Metaverse in a Wi-Fi 7 World

CommScope Ruckus Networks

The Evolution from Web1 to Web3

When Wi-Fi was first introduced in 1997 with the introduction of 802.11, the World Wide Web was still in its infancy. To connect and get online, people had to go to a place that had a phone line in order to dial up at 56Kbps (if you were lucky) to connect and surf the couple of websites that existed. The idea that someone could connect from their current location without needing to go to a pre-determined location and hope that no one else was using it was the stuff of science fiction. Unfortunately, the bar to entry for this technology was pretty high. You needed to know that it existed, be in the range of the few access points (APs) that existed at the time, and have a computer that had the required additional hardware that enabled your computer to join the airways.

Fast forward a quarter of a century and it is hard to imagine living in a world where Wi-Fi doesn't exist. Even with the explosion of personal cell phones (not that giant brick from the early 1990's), Wi-Fi has grown from a niche, nerdy technology to be on par with basic utilities like lights and running water. When we enter a building, we expect the lights to be on, there to be running water in the bathrooms, and that they have Wi-Fi for us to connect to. Whereas cellular requires the user to be in range of the providers tower, Wi-Fi is a Common Air Interface (CAI) technology that has now come to where the people are. Whereas just 10 years ago the average person had 3 Wi-Fi enabled devices, that number has now jumped to 5 Wi-Fi devices for the average person and even more for power users. Wi-Fi is the preferred medium of connecting people to the internet.

As society and technology has evolved, we are now entering the third generation of the World Wide Web (WWW), also known as Web3. The first generation, or Web1, is considered to be the growth of the WWW, while Web2 was the second generation with the explosion of the social media world. Web3 is the generation where individuals are able and actively involved in creating their own world on the web, that being a virtual world. This generation is bring to live another new term, known as "Metaverse". Metaverse is a contraction of the Greek word "Meta", meaning beyond, and the word universe . The generation we are entering is literally the idea that we are evolving into a world that is beyond our known universe.

That is a heady term to embrace, and we aren't suggesting that we are embarking on a journey through space to leave our actual known universe, but the idea that people are starting to push their boundaries beyond anything they can conceive today in the part of the universe that they exist in. As a technology company, we need to be able to support this effort because a virtual universe built on a shaky foundation isn't going to last. One of these foundational elements is actually Wi-Fi 6E. That might seem weird, but both Wi-Fi 6 and Wi-Fi 6E introduced technology that is critical in how Wi-Fi 7 will be able to support the Metaverse of the future.

Wi-Fi 7 as a foundation

Wi-Fi 7, or 802.11be, is the next generation of the PHY rate in Wi-Fi. What makes Wi-Fi 7 unique and capable of being a building block for the new Metaverse is the final combination of a couple of features and advancements that came in the previous generation, and it is worth it to review these features and advancements.

Orthogonol Frequency Division-Multiple Access

With the exception of 802.11b that used High-Rate Direct-Sequence Spread Spectrum (HR DSSS) the modulation used in Wi-Fi was, and still is for those previous generations, some version of Orthogonal Frequency-Division Multiplexing, or OFDM[2]. A great leap forward in technology, it defined Wi-Fi for a long time, and enabled us to move from speeds of 11 Mbps all the way to a theoretical PHY rate of 2,340 Mbps[3]. What came next in the modulation evolution came in the form of Orthogonal Frequency Division-Multiple Access (OFDMA), introduced Wi-Fi 6. While it sounds counterproductive in the evolution of faster speeds, OFDMA is the concept that within the standard 20 MHz wide channel used in Wi-Fi, there are times when the entire 20 MHz worth of spectrum isn't needed. Instead of dedicating that time on the resource to a single device, why not sub-divide the spectrum and allow multiple devices to send or receive data at the same time? By allowing multiple devices to access the resource at the same time, it frees up time for the devices that actually need that amount of spectrum, if not more.

1 https://www.consilium.europa.eu/media/54987/metaverse-paper-9-march-2022.pdf
2 802.11g has a modulation that introduced Extended Rate Physical (ERP) that could be used with OFDM and DSSS.
3 802.11ac Wave 2, 3 Spatial Streams, 256 QAM Modulation, 3/4 Coding Scheme, 160 MHz wide channel

The same concept of OFDMA is the impetus for modern developments like strip malls (multiple, smaller stores sharing a single building and parking lot) and is the literal basis for how LTE operates.

While changes in social behaviors around the world starting in 2020 has limited the effectiveness of this advancement, it will still play a key part in how Wi-Fi 7 will be able to support the Metaverse explosion that is projected to be on the horizon.

New 6 GHz Spectrum

While 802.11ac (Wi-Fi 5) came at the technology world in two waves that impacted real world performance (most notably the introduction of the 160 MHz wide channel in Wave 2), Wi-Fi 6 also came at the technology world in two waves. This time, instead of calling it Wave 1 and Wave 2, these waves were known as Wi-Fi 6 (introducing OFDMA from above) and Wi-Fi 6E which "Extended" the Wi-Fi 6 protocols into a new spectrum, the 6 GHz spectrum. This new spectrum, which is still in plenty of flux in 2022, has been called "the most significant improvement to Wi-Fi in several years"[4]. Others might say that this new spectrum is the most significant improvement to Wi-Fi since 802.11 was first introduced in 1997.

The reason this new spectrum is so impactful is just because of the sheer amount of spectrum being allocated with this announcement. As seen below in graphical comparison, this new spectrum is a game changer.

Figure 1 Wi-Fi Spectrum Comparison, courtesy Wireless LAN Professionals[5]

For clarification, the 6 GHz spectrum shown here isn't available in all regions as of the publication of this document so please consult your local regulations for the 6 GHz spectrum available to you. Also, the spectrum shown is the amount of usable spectrum, not the total bandwidth allocated. We are looking at you UNII-2b.

OFDMA in 6 GHz

With the foundational blocks of OFDMA and 6 GHz in place, technology is now ready to move into position to support Web3 and Metaverse, but the job isn't done, at least not yet. Just like anyone can buy a supercar and then crash it on the way home from the dealership[6], how these new Wi-Fi 7 networks are deployed and their configuration will play a crucial role in how much enjoyment the users will get from this new technology. Never underestimate the ability of a well intention engineer to cause a network to underperform. This isn't done out of malice but simply when the best intentions don't always go the way we had hoped.

Enabling the Metaverse with Wi-Fi 7

In order to support the Metaverse, designers are going to need to understand some key fundamentals of Wi-Fi and then agree to follow some key design and operational parameters to meet these new and very strict requirements. Requirements have always been at the heart of any network design, wireless or wired, but not taking the time to gather all the requirements and then making sure the end design meets those requirements is the hallmark of any network that underperforms after being deployed. What other applications might experience as a small glitch, the Metaverse will expose as a glaring problem, completely destroying the experience for users and delaying adoption of the newest technology.

Wi-Fi Fundamentals

No matter how advanced the 802.11 protocol gets with the latest amendments and faster PHY rates, there are some universal truths that still remains and to design and implement a Wi-Fi 7 network to support the Metaverse, these fundamentals will need to be adhered to.

4 https://packet6.com/impact-of-6-ghz-future-of-wifi/
5 www.wlanpros.com/spectrum
6 https://www.cnbc.com/2017/07/28/ferrari-driver-crashes-288000-supercar-just-an-hour-after-purchase.html

Wi-Fi is a hub

Even with 802.11be (Wi-Fi 7), Wi-Fi is still a network hub in the air. Many younger technology practitioners might not remember hubs, even haven't ever used hubs in production networks, but Wi-Fi is more like a hub than a network switch. This means that the technology employs Carrier Sense Multiple Access – Collision Avoidance, or CSMA-CA. To explain it in the simplest of terms, this means the technology can't detect when a collision happens between two frames (a packet is transmitted as a Layer 2 frame in the air) so it employs multiple precautions in an attempt to avoid a collision since it can't detect it.

Conversely, a network switch employs Carrier Sense Multiple Access – Collision Detection, or CSMA-CD. That detection part is what allows a wired network to always perform faster, and more reliable, than the latest Wi-Fi. While there are other reasons as to why a Wi-Fi network won't ever surpass its wired counterpart, CSMA-CA will always be a stumbling block. It's one we can overcome, if some best practices are followed, but it requires a designer to always keep this in mind.

Wi-Fi is half-duplex

Again, this goes back to old technology that many younger practitioners may have seen as a potential switchport configuration, always wondered what that meant but was too afraid to ever ask what it meant. Half duplex means that at any given time, a Wi-Fi Network Interface Card (NIC) can either transmit or receive, but never both at the same time. This is an old radio physics issue that is still around today. While many Wi-Fi professionals see a light at the end of the tunnel with some potential solutions (this author being one of them) as of Wi-Fi 7, this is still an issue to contend with.

Conversely, a network switch has what is known as full duplex. It is so ingrained in the vernacular that saying a port came up at "1 Gig full" or "10 Gig full" hardly registers any longer that there is still the potential that a port could still come up as "half" and not "full". While very slim these days, that potential is still there. Full duplex means that the wired network device can transmit and receive data at the same time. It accomplishes this by using half of the wires in an 8 wire Cat6 cable for transmitting, the other half for receiving. The solution for Wi-Fi would be to separate the transmit and receive aspects of the radio interface on to two separate channels, but there are some Common Air Interface challenges as well as RF physics problems that we need to solve before this can be discarded into the trash bin of networking, like thick coax, taps, and a token ring.

Wi-Fi still can't manipulate time

This sounds like something that shouldn't even be discussed, but Wi-Fi is still seen in many areas as magic and like magic, sometimes the end users and administrators alike expect magic-like things to be a possibility. I am sorry to report that this still isn't possible. We can manipulate signal by using antennas and technology like BeamFlex[7], manipulate modulation, manipulate the CSMA-CA algorithms by using QoS, but at the end of the day, we can't manipulate time.

One of the key elements in the Metaverse, and in making it work well, is the concept of low-latency connections. Given that at its heart, Wi-Fi is still a half-duplex hub, we are asking Wi-Fi to overcome a lot to deliver data at over 1 Gbps today, while the requirements for the Metaverse could possibly reach up to 10 Gbps. While that is almost theoretically possible today with a 320 MHz wide channel and using 802.11ax and 8 spatial streams, Wi-Fi 7 should get us closer. This also assuming that the client devices have a power source that can support the power required to run a Wi-Fi radio flat out for more than a couple of minutes.

Design Fundamentals to support the Metaverse

Given the fundamental limitation faced by the Wi-Fi designer of today, there are still some "best-practices" that can be followed today that will give the network of today the best chance to deliver on the requirements or tomorrow.

Client assignment

For many years Wi-Fi architects have long sought to limit the number of SSID's that are supported by a single Wi-Fi radio. They accomplish this using a concept of one SSID per encryption/authentication method. This means one SSID for Enterprise, one SSID for Personal (PSK or SAE) and then one for open. By utilizing technology like RUCKUS Cloudpath[8] administrators can utilize the method of authentication and/or encryption to enable Role Based Access Control (RBAC) for different experiences on the wired network. In the future, this same type of consideration will need to be followed but with the client assignment to the bands available to Wi-Fi networks.

Designers need to think of the bands much like the encryption used today. To enable the Metaverse, only those clients that can fully utilize the benefits that come with this large allocation of 6 GHz spectrum should use that spectrum. Requirements like Virtual Reality (VR) and Augmented Reality (AR) or any other specially curated use cases should be using that spectrum today.

7 https://youtu.be/K2ZhXLuJMfg
8 https://www.commscope.com/product-type/enterprise-networking/network-access-policy/network-access/

The truth is that for 98% of users today, not counting VR/AR, are functioning well using the 5 GHz spectrum. While everyone likes to go fast, it isn't something that is needed.

To borrow from the spectrum chart earlier, architects and engineers need to think of band utilization in a new concept, something like this:

2.4 GHz	**Latency Insensitive - Headless devices, IoT**
5 GHz	**Latenency Sensitive - User interfaced deevices; phones, tables, computers**
6 GHz	**Latency Critical - Metaverse, medical, financial, gaming**

Figure 2: Wi-Fi Spectrum Allocation

While not a hard and fast rule, keeping devices in their lane, so to speak, is the best starting point to allow devices to have the best chance at achieving their desired performance levels.

SSID and device management

As Wi-Fi 7 and the Metaverse starts to be seen in the wild, there will be issues and problems. There are already supply chain issues, AFC issues with deploying outdoor 6 GHz APs, and there will be code issues. Architects and engineers will find themselves in positions to where being able to be flexible in their code management and configuration management will become a key issue. Being able to support different hardware versions as critical areas get new APs and other areas stay on older hardware will become the norm, if it isn't there already. While most platforms support managing SSIDs for different groups of APs, not all engineers are comfortable managing that in production.

Executives are going to need to be comfortable with understanding that not everything is going to happen seamlessly and perfect, every time the first time. There will be mistakes, there will be problems, and the engineers are going to need time to work through those issues. Engineers are also going to require platforms that allow them enough flexibility to work through these issues.

Channel management

Just like with water and energy, spectrum is a finite resource that we can no longer afford to squander. At a certain point, there won't be additional band of spectrum to grant the Wi-Fi world to bail us out of lack of channels. Combined with the use cases from above, Engineers need to ensure that they are setting channel widths that make sense. It is fun to get onto a 160 MHz wide channel with a high-powered laptop and run speedtests and see how fast that needle moves, but in real world use cases, it doesn't translate over. A tablet might be able to do a speed test of 400 Mbps, but in day-to-day use, 100 Mbps might be the most it ever needs. Downloading updates or files might take a little bit longer, but unless that is the normal, average use case for the network, let the device spend a little more time on a narrower channel to get that occasional download.

If the requirements of the network demand the ability to download or upload large files on a consistent basis, then by all means design for it, even to the point of putting those device on the 6 GHz spectrum, but do it in a reasonable and justifiable manner, not just because someone wants a faster speedtest.

Metaverse Design Criteria

While many of the exact parameters that will be needed to support the Metaverse are still being defined into numbers that engineers need, we do know of two criteria that will be essential to make it work.

- High throughput
- Low latency

High throughput

While not a great metric to design for without a number, the common belief is that the amount of data needed to make the Metaverse functionable will need to match the “throughput” of the human eye. What that number might be is still under debate, but the human eye needs to be fooled into thinking that what it is receiving is real world data, and what we do know for certain is that it is more than the 4K streaming we are delivering today.

To complicate this number will also be the compression used in such a service. The more the data can be compressed, and then recovered on the other end, then less throughput that will be needed. Until these numbers are better understood, the best you can deliver is going to be the requirement to design for.

Low latency

Combined with life-like throughput requirements, low latency will also be critical. While low latency is a normal design criterion for today's networks that are delivering Real-Time Protocols like VoIP calls or video conferencing, the latency requirements for the Metaverse are going to be in the realm of "ultra-low latency" and we need to start planning for that today.

What do we mean by "ultra-low latency"? In networks of today, the common benchmark for looked for by designers is no more than 250 milliseconds (0.25 seconds) of latency[9], considering everything else is perfect. Ideally, the latency number will always be as low as we can get it, but anything less than 100 milliseconds (0.10 seconds) is considered good. For the Metaverse, some of the numbers being discussed range from no more than 20 milliseconds (0.02 seconds) to ideally less than 10 milliseconds (0.01 seconds) of latency.

With protocols of today, the human brain understands that it is looking at something that is artificial. To trick the human brain into believing that what they are seeing is real life and not a simulation, any delay in updates between movement and sound and vision will be noticed. A recent joint university study into prolonged use of the Metaverse found multiple pitfalls to current versions of the Metaverse, but one that could be attributed directly to latency issues. From the report published in Fortune magazine[10]: "All participants reported more frequent or intense instances of eye strain, visual fatigue, and nausea."

While the other issues discovered during this test fall outside the realm of the network's problem to solve, latency falls well within the scope of the network. To bring it into the context of today, any issues with latency in the Metaverse will be like riding in a car and getting motion sickness, but unable to get out of the car. What the eyes perceive and send to the brain needs to match almost exactly with all the other sensory inputs, and any latency will lead to bigger problems.

Metaverse and Wi-Fi 7 Together

Technology, just like time, likes to continue and move into the future. While network engineers might prefer to envision a Metaverse that includes visions of SFP+ running at least 10 Gbps over fiber optic cables, at a bare minimum, that time has passed. End users, customers, have been introduced to a mobile world and trying to move back to a stationary, wired experience isn't something they are looking forward to, so wireless it is. Whether that wireless is Wi-Fi, Private LTE using CBRS, or licensed LTE from a third party carrier, the solution that works the best will all come down to time.

The Metaverse is going to be a time hog, not just personal time but network time, time on the wire or time in the air. Making sure they have their own channels or resources to conserve time will be imperative. Not wasting time trying to find a suite of products to help manage the Metaverse supporting infrastructure will also be critical. Resources like a RUCKUS vSZ High Scale controller (or RUCKUS Cloud) to manage multiple platforms and code versions, with accompanying SSID's and configurations. RUCKUS ICX switching to carry all this data over a stable wired infrastructure. CommScope copper and fiber optic cables to connect it all together, combined with imVision to manage the miles of cables. RUCKUS Cloudpath as the central clearing house for managing end users, ensuring sure time isn't wasted getting people onto this superhighway of Web3. RUCKUS Analytics to watch over this critical infrastructure and alert the administrators when potential problems are identified, before they can disrupt the end users.

Maybe your wireless path to the Metaverse starts with Privat LTE and CBRS instead of Wi-Fi 7. RUCKUS CBRS Portfolio is there to provide for that as well, possibly in conjunction with Wi-Fi 7. Even if your route to the Metaverse is over third party cellular. Once again, CommScope has the solution with Small Cell cellular and even in building DAS if that is your chosen route.

We know that time is of the essence when it comes to the Metaverse, the question now is can risk not taking the time to look at CommScope RUCKUS as the provider to take you into the future? Visit us at https://commscope.com and https://commscope.com/ruckus to view all the solutions you need to carry your organization into the future.

Time waits for no one.

9 https://netbeez.net/blog/impact-of-packet-loss-jitter-and-latency-on-voip/
10 https://fortune.com/2022/06/21/study-working-in-metaverse-low-productivity-high-anxiety/