IoT & 5G: WAIT OR MOVE?

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ABOUT THE AUTHOR

PETER RYSAVY is the president of Rysavy Research LLC, a consulting firm that has specialized in wireless technology since 1993. A broadly published expert on the capabilities and evolution of wireless technology, Rysavy has written more than 160 articles, reports, columns and white papers, and has taught more than 40 public wireless courses and webcasts. He has also performed technical evaluations of many wireless technologies including cellular data services, municipal/mesh Wi-Fi networks, Wi-Fi hotspot networks, mobile browser technologies, wireless email systems and social networking applications.

From 1988 to 1993, Rysavy was vice president of engineering and technology at Traveling Software (later renamed LapLink) where projects included LapLink, LapLink Wireless and connectivity solutions for a wide variety of mobile platforms. Prior to Traveling Software, he spent seven years at Fluke Corp. where he worked on data acquisition products and touch-screen technology. Rysavy is also the executive director of the Wireless Technology Association (WTA), an industry organization that evaluates wireless technologies, investigates mobile communications architectures and promotes wireless data interoperability.

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IoT AND 5G, TWO OF THE HOTTEST TRENDS IN TECHNOLOGY, ARE COMBINING TO TRANSFORM OUR future by interconnecting everything: humans, cars, appliances, utilities, transportation infrastructures, mailboxes, light switches and anything else that might benefit from an intelligent connection. Expected 5G IoT capabilities include multiyear modem battery life, support for 1 million devices per square kilometer and low-cost modems.

But before you recommend that customers develop Internet of Things initiatives around 5G capabilities, know that, despite all the excitement and press being generated about 5G, operators will not begin deploying it in earnest until the 2020 time frame. Before then, companies may pilot pre-5G technologies in limited areas, but efforts will emphasize consumer broadband service to fixed locations, not IoT.

Fortunately, IoT improvements in 4G LTE are occurring at a steady pace, meaning IoT wireless connectivity options will continually improve even before 5G. In many ways, 4G is setting the stage and providing a foundation for 5G. In this Report we'll cover 4G and 5G IoT capabilities, the implications of radio spectrum allocation on the IoT and time frames for various features.

THE MANY FACES OF 5G

The greatest success of 4G has been in mobile broadband, enabling popular smartphone applications such as streaming, social networking and mapping. But that's changing as IoT gains steam. Chetan Sharma Consulting reports that in 2Q 2016, for the first time in the United States, we added more IoT-enabled wireless endpoints, including connected cars, than smartphones and tablets combined.

With smartphone and tablet subscriptions approaching saturation, connecting things is the best way for cellular operators to grow revenues. That explains the emphasis on making LTE more IoT-capable, as well as on baking entirely new IoT-related capabilities into 5G.

This IoT emphasis is clear in the 5G use-case model developed by the International Telecommunication Union, the United Nations-affiliated standard-setting organization that has defined 5G requirements. As the figure on Page 6 shows, use cases fall into three categories.

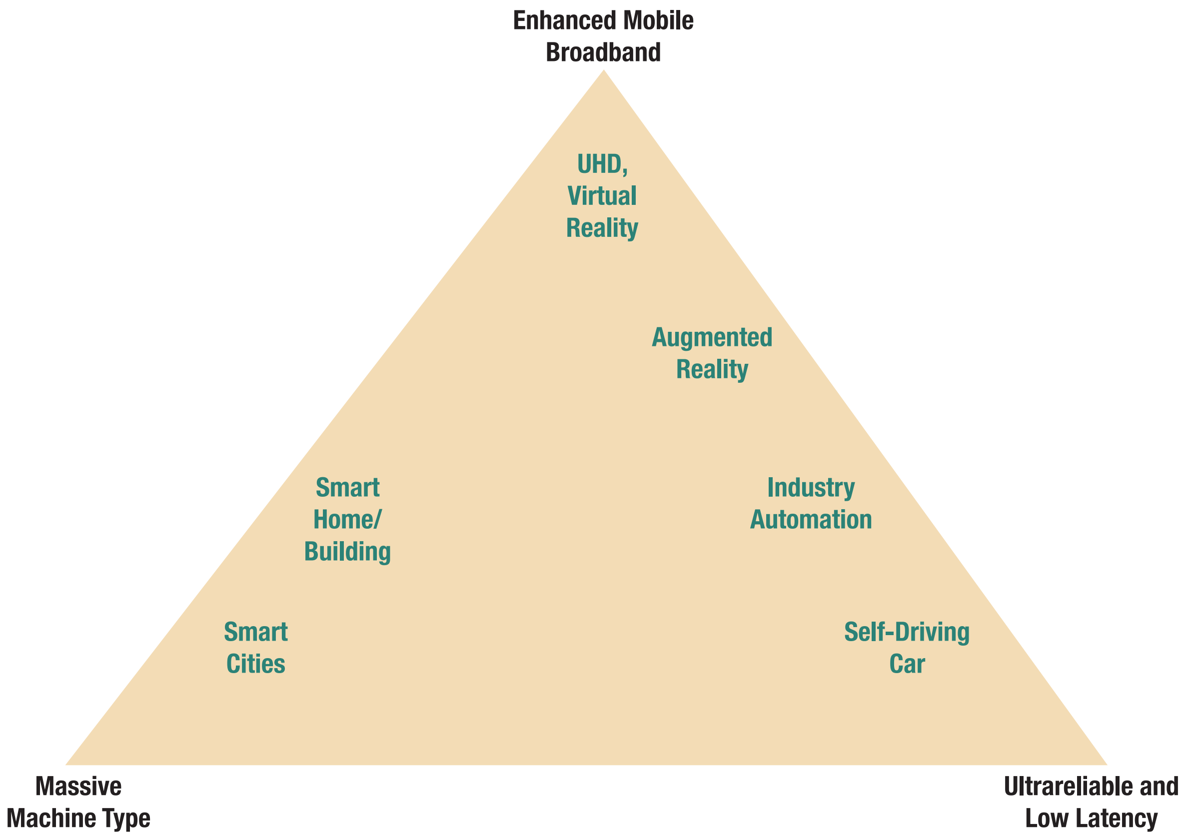
At the top of the triangle, "enhanced mobile broadband" augments 4G broadband capabilities, reaching for 100 Mbps typical throughput rates and peak rates well over 1 Gbps.

At bottom left, "massive machine type" represents the IoT applications emerging today with 4G LTE, but at much denser levels. 5G calls for networks able to support up to 1 million devices per square kilometer, 10 times more than with 4G. What those devices will be, exactly, depends on IoT developers, but smart cities are an often-cited example.

5G also includes a 100-times gain in energy efficiency, translating to much longer life for battery-operated devices, whether sensors in the environment or fitness bands. To achieve this gain, 5G engineers are designing new radio waveforms and protocols better suited for sending the small payloads typical of many types of IoT applications.

The third category, "ultrareliable and low-latency" communications, is entirely new. It will power applications never before feasible, including the use of cellular networks for autonomous vehicles, industrial automation, new forms of telemedicine and applications yet to be invented. The key mechanism enabling this category of use case is low latency, with 5G requirements specifying down to a 1 millisecond (msec) round-trip time from device to base station — that's at least 10 times faster than with 4G.

Trio of 5G IoT Use Case Categories



Source: ITU, Rysavy Research

Hanging like a dark cloud over the ultrareliable, low-latency category, however, are network neutrality regulations that ban traffic prioritization. The only way to obtain ultrareliable and low-latency traffic streams is by prioritizing them higher than a YouTube or Netflix stream, especially if the network is congested. 4G networks already have such traffic-prioritization mechanisms, but operators, concerned about neutrality rules, have thus far hesitated to offer services that leverage quality-of-service mechanisms, with the exception of their own offerings, such as packetized voice.

For now, all application developers can do is wait to see if regulators will update their current, overly simplistic neutrality policies.

The following table summarizes 5G capabilities compared with 4G.

As exciting as the new 5G capabilities are, they will not all be available simultaneously. For example, achieving low costs and high energy efficiency means sacrificing throughput. Fortunately, sending 10 bytes of data from a sensor once per day or even per hour does not require high throughput.

On the other end of the dial, a modem capable of 1 Gbps throughput will not be able to stream data for hours on end using a small battery.

4G vs. 5G: Exciting Advances on the Horizon

	IMT-Advanced (4G)	IMT-2020 (5G)
Peak Data Rate	DL: 1 Gbps UL: 0.05 Gbps	DL: 20 Gbps UL: 10 Gbps
User Experienced Data Rate	10 Mbps	100 Mbps
Spectrum Efficiency	1 (normalized)	3X over IMT-Advanced
Peak Spectral Efficiency	DL: 15 bps/Hz UL: 6.75 bps/Hz	DL: 30 bps/Hz UL: 15 bps/HZ
Mobility	350 km/h	500 km/h
User Plane Latency	10 msec	1 msec[1]
Connection Density	100,000 devices/sq. km.	1 million devices/sq. km
Network Energy Efficiency	1 (normalized)	100X over IMT-Advanced
Area Traffic Capacity	0.1 Mbps/sq. m.	10 Mbps/sq. m. (hotspots)
Bandwidth	Up to 20 MHz/radio channel (up to 100 MHz aggregated)	Up to 1 GHz (single or multipole RF carriers)

[1]Per 3GPP TR 38.913 (V0.3.0, Mar. 2016), 0.5 msec for DL and 0.5 msec for UL for Ultrareliable and Low-Latency Communications and 4 msec for UL and 4 msec for DL for Enhanced Mobile Broadband.

Source: Rysavy Research

NEW COMPUTING ARCHITECTURES: NETWORK FUNCTION VIRTUALIZATION AND MOBILE EDGE COMPUTING

Operators are in the process of virtualizing their 4G networks, allowing core network functions to move away from expensive dedicated hardware to lower-cost commoditized computing platforms. Virtualization also provides faster scaling of services and lowers the cost of deploying new capabilities. 5G continues the trend; these networks will be fully virtualized. That by itself does not provide developers any huge advantage, but virtualization will be used to create a planned capability for 5G: network slicing.

With a network-slicing architecture, operators will be able to create independent virtualized networks for different use cases. For example, one slice could be for a large enterprise customer with specialized direct routing from the operator to the customer network; another network slice could be for industrial IoT applications that require high degrees of reliability; and another slice could be for consumer wearable computing with an emphasis on low cost and long battery life.

Another architectural development, coming soon to 4G and expected as part of 5G, is mobile edge computing, or MEC, which refers to running applications on computing nodes close to a base station. Applications able to take advantage of this capability will be ones that demand server-side processing but are location-specific.

Delay-sensitive applications will also benefit. Examples include connected cars communicating with local infrastructure and premises-based IoT gateways that process massive volumes of locally produced data. The European Telecommunications Standards Institute (ETSI) is currently standardizing MEC (white paper here).

IMPLICATIONS OF SPECTRUM FOR 5G

Frequencies that are good for consumers — namely, those capable of extremely high throughputs — are not necessarily best for IoT. In mobile broadband, engineers have been marching toward higher frequencies because more spectrum is available, but those frequencies come at the price of reduced range.

In contrast, many IoT applications transmit only small amounts of data but need to do so either over large distances or from locations where the signal has to penetrate multiple walls and other obstacles. Thus, the millimeter wave (mmWave) frequencies touted for 5G at 28 GHz and higher will be used for small cells and broadband applications, while most IoT systems will operate using current cellular frequencies that range from 600 MHz to 2.5 GHz.

Operators will likely deploy 5G as a combination of a low-frequency underlay, for broad coverage, and localized small cells in dense urban areas using high frequencies, for capacity. The good news is that because many IoT applications can operate happily with sub 10 Mbps, or even sub 1 Mbps, throughputs, they will have access to the broad-coverage underlay network.

The challenge, however, is that because 4G LTE is working so well, operators could continue using 4G in current cellular bands as long as they can and initially deploy 5G only for small cells to beef up capacity in select locations. Eventually, however, to achieve higher network efficiency, operators will move all their operations to 5G, just as they are now starting to phase out 2G and move more and more traffic to 4G.

HOW LONG WILL WE HAVE TO WAIT FOR 5G IoT?

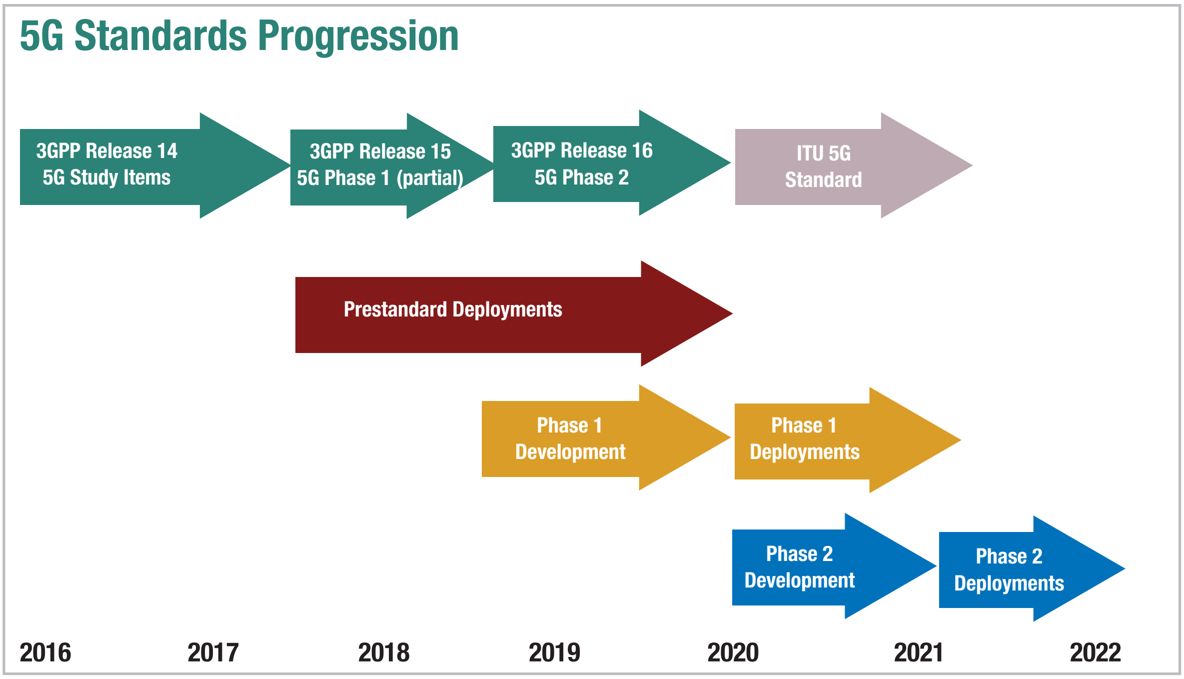
5G is at the apex of hype, meaning lots of promises with no availability.

From a standards point of view, as shown in the figure on Page 9, the primary cellular standardization body, the Third Generation Partnership Project (3GPP), is currently studying 5G in work that it terms “Release 14.” The first phase of standardization will commence next year as part of Release 15, concentrating on mechanisms for the radio link.

Standards expected in 2018 will enable Phase 1 deployments in 2020. Release 16, which will standardize the remaining capabilities, including core network functions, will be completed close to 2020, which is the scheduled ITU date for an official 5G standard.

Any 5G deployments before 2020 will be prestandard networks likely deployed to enable mmWave in select areas for nonmobile consumer broadband applications.

Don’t expect widespread 5G coverage until the early 2020s, if not the mid-2020s.



Source: Rysavy Research

OR DON'T WAIT — 4G-LTE HAS COMPLETELY RE-ARCHITECTED IOT SUPPORT

The time frames for 5G IoT require patience. For customers that need something sooner, 4G LTE has a number of planned enhancements, beginning with what are called "Category 1" modems available today; Category M (or LTE-M), likely available in 2017; and LTE Narrowband-IoT, referred to as Category NB-1, also likely available from some operators in 2017. (See this Ericsson research note for more detail.)

Cellular engineers have designed LTE-M and NB-1 for long battery life, modest throughputs (1 Mbps max for LTE-M and 200 Kbps max for NB-1), and low-cost modems intended to be competitive with GSM modems that use General Packet Radio Service (GPRS), which today are the lowest-cost cellular modems available for IoT. If all goes as planned, LTE IoT modules, in volume, could drop below $10. Partners with projects that need long-life applications should consider LTE, which likely will remain available through 2030.

Many operators will phase out their 2G networks, starting with AT&T at the end of this year. However, some carriers will keep 2G around longer, and a few even plan to deploy an IoT capability called "Extended Coverage-GSM-IoT," providing yet another option. Currently, 2G GSM GPRS modems are the lowest-cost modems available.

The bottom line is that we are at the dawn of a new era of IoT, and network operators are doing everything possible to support IoT applications. Connectivity options are already good today, and they will become significantly better with innovations such as LTE-M and LTE NB-1 next year and 5G in the next decade.