

RCR Wireless News

INTELLIGENCE ON ALL THINGS WIRELESS

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The state of Wi-Fi 6, 6E and 7

By Catherine Sbeglia Nin

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Introduction: Looking back and ahead

The past few years have been big for Wi-Fi. First, 802.11ax, or Wi-Fi 6, was certified by the Wi-Fi Alliance in the fall of 2019. Unlike past upgrades, which focused solely on faster speeds and bigger channels, Wi-Fi 6 highlighted efficiency by introducing multi-user concepts. But this development was nothing compared to the emergence of Wi-Fi 6E, which refers to extending Wi-Fi 6 into the 6 GHz band. With this decision, the Federal Communications Commission (FCC) made an additional 1,200 megahertz of spectrum available for unlicensed Wi-Fi use, and according to most industry experts, it was the biggest thing to happen to Wi-Fi in the last decade.

Now, though, everyone is talking about Wi-Fi 7, also known as Extremely High Throughput, thanks to its support of up to 30 Gbps throughput, roughly three times faster than Wi-Fi 6. The next generation of Wi-Fi also promises higher spectrum and power efficiency, better interference mitigation, higher-capacity density and better cost efficiency.

This report will take a look back and ahead to both evaluate the state of 6/6E adoption and delve deeper into what makes Wi-Fi 7 such a standout. It will also lay out several challenges that come along with such drastic advancements, particularly those around multi-user Wi-Fi and the reality that the decision

to open up the 6 GHz band for Wi-Fi operation is a regional one, and that not every country has opted to do so.

Wi-Fi 6/6E

The most obvious improvement that Wi-Fi 6 will offer over previous generations of Wi-Fi is, of course, speed. In fact, when used with a single connected device, maximum potential speeds should be up to 40% higher compared to Wi-Fi 5 — a 6.1 Gbps increase. This feat of speed is accomplished through more efficient data encoding, resulting in higher throughput. While the 9.6 Gbps speed of Wi-Fi 6 is more of a theoretical maximum, this speed can be split up across a whole network of devices, resulting in speed improvements for each device on the network.

Additionally, unlike Wi-Fi 5, Wi-Fi 6 utilizes a channel access method called Orthogonal Frequency Division

Multiple Access, or OFDMA. The method allows for the division of a wireless channel into a large number of sub-channels, with each one carrying data intended for a different device.

“Wi-Fi 6 was very important for the Wi-Fi industry,” said Jeorg Koepp, IoT market segment manager at Rohde and Schwarz. “I always call it a kind of revolution ... because it was necessary for [Wi-Fi] to go the next mile.”

Wi-Fi 6E, though, is not a generation of wireless technology. Instead, it refers to the ability for Wi-Fi to leverage the 6 GHz band for unlicensed operation. The United States Federal Communications Commission (FCC) approved opening up the entire 6 GHz frequency band (5.925–7.125 GHz) for unlicensed use, including Wi-Fi 6 technology, in April 2020, a decision many called monumental. In fact, at the time, the Wireless Broadband Alliance’s CEO

The generations of Wi-Fi

| IEEE standard | Frequency | Maximum data rate | Year certified |
|-----------------------|--------------------|-------------------|----------------|
| Wi-Fi 1 (802.11b) | 2.4 GHz | 11 Mbps | 1999 |
| Wi-Fi 2 (802.11a) | 5.4 GHz | 54 Mbps | 1999 |
| Wi-Fi 3 (802.11g) | 2.4 GHz | 54 Mbps | 2003 |
| Wi-Fi 4 (802.11n) | 2.4 & 5 GHz | 600 Mbps | 2008 |
| Wi-Fi 5 (802.11ac) | 5 GHz | 6.9 Gbps | 2014 |
| Wi-Fi 6/6E (802.11ax) | 2.4, 5 GHz & 6 GHz | 9.6 Gbps | 2019/2021 |
| Wi-Fi 7 (802.11be) | 2.4, 5 GHz & 6 GHz | 46 Gbps | TBD |

WI-FI 6E-capable handsets

(as of October 2022)

Samsung Galaxy S21 Ultra

Xiaomi Mi 11

ASUS ROG Phone 5

Xiaomi Mi 11 Ultra

ASUS Zenfone 8 and 8 Flip

ASUS ROG Phone 5 Ultimate

Galaxy Z Fold 3 5G

Samsung Galaxy S22 Plus and S22 Ultra

Google Pixel 6 and 6 Pro

Nubia Redmagic 7

Google Pixel 6a

Galaxy Tab S8+ and Tab S8 Ultra

Nubia Red Magic 7 Pro and 7s Pro

Galaxy Z Fold 4 5G

Motorola Edge 2022

Motorola X30 Pro

Motorola Edge 30

Motorola Edge 30 Ultra

Motorola Edge 30 Pro

Motorola Edge 30 Fusion

Moto Razr 2022

Tiago Rodrigues said that “Wi-Fi 6E will rewrite the rules of what is possible” and that it will lead to “higher speeds, low latency and service levels that are equivalent to 5G networks.”

Wi-Fi 6E promises to deliver faster connectivity speeds and improved capacity when compared to both 2.4 GHz and 5 GHz Wi-Fi, making it ideal for smartphones, tablets, laptops and virtual/augmented devices. The multi-user,

multiple-input, multiple-output technology (MU-MI-MO) capabilities of Wi-Fi 6, combined with 6 GHz, will also create a number of use cases both in the home and in the enterprise space. Further, inefficient legacy Wi-Fi devices won’t operate on the 6 GHz band, and therefore, won’t bog down the network. As a result, the new technology is expected to be ideal for indoor mesh connectivity, as well as delivering more reliable video streaming and home security connections.

Wi-Fi 6/6E adoption

The Wi-Fi Alliance predicts that by 2025, Wi-Fi 6 and Wi-Fi 6E will surpass 80% market share, while IDC estimates that by the same year, there will be 5.2 billion Wi-Fi 6 product shipments, 41% of which will be Wi-Fi 6E devices. Further, the Wireless Broadband Alliance provided a more recent update, finding in its October Annual Industry Report that 53% of service providers, technology vendors and enterprises have deployed Wi-Fi 6, and an additional 44% said they are currently working to adopt Wi-Fi 6E in the next 12-18 months.

According to the Wi-Fi Alliance, this global growth can be attributed to the combined momentum around products, deployment and regulations.

Product momentum

The Wi-Fi Alliance expects that more than 2.3 billion Wi-Fi 6 products and

350 million Wi-Fi 6E products will enter the global market in 2022, and that more than 15% of all Wi-Fi 6 shipments this year will also be Wi-Fi 6E.

Alex Roytblat, vice president of worldwide regulatory affairs at Wi-Fi Alliance, reported that as of November 2022, Wi-Fi Alliance has certified more than 660 Wi-Fi 6E devices for Wi-Fi 6E, from smartphones to laptops to access points.

Keysight Technologies’ Senior Application Engineer Bill Koerner said that in the U.S., specifically, there has been a material increase in Wi-Fi 6E certifications by the FCC. “In the U.S., the FCC



“In the U.S., the FCC has seen certifications for 6E products increase substantially, from an estimated 89 products in 2020 to over 285 as of November 2022.”

Bill Koerner, Senior Application Engineer, Keysight Technologies

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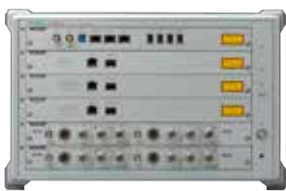
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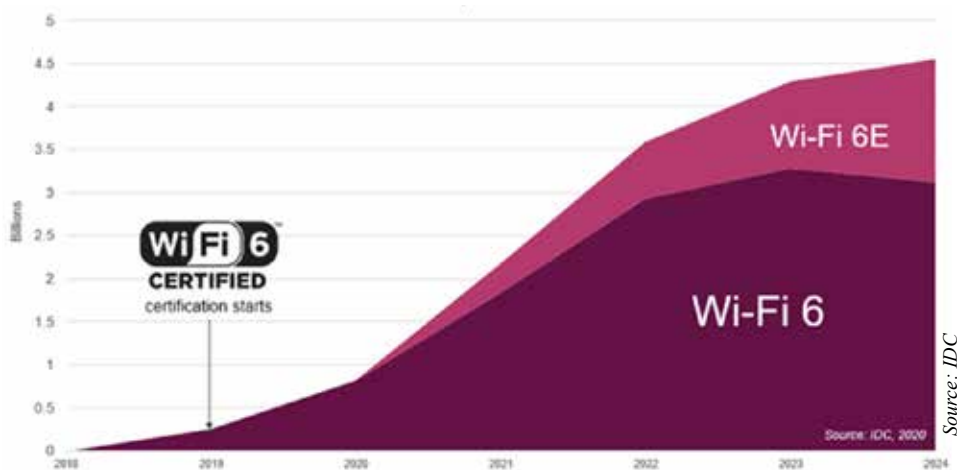


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Wi-Fi 6 shipment forecast



has seen certifications for 6E products increase substantially, from an estimated 89 products in 2020 to over 285 as of November 2022. Most of these devices have been station or client devices, such as smart TVs and Wi-Fi cards for computers,” Koerner said.

He added that reporting data for the European Union is harder to come by because manufacturers are not required to get their products certified before use, as in the case of the United States. “Therefore, it is difficult to predict the growth of 6E products available for use in the EU,” he explained. “Given the EU adopted their portion of the 6 GHz spectrum in late 2021, it is reasonable to expect the number of 6E products is lower than the U.S.”

This year also saw Broadcom hit the key milestone of surpassing 1 billion Wi-Fi 6 and Wi-Fi 6 E chip shipments, while Extreme Networks shared on an

April earnings call that Wi-Fi 6E has become 10% of its bookings.

Deployment momentum

The benefits of Wi-Fi 6E have been demonstrated in deployments across several verticals including education and large-scale entertainment. The

University of Michigan, for example, has installed 16,000 Aruba Wi-Fi 6E access points across 225 campus buildings in what is thought to be the largest deployment of its kind to date.

“People are getting download speeds of upward of 300 to 400 megabits per second, which allows us to reduce the number of wired ports that we have across the campus and reduce the number of switches in all of our closets,” the university’s Vice President of IT and CIO Ravi Pendse commented. “You’re talking about almost 80,000 wired ports being removed or reduced. That saves us several thousand switches in the closets.”

The Chase Center in San Francisco—home of the Golden State Warriors—also installed more than 250 Wi-Fi 6E Aruba access points to



The Chase Center in San Francisco has more than 250 Wi-Fi 6E access points.

enable thousands of fans to simultaneously stream videos and share photos, listen to the play-by-play commentary and pull up match statistics from the Warriors + Chase Center app.

Regulatory momentum

The U.S. was the first country to open up the 6 GHz band for Wi-Fi; however, as of November, 31 countries across

the Americas, EMEA and APAC have followed suit, and an additional 13 are considering doing the same. But all adoption is not created equal, which Koerner thinks will result in some “interesting” impacts on the market.

“Over the last year, the number of countries adopting part, or all the 6 GHz band has increased. A portion have adopted different frequency

ranges. For example, some countries in the EU have adopted 5945-6425 MHz, while the rest have adopted 5925-6425 MHz. This will place more design constraints on device manufacturers. Some countries have adopted 5925-6425 MHz but are considering the range of 6425-7125 MHz. This could create interesting market deployments for device manufacturers, as they may

Countries Enabling Wi-Fi in 6 GHz (Wi-Fi 6E)

| | | | | | |
|--------------------|-------------|--|----------------------|-------------|---|
| Argentina | Considering | 5925-6425 MHz | Jordan | Adopted | 5925-6425 MHz |
| Australia | Adopted | 5925-6425 MHz | Kenya | Adopted | 5925-6425 MHz |
| | Considering | 6425-7125 MHz | Liechtenstein | Adopted | 5925-6425 MHz (*only adopting 5945-6425) |
| Bahrain | Adopted | 5925-6425 MHz | Malaysia | Adopted | 5925-6425 MHz |
| Brazil | Adopted | 5925-7125 MHz | Mexico | Considering | 5925-7125 MHz |
| CEPT | Considering | 5925-6425 MHz (*only considering 5945-6425) | Morocco | Adopted | 5925-6425 MHz |
| Canada | Adopted | 5925-7125 MHz | New Zealand | Adopted | 5925-6425 MHz |
| Chile | Adopted | 5925-6425 MHz | Norway | Adopted | 5925-6425 MHz |
| Colombia | Adopted | 5925-7125 MHz | Oman | Considering | 5925-6425 MHz |
| Costa Rica | Adopted | 5925-7125 MHz | Peru | Adopted | 5925-7125 MHz |
| Dominican Republic | Adopted | 5925-7125 MHz | Qatar | Adopted | 5925-6425 MHz |
| Egypt | Considering | 5925-6425 MHz | | Considering | 6425-7125 MHz |
| European Union | Adopted | 5925-6425 MHz (*only adopting 5945-6425) | Saudi Arabia | Adopted | 5925-7125 MHz |
| Guatemala | Adopted | 5925-7125 MHz | South Korea | Adopted | 5925-7125 MHz |
| Honduras | Adopted | 5925-7125 MHz | Switzerland | Adopted | 5925-6425 MHz |
| Hong Kong | Adopted | 5925-6425 MHz | Tunisia | Considering | 5925-6425 MHz |
| | Considering | 6425-7125 MHz | Turkey | Considering | 5925-6425 MHz |
| Iceland | Adopted | 5925-6425 MHz (*only adopting 5945-6425) | United Arab Emirates | Adopted | 5925-6425 MHz |
| Japan | Adopted | 5925-6425 MHz | United Kingdom | Adopted | 5925-6425 MHz |
| | Considering | 6425-7125 MHz | | Considering | 6425-7125 MHz |
| | | | United States | Adopted | 5925-7125 MHz |

Source: Wi-Fi Alliance

SIMPLICITY // THROUGH INNOVATION

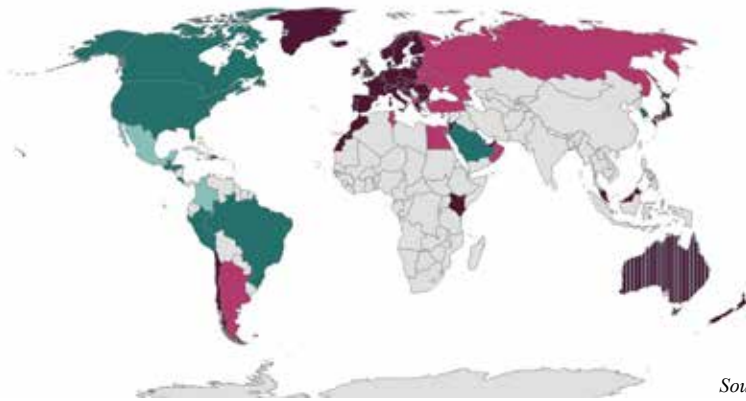


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Source: Wi-Fi Alliance

need to have their original products reassessed in the future should those countries adopt the higher frequencies. They may also decide to leave their existing products with the original frequency range,” he said.

Wi-Fi 7:



The next generation on the docket, Wi-Fi 7 (or 802.11be), is designed from the ground up for operation in

the 6 GHz, resulting in some really powerful capabilities. Specifically, Wi-Fi 7—which is expected to be certified at the end of 2023—will deliver higher spectrum and power efficiency, better interference mitigation, higher capacity density and better cost efficiency. And its projected ability to support up to 30 Gbps throughput makes it ideal for the enterprise space as they continue their digital transformations, adding AR/VR, IoT and industrial IoT applications to their workflows.

Direct feature enhancements over Wi-Fi 6 include support of 320 megahertz transmissions, which is double the 160 megahertz of 802.11ax, the use of higher modulation orders and optionally supporting 4096-QAM – up from 1024-QAM in 802.11ax. Wi-Fi 7 will also introduce advanced multi-link and flexible channel utilization capabilities.

How Wi-Fi 7 addresses Wi-Fi 6/6E pitfalls

While the introduction of Wi-Fi 6 signaled improved performance and capacity for mobile, IoT devices and even critical applications that require low latency, LitePoint’s Director of Marketing Adam Smith claimed that the wireless industry may have bitten off a bit more than it could chew. “Wi-Fi 6 is such a big change to Wi-Fi that we didn’t quite realize the magnitude of taking a well-adopted, single-user technology and making it multi-user,” he told RCR Wireless News. “It has been a bigger challenge than I think many people thought it was going to be.”

He acknowledged that yes, when you look at the number of shipments of access points, Wi-Fi 6 has likely surpassed those of Wi-Fi 5, but this is mostly because there is no longer a cost advantage to sticking with Wi-Fi 5. “The chipmakers have made Wi-Fi 6 the new standard, if you will,” he explained, adding that despite what the shipment logs say, “the dirty little secret” is that multi-user—Wi-Fi 6’s headlining capability—has yet to be deployed in “any significant way,” particularly in the 5 GHz band.

“So, what I might say is that peaceful coexistence between Wi-Fi 5 and Wi-Fi 6 is kind of a joke right now,” Smith continued. Providing additional context, he argued that in order for a device to operate in a multi-user fashion, it has to be a Wi-Fi 6 device, meaning



“Peaceful coexistence between Wi-Fi 5 and Wi-Fi 6 is kind of a joke right now.”

Adam Smith, Director of Marketing, LitePoint

Wi-Fi 5 or earlier devices—which make up more of the devices currently in operation—will always be single user. “If you’re trying to lay a Wi-Fi 6 network on top of it, you either need to rip and replace—to use a cellular term there—or you need to somehow figure out how to coexist,” he added.

Enabling multi user with MLO

Multi-link operation is a key Wi-Fi 7 capability that chipmaker Broadcom considers to be Wi-Fi 7’s “marquee feature.” Gabriel Desjardins, director of product marketing in Broadcom’s Wireless Connectivity division, explained that while Wi-Fi 6 introduced OFDMA and then Wi-Fi 6E added a tremendous amount of capacity using the 6 GHz band, quality of service limitations remain, particularly around latency.

“There’s a lot more capacity [in 6E], but higher throughput doesn’t help you if you’re still contending with other devices that take up resources in the network. Your latency will [still] be great,” he said, adding that applications growing in popularity like video conferencing and mobile gaming require very low latency, which can be hard to achieve on a crowded home or business network.

“Existing Wi-Fi networks really don’t have a good way to move critical traffic between networks to help you get that quality of service,” he continued. “There is a lot more open spectrum

with the introduction of 6 GHz, but there isn’t really an easy way to make use of it to help things like latency. You can slowly switch networks, but that isn’t going to help you when you have applications that need millisecond-level latency.”

“The marquee feature of Wi-Fi 7 is Multi-Link Operation,” Desjardins claimed, explaining that this feature allows for “rapid switching between two different Wi-Fi bands.”

Beyond the clear performance improvements that MLO offers, this feature, according to Smith, actually solves the multi-user problem that Wi-Fi 6 introduced. Thanks to this feature, Wi-Fi 7 will actually enable the promised multi-user capabilities first outlined in Wi-Fi 6 standards by automatically—and very quickly—allowing a device connected in the 5 GHz band to switch over to the 6 GHz band when it begins to suffer from degraded performance due to another device popping up on the network.

“Wi-Fi 7 can use the spectrum that’s available more efficiently,” explained

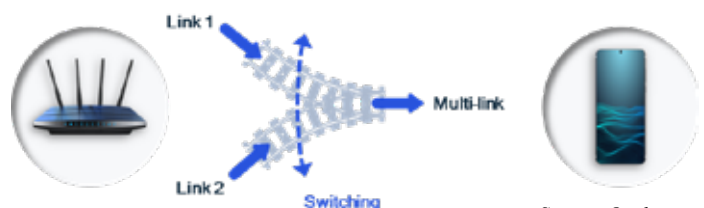
Simultaneous Multi-Link

Dual radios in the device for simultaneous connectivity



Alternating Multi-Link

Single radio in the device, switching between bands



Source: Qualcomm



WiFi7 is here



broadcom.com/wifi7

Qualcomm Senior Director of Engineering Andy Davidson. “This is often the spectrum that is available at your specific location. ... Depending on the interference that is around you at any particular time, you can adjust with Wi-Fi 7 to always go to higher throughput.”

Getting 6 GHz benefits without 6 GHz

As discussed previously, 6 GHz Wi-Fi operation isn’t available in every country. For those without the full or even partial 6 GHz access, MLO will also prove useful in allowing them to get the most out of Wi-Fi 7 regardless. China—which famously has no plans to use 6 GHz for Wi-Fi operation—is one of Qualcomm’s biggest markets, and Davidson said the chip vendor isn’t concerned because with MLO, channels can be combined to achieve higher throughput.

“There are obviously regions that don’t support 6 GHz and the only 320-megahertz channel is in 6 GHz, so it’s nice to be able to, in those regions, combine [for example] two 160-megahertz channels in 5 GHz. Or in China, you can take a 160-megahertz channel [and] combine it with an 80-megahertz channel that is available. That means you’re still fulfilling that extremely high throughput promise that comes with Wi-Fi 7,” provided Davidson.

In addition, one of Smith’s favorite Wi-Fi 7 features, preamble puncturing, will also help those regions not intending to use 6 GHz, or all of 6 GHz, for Wi-Fi.

This feature improves spectral efficiency by allowing a Wi-Fi AP to transmit a “punctured” portion of the spectrum channel if some of the channel is being used by legacy users. By avoiding a channel that is already in use by incumbents, a wide swath of spectrum can still be obtained, even for those without the full 6 GHz band available.

Traditionally, for instance, if an incumbent user is occupying a portion of an otherwise free channel, an AP will be prevented from using this spectrum. Preamble puncturing, however, lowers the overall bandwidth by the punctured amount and delivers a wider channel.

The headlines for Wi-Fi 7 are



“You should really think about 6E as an expansion of capacity rather than a core technology upgrade; Wi-Fi 7 is the upgrade to Wi-Fi 6.”

Andy Davidson, Senior Director of Engineering, Qualcomm

higher-data rates and capacity, but Smith summarized: “Largely what it’s doing is fixing some of the things in Wi-Fi 6 to make it more flexible to deploy.”

Wi-Fi 7 and 6 GHz aren’t the same thing

Davidson further pointed out that while people often equate Wi-Fi 7 with the 6 GHz band, they’re not necessarily tied together. “Qualcomm wants to clear up that confusion in the industry,” he said, adding that the only feature in Wi-Fi 7 that requires 6 GHz is the 320-megahertz channel. “Everything else in Wi-Fi 7 applies to China and everywhere in the world. It’s great for Wi-Fi, in general, to get much more capacity, but 7 brings a lot of value in and of itself.”

He continued: “I suspect this cycle feels different to people because we had this once-in-a-generation allocation of new spectrum. Wi-Fi 6E is just Wi-Fi 6 at 6 GHz...You should really think about 6E as an expansion of capacity rather than a core technology upgrade; Wi-Fi 7 is the upgrade to Wi-Fi 6, and the nice thing is, it includes features that take advantage of 6 GHz in regions where it is available.”

Testing challenges in 6 GHz Wi-Fi operation

Wi-Fi 7, designed with the 6 GHz band in mind, has a host of exciting new features that promise higher spectrum and power efficiency, better

interference mitigations, higher capacity density and higher cost efficiency. But some of these features—most notably 4096-QAM, Multi-Link Operation (MLO) and preamble puncturing—are causing some hiccups in the test and measurement world.

“Wi-Fi 7 is adding a bunch of tools for deployment flexibility,” LitePoint’s Adam Smith told *RCR Wireless News*, but added that with flexibility comes complexity. “That is what most people talk about in test,” he said, “What Wi-Fi 7 has done is introduce all these flexibility features, and they all have to be characterized.”

Breaking the 6 GHz barrier

Because almost all commercial wireless technologies were sub-6 GHz prior to the introduction of Wi-Fi 6E, the biggest change in the test field was breaking this 6-GHz barrier. “With the 6E requirements, this will require upgrades to cover up to at least 7.125 GHz,” said Keysight’s Bill Koerner.

Smith agreed, commenting: “That was something, as an industry, we needed to figure out.” However, he added that at this point, that problem has been solved.

Still, breaking this barrier has, in some cases, led to entirely new tests. For example, to protect incumbent 6 GHz band users in the U.S.—such as satellite links, mobile TV broadcasts and utility communication links—the Federal Communications Commission

(FCC) added a Contention Based Protocol (CBP) test for the 6 GHz band. CBP enables multiple users to use the same channel without pre-coordination, and now, all Wi-Fi APs and clients must be tested in this way.

“This type of Listen Before Talk [LBT] testing has been required for the EU [end user] for all frequency bands and is not new for the 6 GHz band. However, this is a relatively new approach for the FCC to focus on the receiver functionality and employ a LBT capability,” Koerner explained. “This will require a slightly different test set-up, and potentially new equipment.”

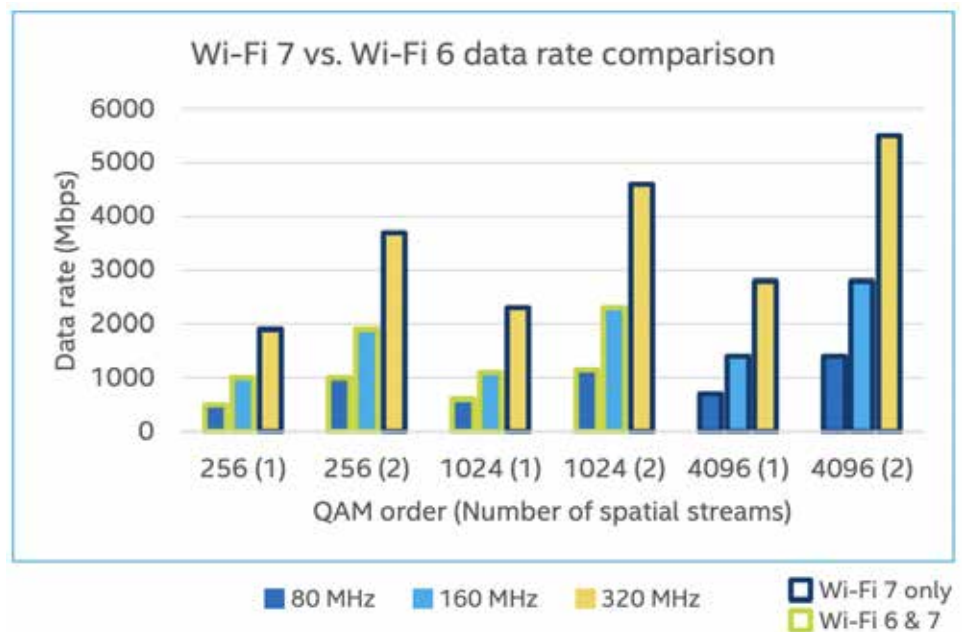
He went on to say that some of these receiver tests are more complex than others. “Notably, the Receiver Selectivity tests will require testing at more frequencies,” Koerner said.

4096-QAM

Wi-Fi 7 will support 4096-QAM or 4K QAM, which boosts the peak rates to increase throughput and capacity compared to Wi-Fi systems using 1K QAM modulation. More specifically, LitePoint claims that 4K QAM can increase the physical layer (PHY) data rate by 20% and improve modulation accuracy.

“The 802.11be standard increases the QAM modulation order to 4096 QAM to achieve the highest data rate. With a denser constellation, the transmitter modulation accuracy requirements are also increased,” LitePoint states on its website. “The IEEE standard sets a transmitter target Error Vector Magnitude (EVM) requirement at -38 dB for 4096 QAM, increasing the performance requirement by 3 dB compared to 802.11ax [Wi-Fi 6].”

However, all experts spoken to agreed



Source: Intel

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“4096-QAM brings the test equipment to its limits.”

Joerg Koepp, IoT Market Segment Manager, Rohde & Schwarz

that these higher data rate modes are the biggest challenge still facing the test and measurement space. Koepp of Rohde & Schwarz said simply that this feature “brings the test equipment to its limits.”

To measure wireless modulation, testing companies use a metric called Error Vector Magnitude (EVM), which measures the deviation of actual transmissions from their ideal locations in the constellation diagram, capturing the sum of these imperfections to decipher a device’s transmit accuracy.

In the most simple type of modulation used in Wi-Fi, signals exhibit only two states that allow the transfer of either a 0 or 1, making it relatively easy to tell which is which. But, as you get to higher order modulation formats, like in the case of Wi-Fi 7, it

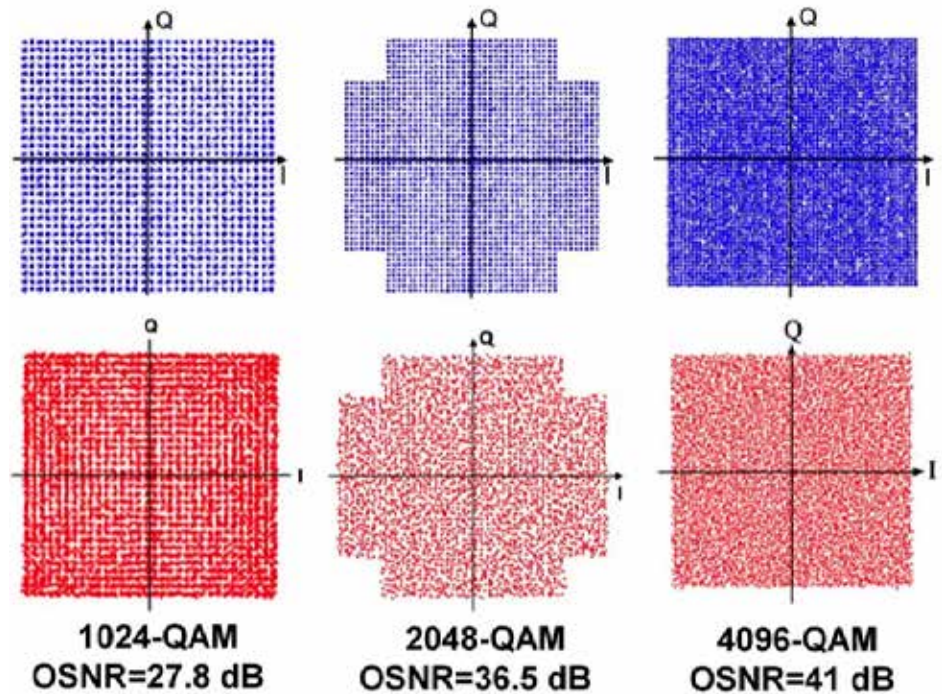
gets increasingly harder to transmit and receive data error-free. That’s because in higher-order modulation, much more data is encoded into the signals, putting the constellation points much closer together. This makes the signal extremely susceptible to noise and distortion, requiring careful attention to ensure that each component in a device’s transmitter chain is optimally calibrated.

“It’s great we now have all this spectrum, but it’s higher frequency so your signal is much more susceptible to issues in the environment,” said Brian Davis, technology strategy manager at Anritsu. He listed several potential issues related to



“It’s great we now have all this spectrum, but it’s higher frequency, so your signal is much more susceptible to issues in the environment.”

Brian Davis, Technology Strategy Manager, Anritsu



Transmission performance of 1024-QAM, 2048-QAM and 4096-QAM over 150 km, 150 km, and 160 km, respectively.

(Courtesy of Li, Si-Ao & HUANG, HAO & Pan, Zhongqi & Yin, Runze & Wang, Yingning & Fang, Yuxi & Zhang, Ywen & Bao, Changjing & Ren, Yongxiang & Li, Zhaohui & Yue, Yang)

propagation loss, signal reflections and non-line of sight.

He added: “A lot of OEMs that I’ve talked to were used to the 2.4 GHz band. When [Wi-Fi] moved up to the 5 GHz, they had all these higher frequency troubles and didn’t want to move onto it, but they were sort of forced to because their customers were having so much trouble with congestion in 2.4. We’re going to see the same thing with 6 GHz.”

Therefore, 4096-QAM results in the need for more linear instrumentation when testing the functionality of the Wi-Fi chips. In order to know if a Wi-Fi chip meets the requirements for transmitting and receiving the 4096 discrete phases of magnitude supported by Wi-Fi 7 standards, you need to have test equipment that can also meet these requirements.

“In Wi-Fi 7, we break most equipment out there with how pure it needs to get to,” Smith stated.

Davis also shared that as new use cases and solutions hit the market, test and measurement has to start to

truly emulate them, rather than simply testing something like a power specification or a spectrum specification. “So we’re looking at ways to address the new kinds of applications in the market,” he said. “There is a lot of measurement that needs to be done.”

Multi-Link Operation

Multi-Link Operation, as mentioned previously, lowers latency by allowing rapid switching between two different Wi-Fi bands, and is considered to be Wi-Fi 7’s headlining feature. But, according to Smith, this feature is also “driving the frontend module companies nuts.”

This is because the ability to use the 5 and 6 GHz bands simultaneously means that there isn’t much space between them, a fact that puts particular pressure on filter companies. “How do you notch out your 5 GHz transmitter from swamping your 6 GHz receiver, for example?” Smith posited. To answer this question, Smith said there is tremendous work being done in the frontend modular component space

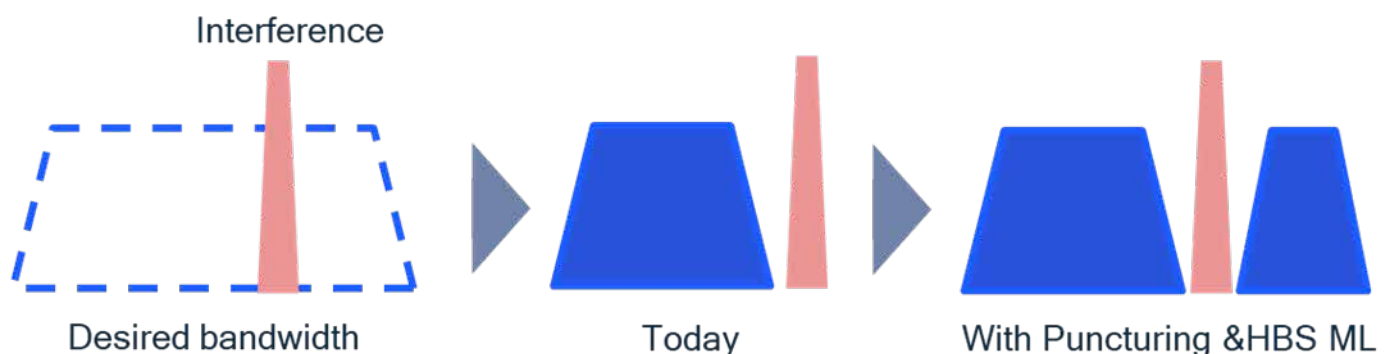
that LitePoint is supporting.

Further, Koerner explained that MLO is one leg of a three-legged stool of features. This stool also includes orthogonal frequency-division multiple access (OFDMA) and Multiple Resource Unit (MRU). OFDMA, first introduced in Wi-Fi 6, establishes independently modulating sub-carriers within frequencies, allowing for simultaneous transmissions to and from multiple clients. And MRU provides enhanced interference mitigation and OFDMA efficiency, which results in reduced latency.

“Each requires the other to work well — but come up short on any and the stool will fall,” he said. “To that end, exhaustive and predictive testing must be made available to cover the many test cases these three features introduce.”

Preamble puncturing

And then there is preamble puncturing, the powerful capability that makes it possible for regions that did not open up the full 6 GHz band for



Source: Qualcomm



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Wi-Fi to still achieve wider channels. According to Koerner, this capability represents some “unusual changes” to existing tests, most notably in the interference-type tests. Further, Smith indicated that preamble puncturing will stress the frontend of Wi-Fi 7 devices and that power amplifier modules and filtering components will all have to be characterized for this feature.

Koepf shared that Rohde & Schwarz’s customers are struggling somewhat with the new level of flexibility that Wi-Fi 7 features provide. This agility, he said, is great from an end user’s perspective, but is proving challenging for device makers, especially those looking to enter the global market.

“They ask, ‘Do I really have to test all of this stuff?’” he said. “Yes, if you want to support it. This flexibility is always good in terms of what you can do, but it does not make the lives of those who have to test all these things easier.”

Is AFC the answer to Wi-Fi’s low-power problem?

In order for unlicensed Wi-Fi 7 devices to play nice in the 6 GHz band with the licensed users already occupying that band, the FCC established Automated Frequency Coordination (AFC), a spectrum use coordination system designed specifically for 6 GHz operation that resembles similar systems in place such as the one that supports CBRS wireless operation.

When the FCC opened up the 6 GHz band for unlicensed Wi-Fi operation two years ago, the Wi-Fi world rejoiced.

However, because the 6 GHz band was already occupied by incumbent users, such as fixed satellite providers, the FCC imposed some pretty significant restrictions on the Wi-Fi devices looking to transmit in this band. More specifically, to avoid potential interference with existing 6 GHz incumbents,

the FCC defined two types of device classifications with different transmit power rules for Wi-Fi devices operating on the band: low power access points (APs) for indoor Wi-Fi and standard power APs that can be used indoors and outdoors. Standard power APs, particularly when used outdoors, are the most likely to interfere with existing 6 GHz users in the area, and therefore, AFC will prove most valuable in outdoor scenarios.

Litepoint’s Adam Smith shared that while the U.S. has the entire 6 GHz band available for Wi-Fi, it comes with an asterisk on it. “We operate under outdoor/indoor low-power functionality or very low indoor functionality unless you employ AFC,” he said. “In order to do standard power operation, you have to have an AFC system in place.”

Otherwise, he continued, you effectively have a “speed limit” on Wi-Fi’s highway, which impacts range and the

ability to use higher data rate modes. “AFC is extremely important to take full advantage of the 6 GHz band,” Smith summarized.

In a public statement on the matter, the FCC stated: “Once per day each AFC system is required to access the Commission’s Universal Licensing System (ULS) to obtain the most up-to-date information on licensed microwave links including their transmitter and receiver locations, frequencies, bandwidths, polarizations, transmitter EIRP, antenna height, and the make and model of the antenna and equipment used.”

The Commission went on to explain that this information will be used “to determine on which frequencies and at what power levels standard-power devices may operate.”

The FCC conditionally approves several AFC systems

In early November, the FCC’s Office of Engineering and Technology announced the conditional approval of thirteen proposed automated frequency coordination (AFC) database systems in preparation for the testing phase of 6 GHz Wi-Fi operations. Specifically, the FCC approved automated frequency coordination systems proposed by Broadcom, Google, Comsearch, Sony Group, Kyrio, Key Bridge Wireless, Nokia Innovations, Federated Wireless, Wireless Broadband Alliance, Wi-Fi Alliance (WFA), Qualcomm, Plume Design and RED Technologies.

The testing process for those looking

to move forward with their AFC system will include both lab testing and an opportunity for public testing, and each applicant will be required to make its system available for a specified period of time to provide an opportunity for members of the public to test each AFC system’s functionality.

Davidson from Qualcomm—one of the companies to have received conditional approval from the AFC—revealed that AFC is “especially great for mesh access points” because it will enable them to communicate with each other over very high speed 6 GHz backhaul throughout a user’s home.

He described Qualcomm’s AFC system as a “complete turnkey” implementation with access point (AP) agent and cloud systems with end-to-end validation and certification. Upon official FCC approval, the solution will be available across Wi-Fi 6E- and Wi-Fi 7-based networks, and according to the company, deliver significant performance enhancements indoors, where an increase in peak transmit power of 63 times can be realized, as well as outdoors operations that are enabled with AFC.

Chris Szymanski, director of product marketing for Broadcom’s Mobile Connectivity Division, told *RCR Wireless News* that AFC brings “the best of both worlds” by protecting incumbent license holders while allowing Wi-Fi devices to operate at maximum performance. He said that AFC will boost AP power by 63 times in 6 GHz. “We can do so much with that sort of power in terms of

range, throughput and resiliency. Nothing trumps power,” he added.

According to Szymanski, Broadcom believes that most AFC-enabled APs are going to be indoor. “You need it for outdoor, but it gives you more power for indoor. What AFC is going to do is make your link reciprocal with 5 GHz. In the 5 GHz band, our customers are allowed to do more power on the AP and the client side. With AFC, we can derive roughly the same amount of power in 6 GHz as we can in 5 GHz, which is going to give you similar rate vs range.”

Broadcom’s customers care about whole-home, whole-premises coverage, Szymanski, adding that AFC addresses this need by making their customers’ coverage more robust.

“American businesses and households rely on Wi-Fi for work, school, access to healthcare, and connecting with friends and family,” said FCC Chairwoman Jessica Rosenworcel. “We are moving forward on our plan to open doors for next generation, faster, better Wi-Fi — including Wi-Fi 6E and laying the groundwork for Wi-Fi 7. This is good news and real progress.”

There’s a notable caveat here, though. AFC is only relevant to the U.S. This means that for those other countries that have opened up the 6 GHz band for Wi-Fi operation — like many in Europe, for instance — there is currently no such mechanism, and these low-power problems can be expected to persist in the Wi-Fi 7 era.



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The race for better home broadband means a race for better Wi-Fi

Despite these challenges, industry experts see a bright future for 6 GHz Wi-Fi operation. For operators, specifically, 6 GHz Wi-Fi presents them with the opportunity to offer customers Wi-Fi that can keep up with their lofty broadband goals.

“For an operator, these wide channels in the 6 GHz band are ideal,” said Szymanski. “Every major European and U.S. operator has 6 GHz Wi-Fi on their roadmap,” he continued.

Broadcom’s Senior Director of Product Marketing Manny Patel explained that Wi-Fi troubles are more likely to occur when a household is running multiple devices over a single Wi-Fi network at the same time. Wi-Fi on 6 GHz, though, can fix this.

“Wi-Fi networks come under stress when you start loading them with simultaneous applications such as file downloads, video streaming, video conferencing, gaming, etc. Many people experienced issues with their home

Wi-Fi networks during COVID-19 when work from home and distance learning scenarios collided. The technology in Wi-Fi 6/6E was specifically targeted to improve these scenarios and those that did upgrade to Wi-Fi 6 and 6E began to report better performance at home,” Patel said.

As operators continue to move towards offering 10 gigabit broadband, they are also thinking about the wireless experience for their customers. According to Szymanski, this is because if a customer has a poor broadband experience, they are going to contact their network provider regardless of where responsibility lies. “They’re getting the service call whether the problem is with their router or not, so they want to provision the routers,” he claimed. “By providing broadband and Wi-Fi, operators have the ability to deliver the user experience their subscribers are looking for.”

This, he continued, is leading to a sort of convergence where broadband can be thought of as two parts: the cable modem and the Wi-Fi router. These

can be in a single box or provided separately, but either way, operators are pairing 6 GHz Wi-Fi with their broadband offering and are treating this as “a complete package,” and if current



“The race for better broadband in the home also means a race for better Wi-Fi. We’re giving them that better Wi-Fi experience through the 6 GHz radio.”

Chris Szymanski, Director of Product Marketing, Broadcom’s Mobile Connectivity Division



Source: Vodafone

messaging is any indication, each one is highlighting different aspects for their customers.

For example, Vodafone UK said that its new Wi-Fi boosters can connect up to 150 devices on a Wi-Fi 6E channel, signaling that for them, the problem to solve is network complexity and the number of devices. Swisscom, on the other hand, focused on the ability to reduce congestion and deliver ambient home connectivity when announcing its new internet box, created with help from SoftAtHome.

“The race for better broadband in the home also means a race for better Wi-Fi. We’re giving them that better Wi-Fi experience through the 6 GHz radio,” Szymanski said, adding that in this way, 6 GHz is “synonymous with wireless broadband.”

Conclusion: Wi-fi 7 is coming fast

“Wi-Fi continues to be the workhorse that connects the world,” said Keysight’s Koerner, and as such, predicted that Wi-Fi 7 adoption will be “rapid.”

Koepp of Rohde & Schwarz agreed, claiming that Wi-Fi 7 is coming so fast that some users are bypassing purchasing 6E devices and are instead planning to hold out for 7. “But I think there are good reasons for it,” he continued, referring to Wi-Fi 7’s fast approach, “because the technology enhancements are very attractive.”

In the same annual industry report published by the Wireless Broadband Alliance referenced earlier, 33% of respondents confirmed that they already have plans to deploy Wi-Fi 7 by the end of 2024. The report cited “a growing

appetite for data-intensive, low-latency applications and use cases” as the reason behind the early interest.

“What we’re seeing here is the industry at large identifying increasing value in Wi-Fi technology in the wake of highly anticipated new use cases. What’s more, service providers, equipment manufacturers and enterprises around the world know that those use cases are best served in a converged environment, where Wi-Fi and 5G complement each other,” commented the Wireless Broadband Alliance’s Rodrigues. “Therefore, we’re seeing the industry advance at breakneck pace toward Wi-Fi 7, with mobile operators leveraging Wi-Fi as part of their 5G strategies to maximize coverage and optimize capacity — it’s all about the user experience.” (↔)



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