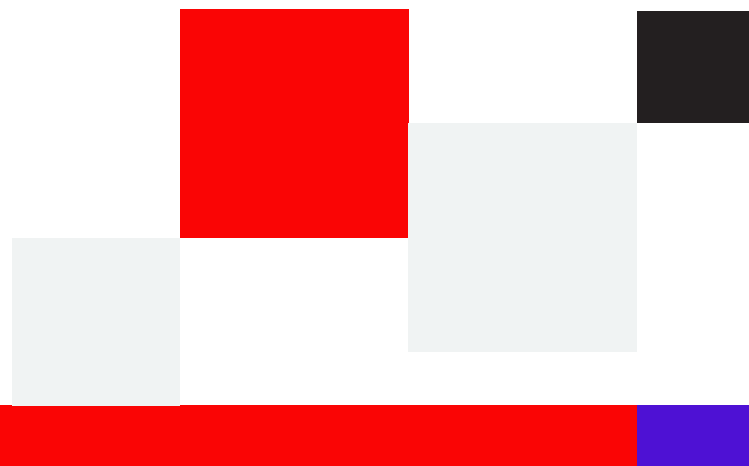


Whitepaper

Why Wi-Fi 6 goes hand-in-hand with cellular to enable the hyper-connected enterprise future



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Introduction

Wi-Fi 6 is increasingly seen as a complementary to cellular technologies such as LTE-M and even 5G –when it becomes widely available. In private networks, the performance uplift of Wi-Fi 6 over Wi-Fi 5 is substantial and more than sufficient to support innovative use cases such as automated guided vehicles, industrial robots and many other applications. In indoor locations such as stadiums, large venues, offices and hotels, Wi-Fi 6 has attractive attributes. In addition, the technology is being utilized in the automotive industry to enable applications such as infotainment, monitoring, maintenance and upgrades by the manufacturer alongside greater personalization of vehicle features.



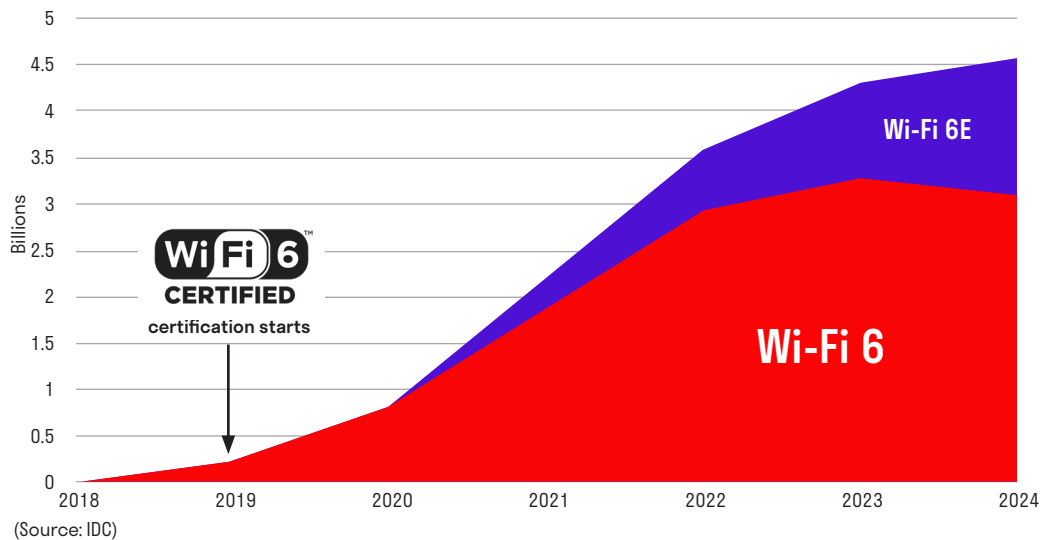
Wi-Fi 6 uptake status

Research firm, IDC, estimates that Wi-Fi 6 will account for 79% of all Wi-Fi product shipments within the next two years. The firm anticipates two billion Wi-Fi 6 device shipments in 2021, accounting for more than 50% of all Wi-Fi shipments. The firm expects to see more than 3.5 billion Wi-Fi 6 product shipments in 2022 with nearly 20% of all Wi-Fi 6 device shipments able to support 6 GHz by 2022.

The introduction of the latest generation of Wi-Fi and the allocation of new spectrum in the 6GHz band which allows unlicensed use worldwide is enabling Wi-Fi 6E, in particular, to deliver higher data rates and increased capacity to environments that have many connected devices. The Wi-Fi Alliance reports that in addition to these benefits improved power efficiency means that Wi-Fi 6 will support unified communications, cloud computing, augmented and virtual reality and telepresence¹.

Wi-Fi 6E offers the features and capabilities of Wi-Fi 6 that have been extended into the 6GHz band and, with Wi-Fi 6E devices now possible to certify, the benefits of 6 GHz spectrum are available to consumers, device manufacturers and service providers as the band is being made available around the world.

Figure 1: Wi-Fi 6 shipments 2018-2024



¹ <https://www.wi-fi.org/ beacon/the-beacon/wi-fi-6-shipments-to-surpass-52-billion-by-2025>



Key findings include:

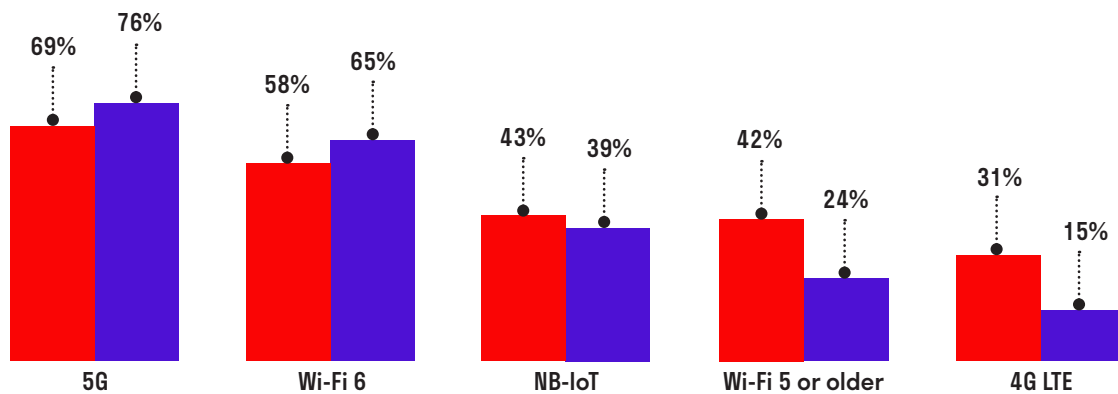
- 58% of respondents said 6GHz was critical or very important to their strategy
- 41 countries, representing 54% of world GDP, have authorized 6GHz spectrum for use
- More than 338 million Wi-Fi 6E devices will enter the market this year
- Nearly 20% of all Wi-Fi 6 device shipments will support 6GHz by 2022

IDC is not alone in its enthusiastic projections. The Wireless Broadband Alliance has reported that 83% of service providers and equipment manufacturers and enterprises worldwide will have deployed Wi-Fi 6 or 6E or plan to do so before the end of 2022 . That is one finding from the Alliance’s survey which forms part of its Annual Industry Report 2022. The Alliance expects 6GHz spectrum will enable Wi-Fi to support more users and new use cases, such as time-sensitive networking (TSN) for Industry 4.0 applications.

Momentum is swinging behind Wi-Fi 6 as revealed by comparing the 2021 Deloitte Study of Advance Wireless Adoption with the firm’s 2020 study. The 2020 study found that US-based networking executives still viewed 4G/Long Term Evolution (LTE) and current or previous versions of Wi-Fi as the most critical wireless technologies for their businesses with most viewing 5G and Wi-Fi 6 as set to arrive over the next few years. Attitudes have shifted quickly and global networking decision-makers now regard 5G and Wi-Fi 6 as the most critical wireless technologies for their business initiatives.

Figure 2: Networking executives regard 5G and Wi-Fi 6 as most critical wireless technologies

Percent ranking each a top-three critical wireless networking technology for their organization’s business initiatives



Note: N=437 global networking executives.
(Source: Deloitte)

2 <https://wballiance.com/83-will-have-deployed-wi-fi-6-6e-by-2022/>





67%

of respondents' organizations are either running pilots or deploying Wi-Fi 6 solutions



58%

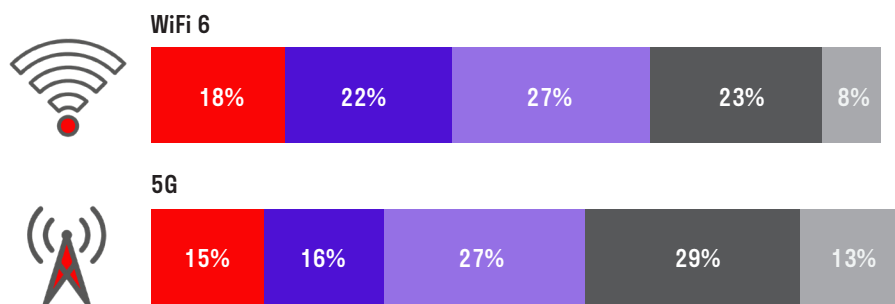
are doing the same with 5G

In the next three years, as physical 5G infrastructure is built out and 5G devices become more available, respondents expect the new technologies to become even more significant.

The consulting firm found that adoption is well past the planning stage with two-thirds of respondents' organizations are either running pilots or deploying Wi-Fi 6 solutions already, while 58% are doing the same with 5G. Approximately a further 25% are in the process of actively preparing to utilize each technology – for example by acquiring devices and infrastructure or identifying potential providers and partners.

Figure 3: Extent to which enterprises are running pilots or deploying Wi-Fi 6 and 5G

Level of adoption of each technology



Note: N=437 global networking executives. Numbers may not total 100% due to a small number who reported "no plans to use."

(Source: Deloitte)

- Deploying enterprisewide
- Deploying in many departments
- Started pilots/experiments in several departments
- Preparing to use
- Planning to use in two to three years



Why Wi-Fi 6?

Wi-Fi has existed since the late 1990s but has improved dramatically in the last decade. Wi-Fi 6 is a substantial upgrade over previous generations, although the differences may not seem immediately obvious to the average user. Speed is the most obvious characteristic with 9.6Gbps the maximum output of Wi-Fi 6 across multiple channels. This is apparently a significant uplift over the 3.5Gbps offered by Wi-Fi 5 but don't forget that capacity is shared across all the connected devices and Wi-Fi 6 can support more devices than Wi-Fi 5. Wi-Fi 6 also offers improved latency by handling network traffic more efficiently.

Wi-Fi 6 has adopted orthogonal frequency division multiple access (OFDMA), which provides support for high-density deployments, enabling more efficient allocation of bandwidth to multiple users simultaneously. This will also help reduce power consumption on devices, ensuring that they receive high-quality connectivity without regularly searching for the required bandwidth.

Figure 4: How Wi-Fi performance has developed through the generations

Generation/IEEE Standard	Frequency	Maximum Linkrate	Year
Wi-Fi 6 (802.11 ax)	2.4/5 GHz	600-9608 Mbit/s	2019
Wi-Fi 5 (802.11 ac)	5 GHz	433-6933 Mbit/s	2014
Wi-Fi 4 (802.11 n)	2.4/5 GHz	72-600 Mbit/s	2009



Wi-Fi 6 use cases



Wi-Fi 6 can provide high data rate, low latency, high network density features which obviously bring many benefits for private networks. For example, use cases such as video applications need high throughput, industrial controls need low latency, smart homes need lots of stationary device connections. However, it is not enough for all kinds of applications, such as those with high mobility requirements such as POS devices, or applications that need very long range communication. For applications such as outdoor IP cameras, the Wi-Fi range may not be sufficient.

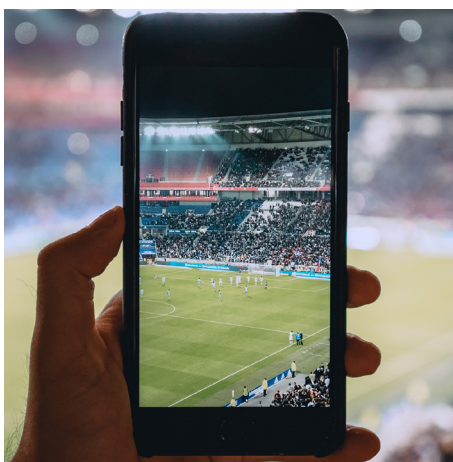


Wi-Fi 6 can improve connectivity within the enterprise by connecting employees, guests, visitors, and customers securely, and increasing productivity and flexibility via a range of different devices. Enterprise applications are expected to be a significant part of the market for Wi-Fi 6 and analyst firm ABI Research expects Wi-Fi 6 enterprise access point shipments will increase from 4.3 million in 2021 to 13.4 million in 2026, at a CAGR of 25%.

Industry 4.0, smart manufacturing, connected vehicles and infotainment industries are all looking to utilize Wi-Fi 6 and 5G. It's therefore important to assess both technologies in parallel and recognize that each has compelling characteristics to bring to enterprises.



Deloitte reports that municipalities are already employing a combination of Wi-Fi 6 and 5G to power smart-city solutions such as real-time traffic monitoring and geofencing applications that can deliver personalized alerts to anyone within a predetermined geographic area. In healthcare, the firm reports that next-generation wireless initiatives are enabling real-time remote patient monitoring, high-definition video consultations and even remote medical procedures using robots. Sports organizations are using 5G and Wi-Fi 6 to deliver more engaging, immersive stadium experiences while retailers are combining advanced wireless with IoT sensors and analytics to support smart inventory systems, optimize product pricing, and personalize shopping.

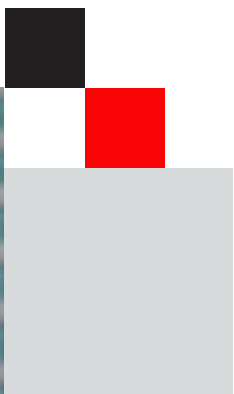
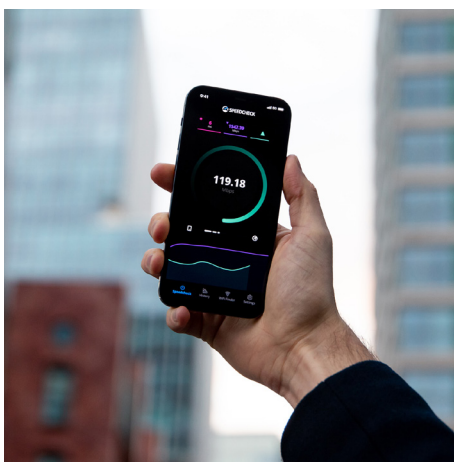




Quectel sees substantial applications within the automotive market. Wi-Fi 6 features access points designed to support gigabit in-car hotspots and to deliver efficient Wi-Fi connectivity throughout the vehicle, supporting ultra-high definition (ultra-HD) video streaming on multiple displays, screen mirroring from compatible devices and wireless back-up cameras. It also features full MIMO client capability designed to extend range at high data rates for connecting to external access points for automotive services, such as vehicle diagnostics, software updates and automatic check-ins when pulling up to dealerships. In addition, the technology will deliver improved connectivity and enhanced in-vehicle experiences. As vehicle connectivity continues to advance from 4G to 5G, Wi-Fi 6 is an integral part of the connectivity evolution, as it enables seamless connections, across multiple devices, and in congested environments.



Both technologies will have a significant role to play in the future of wireless and unlike past generations of wireless, it's not an either/or decision. 5G cellular and Wi-Fi 6 networks will be able to interoperate with each other and are seen as complementary technologies in the wireless ecosystem. The Deloitte study uncovered that organizations indicate that they prefer Wi-Fi 6 for indoor, on-campus and fixed network situations while they will turn to 5G for outdoor, off-campus and mobile networks. Adopting the technologies in parallel makes sense and 45% of survey respondents are already deploying both Wi-Fi 6 and 5G in their business or piloting/experimenting with them, with another 35% actively preparing to use both. Nearly all expect their organization to be using both 5G and Wi-Fi 6 within the next two to three years. Projected investment reflects co-adoption with Deloitte reporting that from 2021-2024, these organizations expect to split their wireless spending between Wi-Fi (48%) and cellular technologies (52%).



What Quectel offers

Quectel announced a series of brand-new Wi-Fi 6 modules, including the industrial-grade FC6X series based on Qualcomm's QCA206x Wi-Fi 6 chip, which is designed to deliver faster, more secure and more robust Wi-Fi experiences as well as new Bluetooth audio capabilities. The company also launched the automotive-grade AF50T module based on the Qualcomm Automotive Wi-Fi 6 chip, the QCA6696.

These two module series are designed to deliver enhanced performance in capacity, data rates, latency, power consumption and coverage. They bring premium wireless performance to a variety of consumer, industrial and automotive applications, such as smart homes, MiFi, smart TVs, over-the-top (OTT) devices, industrial controls, customer premises equipment (CPE), the Internet of Vehicles and much more.

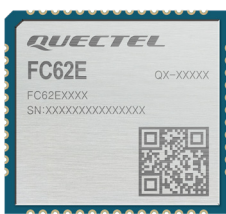
When used in combination with Quectel's 5G module, the Wi-Fi 6 module series offers a superior 5G and Wi-Fi 6 solution for MiFi and CPE that is designed to ensure high-speed connections which can support up to 32 clients at a time, and guarantee smoother and more reliable connections for smart home gadgets and many other multi-user scenarios. It also reduces network congestion for complex indoor scenarios like smart homes, shopping malls, schools and factories. Moreover, the FC6X series utilizes the WPA3 encryption mode to greatly improve the security of Wi-Fi connections.



Quectel FC6x Wi-Fi and Bluetooth modules

The Quectel FC6x series comprises a portfolio of high-performance Wi-Fi 6 and BLE (Bluetooth 5.2) modules in an LCC package. The modules can be used to establish WLAN and Bluetooth connections. Supporting 2 × 2 MIMO, the FC6x family provides a maximum data rate up to 1200 Mbps. With a compact and unified form factor of 19.9 mm × 18.0 mm × 2.1 mm, the FC6x modules are an ideal Wi-Fi/Bluetooth solution for size-sensitive applications, and can help customers reduce product size and optimize application design cost.

The surface-mount technology enhances these modules' durability and robustness, and the LCC package ensures that they can be easily embedded into size-constrained applications and provide reliable connectivity. The advanced package allows for large-scale automated manufacturing that has strict requirements on cost and efficiency. Designed with a reliable PCIe 3.0 interface to provide WLAN capability, the FC6x series achieves low-power and high-speed data transmission. This, coupled with its compact size and extended operating temperature range, enables the module to meet Wi-Fi/Bluetooth application design requirements in industrial, consumer and automotive fields.



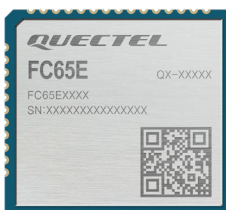
Quectel FC62E key features

- Wi-Fi and Bluetooth module supporting 2.4 GHz, 5 GHz and BLE (Bluetooth 5.2)
- Support for PCIe 3.0 interface, which provides higher data transmission rate and lower power consumption
- Fast time-to-market: simple design minimizes design-in time and development efforts
- Wide operating temperature range (-30 °C to +85 °C)



Quectel FC64E key features

- Wi-Fi and Bluetooth module supporting 2.4 GHz, 5 GHz and BLE (Bluetooth 5.2)
- Support for DBS
- Support for PCIe 3.0 interface, which provides higher data transmission rate and lower power consumption
- Fast time-to-market: simple design minimizes design-in time and development efforts
- Wide operating temperature range (-30°C to +85°C)



Quectel FC65E key features

- Wi-Fi and Bluetooth module supporting 2.4 GHz, 5 GHz and 6 GHz triple-band and BLE (Bluetooth 5.2)
- Support PCIe 3.0 interface, which provides higher data transmission rate and lower power consumption
- Fast time-to-market: simple design minimizes design-in time and development efforts
- Wide operating temperature range (-30 °C to +85 °C)

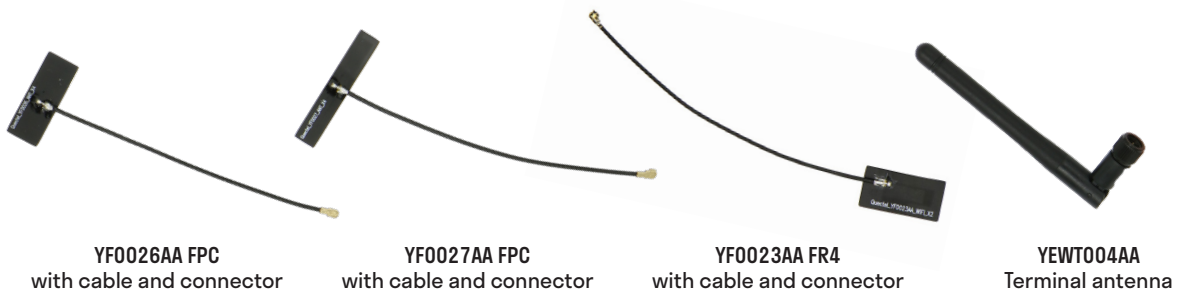


Quectel FC66E key features

- Wi-Fi and Bluetooth module supporting 2.4 GHz, 5 GHz and 6 GHz triple-band and BLE (Bluetooth 5.2)
- Support for DBS
- Support for PCIe 3.0 interface, which provides higher data transmission rate and lower power consumption
- Fast time-to-market: simple design minimizes design-in time and development efforts
- Wide operating temperature range (-30 °C to +85 °C)

Quectel antennas

The Quectel FC62E and FC64E support 2.4 and 5GHz while the FC65E and FC66E support 2.4, 5 and 6GHz. The following antennas will work for all four modules because they support 2.4, 5 and 6GHz:



YF0026AA Wi-Fi 6E/BT FPC Antenna

Key features include:

- Frequency band: 2400–2500MHz, 5150-5850MHz, 5925-7125MHz
- Dimensions: 28.9mm x 11mm
- Cable length: 100mm
- Efficiency: 86%

This FPC embedded antenna is a multiband device offering excellent performance for Wi-Fi 6E applications in the 6GHz band (5.925GHz to 7.125GHz) plus 2.4GHz and 5GHz Wi-Fi/WLAN solutions. The flexibility and adhesive backing makes this antenna easy to mount in any non-metallic standard or custom enclosures. Highly efficient and ground plane independent, connection is made to the radio via the 100mm cable, terminated with a IPEX MHF 1 connector. Quectel also provides comprehensive antenna design support such as simulation, testing and manufacturing for custom antenna solutions to meet your specific application needs.

Turning to the FC62E and FC64E modules, customers could also use the following 2.4 and 5GHz-only antenna options in addition to the options above:



YE0032AA Wi-Fi/BT Terminal Mount Antenna

Key features include:

- Frequency band: 2400–2500MHz, 5150–5850Hz
- Dimensions: 50mm x Ø10mm
- RoHS and REACH compliant

The Quectel YE0032AA is a small Wi-Fi/Bluetooth omnidirectional antenna with high gain and good efficiency. The antenna is designed to work with various GND plane sizes or in free space. Quectel also provides comprehensive antenna design support such as simulation, testing and manufacturing for custom antenna solutions to meet your specific application needs.

Conclusion

Wi-Fi 6 is a new generation of Wi-Fi and will exist for a long time, perfectly matching the IoT industry's growth trend. As IoT device numbers grow rapidly, more and more devices require high throughput such as virtual reality devices. Others, such as industrial controls demand low latency or require low power consumption such as those that use battery power. As huge volumes of IoT devices connect to the network, this increases the device density and brings up the single interference due to cross coverage. By using OFDMA, MU-MIMO, TWT, BSS colouring and Spatial Reuse Technique, Wi-Fi 6 products achieve substantially improved performance that addresses the problems mentioned above. When aligned with 5G, IoT organizations can access the most appropriate connectivity for their deployments with the confidence that each technology interoperates smoothly and is here for the long-term.

To learn more about Quectel's portfolio of Wi-Fi 6 smart modules and antennas, visit: www.quectel.com

