Wi-Fi .11AX – What's It All About?

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Is Wi-Fi Running Out of Steam?

Despite the fact that nobody could keep track of the array of acronyms underlying Wi-Fi (IEEE 802.11b, .11a/g, .11n, .11ac), the good news was that each new version was a clear step forward in raw data rate. In four generations, that rate went from 11 Mb/s to 6.9 Gb/s – an increase of more than 650 percent!

After all, raw data rate is the "name of the game." This comes as no surprise, since Wi-Fi is about pure data communication.

Now there is the imminent arrival of IEEE 802.11ax, with a maximum raw data rate of 9.6 Gb/s. But given its slow appearance (ratification is now planned for late 2018) and marginal improvement, one might wonder if this is an indication that Wi-Fi is running out of steam.

But don't be fooled! Underneath the acronym, there is a real shift going on from raw data rate toward multi-channel capacity and improved spectral reuse. This means that the real-life throughput experience of .11ax may be an increase of as much as four times that of .11ac. Let's explore, because this has consequences for consumers, as well as for product builders.

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Interference

For the consumer, there are always two important points with Wi-Fi. The first is performance (data rate). The second is range (e.g., "how can I get the highest speed in every corner in my house and backyard or basement, etc.?").

In urban areas these days, consumers have grown accustomed to what is now a common scenario – turning on a laptop, for example, and having to weed through the many routers or access points that are visible when trying to find a Wi-Fi network. Many of the routers use the limited number of overlapping channels, which means users are sharing those channels. Or to put it another way, there is interference on those channels.

When two devices are talking through each other, over the same channel at the same moment, it means that the messages are getting garbled and both need to be sent again. It's no surprise, then, that the throughput in dense environments can collapse in continuous retransmissions. Again, this is a form of interference.

This form of interference is made worse by the fact that routers and access points have attempted to improve range via the highest output power possible. Anyone who has ever been to a crowded party can understand this scenario. The more everyone speaks louder to be heard, the overall noise goes up and any real opportunity to communicate goes down. In the same way, more output power just causes more interference. In addition, higher output power in some channels of the band causes the signal to "bleed" from one channel into the channels next to it – another form of interference – causing the capacity of the band and the total Wi-Fi system to degrade. So, what to do?

Distributed Wi-Fi

This is where IEEE 802.11ax comes into play. The goal of this new standard is less about higher data rates, and more about the use of as many channels in the 2.4 GHz band or the 5 GHz band as possible – at the same moment in the same space.

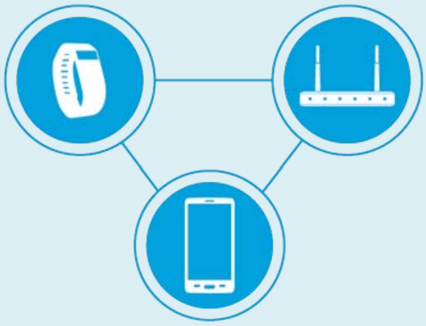
Let's look at an example of why this is needed. Imagine a family living in a house with multiple rooms, running different applications at the same time. In the past, this meant that everyone was using the same channel to communicate with the central router in the closet, but with all the interference limitations as discussed above.

The scenario that .11ax contemplates is that every room in the house has an access point running on a different Wi-Fi channel, and those access points are wirelessly connected over Wi-Fi to the central router in the closet. Now the applications are on different channels and not interfering with each other. This is a true Wi-Fi "system," and the name of the game now is total capacity – using multiple channels at the same time without interfering with each other, thereby optimizing total indoor throughput.

So, the goal of IEEE 802.11ax is full coverage of a home (or a building), and maximum performance in every room, which results in maximum overall capacity at the system level.

What happens if two devices are "talking through each other?"

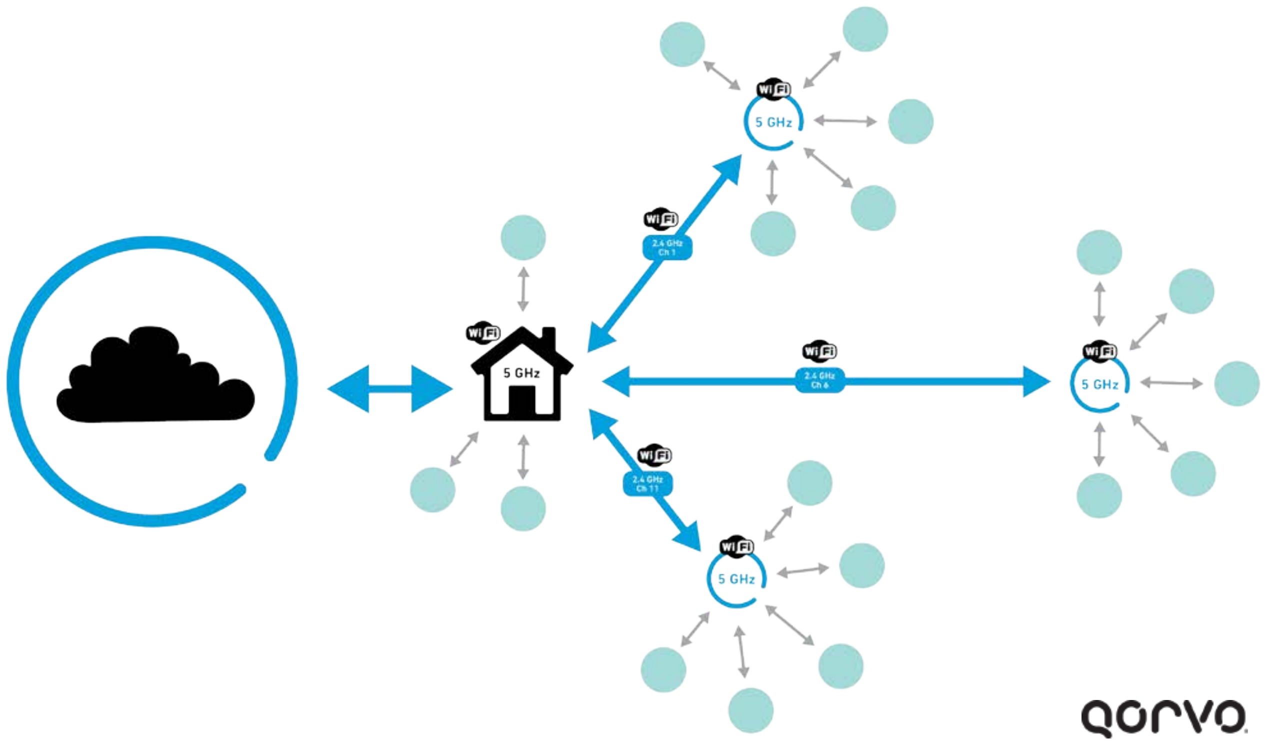
Smart phones, computers, tablets and routers communicating with each other on the same channel sometimes "talk through each other." Not surprisingly, this jumbles the communication.



A sending device usually knows that a packet has not arrived, because it does not receive an acknowledgement back from the receiving device within a certain time frame (we are talking milliseconds here).

The "mechanism" with which devices communicate is called a protocol, which describes how proper communication needs to be handled, including what to do when "talking through each other." A simple part of a protocol is "listen-before-talk," which means that before a device starts to send a data packet, it listens to ensure that nobody else is "on the air." But, if two devices both listen and, both conclude that the "air is clear" and start communicating at the same time, it creates a "collision." Some devices can "hear" the interference and will "back-off," or stop and wait (again, milli-seconds) before sending again.

So, typically what happens in dense environments is that more packets collide, more packets need to be retransmitted with now higher chances of another collision, and the consequence is that the performance of the network as a whole can break down. This is what happens, for example, with too many people on a single hotspot.



What are the Consequences for Product Suppliers?

Interestingly, output power to achieve range is no longer the most important criteria. Other things are becoming more important. In the first place, there is "flat power." This means uniform output power across the band, taking care that all the channels in the band are at maximum strength. In many products, the channels in the middle of the bands are strong, but channels at the side of the band are less well served, essentially creating capacity limitations.

This also relates to an item that called "band edge performance." In order to maximize the overall system capacity, one would like to achieve maximum output power over all the channels in the (2.4 and 5 GHz) bands, including the channels at the edges of the bands. But what is more typical is that the channels at the edges of the band have lower output power to meet the radio emission requirements (i.e., to make no noise outside of the band). Many product suppliers squeeze the channels on the edge of the band to meet the emission requirements, and therefore severely limit the overall system capacity.

And Additional Consequence for Consumers

Consumers do not like big boxes with large antennas. And especially with a distributed Wi-Fi router in every room, consumers will want small boxes, preferably with no antennas at all.

Unfortunately, there is a reason that routers today are so big. It is the only way that the box can spread and get rid of the heat from all the components inside. All these radio communication components generate heat. Ever watched a movie on your cell phone and felt how hot it gets?

The component makers for these boxes are working hard to make their components efficient, which means that they can radiate a lot of Wi-Fi with as little heat as possible. Again, remember that the old idea was maximum raw data rate

"Consumers do not like big boxes with large antennas."

and the highest (allowed) output power. But the new goal is using all the available channels with the highest efficiency. This is what makes IEEE 802.11ax a new standard and a big step forward.

2.4 GHz or 5 GHz?

There is one final question of note in this scenario. Assuming an access point in every room, and all the access points talking with the router in the closet over Wi-Fi, what frequency bands are preferred?

The reason to ask the question is the fact that 2.4 GHz gives better range than the 5 GHz. So, a logical choice would be to use the 2.4 GHz as the "backbone" and the 5 GHz as the connection between the access point and the end device. There is a little issue, though. The backbone is supposed to aggregate the traffic, which means that it is supposed to have the higher data rate (performance). In reality, the data rate in the 5 GHz is higher than in the 2.4 GHz, in particular because in the 5 GHz more channels can be "bundled together." However, the range in the 5 GHz is less, and therefore it is less suitable for a backbone function.

So, not surprisingly, you can find products today that have different Wi-Fi system design philosophies. Some have 2.4 GHz as a backbone, others are using the 5 GHz for that. The industry is clearly not unanimous about this yet. And since indoor radio behavior can be fickle, there may not be an ultimate final solution – other than that if these distributed Wi-Fi systems are getting smart enough they can configure themselves, based on optimizing the indoor environment. Maybe this configuration can even be made dynamic, based on the data consumption requirements in various parts of the distributed Wi-Fi system. This means it would reconfigure itself automatically as it "understands" the complete environment, including negotiating with the neighbors so everyone gets a fair share of the spectrum!

For now, the conclusion seems clear – IEEE 802.11ax is not the end of Wi-Fi. It is the start of building even higher performance systems!

About the Author

Cees Links was the founder and CEO of GreenPeak Technologies, which is now part of Qorvo. Under his responsibility, the first wireless LANs were developed, ultimately becoming household technology integrated into PCs and notebooks. He also pioneered the development of access points, home networking routers, and hotspot base stations. He was involved in the establishment of the IEEE 802.11 standardization committee and the Wi-Fi Alliance. He was also instrumental in establishing the IEEE 802.15 standardization committee to become the basis for the Zigbee® sense and control networking. Since GreenPeak was acquired by Qorvo, Cees has become the General Manager of the Low Power Wireless Business Unit in Qorvo.

For more information, please visit **www.qorvo.com.**

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