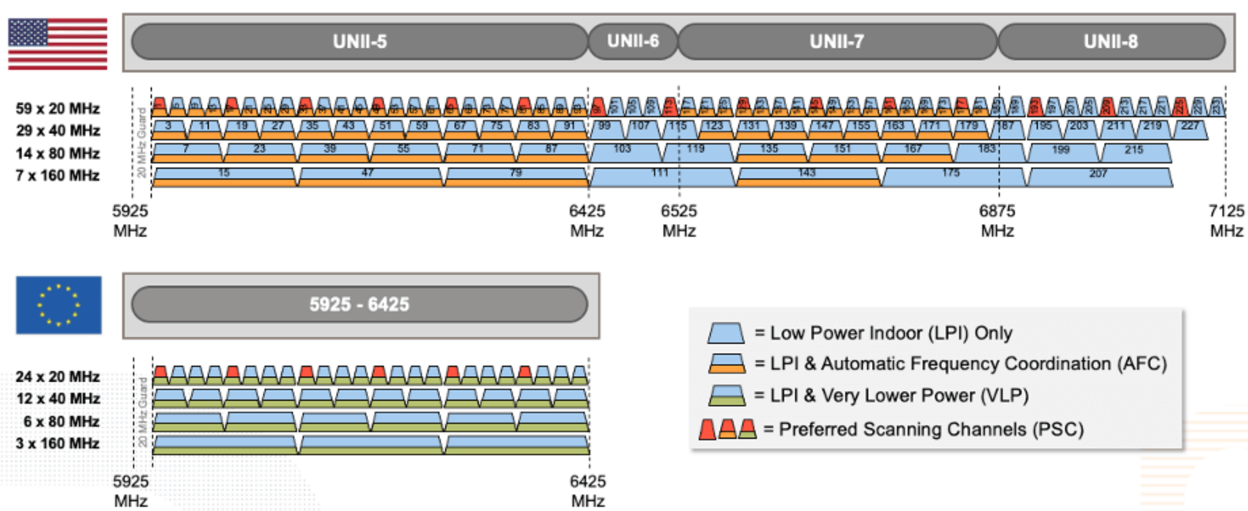
- **TWT (Target Wake Time)**: Better power consumption management using targeted wake times rather than requiring that stations all wake in the same way so stations that do not require as much "awake" time can sleep longer.
- **WPA3 –Enhanced Open:** new wireless security protocols provide more security and overcome the WI-FI **KRACK ATTACK** for WPA 2 and also incorporate better encryption for customers requiring open SSIDs, such as hotspots, airports, and hotels.
- **Wi-Fi 6** can theoretically reach up to **9607.8 Mbps** using **160 MHz** channel widths, 8 spatial streams and **800 ns** guard intervals using **MCS 11** with **1024 QAM** modulation.

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	1 960	15 680	7 840	576.5	544.4	490.0
1		QPSK	1/2	2		31 360	15 680	1 152.9	1 088.9	980.0
2			3/4				23 520	1 729.4	1 633.3	1 470.0
3		16-QAM	1/2	4		62 720	31 360	2 305.9	2 177.8	1 960.0
4			3/4				47 040	3 458.8	3 266.7	2 940.0
5		64-QAM	2/3	6		94 080	62 720	4 611.8	4 355.6	3 920.0
6			3/4				70 560	5 188.2	4 900.0	4 410.0
7			5/6				78 400	5 764.7	5 444.4	4 900.0
8		256-QAM	3/4	8		125 440	94 080	6 917.6	6 533.3	5 880.0
9			5/6				104 533	7 686.3	7 259.2	6 533.3
10		1024-QAM	3/4	10		156 800	117 600	8 647.1	8 166.7	7 350.0
11			5/6				130 666	9 607.8	9 074.0	8 166.6

Wi-Fi 6E is built on the same capability and enhancements of Wi-Fi 6 and extends over the new 6 GHz frequency band

Frequency Band History

- In April 2020 the Federal Communications Commission (FCC) announced the opening of the new**6 GHz** band for Wi-Fi and other unlicensed uses.
- Since **1985** Wi-Fi and other unlicensed technologies using 2.4 and 5 Ghz were only allocated approximately 583 MHz of spectrum in both the 2.4 and 5 GHz bands with fewer than 30 total non-overlapping channels for 20 and 22 MHz channels.
- In **April 2020**, Wi-Fi expanded over new 6 GHz Band for 1200 MHz of possible spectrum, more than doubling the current Wi-Fi spectrum in the U.S. and significantly increasing it in other regulatory domains as well.



SOURCE: https://blogs.arubanetworks.com/solutions/wi-fi-6e-in-europe-frequently-asked-questions/

Challenges in the 6 GHz Band

The 6 GHz band has a lot of challenges to be used for free unlicensed technologies like WI-FI as there are already other technologies allocated this band as below:

- **Fixed service:** Point-to-point microwave links used for backhauling many systems such as public safety dispatch systems and cell tower backhaul.
- **Satellite service:** Fixed earth-to-space links as well as mobile space-to-earth links, both common across 6 GHz.

- **Television broadcast services**: operating in both U-Nll-6 and U-Nll-8, which are reserved for Standard Power access.
- **Existing unlicensed users**: as ultra-wide-band users, which operate unlicensed across U- Nll-5 through 8 and will keep using this band.

Interference with these users should be addressed and acoided/coordinated correctly.

U-Nll-6 and 8 are used for mobile operators and won't be easy to coordinate in some areas.

Satellites are a very far, and the Received Signal Strength Indicator (RSSI) is not nearly as robust as a local Wi-Fi signal would be.

Restricting Standard Power access to **U-Nll-6 and 8 bands** will be a better solution to avoid issues.

Cellular Backhaul

Microwave Links

Satellite & TV

AFC: Automated Frequency Coordination Service

The following summarized facts related to AFC:

- **AFC** provider. Is an agency who builds databases for all registered users at 6 GHz to avoid interference for standard power APs.
- The **AFC provider** will contain a database of existing 6 GHz operators, including geolocation, frequencies, power levels, antenna coverage, etc.
- **Spectrum use coordination system**: The basic concept is that a new wireless device (access point) will search a registered database to confirm that its operation will not harm or interfere with any registered user.

- **Registration and Consultation** from AP to AFC will be controlled via central management as a cloud-type service or via a wireless controller acting as proxy.
- **Standard power APs** must use an AFC service to protect current 6 GHz operations from RF interference and this occurs one time daily.
- It will send the geolocation, including location confidence, antenna height, and FCC ID and AP serial number to an AFC provider.
- The **AFC** will do a lookup in the FCC Universal Licensing System (ULS) and then return a list of allowable frequencies and output power levels.
- Then AP can decide it's operating channel and power based on list sent by AFC.

Supported Device Types for 6 GHz Deployments

The FCC, as well as some other regulatory agencies, defines two types of device classifications with very different transmit power rules. (NOTE: Check with your regulatory agency to verify allowed operational parameters.)

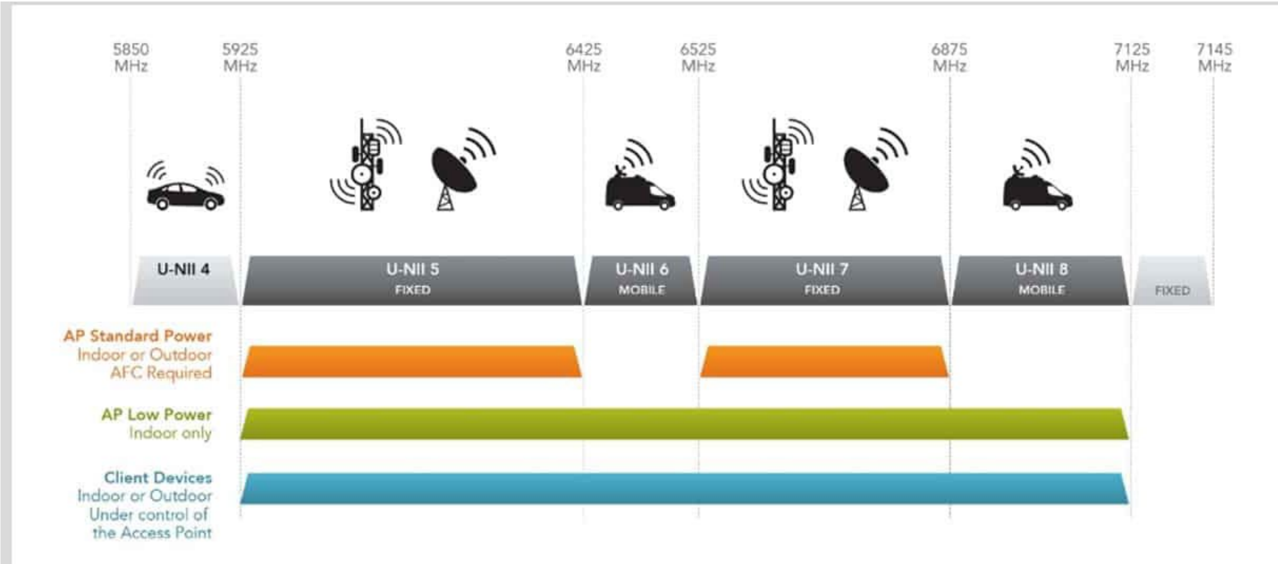
Standard Power AP:

- **Standard power APs** can operate in U-NII 5 & U-NII 7 bands indoors or outdoors at full power, but they must operate under control of an (AFC) system.
- **Standard power APs** can operate with a maximum effective isotropic radiated power (EIRP) of **36 dBm** or maximum spectrum density of 23 dBm/MHz.
- This power class is calculated as 20 MHz channels have highest PSD (power-spectral density).

Low Power AP:

- **Low power APs** can operate across the entire **6 GHz band** (U-NII 5, U-NII 6, U-NII 7 and U-NII 8) for indoor deployments only and don't need to consult an **AFC**.
- This will allow faster implementation for indoor devices which have low impact in 6 GHz registered services
- **LPI (low power indoor) APs** will have a maximum allowed EIRP of **30** dBm or **5 dBm/MHz PSD**.
- **LPI APs** will be able to use wider channels with higher power than **Standard APs**

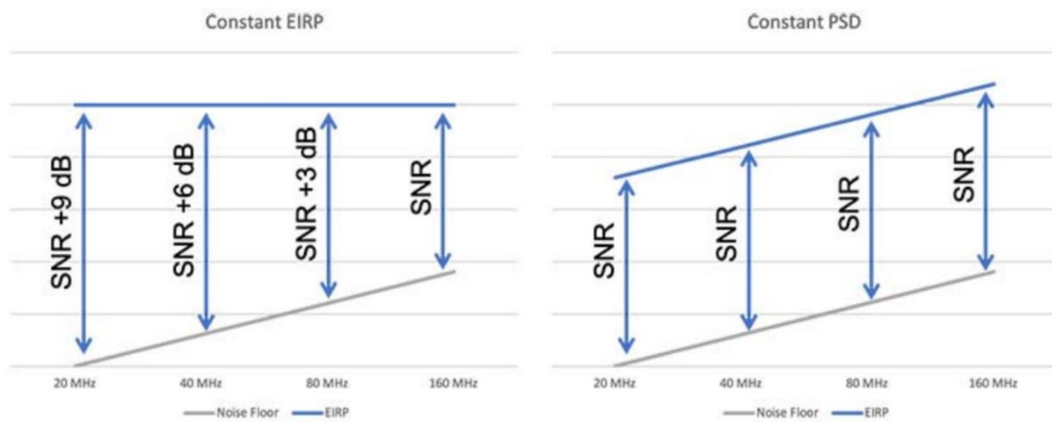
- Client devices connected to an LPI AP operate 6 dB lower.



SOURCE: https://www.litepoint.com/zh-hans/blog/an-introduction-to-wi-fi-6e-spectrum/

PSD: Power Spectral Density

- Channel bonding requires contiguous spectrum to bond two channels.
- 5 GHz has soma gaps in the total spectrum as DFS is often required and so the system cannot make use of all channels using channel bonding.
- With channel bonding noise is doubled as noise is accumulated from two adjacent channels while the AP transmits at the same power so the SNR is decreased.
- Every Channel Bonding (of 40 MHz) results in SNR decreased by 3 dB.
- For an 80 MHz channel SNR will decrease by 6 dB.
- EIRP rules identify the maximum level of transmitted power regardless channel width.
- With 6 GHz there is new threshold instead of EIRP - it's called Power Spectral Density (PSD).
- PSD: Allows Low Power Indoor (LPI) APs to transmit more power while using more channel width capacity to overcome this issue.
- The maximum power for Wi-Fi 6E LPI is 5 dBm/MHz PSD.
- This translates to 3 dB of maximum power being added every time the channel width doubles.



SOURCE: https://www.mist.com/power-spectral-density/

Enhancements

Wi-Fi 6E provides significant improvement and enhancements as below:

- More channels by adding a new frequency band: 6 GHz.
- More Channel Width by using 160 MHz for enterprise networks.
- Better interference immunity by defining a new power control mechanism: PSD.

The following table summarizes the Wi-Fi 6E improvements by adding new 6 GHz frequency bands.

More Channels	**59 x 20 MHz channels 1200 MHZ Bandwidth**
Bigger Channel Width	7 x 160 MHz channel compared with 2 Channels only at 5Ghz used at AX and AC
Higher Data Rates	Up to 1.2 Gbps with 1 x SS using 160 MHz Up to 2.4 Gbps with 2 x SS using 160 MHz

