White Paper

Wi-Fi 6E
October 2021

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Intended Audience

This document addresses factors and concerns related to the advancements of Wi-Fi 6E. This document is written for and intended for use by technical engineers with some background in Wi-Fi and 802.11/wireless engineering principles.

For more information on how to configure CommScope products, please refer to the appropriate CommScope user guide available on the CommScope/RUCKUS support site. https://support.ruckuswireless.com

Overview

Wi-Fi has been around for many years now with astounding success. Wi-Fi networks went from a barcode scanning backbone in warehousing to the backbone of communications globally in astounding time. Wi-Fi is integrated into many things we use today, from our phones and laptops to in-home devices like refrigerators and nanny cams. This explosion in technology has enabled us to do many things but the proliferation of devices has also caused RF congestion issues in many urban and other high-density areas. To put it simply the world is running out of allocated frequency space. In 2017 the Wi-Fi Alliance (WFA) released a study outlining the need for 1.5 GHz by 2025. The FCC in response to this report and influence from the Wi-Fi community identified the 6Ghz spectrum for use in Wi-Fi devices. The Wi-Fi alliance in response to the FCC created standards for use of the 6 GHz spectrum. You will see many references to the new 6Ghz spectrum as Greenfield and while it is Greenfield for Wi-Fi usage, meaning no incumbents utilizing the frequency range for that purpose, there are some incumbents utilizing the same range in licensed point to point systems. We will talk more about how Wi-Fi 6E works and how it is safe guarded to protect new systems and incumbent systems later in this document.

A Brief History of Wi-Fi Naming

The new Wi-Fi 6 marketing term may seem strange to some and for good reason. Before 802.11ax, the WFA didn't assign any marketing names to the different amendments that define the PHY rate. Wi-Fi standards are defined by the IEEE and follow a specific format based on the group that is formed to focus on a particular standard:

- 802 – The year and month that the IEEE first met. February 1980 is that date, hence "80" + "2".
- .11 – The working group of the IEEE for wireless communications. Other well-known groups are 802.3 (Wired Ethernet on UTP) or 802.5 (Token Ring)
- ax – The latest amendment to the standard. Amendments most known are usually related to the speed at which a station can transmit data over the air, also known as the PHY rate. Other well-known amendments not related to the PHY rate are 802.11i (marketed as WPA2), 802.11s (Mesh), and 802.11w (Protected Management Frames or PMF).

To understand a lot of the hype around Wi-Fi 6, we need to understand the suffixes that have been assigned to the standard by the IEEE.

802.11n **HT** (Wi-Fi 4) is known as "High Throughput" since that standard was a monumental leap forward in the PHY rate taking it from the 54 Mbps offered by 802.11g all the way to 600 Mbps.

802.11ac **VHT** (Wi-Fi 5) is known as "Very High Throughput" as that standard took the PHY rate up to 6.9 Gbps.

802.11ax **HE** (Wi-Fi 6) is known as "High Efficiency". Even though there is an advancement in the maximum speed, the biggest improvement with this standard was not speed but in the efficiency improvements introduced. Very few devices will be able to achieve anything close to the theoretical top end speed of Wi-Fi 6, but **every device will be able to take advantage of the improvements in spectral efficiency**.

The following chart shows how the previous, well-known PHY rates associate to the new naming convention.

802.11	Suffix	Wi-Fi Alliance Marketing Term	Maximum Speed (PHY)	Year Introduced	Supported Bands
802.11a	N/A	Wi-Fi 2*	54 Mbps	1999	5 GHz
802.11b	N/A	Wi-Fi 1*	11 Mbps	1999	2.4 GHz
802.11g	N/A	Wi-Fi 3*	54 Mbps	2003	2.4 GHz
802.11n	HT	Wi-Fi 4	600 Mbps	2009	2.4 & 5 GHz
802.11ac	VHT	Wi-Fi 5	6.9 Gbps	2013	5 GHz
802.11ax	HE	Wi-Fi 6, Wi-Fi 6E	9.607 Gbps	2020	2.4, 5, & 6 GHz

TABLE 1: WI-FI NAMING CONVENTION

Note: The Wi-Fi Alliance only officially named Wi-Fi 4 (802.11n), Wi-Fi 5 (802.11ac) and Wi-Fi 6 (802.11ax). Wi-Fi 1 – 3 is the assumed naming convention.

Wi-Fi 6E frequencies and regulations worldwide.

The USA and the FCC were the very first country and its regulatory agency to prepare the framework and ratify standards for Wi-Fi 6E, but as usual Europe and the rest of the world is following along. Worldwide conformity has many advantages as users are travelling the world at a rate unseen in human history. As it stands now at least 480 MHz of bandwidth will be used worldwide, this will allow manufacturers to create equipment that can be used by devices worldwide without user intervention to assure connectivity.

USA:

In the United States and its territories, the FCC has defined Wi-Fi 6E to use 1200 MHz of spectrum with usable spectrum starting at 5.945 GHz and continuing up to 7.125 MHz, in comparison, the existing 2.4 and 5 GHz spectrum combined have 653.8 MHz of bandwidth.

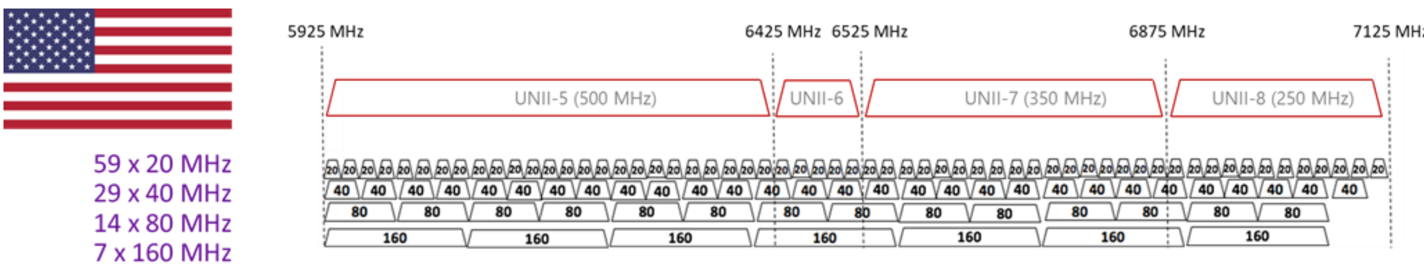

FIGURE 1: USA WI-FI 6E FREQUENCY CHART

A comparison in existing channels and Wi-Fi 6E channels reveals Wi-Fi 6E has more than double 20 MHz channels.

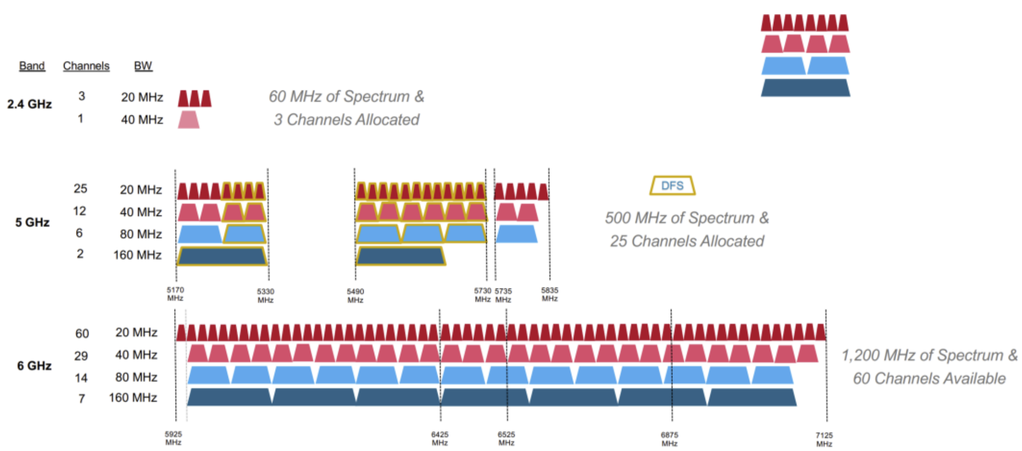

FIGURE 2: COMPARISON FREQUENCY CHART

European Union:

The EU regulations are allowing operation utilizing just 500 MHz of the lower band. This is due the EU regulatory service's concerns on spectrum reusage and incumbent users in the 6 GHz band. At this time only lower power indoor units will be allowed to be deployed in any countries in the EU. Many other countries worldwide are in the process of creating their own Wi-Fi 6E standards.

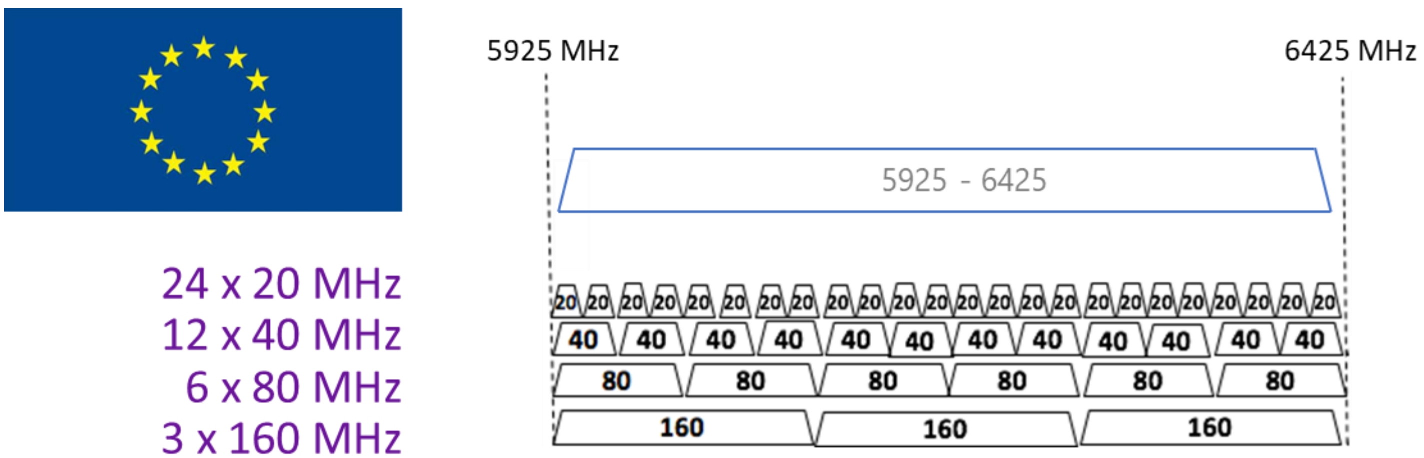

FIGURE 3: EU WI-FI 6E FREQUENCY CHART

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Equipment Classes

Low Power Indoor (LPI) APs

Low Power Indoor, this will be the most common class of AP, most home and enterprise APs will fall into this classification. LPI APs can operate across the entire band as their power is considered safe for incumbents and the structural materials, they are deployed inside of shield from RF leakage.

These cannot be used outdoors, and the FCC has regulations to prevent just such usage.

- No external antennas.
- No battery power.
- No weatherized enclosures.

The actual power level (EIRP) for LPI APs is not defined in absolute dBm, as for the lower bands, but at 5 dBm/MHz, adding 3 dB for every doubling of channel bandwidth, which gives 18 dBm EIRP for a 20 MHz channel, and up to 27 dBm for a 160 MHz channel. This is possible due to incumbents operating in a very narrow band. It is advantageous to the Wi-Fi network because background noise increases proportionally with bandwidth, so the SNR for a Wi-Fi receiver will be constant for different channel widths, given maximum transmit power levels.

NOTE: The European regulatory authorities allow a max EIRP of 23 dBM.

Standard Power (SP) APs

Standard Power APs are defined as any Wi-Fi 6E AP operating either indoor or outdoor operating at power levels above the LPI AP rules.

These APs are where the Automatic Frequency Coordination, or AFC, comes in. Operating at power levels above that of a LPI AP, SP APs can interfere with incumbents and must be able to check in with the AFC to comply with FCC regulations.

The maximum allowed power for SP APs is set at 36 dBm EIRP. (USA only)

SP APs are only allowed in the UNII-5 and UNII-7 bands which allows for forty-one 20 MHz channels; twenty channels with 40 MHz wide; nine channels at 80 MHz wide, or four channels at 160 MHz

NOTE: No SP APs are approved for use by the European regulatory authorities and only LPI APs are allowed with a max EIRP of 23 dBM.

Client devices

Client devices are assumed to be connected to a Wi-Fi 6E AP operating within regulations.

Client devices must connect at 6dB lower than the AP they are connecting to.

Very Low Power (VLP) devices

These are defined as hotspots, wearable devices and vehicular mounted devices transmitting at very low power levels. These are expected to cause no interference issues and will not require AFC connectivity and will be able to utilize all the UNII bands allocated for Wi-Fi 6E.

All of the standards for this class have not been defined as of yet.

Automated Frequency Coordination (AFC)

To protect incumbent licensed users, the FCC has mandated automated frequency control system (AFC) for Standard Power operations. There are already Incumbent wireless technologies like LTE and CBRS using SAS (Spectrum Access Server) to protect incumbents and new systems from interference. The AFC will be the first such system accessible for enterprise Wi-Fi deployments.

These systems are still in development and are not expected to be available until 2022.

Expect AFC providers to charge for access to the AFC just as SAS providers do today.

As the systems used by the Wi-Fi Alliance for certification and testing work today, an access point or controller acting as a proxy will send geolocation information, antenna height, FCC ID, and device serial number to the AFC. The AFC will do a lookup in the FCC Universal Licensing System (ULS) and calculate the ratio of interference to noise power based on the distance from the licensed antenna. The AFC then returns a list of allowable frequencies and output powers, for which the AP, based on the list, can use and what power it can operate at.

The FCC has mandated AFCs will include exclusion zones near observatories.

This will only be needed for Standard Power APs; Low power APs will not be required to use an AFC.

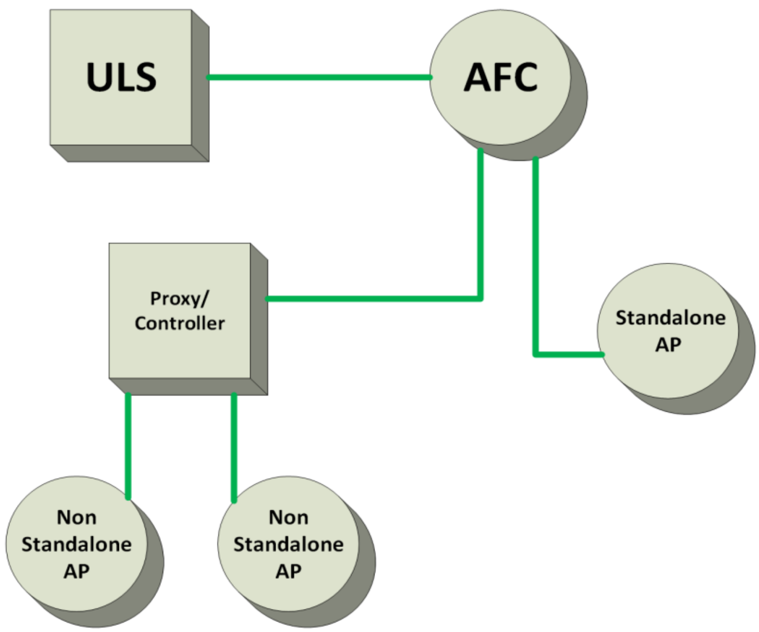

FIGURE3: AFC TOPOLOGY

Detailed topologies and traffic flows can be obtained from the Wi-Fi Alliance at the below link.

https://www.wi-fi.org/news-events/newsroom/wi-fi-alliance-furthers-automated-frequency-coordination-specification-and

Incumbents

We have talked about incumbents and how Wi-Fi 6E has things like the AFC, Low Power APs and a list of regulations to help protect these incumbents, this is who the incumbents are.

1. **Fixed Service**

   Fixed Service has over 50,000 registered links in the US. These links are for a myriad of purposes, from cell tower backhaul, emergency services. Many of these links are designed for less than 30 seconds downtime per year and operate in the UNII-5 and 7 with a few in UNII-8.

2. **Satellite Service**

   This band is part of the conventional C-band and is commonly used for TV and Radio uplinks and backhaul for voice and data; mobile space-to earth satellite use portions of UNII-7 and 8 as well.

3. **Television and Broadcast Services**

   Mostly Local news trucks and cable TV entities in the UNII-6 and UNII-8 range, also UNII-8 for venue sound and production companies.

4. **Existing unlicensed use – Ultra Wide Band across UNII-5, 6, 7, and 8.**

   Ultra-Wide Band had previously been allowed unlicensed use of 6 GHz, which doesn't change

Operation of Wi-Fi 6E

Wi-Fi 6E devices are full of new and innovative features. Since there are no other legacy Wi-Fi devices in the Wi-Fi 6E space, many of the old communications rules are no longer needed. New security and traffic protocols specific to Wi-Fi 6E help to keep client traffic secure and speed up the AP discovery process, some of these are listed below.

- **WPA3**-Over the air (OTAR) communications are secure even before authentication takes place.
- **Faster AP discovery**-Every 4^{th} 20 MHz channel is a preferred scanning channel (PSC)
- **Reduced probe request**-Clients are not allowed to probe in a PSC channel unless an AP has been discovered
- **Shortened beacon size**-Since there is no need for backwards compatibility the beacon does not need to accommodate legacy device information, a Wi-Fi 6E 6GHz beacon contains 13 separate sections as compared to a Wi-Fi 6 5GHz beacon contains 17 sections.
- **Multiple SSIDs in a single beacon**-This has been around for a while but was never supported on the client side, but since Wi-Fi 6E will be greenfield all of the new 6GHz clients will support this. This allows APs to broadcast up to 4 SSIDs in one beacon as opposed to the current method of one SSID per beacon.
- **Unsolicited probe responses**-Standard legacy beacon intervals are 102.4 msec, unsolicited probe responses can be transmitted every 20 msec, this allows a client device to decide whether the AP is suitable for a connection through passive scanning rather than active probing, also to discover neighbor APs through the reduced neighbor report. The client can now listen for just 20 msec. There is also no frame exchange during this process, reducing contention.

- **Fast Initial Link Setup (FILS)-**these contain mini beacons that allow a client to determine which AP to connect to, these are commonly referred to "short SSIDs".
- **Out of band AP discovery-**This feature allows Wi-Fi 6E client devices that are connected with 2.4 or 5GHz to discovery 6GHz APs without turning on their 6Ghz radio.
- **The Reduced Neighbor Report (RNR)-**Wi-Fi 6E clients associated in 5GHz can request an RNR to identify APs transmitting in 6GHZ and then move to that AP. (Part of Out of band AP discovery)
- **Access Network Query Protocol (ANQP**)- this capability is used in multiband networks; the APs would send ANQPs separate from probes or beacons, this is more efficient and allows clients to discover 6Ghz APs without leaving their current connection. (Part of Out of band AP discovery)

Deployment considerations

- Deploying Wi-Fi 6E capable APs will not change much in the actual RF footprint of what an existing deployment looks like today as far as the 2.4 and 5GHZ bands are concerned, 6GHZ propagation will be slightly less than current 5GHZ but not enough to drastically change planning. Many upgrades are not full campus upgrades and until the full propagation of 6GHz client devices, many operators will probably do targeted sections of their existing Wi-Fi deployments for upgrades. This poses potential problems with how many and where Wi-Fi 6E APs are placed, isolating a Wi-Fi 6E AP takes away many of the advantages described in the document thus far, attention should be focused to make sure "zones "are upgraded so that the full potential of Wi-Fi 6E is realized.
- Power consumption of the new APs will also be a consideration when designing and deploying new networks. Wi-Fi 6E APs will include 3 WLAN radios, increasing the power requirements where full operation will be right at the limit of PoE+ (30 Watts). Most deployments will require PoE++ (802.3bt class 5, 51 Watts) for full feature capabilities.
- Ethernet port capabilities of the internal switching are another important consideration. Most enterprise class Wi-Fi 6E access points will ship with 2 ethernet ports, these ethernet ports will be capable of 802.3bz (Multi-Gigabit) operation at 1, 2.5 and perhaps 5 Gbps. This may trigger the need for switching upgrades for at least the zones to be upgraded to Wi-Fi 6E APs. Upstream connections between the access layer switch and the rest of the network will also need to be examined as part of this.

Summary

Wi-Fi 6E will bring many new features and once client devices that support it are more plentiful, we will begin to see a much larger push for the latest and greatest. Operators should be methodical in their new deployments; approaching Wi-Fi 6E deployments in targeted zones in the beginning will give operators time to identify what the new features can do for them and what if any changes need to make to their infrastructure for future deployments. Wi-Fi 6E will increase the AP to client capabilities but will also add some complexity to design considerations. CommScope/RUCKUS will have a full line of Wi-Fi 6E APs and enterprise-class Ethernet switches to accommodate our partners regardless of the type or size of deployment.

Ruckus solutions are part of CommScope's comprehensive portfolio for Enterprise environments (indoor and outdoor).

We encourage you to visit **commscope.com** to learn more about:

- Ruckus Wi-Fi Access Points
- Ruckus ICX switches
- SYSTIMAX and NETCONNECT: Structured cabling solutions (copper and fiber)
- imVision: Automated Infrastructure Management
- Era and OneCell in-building cellular solutions
- Our extensive experience about supporting PoE and IoT

commscope.com

Visit our website or contact your local CommScope representative for more information.

Appendix A: Glossary

- EIRP – Effective Isotropic Radiated Power; hypothetical power radiated by an isotropic antenna to achieve the same signal strength. https://en.wikipedia.org/wiki/Effective_radiated_power
- RF – Radio Frequency, used at Layer 1 for wireless communications.
- RSSI – Received Signal Strength Indicator; estimated measurement of how well the signal is received.
- SNR – Signal to Noise Ratio; an absolute value of the difference between the signal received and the noise floor at the time. Value is always represented as a positive number.
- U-NII Band – Unlicensed National Information Infrastructure RF spectrum for Wi-Fi 6E
    - U-NII-5 through 8; 5.925 GHz to 7.125 GHz
- WFA – Wi-Fi Alliance https://www.wi-fi.org
- Low Power Indoor AP (LPI)
- Standard Power AP (SP)
- Very Low Power AP (VLP)
- Automatic Frequency Coordination (AFC)
- FCC Universal Licensing System (ULS)
- Over the air (OTAR)
- Preferred Scanning Channel (PSC)
- Fast Initial Link Setup (FILS)
- The Reduced Neighbor Report (RNR)
- Access Network Query Protocol (ANQP)

Appendix B: Referenced Links

- WPA3: https://www.commscope.com/blog/2018/wpa2-wpa3-the-new-the-changed-the-future/
- Wi-Fi 6E: https://www.commscope.com/globalassets/digizuite/565283-wifi-6e-tech-brief-co-114896-en.pdf