Why Should We Care About 6GHz and Wi-Fi 6E?

By Charles Cheevers, CTO, CPE, Commscope

1.2GHz of spectrum in the U.S. and 500MHz in EMEA is potentially available for new Wi-Fi 6E clients to use.

Charles Cheevers, Chief Technologist, Customer Premises Solutions Office of the CTO

Charles Cheevers is Chief Technologist of CPE (Consumer Premises Equipment) Solutions at CommScope. He's responsible for the two- to five-year technology vision of CommScope's CPE business. In this role, he defines new home architectures for CPE devices and cloud-to-ground solutions as well as the evolution of CommScope's home gateways, set-tops and connected home solutions.

In his more than 20 years in the telecommunications industry, Mr. Cheevers has been responsible for bringing to market a range of technologies — including DVB, DOCSIS, DSL, PON Network and CPE Video Voice and Broadband solutions. Over the last six years, Mr. Cheevers has focused on delivering the next generation of connectivity and technology-driven user experiences to the home. As a result, he's played a key role in pioneering major trends in Wi-Fi®, IoT, IP video, TV experience and set-top technology, and most recently AI-driven smart solutions, with the debut of CommScope's Smart Media Device.

Mr. Cheevers and his team have also been creating new home platforms for many of the world's leading service providers. With the emergence of new Wireless convergence solutions in both unlicensed and licensed bands — from 1 to 100GHz — Mr. Cheevers and the CommScope CTO office have been innovating new architectures for consumer and home wireless convergence across Wi-Fi, LTE and 5G.

Mr. Cheevers joined CommScope through its acquisition of ARRIS, where he served as Chief Technology officer of CPE Solutions from 2012 to 2019. He joined ARRIS in 2003. Prior to his tenure at ARRIS, Mr. Cheevers was VP of Engineering and an Officer of Com21 Inc and held senior management positions for Apple Inc.

Mr. Cheevers has served on the board of the Open Connectivity Foundation, one of the leading IoT standards initiatives, served on the SCTE organising committee for 2018 and 2019 and is a recipient of the 2006 and 2011 Cable and Satellite Euro50 award for his contributions to cable technology.

Wi-Fi has been moving along for the last 20 years but, in 2018/19, it saw the greatest change since its creation with the revision of the standard to 802.11ax. This new standard also drove the Wi-Fi Alliance to rename the generations of Wi-Fi, starting with Wi-Fi 6E denoting the 802.11ax standard (Wi-Fi 5 802.11ac and back to Wi-Fi 1 as 802.11a where it all began). This new Wi-Fi 6E standard set some ambitious changes to Wi-Fi and its performance, whilst being backwards-compatible to previous Wi-Fi generations.

Wi-Fi 6E was designed to provide higher data rates and capacity (Gbps speeds), work better in environments with lots of devices and improve battery efficiency for IoT devices and connected smartphones/tablets/laptops using Wi-Fi. At the same time, it is backwards-compatible with Wi-Fi 5 older clients – and makes them more efficient.

At its simplest, it is designed for 4x better performance in all-Wi-Fi 6E client environments but, even today with mixed Wi-Fi 5 and Wi-Fi 6E devices, it is typically 25 per cent or more efficient than a Wi-Fi 5 AP solution.

Additional WiFi spectrum

However, there is more to come with the addition of 6GHz spectrum to be used ONLY for Wi-Fi 6E clients. This will accelerate the 4x performance improvement for consumers as the current 2.4GHz and 5GHz spectrum will be occupied by Wi-Fi 5 devices and older, for years to come.

This is probably the most exciting change in Wi-Fi in the last ten years where 1.2GHz of spectrum in the U.S. and 500MHz in EMEA is potentially available for new Wi-Fi 6E clients to use. This will be game-changing as the acceleration of the 4x efficiency and Wi-Fi 6E features, using a new super clean and dedicated RF highway, will drive new applications faster and will change the paradigm of wireless networking, particularly in the home.

As the Federal Communications Commission (FCC) decides the spectrum allocation in the U.S., there are some proposals to initially leverage what is called Lower Power Indoor (LPI) mode (potentially 250mW EIRP) to start the use of 6GHz. Currently, the incumbent user of most of the 6GHz band is microwave services. To support their services and the use of Wi-Fi, there are evolving proposals to create an Automated Frequency Control (AFC) solution that is very analogous to Spectrum Sharing solutions, such as the SAS found in CBRS implementation.

A cloud database platform can be queried by Access Point to validate use of the 6GHz channel and the appropriate power to use. This solution would also allow higher power to 1W to be used where there is no microwave interference. UK and EMEA regulators are also working closely with the FCC to define a harmonised solution for opening access to this spectrum for Wi-Fi.

While there is still much work to do with the U.S. FCC and European regulators to grant access to this spectrum,the industry is forging ahead to be ready to create 6GHz networks in a 2021 timeframe. Wi-Fi 6E and 6GHz (many people confuse the two – Wi-Fi 6E is a new technology and 6GHz is a new frequency) when put together are as transformational for wireless home networking as the Bugatti Chiron is to the Model T Ford!

As 6GHz spectrum is introduced, the potential for Wi-Fi to be more deterministic (like a wired ethernet link) becomes more likely for Wi-Fi 6E applications. The diagrams below illustrate the relative bandwidth and capabilities of each Wi-Fi solution relative to 100BT, 1GB, 2.5GB and 10GB Ethernet LAN services.

Why does 6GHz Wi-Fi 6E change things so much? The reason is the modulation scheme used for Wi-Fi 6, coupled with this new spectrum. Wi-Fi 5, and previous generations of Wi-Fi, typically had to work in congested spectrum areas. The 2.4GHz spectrum, which was the first to be granted to Wi-Fi, is now fully congested and even contains Bluetooth and ZigBee devices. While great for range, it is now pretty exhausted and not the spectrum upon which to build the future of high capacity. Enter the addition of 5GHz spectrum in the U-NII 1, 2, 3 bands and the availability of more spectrum for applications such as Video over Wi-Fi. This has served us well, allowing the first generation of HD Video streaming in the home over Wi-Fi in the 5GHz

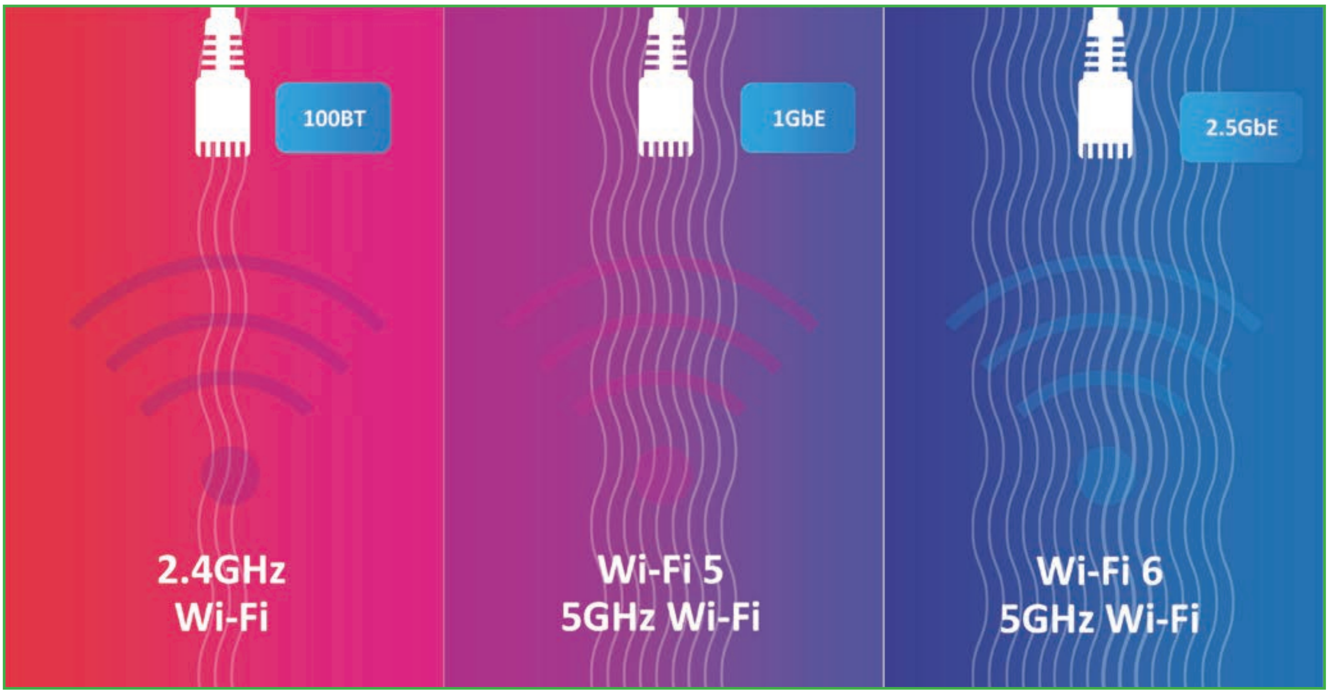


Figure 1: Wi-Fi 5 to Wi-Fi 6 - Ethernet LAN capabilities

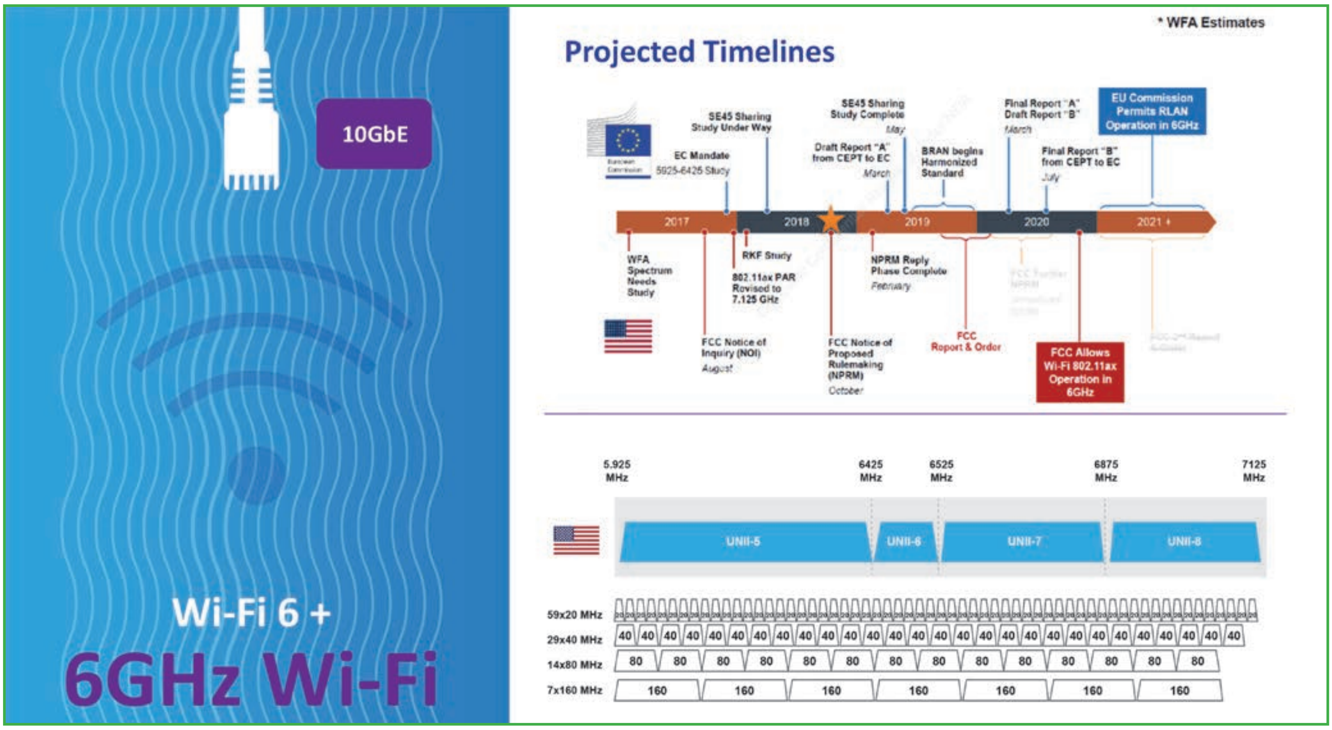


Figure 2: Wi-Fi 6E running in 6GHz has true 10GbE potential

band, but now this spectrum is also filling up as more and more applications favour the shorter range but higher capacity spectrum. This spectrum is also shared with RADAR and invariably all channels are not available – see Figure 3 below.

The use of the spectrum is also typically a CSMA/CD (Carrier Sense Multiple Access/Collision Detection) scheme where all clients transmit, listen to see if their transmission got through and retry in a collision. This worked well in the past but compared to other solutions, such as LTE or DOCSIS (where scheduling can also be applied to best effort transmission), it was time for an overhaul to the MAC for Wi-Fi 6.

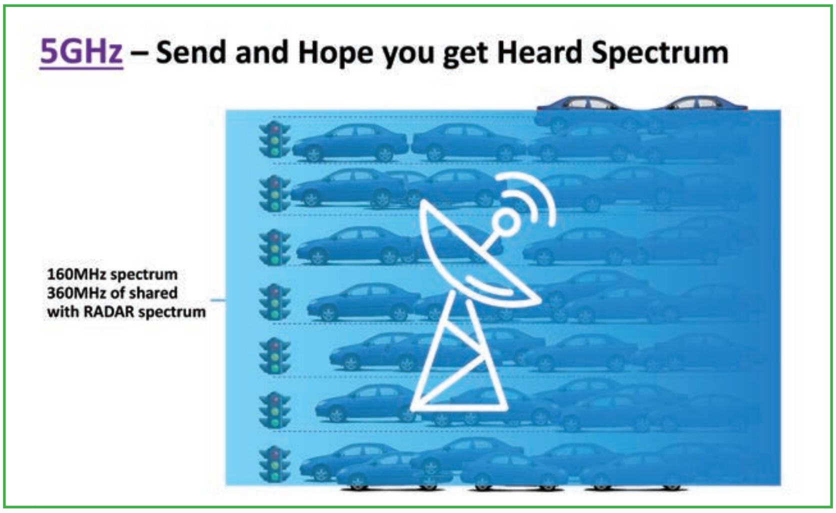


Figure 3: 5GHz - CSMA/CD with RADAR as well

With the introduction of 6GHz spectrum – the potential is there for:-

- **U.S. – 1.2GHz** to allow potentially 7x160MHz channels to use or 14x80MHz channels.
- **EMEA – 500MHz** to allow potentially 3x160MHz to use or 6x80MHz channels.

Wi-Fi 6E principally introduces the OFDMA modulation scheme (which is similar to that used by LTE and DOCSIS Upstreams) that improves channel efficiency by assigning subsets of carriers to individual clients. On top of this, it adds Multi-User MIMO not only on the Downlink but now also on the uplink to allow more concurrency to the AP.

While wider channels were available in 802.11ac – we will see ALL Wi-Fi 6E devices now supporting 160MHz-wide channels (80MHz had been the norm) – this means a doubling of potential capacity to the clients supporting 160MHz. QAM1024 modulation is also now supported, allowing 10Gbps speeds on 160MHz QAM1024 MU MIMO capable Wi-Fi 6E Access Points.

Demonstrating new capacity

To underscore the raw benefit of the newly expanded bandwidth available, we can

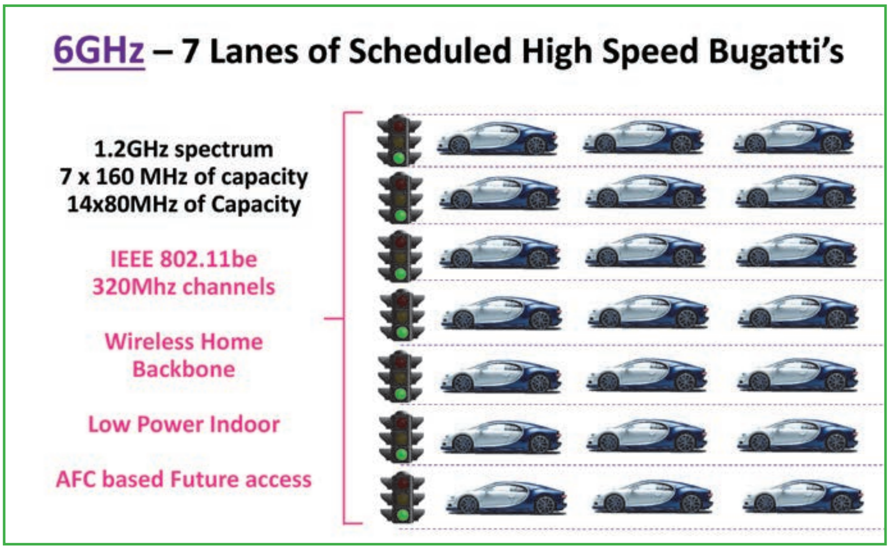


Figure 4: 6GHz - VIP lanes for Wi-Fi 6E only clients and potential to schedule transmissions

construct a fronthaul exercise which demonstrates the rather profound capacity of a 160MHz trunk operating between a GW device and an extender at U-NII-6 in the 6GHz band. We will use this to source services to an extender device, which features three clients operating at 6GHz in addition to legacy connections in the 5GHz and 2.4GHz bands.

A mix of WiFi4 and WiFi5 MAC traffic at the lower bands is presumed and captured in the tabular summary. Note that a particularly nasty link (narrow bandwidth and few spatial streams, carrying 70Mbps UHD/HDR video data to a client that is 50 feet away from the extender) was also included. Table 1 below summarises this; note the margins shown are achieved without recourse to any particular scheduling scheme, except for the priorities listed:

To round it off, there has been an emphasis in Wi-Fi 6E on Transmit Beamforming to work more efficiently at targeting power to clients (particularly to increase performance at range).

Using a new solution called Target Wake Time, Wi-Fi 6E is also targeting the same massive IoT increase that 5G is looking to support. Battery life on laptops, smart phones, tablets as well as other sensor and battery-operated Wi-Fi devices can now be significantly controlled with deterministic sleep and wake support.

When we add 6GHz clean and unused spectrum to the Wi-Fi 6E equation, all of these features can be used to their highest designed efficiency because they are not competing with Wi-Fi 5 devices.

Table 2 overleaf illustrates the greenfield advantage offered by a 6GHz hosting of Wi-Fi 6E versus adoption of this same MAC in the more contentious 5GHz band. Note that, even with a power budget, a full 6dB higher at 5GHz, the EIRP-constrained performance at 6GHz versus a 35% airtime-contended hosting at 5GHz manifests a 50% better throughput (at the same spatial stream count and bandwidth) out to a 25-foot service radius (including propagation through one drywall).

While this advantage tails off over accumulated path losses, the two services do not exhibit similar throughput until the service throw has reached 115 feet, through two walls and one floor:

Device	Bandwidth	Radio Type	Tx Pwr (dB)	Spatial Streams	Atten (dB)	Distance	Frequency	Priority	Throughput Requested (Mbps)	Link Rate (TCP) Mbps	%Channel Use !OFDMA
Trunk	160 MHz	802.11ax	24	4	16	10.7m (35 feet)	UNII-6	BE	551	1780.47	
L1	40MHz	802.11ax	24	2	19	15.2m (50 feet)	UNII-6	VI	70	222.05	31.52%
L2	20MHz	802.11ax	24	2	3	6.1m (20 feet)	UNII-6	VO	0.4	236.65	0.17%
L3	80MHz	802.11ax	24	2	9	12.2m (40 feet)	UNII-6	VI	30	596.07	5.03%
CL-2	20MHz	802.11n	27	1	8.7	9.1 (30 feet)	2.4	BK	50	*45.17*	
CL-1	80MHz	802.11ac	27	4	10.9	9.1 (30 feet)	UNII-3	VI	400	1419.38	
								Aggregate Request	550.4		30.91%
	Pathological Case: 2x2, relatively narrow BW, long service throw and 70 Mbps UHD video stream							***Total UNII-6 Channel Use***			***67.64%***

Table 1: A summary of WiFi4 and WiFi5 MAC traffic at the lower bands

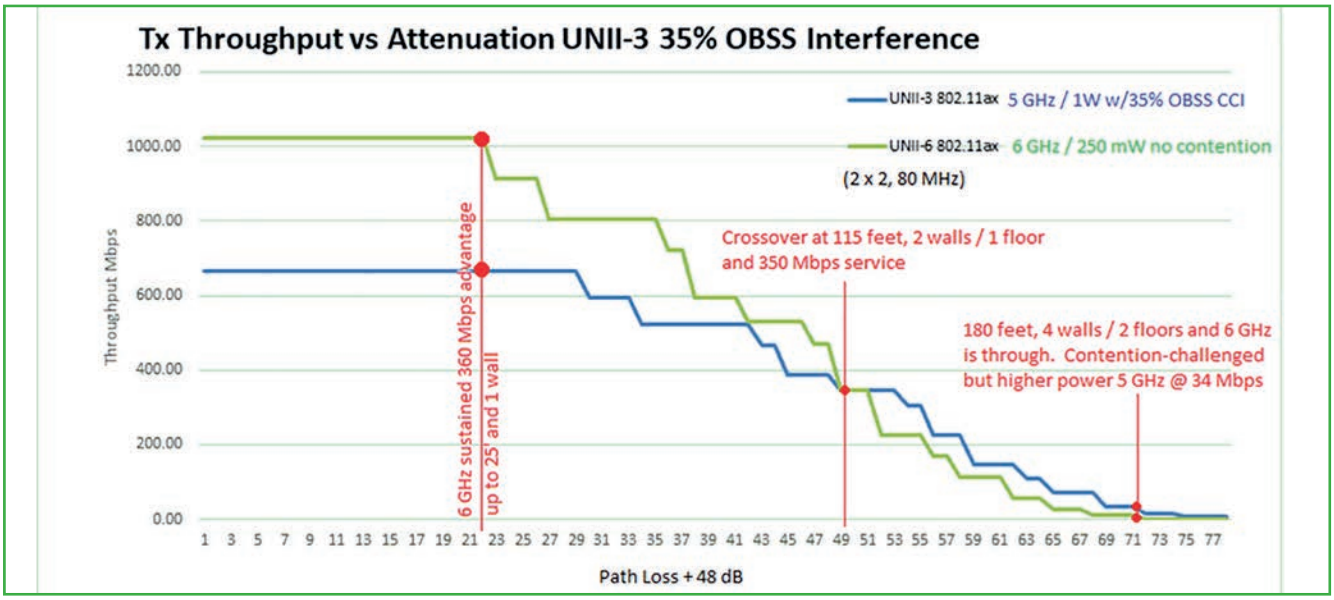


Table 2: The greenfield advantage offered by a 6GHz hosting of Wi-Fi 6 versus adoption of this same MAC in the 5GHz band

One of the features of OFDMA that will be leveraged in 6GHz is the scheduling of transmissions to/from clients. Today, in Wi-Fi 5 environments, ALL clients use CSMA/CD where they send a frame and then listen to see if the frame got through.

If there was a collision, then they retry. This is highly inefficient when compared with OFDMA schemes such as LTE and DOCSIS, where scheduling packets play a large part in the Medium Access Controller.

Unlocking new opportunities

With Wi-Fi 6E and 6GHz, there can be more determinism to Wi-Fi with the scheduled delivery of packets. So much so that new applications, such as connecting LTE/CBRS femto cells on Wi-Fi and being able to clock them with 1588 timing, can emerge.

And it does not stop there. The IEEE have kicked off the 802.11be initiative which is now going to specify the next step for Wi-Fi with even wider channels to 320MHz that can sit in the 6GHz band. This creates the opportunity for new architecture

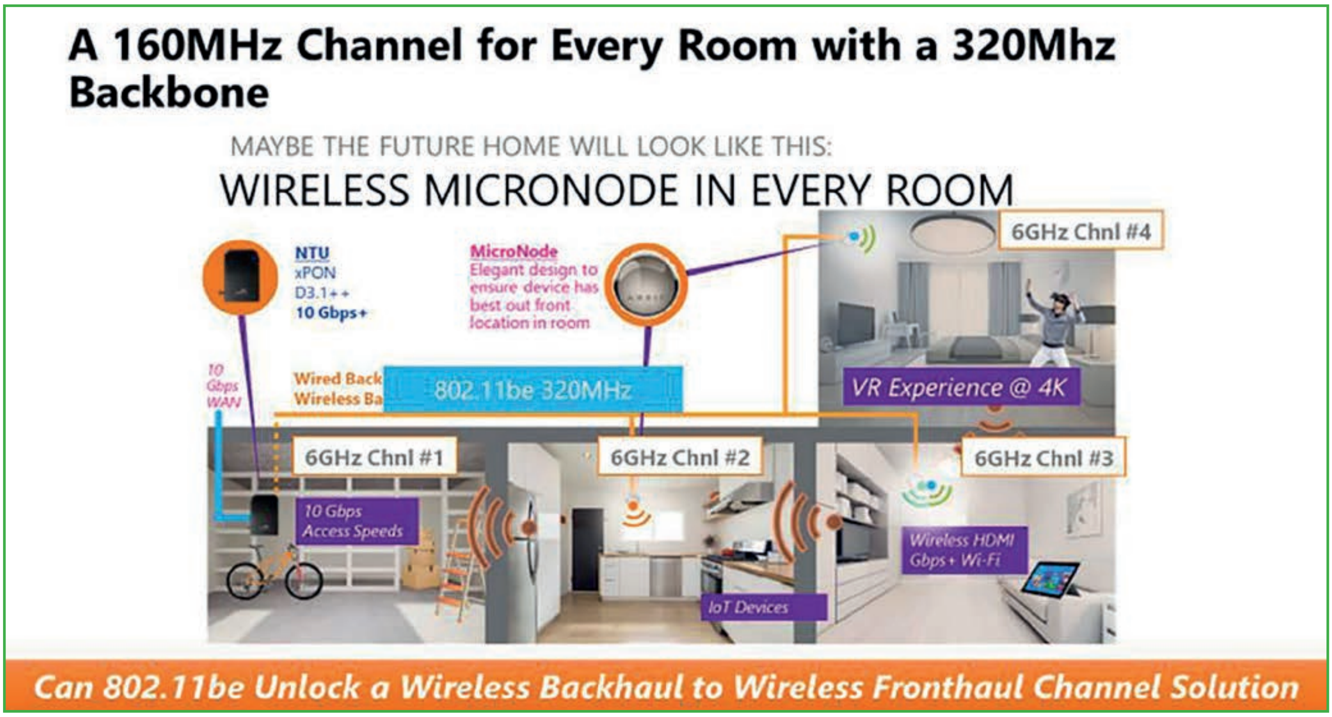


Figure 5: Potential all wireless backbone and room channel assignment with 6GHz and 5GHz spectrum

based on Wi-Fi backbone of 320MHz and in-room separate channels for 10Gbps in-room capability for future wireless applications – see Figure 5 on previous page.

Companies such as CommScope are actively building Wi-Fi 6E DOCSIS GW, Telco PON and xDSL GW, Extenders to complete the full suite of Wi-Fi 6E products – and see a 2021 migration to 6GHz Wi-Fi 6E to reap the benefits of the added spectrum when it becomes available.

We expect that DOCSIS GW, Telco GW, Extenders and STB will all emerge with 6GHz solutions and will require Tri-band AP capabilities in the GW/AP. Today, Tri-band devices typically have 2.4GHz+5GHz+5GHz (2 5GHz channel ability) but 6GHz devices will probably have 2.4GHz+5GHz+6GHz Tri-band radios allowing access to both the 5GHz and 6GHz spectrum for legacy and new 6GHz-capable clients.

However, there will be immediate potential use of 6GHz for key applications such as:

- Backhaul and mesh.
- Gaming and lower latency.
- STB and high-resolution video QoS.
- NAS drive and fast backups.
- Un-tethered VR.
- 5G/LTE Femtocell with Wi-Fi.

These can be driven directly by SPs/Operators as opposed to waiting for smartphones etc. to emerge.

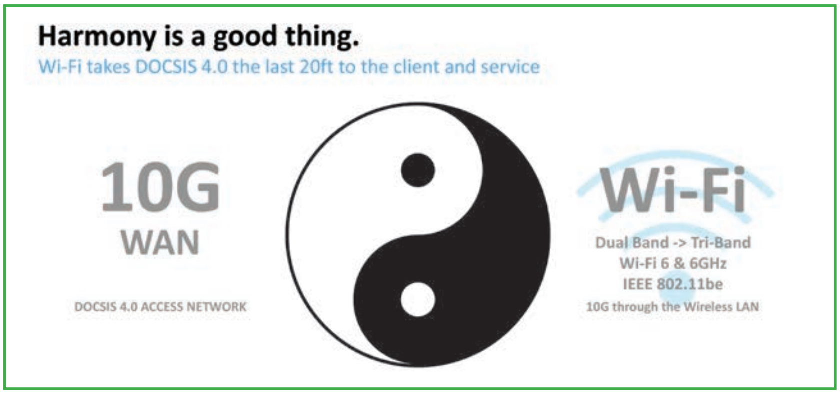
Figure 6 below illustrates how Service Providers can take the lead with 6GHz Wi-Fi 6, developing bookend applications where they can derive consumer value.

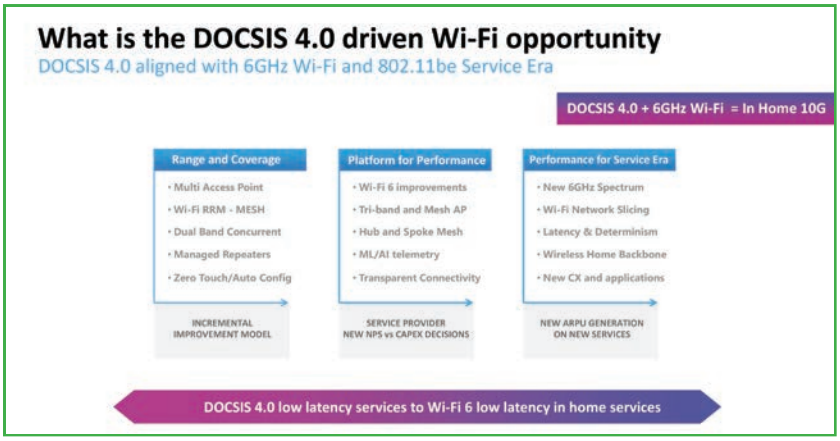
It's all good timing too, especially for the drive to Gigabit speeds. With PON systems moving to XGS-PON 10Gbps speeds and DOCSIS benefiting from a new revision to DOCSIS 4.0 (10G brand), we see the alignment of Wi-Fi 6GHz lining up with more of a move towards 10Gbps services on XGS-PON as well as DOCSIS 4.0 devices and services.

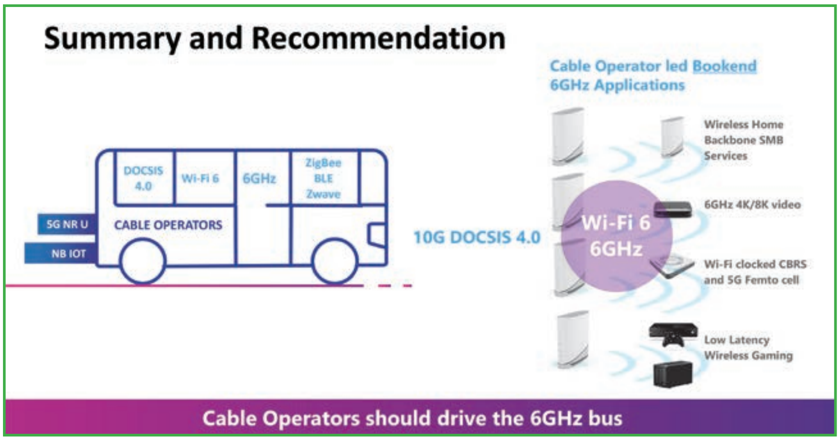
In the DOCSIS space, as DOCSIS is OFDM-based, as is the new Wi-Fi 6, we see the ability for the DOCSIS network Quality of Service to map very well into the Wi-Fi scheduler and OFDM transmission opportunities. This will improve the determinism and latency of services so that we can see even 1588 clocking abilities of Femto Cells over Wi-Fi deeper in the home. This is not possible today and needs Ethernet-based connections to the DOCSIS modem or GPS lock.

Today, we are still typically in the range and coverage era of Wi-Fi rollout (see overleaf). With the advent of Wi-Fi 6E and Tri-band whole home solutions, we are moving into the performance era where matching WAN and LAN speeds for Gbps services is possible.

Figure 6: Bookend 6GHz applications which Service Providers can drive







However, with XGS-PON and DOCSIS 4.0 at 10Gbps capable speeds, this will move the bar to drive 6GHz Wi-Fi usage in this spectrum and determine scheduled wireless delivery to drive new services and QoS guarantees for the homeowner and business. This will lead to new opportunities and applications from true un-tethered gaming and VR, lowest latency wireless gaming, Wireless NAS backups and wireless 8K connections for Video.

We see the XGS-PON/DOCSIS 4.0 + Wi-Fi 6GHz combination giving Service Providers and Cable Operators the tools to 'drive the bus' for home connectivity into the next era and complement what happens outside the home with 5G rollouts.