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4G LTE OR 5G? EVALUATING WHAT MATTERS FOR UTILITY GRADE WIRELESS BROADBAND

BY Bruce W. Albright

Excitement is building over 5G wireless solutions. Utilities face a host of considerations — all boiling down to selecting the communications technology that best supports business needs today and in the future.

Utilities evaluating build-outs of foundational communications networks like private long-term evolution (PLTE) are about to make generational decisions. A PLTE network can serve as a platform to drive the business for the foreseeable future. This is why each component must be examined with appropriate rigor to clearly outline and forecast the benefits that will be realized over its lifetime of service.

Moreover, once a decision is made to investigate PLTE, the focus should immediately shift to spectrum and the proper technology to achieve desired outcomes.

Several recent Federal Communication Commission (FCC) rulings have provided a clear path for utilities to solve their grid challenges with wireless broadband solutions. With the three most impactful rulings thus far being the 900 MHz (3x3 MHz Channel) rebanding order in May 2020, the 3.5 GHz (10 MHz Channel) Citizens Broadband Radio Service (CBRS) auction that concluded in August 2020, and the reallocation of the 4.9 GHz band in September 2020.

Each spectrum offering has its own specific pros and cons and use cases. But now the focus has shifted from spectrum to technology and an interesting debate over the relative merits of 4G versus 5G.

THE PROMISE OF 5G

Based on what is being said about 5G, one could conclude it is the sole technology to consider. However, like any other technology evaluation, multiple considerations must be weighed in order to properly assess the two technologies and their benefits to utilities.

It is easy to find headlines publicizing the theoretical benefits of 5G. These include the promise of capacity to support millions of devices per unit area, over 20 times the download (DL) and upload (UL) speeds, ultra-low latency (sub 1 millisecond) and other core improvements enhancing overall network performance that would have seemed impossible just a few short years ago.

5G does provide a new system for transforming bytes over the air, offering the potential to transfer more data over the air at faster speeds, with reduced congestion and lower latency. This result is achieved by utilizing the 5G New Radio (NR) interface, Massive MIMO (multiple-input and multiple-output), along with expanded spectrum bands that use much higher radio frequencies (28 GHz versus 700-2500 MHz for 4G) and larger spectrum segments (100 MHz channel sizes).

THE NEW AIR INTERFACE

5G NR is not only a new radio, but a new air interface. The changes to the air interface include changes to the physical resource blocks (PRB) for 5G. In 4G, there is only one type of subcarrier spacing, whereas in NR there are multiple types of subcarrier spacing available. 5G NR can choose subcarrier spacing from 15 kHz to 240 kHz, with a maximum 3,300 subcarriers in simultaneous use on one channel. However, channels can be no more than 400 MHz wide. The standard is frequency agnostic, meaning any subcarrier configuration can be used on any band. In practice, the mid- and low-band frequencies below 6 GHz have markedly different channel and noise characteristics, as well as different maximum bandwidths, than the high-band allocations, so they will use 15 kHz to 60 kHz channel spacing, while high-band will use 60 kHz to 120 kHz. There are currently no 5G band allocations between 6 GHz and 24.25 GHz, but the standard allows for optimal orthogonal frequency-division multiplexing (ODFM) configuration to match any future expansion into this spectrum.

Unfortunately, the spectrum that is most common for PLTE utility deployments (900 MHz and CBRS) won't provide this advantage. For example, a 5 MHz NR carrier using 5G has the same number of PRBs as a 5 MHz carrier using 4G LTE (25 in both cases). This means no performance gain is realized for these smaller-size spectrum segments.

For carriers at 20 MHz or larger, NR does begin to provide extra PRBs. By using 20 MHz, for example, 100 PRBs are available for 4G and 106 for 5G. This is generally the point where utilities begin realizing improved throughput in 5G. The ability to support up to 500 MHz channel sizes means that a large 5G channel can achieve DL/UL speeds not possible in 4G.

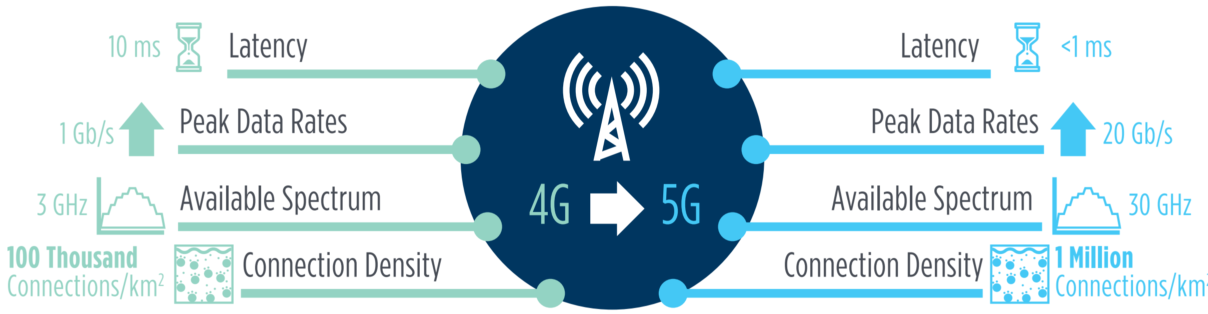

FIGURE 1: *Comparing stated 4G and 5G performance criteria. Weighing these criteria relative to utility needs, use cases and costs is key.*

Simply speaking, utilities must acquire appropriate and prudent levels of spectrum if they plan to build their own networks for improved performance. But most utility applications haven't necessitated large channel sizes or capacity at this stage. Thus, it may be difficult to make a business case to acquire the necessary spectrum for some future needs for larger bandwidth and higher performance.

DEVICE DENSITY FOR PLTE NETWORKS

There is no question 5G provides more capacity for streaming, video calls and other high-bandwidth applications. But do utilities gain those benefits when they do not have access to the millimeter wave (mmWave) spectrum or large spectrum bandwidth within other bands? Probably not.

The new 5G air interface utilizes mmWave spectrum. It is the band of spectrum between 30 GHz and 300 GHz and is the reason many more devices can be used within the same geographic area. On this basis of comparison, 5G is clearly superior because it can theoretically support millions of devices per square kilometer, compared with 4G, which can theoretically support about 4,000 devices in that same area.

It also must be noted that for utilities, a 3 MHz x 3 MHz 4G LTE network deployment would likely be sufficient to address all fixed data device deployments needed for years to come. While there may be limitations to livestreaming of multiple simultaneous video streams for security or some other livestreaming services, those use cases can be better served by leveraging other parts of utility infrastructure, saving more critical grid control use cases for the PLTE network.

FINANCIAL IMPACT OF DEVICE CHOICES

The largest overall cost of deploying PLTE resides with the end devices. The fixed costs of thousands of these devices — combined with labor and other costs incurred by the utility in installing them across utility networks — far outweigh other costs of the network and enabling spectrum.

These devices will be deployed and costs incurred regardless of whether utilities move forward with PLTE or stay the current course. Utilities today have many disparate network options. Whether the decision is to go with a public carrier or a PLTE network, the cost of the device along with the cost for communications connectivity becomes the single most important driver in determining the costs for future grid applications. With a PLTE network, those costs are known and, as more use cases are developed, more financial benefit will be derived from PLTE.

For 5G, there are costs associated with device hardware — both radio modem and antennas — required to support and enable those high-speed connections. Currently, the 4G LTE modems are integrated on the same chip as the processor and in 2018 the cost of one of these processors was approximately $70. The cost of an antenna for a leading 4G-enabled smartphone was around $20 in 2018.

Antennas for 5G are more complicated — and expensive. With 5G, businesses can expect significant increases in component costs, likely $40 to $50 more, and overall device costs of $200 to $300 more. 5G chipsets, antennae

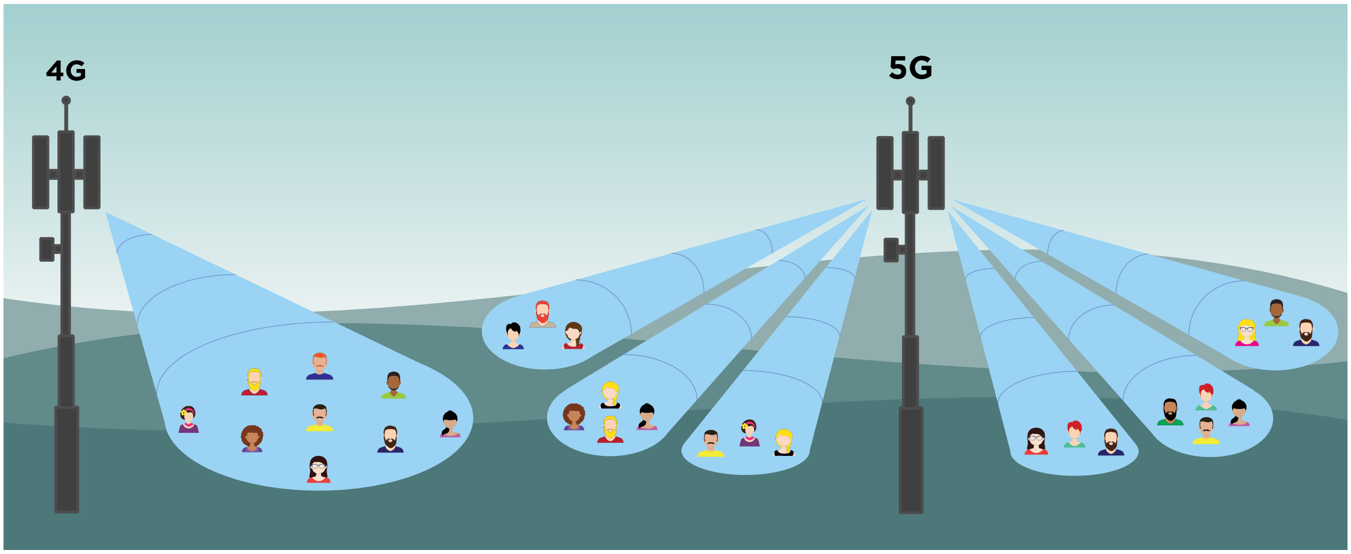

FIGURE 2: *5G introduces dynamic beamforming technology to improve signal quality at end devices by focusing signals in a specific direction.*

and devices are simply far more expensive, as are proprietary network devices.

Of course, as the 5G ecosystem advances, we can expect device costs for both 5G and 4G to continue a downward trend, though 4G devices will remain lower than 5G for the foreseeable future. Most experts estimate 4G has a 10- to 15-year useful life remaining. It may be even longer given that 5G does not support voice over LTE (VoLTE) today and is being built for a future device ecosystem for autonomous cars and use cases that require ultra-low latency or machine-to-machine type communications. Utilities should strongly consider these factors when making decisions about their deployment.

Devices really drive the business case for deployment of the various use cases. Choosing the right device ecosystem is a key step to being able to control your network and gain cost certainty for the future.

MASSIVE MIMO

MIMO is another important consideration in building a business case for 4G versus 5G. MIMO is a technology used to multiply the capacity of a radio link using multiple transmit and receive antennas for multipath propagation. Depending on the spectrum band and the particular 3rd Generation Partnership Project (3GPP) release utilities plan to utilize, 4G systems can support between two transmit (2T) and two receive (2R) antennas on the low end and up to 32T x 32R antennas on the high end.

Beginning with 4G LTE Advanced (3GPP release 10), 4G networks offered up to 8T x 8R MIMO, while LTE Advanced Pro (3GPP release 14) offers a 32T x 32R MIMO option. Again, utilities must realize that the number of antennas that can be deployed depends largely on the spectrum use, and also understand that the lower the frequency of the spectrum band being utilized, the larger each antenna must be.

5G introduces Massive MIMO, supporting up to 256T x 256R in a single panel antenna. The larger Massive MIMO antenna arrays deployed in this configuration are specifically designed for mmWave spectrum. These Massive MIMO arrays cannot be achieved in the lower spectrum bands due to the large size of the panels required. There are also issues with the device ecosystem today because of Massive MIMO since the device also requires multiple antenna systems that have not been created.

Another new technology used in 5G, dynamic beamforming, increases the value of Massive MIMO. Dynamic beamforming utilizes multiple targeted beams that "spotlight" users. Users are effectively tracked, as by a spotlight on a theater stage, within the eNodeB coverage footprint, improving coverage, speed and capacity. On the other hand, current 4G network technologies function more like floodlights. A wider geographical area is illuminated, or covered, but there are more inefficiencies due to higher amounts of antenna energy required for distribution of a signal over a wide area not directed to the individual receiver (see Figure 2).

As utilities are primarily focused on two spectrum bands, options for those bands must be weighed carefully. For the low-band 900 MHz spectrum, the typical MIMO size is 2T x 2R or 4T x 4R. This means most devices in this band would not support any MIMO configurations higher than those.

However, the mid-band 3.5 GHz (CBRS) spectrum can support 64T x 64R. This provides the utility an advantage but is a very costly deployment option. This is primarily because deploying CBRS spectrum will require more sites to achieve the same coverage density as low-band spectrum. To support CBRS using Massive MIMO, utilities would also need devices that support this 64T X 64R configuration as well as the 5G air interface, so each and every device would add significant cost to any business case, creating financial burden and impacting further deployment strategy.

Massive MIMO and dynamic beamforming are exciting new technologies and will certainly reshape the cellular markets. But it is difficult for utilities to justify a business case for the large spectrum holdings required to take advantage of 5G or to show device density requirements that will create a clear benefit for them in the current market.

CONCLUSION

In the ongoing discussion of 4G versus 5G, utilities face one fundamental question: Which communications technology best supports my business today and prepares my networks for the future?

The technical debate over respective advantages of 5G and 4G will continue and the market excitement will inevitably create noise that confuses the issues. Private networks are proliferating throughout the enterprise and utility markets, and those eyeing these major network changes must focus on the fundamental objectives. The focus for utilities should remain on building a utility-grade, purpose-built communications network that is foundational to all current and future wireless needs and not just look to new technologies to solve singular issues.

There is no one-size-fits-all or an “easy” button in this process. Utilities should focus their efforts and understand the technologies available and what these new technologies mean to their business relative to the spectrum options and application needs. This will help utilities build the network of the future, today.

BIOGRAPHY

BRUCE W. ALBRIGHT is 5G solutions manager for Burns & McDonnell, where he leads efforts to help utilities assess their wireless communications infrastructure and develop road maps to make strategic life cycle business investments. He is currently working with a number of clients, assisting and advising on projects to deploy PLTE networks across the U.S. Bruce has more than 30 years’ experience in wireless telecommunications systems and has deployed multiple critical infrastructure networks for major utilities and first responders. He holds a bachelor’s degree in electrical engineering from the University of Alabama.

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