Wi-Fi 6E:

Wi-Fi® in the 6 GHz band

January 2021

Executive summary

In less than 20 years, Wi-Fi® has grown from a nascent technology to a global necessity in business and in life. Wi-Fi innovation has given individuals more flexibility to work, be entertained, and connect to friends and family in a growing variety of places. Wi-Fi provides both social and economic value globally and has proven to be a star performer in enabling continued productivity in challenging times and during public emergencies, such as the COVID-19 pandemic.

In 2019, Wi-Fi Alliance® introduced a new Wi-Fi generation, Wi-Fi CERTIFIED 6™, designed to meet the growing need for capacity and ensure that Wi-Fi devices could continue to operate reliably in crowded, congested environments. Wi-Fi CERTIFIED 6 is based on the Institute of Electrical and Electronics Engineers (IEEE) 802.11ax standard, continuing broad adoption throughout the technology ecosystem with original equipment manufacturers (OEMs), service providers, carriers, and semiconductor vendors.

As the number of Wi-Fi devices in use worldwide continues to grow rapidly, so does concern over a shortage of available spectrum to support the increasing number of Wi-Fi devices, as well as newer, more demanding applications and increased data consumption. For more than 20 years, Wi-Fi has provided great value while utilizing only the original amount of spectrum available to it. In 2020, nearly 17 years since the last major spectrum allocation, the United States Federal Communications Commission (FCC) approved use of 1200 MHz in the 6 GHz band for unlicensed technologies. In effect, this nearly tripled the amount of spectrum available to Wi-Fi. Other regulatory bodies worldwide are also taking steps to expand Wi-Fi access to the 6 GHz band, including Brazil, Chile, the European Union, Japan, Mexico, South Korea, Taiwan, United Arab Emirates, and the United Kingdom.

As more countries approve unlicensed access to the 6 GHz band, silicon vendors and OEMs prepare to meet demand by developing Wi-Fi 6 devices capable of operation in the 6 GHz band. These devices, known as Wi-Fi 6E devices, extend the benefits that Wi-Fi 6 already provides in the 2.4 and 5 GHz bands to 6 GHz, and help increase overall capacity and performance. Wi-Fi Alliance now offers certification for Wi-Fi 6E products under the Wi-Fi CERTIFIED 6 program.

This paper discusses the importance of Wi-Fi access to the 6 GHz band, the benefits that Wi-Fi 6E devices provide to ensure continued success, and key market segments that will benefit from Wi-Fi 6E deployments.

Wi-Fi 6E benefits

- Increases usable Wi-Fi spectrum capacity by up to 3X
- Provides up to 1200 MHz of uncongested spectrum in 6 GHz
- Provides up to seven superwide 160 MHz channels to enable demanding applications such as AR/VR
- Higher aggregate network performance
- Includes the latest in Wi-Fi security

Wi-Fi 6E device capabilities

- Extends features and benefits of Wi-Fi CERTIFIED 6 into 6 GHz
- Delivers high performance, low latency Wi-Fi experience in 2.4, 5, and 6 GHz
- Supports efficient multiband discovery and onboarding
- Enables better spectrum resource management
- Provides user data protection

The state of Wi-Fi spectrum access

Over the last 20 years, Wi-Fi adoption has grown exponentially, becoming an integral connectivity technology for personal and business applications around the world. For a vast majority of end users, Wi-Fi is the primary means of connecting multiple devices due to its inherent strengths, which include affordable performance, ease of use, ubiquity, and flexibility.

The advent and development of Wi-Fi has changed the way we work and live. Global businesses have been built on Wi-Fi, cellular operators depend on Wi-Fi to efficiently manage and enhance their networks, and Wi-Fi is utilized to bridge the economic digital divide. Most people now expect to be able to connect to Wi-Fi networks wherever they are. Nearly every smartphone, tablet, and laptop computer ships with Wi-Fi, and new types of Wi-Fi capable devices—from fitness trackers to refrigerators—enter the market every year, making up more than 33 billion Wi-Fi devices shipped.[1]

The global COVID-19 outbreak of 2019-2020 made evident the importance of Wi-Fi, which has greatly enabled end users to work and learn remotely, stay in touch with loved ones, see doctors using telehealth applications, and more. This has further cemented Wi-Fi as key to most countries' digital infrastructure.

While each generation of Wi-Fi offers users faster speeds, higher density, lower latency, and faster throughput, the industry held concerns about an eventual shortage of unlicensed spectrum around the world. This anxiety was driven by the high compounded growth rate and deployment of Wi-Fi devices, and the emergence of new applications such as cloud communications, video-enabled meetings, augmented and virtual reality (AR/VR), mobile gaming, and unified communications. The growing number of devices, and increasing popularity of data-heavy applications, generate great amounts of traffic on Wi-Fi networks, often more than the current allocation of unlicensed spectrum can comfortably support while maintaining quality experiences.

Regulators around the world are reacting by making more unlicensed spectrum available in the 6 GHz band due to the well-established economic gains and user benefits that Wi-Fi technology provides. Countries approving access to the full 1200 MHz of spectrum in the 6 GHz band will nearly triple the available spectrum, as indicated in Figure 1. This gives Wi-Fi a significant boost that will enable the global Wi-Fi industry to support demanding applications and reduce congestion in all Wi-Fi spectrum bands.

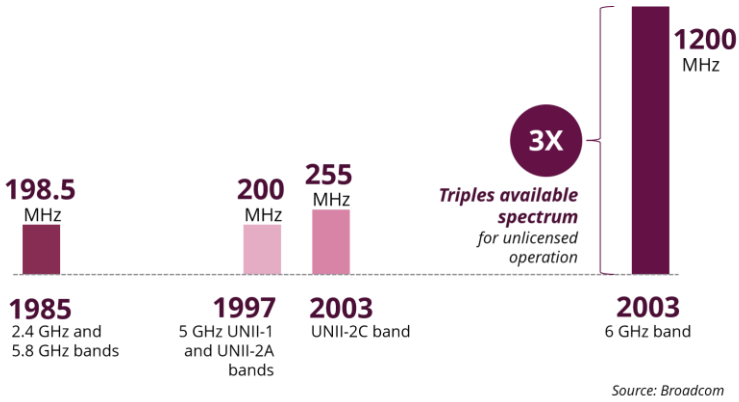

Figure 1. Countries gaining access to all 1200 MHz of the 6 GHz band effectively triple spectrum available to Wi-Fi

The appeal of Wi-Fi in 6 GHz

There is a rising need for more unlicensed spectrum to be made available to Wi-Fi if the trajectory of Wi-Fi adoption continues. In this context, there are several factors that make the 6 GHz band particularly attractive for the deployment of Wi-Fi technology.

Contiguous spectrum: The 6 GHz frequencies under consideration are adjacent to existing 5 GHz Wi-Fi. This reduces the incremental cost of adding 6 GHz capability to devices that already support Wi-Fi in the 5 GHz band. The propagation characteristics of radio signals in the 6 GHz bands are similar to those in 5 GHz, making field upgrades of existing equipment easier.

[1] *IDC, 2020*

Wider channels: Up to 1200 MHz of contiguous spectrum allows for the use of wider channels to support demanding applications that require high throughput and low latency, such as HD video streaming, AR/VR, and telepresence.

Less interference: The 6 GHz band is relatively uncongested and will only be accessed by Wi-Fi devices from the Wi-Fi 6 generation moving forward. Migrating such demanding applications and usage to the 6 GHz band will free up congestion in 2.4 and 5 GHz frequencies, resulting in overall capacity and performance improvements for Wi-Fi devices already deployed.

These features combine to enable Wi-Fi 6E devices to deliver gigabit speeds, extremely low latency, and greater network capacity, referenced in Figure 2.

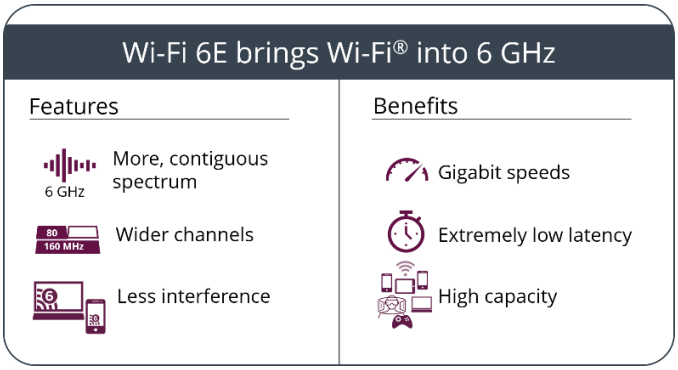

Figure 2. Key features and benefits the 6 GHz band delivers through Wi-Fi 6E devices

Wi-Fi 6E: Turbocharged Wi-Fi for the most demanding applications

Today's networks require enhanced Wi-Fi capabilities that improve performance, spectrum efficiency, and throughput while in the presence of interfering sources in dense networks, heavily loaded access points (APs), and indoor and outdoor deployments. Users demand constant connectivity and efficient Wi-Fi performance at home and work, as well as in transportation hubs, stadiums, and malls—even while using public transportation.

To meet the increasing user demand for swift, secure, and seamless Wi-Fi service, access to 6 GHz spectrum is becoming available. The capacity and performance increases presented by this new spectrum will deliver overall Wi-Fi network performance enhancements.

The Wi-Fi ecosystem is rapidly developing Wi-Fi 6E devices that will bring all the key features of Wi-Fi 6 to the 6 GHz band. Wi-Fi 6E devices comply with all the pre-requisites of Wi-Fi CERTIFIED 6, such as Wi-Fi CERTIFIED Agile Multiband™ for intelligent steering and Wi-Fi CERTIFIED WPA3™ for unparalleled security. Wi-Fi 6E is also suitable for low-power, indoor use cases such as home automation, security, and industrial IoT deployments, as it can benefit from innovations in Wi-Fi 6 specifically designed with the IoT market in mind, such as target wake time (TWT) and advanced scheduling.

Wi-Fi 6E key features

Wi-Fi 6E devices support all the features introduced in Wi-Fi CERTIFIED 6, including:

- Uplink and downlink orthogonal frequency division multiple access (OFDMA)
- Downlink multi-user MIMO
- Target wake time (TWT)
- Efficient modulation schemes
- Increased symbol duration for robust outdoor performance
- Improved MAC signaling

This powerful set of features, which defines the Wi-Fi 6 generation, carry over into the 6 GHz band, enabling Wi-Fi 6E devices to deliver robust, high performance connectivity for businesses, consumers, and service providers alike.

The following features specific to Wi-Fi 6E devices provide additional benefits and enable advanced connectivity uses emerging today.

Vastly increased spectrum

6 GHz generally refers to up to 1200 MHz of contiguous spectrum directly adjacent to 5 GHz, where Wi-Fi already operates. This can triple the spectrum available in countries that allocate the full 1200 MHz. Expanding available operating spectrum enables the use of wider channels and higher aggregate performance, even in highly congested Wi-Fi environments.

Wi-Fi 6E devices support up to sixty 20 MHz wide channels, twenty-eight 40 MHz wide channels, fourteen 80 MHz wide channels, or seven superwide 160 MHz wide channels, as shown in Figure 3. Wider channels enable superior performance for the most demanding applications and scenarios.

Regulators who approve use of the full 1200 MHz of spectrum make it feasible to deploy faster, more efficient networks for their markets, providing better end user experiences as Wi-Fi 6E devices deliver the full benefits of Wi-Fi 6. Countries that allocate the full 1200 MHz in 6 GHz could access seven 160 MHz channels; those who allocate less than the full 1200 MHz, will have access to fewer 160 MHz channels.

Enterprises deploying Wi-Fi 6E networks have access to 40, 80, and 160 MHz channels. When IT managers have access to dozens of non-overlapping channels, it simplifies IT planning significantly, improves frequency reuse, and makes it possible for IT managers to deploy APs that are two to four times faster than 5 GHz APs using 20 MHz channels.

The importance of wider channels

While Wi-Fi has supported channel bandwidths as wide as 160 MHz since 2015 with Wi-Fi 5, this capability has seldom been used in the field. The main constraint in using 160 MHz deployments is the insufficient number of wider bandwidth channels that are unencumbered by dynamic frequency selection (DFS) requirements. To maximize capacity, it was often necessary to restrict network bandwidths to 20 MHz or 40 MHz wide channels. Lower channel bandwidths result in lower speeds, higher duty-cycles, higher latency, and lower battery life for users, even if the user device can support wider bandwidths and higher rates.

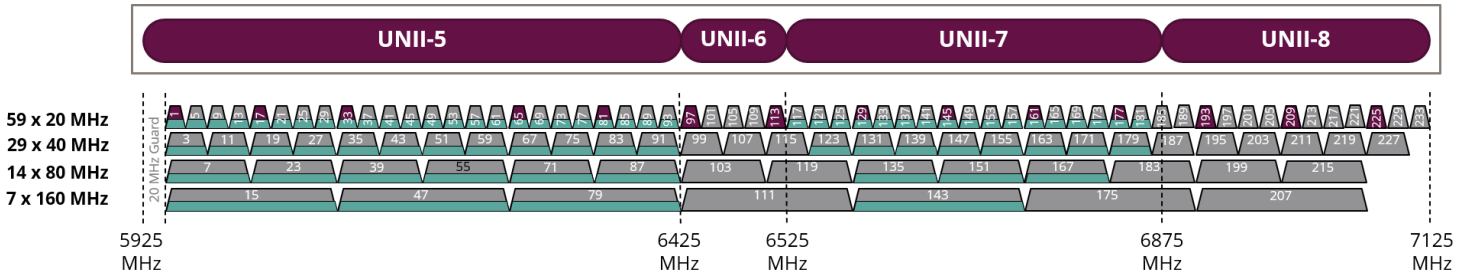

Figure 3. Example of 6 GHz channels in the United States. Available channels and channel widths could vary by country and by MHz approved by governing bodies.

Efficient network discovery schemes

Wi-Fi 6E devices periodically broadcast probe response or Fast Initial Link Setup (FILS) discovery frames in preferred scanning channels, which provide information for enhanced passive discovery by devices. This reduces the need for AP probing and for associated signaling overhead, leading to more efficient use of spectrum.

In addition to enhanced discovery and association within the 6 GHz band, Wi-Fi 6E devices include out-of-band discovery mechanisms that allow multiband devices to detect 6 GHz networks by scanning the 2.4 GHz and 5 GHz bands and leveraging the reduced neighbor report (RNR). Multiband APs typically advertise 6 GHz capability in 2.4 GHz and 5 GHz bands using legacy modulations to aid discovery. This capability, powered by Wi-Fi Agile Multiband™, enhances basic service set (BSS) network performance, by enabling Wi-Fi 6E devices to quickly determine and transition to the optimum channel or band for its current use.

Reduced contention

Wi-Fi 6 introduced new mechanisms to reduce channel contention and collisions between devices. These techniques work exceptionally well in the 6 GHz band, where only Wi-Fi 6E devices with advanced capabilities operate. Hence contention is reduced, as devices strive to respect each other's transmit windows and minimize collisions and retransmissions.

Enhanced security

Wi-Fi 6E devices require WPA3™ security, bringing next generation security to Wi-Fi devices in the 6 GHz band. WPA3 requires the use of Protected Management Frames (PMF) and Wi-Fi CERTIFIED Enhanced Open™, which provide data protections to users accessing unsecured Wi-Fi networks.

Automated Frequency Coordination (AFC)

Some regulatory bodies, such as the FCC in the U.S., intend to create an AFC system to regulate access to the 6 GHz frequencies prior to use. An AFC database will determine the frequencies and power levels with which APs would be allowed to operate without causing interference to incumbent systems already operating in 6 GHz. It is expected that use of AFC will only be required for outdoor deployments, as well as APs operating with standard power in Unlicensed National Information Infrastructure (UNII) bands 5 and 7. Low Power Indoor (LPI) APs will not be required to use AFC systems across the entire 1200 MHz.

Use cases where Wi-Fi 6E is the best technology choice

Modern Wi-Fi use is characterized by large numbers of devices, diverse device types, multiple Wi-Fi generations, and a variety of wireless applications running in a single coverage area. This is true for single family and multi-family residential networks, office networks, and managed networks in shopping malls, hotels, stadiums, and transportation hubs. Users expect to be able to use any application they desire—including high definition and 4K video streaming, online gaming, and video meeting applications—almost anywhere. Homes and offices expand this list with such uses as wireless display, surveillance video, and smart home systems.

Wi-Fi 6 and Wi-Fi 6E devices provide better user experiences and performance improvements in a wide variety of connectivity scenarios (Figure 4), from basic functionality to bandwidth-intensive tasks in dense networks that require high throughput and low latency. Wi-Fi 6E adds major increases in overall network capacity, determinism, and performance by leveraging up to 1200 MHz of greenfield spectrum. This enables the successful implementation of advanced use cases in virtually any connectivity market segment: home Wi-Fi, Internet of Things (IoT), and managed networks everywhere.

Figure 4. Wi-Fi CERTIFIED 6 excels in a wide variety of environments and uses, including industrial IoT and high-density environments

Wi-Fi 6E extends all the Wi-Fi network capabilities of Wi-Fi 6, with mechanisms to effectively handle different types of traffic from multiple users simultaneously. This provides users with higher throughput and improved device battery life in the 6 GHz spectrum band, enabling new use cases and enhancing existing ones.

General uses for Wi-Fi 6 and Wi-Fi 6E devices are well documented; examples of where Wi-Fi 6E is the best choice for enabling advanced connectivity needs are summarized below.

Extremely dense radio frequency environments

While modern Wi-Fi use involves more devices doing more things overall, certain environments can provide greater challenges where Wi-Fi 6E can bring meaningful benefits. Transportation hubs and shopping malls are challenging environments that experience very high interference levels between APs in the same network, or between APs belonging to different networks. Unmanaged networks and other technologies that use the same spectrum present additional interference challenges. These environments tend to see significant levels of device mobility between APs, but must also manage the changing needs for Wi-Fi capacity based on events, time of day, and other factors. Since mobile devices tend to have limited spatial streams, it is key that Wi Fi networks in transportation hubs and

malls have high capacity to handle a massive number of users at once, and that the network edge and roaming capabilities are reliable.

In addition to providing more and wider channels, Wi-Fi 6E devices enable the use of transmit beamforming and enhance each connection to a Wi-Fi AP. This allows more users to connect to APs, while still providing high throughput. The addition of Wi-Fi 6E expands and improves the ability of Wi-Fi networks to deliver better performance for each user application, despite high traffic and interference levels.

Advanced video applications

AR/VR and body computing

There are new uses for immersive, interactive augmented reality, virtual reality, and mixed reality coming to market every year. These new applications require extremely low latency and high throughput to provide the desired experience. Beyond entertainment and gaming, AR/VR and mixed reality are evolving to include remote surgery, remote building walkthroughs, and body worn cameras or computers with live stream feeds. These and other use cases are emerging that require wider channel bandwidths to deliver optimal user experience.

Wi-Fi 6E provides up to 1200 MHz extra bandwidth to handle these applications, including up to seven superwide 160 MHz channels. Using wider channels dramatically decreases data transmission times, which—together with the requirement that all Wi-Fi devices operating in 6 GHz must support Wi-Fi 6—significantly reduces overall network latency. These factors are enabling demanding AR/VR applications to reach their full potential over 6 GHz Wi-Fi networks.

Multigigabit streaming

Wi-Fi 6E can provide a superior user experience for stadiums and other highly congested venues. During events, users want to have access to video from different camera angles, as well as the ability to provide real-time social media commentary in every seat. Attendees frequently upload pictures and videos to share their experiences and download data to augment their knowledge during the events.

When deploying Wi-Fi 6E networks, network planners and venue owners can better manage Wi-Fi coverage and capacity for these dense scenarios, improving coexistence with overlapping networks to provide a seamless, high quality user experience leveraging the full multi-user capabilities and the 60 additional 20 MHz wide channels available with Wi-Fi 6E.

Unified communications and cloud computing

Enterprises that have deployed earlier generations of Wi-Fi typically chose 20 MHz or 40 MHz channel bandwidths to maximize frequency reuse without interruption. Wi-Fi 6E devices can *triple* the amount of available bandwidth—a major benefit to network planners who can now deploy wider bandwidth and more reliable networks, while having enough capacity for channel reuse without overlap. This benefits almost any type of enterprise environment, but a key emerging use for Wi-Fi 6E in the enterprise is the ability to harmonize computing and unify the communications systems that today's digital workforce uses. Unified communications help network managers to cohesively package the many different platforms upon which employees communicate and collaborate to simplify the way teams work. This can result in increased productivity and reduced costs because these systems operate in the cloud. Unified communications can include such applications as messaging platforms, voice and video conferencing, collaboration tools, and file sharing. These can be managed through Wi-Fi locally or in cloud-based computing environments.

Wi-Fi 6E can provide superior capacity and lower latency for these enterprise applications, as well as data storage and backup, training, and more by optimizing frequency reuse with wider bandwidth channels.

Telepresence

In the new digital economy, many employees can work from anywhere. They do so primarily through Wi-Fi. The coronavirus pandemic, which caused worldwide lockdown orders, quickly increased work from home implementations globally. It has also highlighted the importance of reliable, well managed Wi-Fi as a key enabler of work-from-home scenarios.

Telepresence goes beyond enabling individual employees to work from their homes—it can also be used to webcast meetings where streaming content or high-resolution graphics must be delivered to dozens of individual workstations simultaneously, to meet with healthcare professionals, and to access remote areas of the world where sending humans could be cost prohibitive or difficult. Wi-Fi 6E is the premier technology choice in these situations due to its faster higher aggregate data rates, lower latency, and higher number of wider channels.

Wi-Fi 6E certification option

Wi-Fi 6E is the newest addition within the Wi-Fi CERTIFIED 6 program. Wi-Fi 6E devices are tested for critical features of the IEEE 802.11ax amendment in the 6 GHz band, interoperability with equipment from multiple vendors, and performance thresholds.

Wi-Fi 6E will deliver valuable benefits common to all Wi-Fi CERTIFIED™ programs:

- Interoperability with Wi-Fi CERTIFIED equipment from any vendor
- Backward compatibility with previously certified equipment operating in the same frequency bands
- Proven Wi-Fi security provided by WPA3

To fully benefit from the features of Wi-Fi 6E, both the AP and the client device should be certified.

Summary

The IEEE 802.11ax amendment, upon which Wi-Fi 6 is built, already includes support for operation in the 6 GHz band. This band does not have traffic from any unlicensed spectrum legacy devices, making it suitable for delivery of high speed, low latency immersive Wi-Fi services. Devices in this band are unencumbered by inefficiencies introduced by support of legacy devices or the need to ensure backward compatibility requirements are met. With this in mind, Wi-Fi Alliance adds Wi-Fi 6E as an optional certification in the Wi-Fi CERTIFIED 6 program to meet the urgent industry demand for certified products that operate in this newly available spectrum. The addition of Wi-Fi 6E to the Wi-Fi CERTIFIED 6 program continues the 20-year tradition of Wi-Fi Alliance standards-based testing.

Devices certified under the Wi-Fi CERTIFIED 6 program include a broad range of physical (PHY) layer and medium access control (MAC) layer features for efficiently handling demanding applications in dense network environments, even on the network's edge.

Wi-Fi 6E is now ready to take full advantage of available unlicensed frequencies—including the 6 GHz spectrum band—and of all the advanced features provided by Wi-Fi 6. The growth of Wi-Fi 6 and Wi-Fi 6E devices will unleash new innovation and Wi-Fi connectivity experiences for years to come.

About Wi-Fi Alliance®

www.wi-fi.org

Wi-Fi Alliance® is the worldwide network of companies that brings you Wi-Fi®. Members of our collaboration forum come together from across the Wi-Fi ecosystem with the shared vision to connect everyone and everything, everywhere, while providing the best possible user experience. Since 2000, Wi-Fi Alliance has completed more than 50,000 Wi-Fi certifications. The Wi-Fi CERTIFIED™ seal of approval designates products with proven interoperability, backward compatibility, and the highest industry-standard security protections in place. Today, Wi-Fi carries more than half of the internet's traffic in an ever-expanding variety of applications. Wi-Fi Alliance continues to drive the adoption and evolution of Wi-Fi, which billions of people rely on every day.