

5G Update for Lexington Technology Users Group

By Bob Primak -- June 26, 2019

## What Is 5G? And What Is It Not?

<https://www.pcmag.com/article/345387/what-is-5g>

### 1G, 2G, 3G, 4G, 5G

The G in this 5G means it's a generation of wireless technology. While most generations have technically been defined by their data transmission speeds, each has also been marked by a break in encoding methods, or "air interfaces," that make it incompatible with the previous generation.

1G was analog cellular. 2G technologies, such as CDMA, GSM, and TDMA, were the first generation of digital cellular technologies. 3G technologies, such as EVDO, HSPA, and UMTS, brought speeds from 200kbps to a few megabits per second. 4G technologies, such as WiMAX and LTE, were the next incompatible leap forward, and they are now scaling up to hundreds of megabits and even gigabit-level speeds.

5G brings three new aspects to the table: **greater speed** (to move more data), **lower latency** (to be more responsive), and the ability to connect a lot **more devices** at once (for sensors and smart devices).

The actual 5G radio system, known as **5G-NR**, **isn't compatible with 4G**. But all **5G devices** in the US, to start, **will need 4G** because they'll lean on it **to make initial connections** before trading up to 5G where it's available. That's technically known as a "non standalone," or NSA, network. Later, our 5G networks will become "standalone," or SA, not requiring 4G coverage to work. But that's a few years off.

That symbiosis between 4G and 5G has caused AT&T to get a little overenthusiastic about its 4G network. The carrier has started to call its 4G network "5G Evolution," because it sees improving 4G as a major step to 5G. It's right, of course. But the phrasing is designed to confuse less-informed consumers into thinking 5G Evolution is 5G, when it isn't.

5G networks use a type of encoding called OFDM, which is similar to the encoding that 4G LTE uses. The air interface will be designed for much lower latency and greater flexibility than LTE, though.

5G networks need to be much smarter than previous systems, as they're juggling many more, smaller cells that can change size and shape.

Millimeter wave signals also drop off faster with distance than lower-frequency signals do, and the massive amount of data they transfer will require more connections to landline internet. So cellular providers will have to use many smaller, lower-power base stations (generally outputting 2-10 watts) rather than fewer, more powerful macrocells (which output 20-40 watts) to offer the multi-gigabit speeds that millimeter wave networks promise.

*More on jargon:*

**Decoding 5G: A cheat sheet for next-gen cellular concepts and jargon**

<https://venturebeat.com/2018/12/12/decoding-5g-a-cheat-sheet-for-next-gen-cellular-concepts-and-jargon/>

*(This means lower energies than current cell towers put out. Which makes the "femtocells" safer from the point of view of health effects. That means they can be placed closer to people.)*

<https://www.qorvo.com/design-hub/blog/small-cell-networks-and-the-evolution-of-5g>

Wireless infrastructure today includes many elements – macro base stations, metro cells, outdoor and indoor distributed antenna systems (or DAS), small cells and more – all working together in a heterogeneous network, or HetNet (see figure below).

(Illustration 1.1: Today’s Wireless Infrastructure.)

(Illustration 1.2: Relative sizes and coverage of different types of cells.)

## **5G network architecture | 5G protocol stack**

<https://www.rfwireless-world.com/Tutorials/5G-network-architecture.html>

### **5G network architecture: Transitional Model**

(Illustration 2.1)

### **5G NR (New Radio) architecture**

(Illustration 2.2)

### **Lower 5G Bands in sub 6GHz**

(Illustration 2.3)

### **Higher 5G Frequency Bands in mmwave**

(Illustration 2.4)

*Both the Lower 5G Bands and the Higher 5G Bands can use either the Transitional Protocols (which do include 5G-E and LTE- Advanced) and the exclusively 5G Protocols like 5G-NR.*

## **What will the neighborhood antennas and distributed processing units (Edge Computing) look like?**

(See my previous talk for details about what Edge Computing, the Intelligent Edge and Cloud Computing mean. Also add “fog computing” which brings the Cloud outwards toward the Edge, acting as a middle layer.)

(Illustration 3.1 Edge, Fog and Cloud Processing.) <https://www.cbinsights.com/research/what-is-edge-computing/>

(Illustration 3.2) <https://www.dmagazine.com/frontburner/2019/01/the-city-has-to-decide-where-to-hide-10000-5g-nodes/>

**So, now that we know all of this, how does 5G benefit us?**

## **5G: What is it good for?**

[https://www.washingtonpost.com/news/innovations/wp/2018/06/05/5g-what-is-it-good-for/?noredirect=on&utm\\_term=.42efa40c74da](https://www.washingtonpost.com/news/innovations/wp/2018/06/05/5g-what-is-it-good-for/?noredirect=on&utm_term=.42efa40c74da)

Expect to be watching even more high-definition video on your smartphone or tablet, including ultra-high-definition movies and emerging technologies such as augmented- and virtual-reality applications.

(Illustration 4.1) <https://smartphones.gadgethacks.com/how-to/5-best-phones-for-streaming-videos-from-netflix-hulu-youtube-amazon-prime-0176250/>

But the real excitement over 5G comes with new uses that simply aren't possible with today's networks. Many of these involve the revolution in sensors, low-cost transmitters and cloud-based software known as the Internet of Things (IoT), or "connected" or "smart" devices.

(Illustration 4.2) <https://www.makeuseof.com/tag/tips-securing-smart-iot-devices/>

At home, 5G networks will move beyond the cliché of refrigerators that automatically reorder milk to fully integrated living spaces that adjust to the needs of every member of the family, providing home security, optimizing power and water usage, and personalizing entertainment. Smart homes will be much more energy-efficient. But more important for an aging population, 5G networks will help seniors to age in place, monitoring their medications, connecting them to telehealth services and tracking indicators from sleep to insulin levels.

(Illustration 4.3) <https://internetofthingsagenda.techtarget.com/definition/IoT-device>

Rural users will benefit as well, as 5G enables smart agriculture, communicating with sensors in the ground, in crops, and on livestock and farm machinery. Along with weather satellites and drones, these technologies will help farmers know when and how much to water, fertilize and apply pesticides in more effective and environmentally friendly ways. Smart farming may also drive the case for deploying 5G networks to rural areas more rapidly, closing what remains of the digital divide as a happy side effect.

*And many other fine things.*

**But where are we today? How is 5G deployment going right now? What are the challenges holding back the 5G rollout in the US?**

**Testing Verizon 5G in Chicago: Speedy, But Watch Out for That Tree**

(Illustration 5.1)

<https://www.pcmag.com/news/368433/testing-verizon-5g-in-chicago-speedy-but-watch-out-for-tha>

Signal quality improves from 0-200 feet from the site, stays stable until the cell edge (which is generally 500-700 feet) and then ... just drops. This is the magic of beamforming, Verizon tells me.

(Illustration 5.2)

Beamforming:

(Illustration 5.3) <https://www.inverse.com/article/48250-5g-beamforming>

Distance from the cell site isn't necessarily the problem; my tests this week showed that Verizon and its infrastructure providers are improving that. While I only got 300-350 feet of distance from cell sites last month, this month I got 500-675, depending on the site.

But at the moment, that isn't a real 675-foot radius. It's 675 feet, line of sight, with no visual obstacles—no trees, glass, or buildings.

5G may take off faster in lower-lying cities like Dallas, Houston, and Kansas City than in Chicago and New York, because of the line-of-sight requirement.

*(Buildings, trees, hills – all can cause line of sight to be interrupted, resulting in total loss of 5G signals.)*

I ran several tests to show just how difficult that situation is. Last month, I stopped by a Starbucks at the corner of Jefferson and Clinton streets to test indoors and outdoors. I saw similar results this time. Just outside the Starbucks, I got 641Mbps. But when I stepped inside the Starbucks, behind the window just a few feet, speed dropped to 258Mbps, a loss of about 60 percent. That's slightly better than I saw last month, when 600Mbps was cut to 218Mbps, a loss of 64 percent, but it's still a major issue.

Stone buildings are even worse.

I'm also concerned about the effect of trees. Testing on a block with street trees at a 500-foot distance from the cell site, I could make the signal drop by putting a line of three lightly leafed trees between me and the site. Step to the left, with the trees out of the way, and I got 1.1Gbps.

The problem with going around corners, or behind trees, appears to be that Verizon's 5G network doesn't yet have the kind of beamforming that would let phones pick up signals bouncing off buildings. That's coming, at some point—Qualcomm has been talking about it since 2016, and Ericsson (Verizon's infrastructure provider in Chicago) has a paper about it. It just doesn't seem to have been implemented yet.

Trees had less of an effect when I was testing AT&T's 5G network in Dallas, but AT&T site was located higher up and I was only at a 300-foot distance from the site. Both of those variables might have made the difference.

Map of places tested:

<https://www.google.com/maps/d/viewer?mid=1b-pzvk23lEtdlh5DTsj2tiEA7jiISuG&ll=41.895876641635525%2C-87.6276178471594&z=15>

And one more thing:

**It's Still Only Downloads**

## **AT&T 5G Tested: Hits 1.3Gbps Speeds!**

AT&T's 5G network in Dallas is capable of amazing speeds—over twice as fast as we saw on Verizon in Chicago—but millimeter wave coverage and building penetration remain great challenges.

<https://www.pcmag.com/news/367757/at-t-5g-tested-it-hit-1-3gbps-speeds>

Tested with this:

(Illustration 5.4)

This is a mobile hotspot, the closest thing we have yet seen to a home or Fixed Wireless Access point (FWA). Home Internet will use FWA, which is a little more reliable.

The antenna in Dallas is higher up and uses different beamforming technology:

(Illustration 5.5)

Also, there is a different curve of signal falloff compared with the Chicago tests:

(Illustration 5.6)

## **So, what about home Internet?**

### **Mobile 5G vs Fixed 5G**

*What's the difference between mobile 5G and fixed wireless access 5G?*

<https://www.lifewire.com/5g-fixed-wireless-fwa-4178934>

First, the difference between cell or mobile hotspot service, vs. FWA (fixed wireless access).

### **Mobile 5G**

- Works when you leave home
- Could provide 5G internet to other devices on the go
- No hardware installation is necessary

### **FWA 5G**

- All your devices get 5G, including computers
- Provides a reliable connection
- More likely to offer unlimited data usage

## **Mobile 5G Pros and Cons**

### **Advantages**

- Access to the mobile network's entire coverage area
- Easy setup: Buy a mobile device and connect it to a provider with a 5G plan

### **Disadvantages**

- It's easy to get charged overage fees for too much data usage
- You could experience poor coverage in some areas

## **Fixed Wireless Access 5G Pros and Cons**

### **Advantages**

- Fast, 5G-based Wi-Fi access throughout your house
- A dedicated signal from a nearby 5G cell

### **Disadvantages**

- Signal is lost the moment you leave
- Special hardware is required

Fixed wireless access has the major benefit over mobile 5G of reliability. When you're in one location, you're much more likely to receive constant coverage because there aren't as many moving parts that could interfere with the signal.

Another aspect of FWA that makes it outperform mobile access is when it comes to using multiple devices at once. When you're at home with 5G internet, every device in your house can communicate via Wi-Fi with the router to access the fast connection provided to the 5G modem from the closest 5G cell tower. Mobile 5G doesn't offer that same ability, at least not easily.

Compared to mobile 5G, a FWA 5G plan is also more likely to allow unlimited data usage. Most ISPs don't cap data usage for at-home connections like they do with some mobile connections. If multiple devices need access to the 5G network, you'd be way better off getting an unlimited at-home 5G service than a mobile one.

Another advantage over a mobile 5G plan is when accessing the internet indoors. Mobile coverage isn't always great indoors, even if you use a 5G hotspot with your mobile 5G connection. However, in a FWA setup, the 5G connection is really only between the modem and the tower, which is fine tuned during installation. The great coverage in the house is Wi-Fi, or even wired, just like you're probably used to.

However, with 5G fixed wireless access, you can't just buy a device and be done like you can when using a phone on a mobile network. Instead, a special modem and antenna must be installed either on the outside or inside of your house in order to receive 5G service from the nearest cell. Additionally, like with any home internet service, you'll also need a router, potentially a new one that can take full advantage of the fast connection.

*(At the moment, there have only been limited tests of FWA 5G Internet, in just a few cities. No FWA-specific devices or plans have been introduced, and none is expected this year, 2019.)*

AT&T has been running 5G fixed wireless internet trials in places like South Bend IN, Kalamazoo MI, Austin TX, and Waco TX. The speeds seen in one of these 5G deployments were upwards of 1 Gbps, with less than 20 ms latency.

## **AT&T 5G: When and Where You Can Get It**

<https://www.lifewire.com/att-5g-4178303>

### **AT&T's 5G Fixed Wireless Access Service**

AT&T Wireless Broadband is the company's current newest AT&T Business offering that's set to provide speeds of up to 50 Mbps. This is what AT&T says will lay the groundwork for customers to upgrade to AT&T 5G when it becomes available.

Beginning in late 2019, AT&T will make its move to provide 5G fixed wireless access to areas that don't currently have broadband service, but no specific cities have been announced. However, they will kick it off by using LTE in Citizens Broadband Radio Service (CBRS) spectrum before migrating to 5G.

In early 2019, the company's CEO said that in a "three- to five-year time horizon, unequivocally, 5G will serve as a fixed broadband replacement product," and that he's "very convicted that that will be the case. We are obviously on a standards-based path that is mobile first."

*(Pricing has not been announced. Nor has information about data caps and overage charges. 5G FWA will probably be higher-priced, but mobile 5G will have caps and overage charges.)*

*(The devices aren't cheap either. The Netgear Nighthawk hotspot costs about \$500. 5G cell phones from Samsung (Galaxy series) and Huawei are in the \$1300 range. The 5G iPhone has been delayed, more later, and will probably be in the \$1300 to \$1500 price range. FWA access points haven't been announced yet.)*

## **Obstacles to the US 5G Rollout**

### **Technology and Politics**

US Tech Companies reluctant to talk with Chinese Tech Companies

**Chinese spy chips are found in hardware used by Apple, Amazon, Bloomberg says;**

**Apple, AWS say no way**

<https://www.cnn.com/2018/10/04/chinese-spy-chips-are-said-to-be-found-in-hardware-used-by-apple-amazon-apple-denies-the-bloomberg-businessweek-report.html>

**Apple might debut first in-house modem in 2021 as it questions Intel's ability to deliver 5G chip**

<https://appleinsider.com/articles/19/04/03/apple-might-debut-first-in-house-modem-in-2021-as-it-questions-intels-ability-to-deliver-5g-chip>



## **Apple to integrate Qualcomm's 5G chips in iPhone by 2020, report says**

*A surprise settlement in a years-long legal battle over licensing and patents has opened the door for Apple to adopt Qualcomm 5G modems, but the chips are not expected to reach iPhone until 2020.*

<https://appleinsider.com/articles/19/04/16/apple-to-integrate-qualcomms-5g-chips-in-iphone-by-2020-report-says>

## **Intel, Qualcomm, LG Uplus tell employees not to talk to Huawei – Reuters**

<https://www.fiercewireless.com/tech/intel-qualcomm-and-lg-uplus-clam-up-to-huawei>

## **U.S. pushes hard for a ban on Huawei in Europe, but the firm's 5G prices are nearly irresistible**

[https://www.washingtonpost.com/world/national-security/for-huawei-the-5g-play-is-in-europe--and-the-us-is-pushing-hard-for-a-ban-there/2019/05/28/582a8ff6-78d4-11e9-b7ae-390de4259661\\_story.html](https://www.washingtonpost.com/world/national-security/for-huawei-the-5g-play-is-in-europe--and-the-us-is-pushing-hard-for-a-ban-there/2019/05/28/582a8ff6-78d4-11e9-b7ae-390de4259661_story.html)

## **US move against Huawei could slow the global rollout of 5G**

<https://www.cnn.com/2019/05/16/tech/huawei-us-5g-rollout/index.html>

## **Intel exits 5G phone modem business after Apple-Qualcomm settlement**

<https://venturebeat.com/2019/04/16/intel-exits-5g-phone-modem-business-after-apple-qualcomm-settlement/>

## **US may require companies make 5G equipment outside of China**

*It wouldn't be enough to use hardware from non-Chinese companies.*

<https://www.engadget.com/2019/06/23/us-may-require-5g-production-outside-of-china/>

Whether or not there's any justification for such a cautious approach, the rationale would be clear. There have been fears that the Chinese government might ask factories and suppliers to insert surveillance code and backdoors into American networking hardware, giving it a chance to spy on American infrastructure, government bodies and individuals. There's no known evidence this is happening so far, but some aren't willing to take chances -- companies like Super Micro have moved production outside of China precisely to reassure wary customers.

If a requirement like this did go ahead, it would add to the pressure for telecom hardware makers. Ericsson and Nokia are already moving production outside of China to avoid US tariffs, but now they wouldn't have much choice -- they'd either have to shift production or completely rule out US sales.

*(This means the US moves and threats and rumors are already having an effect in Europe. Whether this may delay the European rollout of 5G Internet and cell services, or delay the introduction of new 5G phones and modems, remains unclear. The effects on IoT consumer devices and hubs – most of which are now manufactured in China – are as yet unknown. Streaming devices like Chromecast and Apple TV don't seem to be included in this proposed ban.)*

***And this just in:***

**T-Mobile, Sprint closer to clinching deal: 5 things to know**

<https://www.marketwatch.com/story/t-mobile-sprint-closer-to-clinching-deal-5-things-to-know-2019-06-20>

**So where does all of this leave us now?**

My own take:

Apple has been delayed until 2020 in the smart phone market. Apple TV was supposed to be one of several ways 5G FWA would be used in homes. Modems were supposed to be made by Intel, which has dropped out of the 5G modem business. Qualcomm will make Apple's phone chips, but no announcements as to when or whether anyone will supply the 5G modems for Apple's FWA products.

Google's Chromecast Ultra is available today, and it is supposed to tie in Verizon's 5G FWA services. Apple TV with 4k is also part of this offering. AT&T is offering its 5G FWA services in a few cities as of 2019-2020. Devices like modems for this service have not been announced in details, but are expected to begin rolling out in limited markets in 2020.

Cellular 5G services are going to come in 2020 to limited areas, and are being tested now in very limited parts of a couple of cities. Boston was listed awhile ago as being in line for limited 5G mobile services by 2020, but I suspect 2022 is more realistic.

Costs will be very high to build out the infrastructure. Estimates of \$400 Billion to over \$1 Trillion over the next ten years are often cited. This is not a lot per year for infrastructure improvements, though it comes on top of the need to repair and maintain bridges, utilities, the power grid and roads and sewers. I expect the Federal and State Governments to launch a sort of "moon shot" approach, supplemented by private companies which are already investing heavily in the 5G infrastructure buildout.

I do not expect rural areas to get 5G cellular or Internet services before 2022, and probably not at all in many areas. Many urban low-income areas will also not get 5G Internet or cell services anytime soon.

So, Is 5G Coming to You Soon? Or At All?

What do you think? Thanks to all who participated with questions, comments and further references!

(Discussion)

– Bob Primak – June 23, 2019 – (updated with breaking news June 24, 2019) –

(updated after the meeting on June 26, 2019)