COMMSCOPE®

5G shaping the always on networks of tomorrow

5G is poised to deliver on the exciting promises of our connected world.

It means 10 Gbps throughput. Denser networks. Super-low latency. Unlimited potential. Never before has the future felt this close.

The main drivers for 5G adoption are:

Consumer demand

- Subscribers are demanding more bandwidth as streaming video, augmented reality, peer-to-peer gaming, and other bandwidth intensive services come to prominence.

New business models

- Mobile network operators (MNOs) are seeking new ways to profit from their networks—and 5G opens up the capability to offer new applications and services.

Limitless opportunities

- A new generation of applications—from the Internet of Things (IoT) to self-driving cars to virtual reality—are, or soon will be, in use.

Rising data demand will continue to drive 5G requirements, as will demands for more ubiquitous coverage. Millennials and Generation Z expect to be able to use their mobile devices anywhere, anytime, with high bandwidth and low latency.

Like all of the network generations that have preceded it, the first and most essential step to defining and ultimately rolling out 5G will be ensuring it can accommodate mobile broadband growth. But, in order for 5G to fulfill its potential, it must also deliver on the vision to efficiently enable the wireless interconnection of machines to the cloud. In addition, the need to support low-latency use cases will help shape the architecture to push capability closer to the edge, balanced with the need for greater efficiency, which is best when capability is centralized. Striking the balance between these two competing needs is key to making the 5G standards work.

THREE USE CASES FOR 5G

The wireless industry has coalesced around three primary use cases for 5G:

1 **Enhanced mobile broadband**—5G will strive for a significant improvement in the mobile user experience over 4G. Although it promises up to 10 Gbps per subscriber, it is likely the typical rate per subscriber under 5G will be from 1–7 Gbps, and that there will be 10 to 100 times as many connected devices as 4G. There will also be much lower latency—less than 5 milliseconds, which is 5 percent of 4G's latency. Large venues like stadiums and airports may be some of the first places 5G networks are implemented. Companies constructing new buildings should be planning to support not only today's mobile demand, but deploying the network infrastructure that will support 5G in just a few years.

2 **IoT**—Gartner predicts there will be 20 billion "things" on the IoT by 2020[1]—everything from consumer applications that allow wireless control and monitoring of lighting, heating and appliances to "smart city" applications that monitor traffic, sprinklers, lighting and other aspects of city operations. The IoT will drive several orders of magnitude more connections and it will have a significant impact on the network. CommScope anticipates that one goal of 5G will be to deliver 1,000 times more bandwidth than 4G in any given area, and that the location density of 5G cell sites will be five times that of 4G. 5G networks are being designed to support a diverse set of IoT use cases by implementing a configurable, virtualized core that will be radio technology agnostic.

3 **High-reliability, low-latency networks**—This case imagines the wireless network of the future: a vision of entirely new possibilities. Potential applications include self-driving cars, whose collision avoidance systems will require one-millisecond latency. It's unclear how much a self-driving car will rely on the network versus on-board processing, but navigation and remote diagnostics will certainly rely on the network. Another application is in augmented reality and virtual reality—the amount of information delivered may be more like advanced mobile broadband, but it will have to be very low latency to enable those applications. Remote surgery, drones, and public safety are other applications that require ultra-low latency and high reliability.

5G IN THE CONVERGED NETWORK

The 5G vision will be realized in the converged network in three fundamental ways: through densification, virtualization and optimization of the network.

DENSIFICATION

If 5G is really going to deliver speeds 10 or more times faster than 4G, reason dictates this will require more base stations in a given area—increasing the density of the network itself. Mobile network operators (MNOs) have begun this process in their 3G and 4G networks, with increased sectorization and the addition of small cells. Regardless of how 5G is ultimately defined, it will require more densification across macro sites, in-building and within small cells.

Densification adds complexity to the network because it increases the number of cell borders, where interference becomes a problem and handoffs introduce the possibility of dropped connections. In a 5G world, networks will need to depend on intelligent, automatic spectrum allocation to maintain quality as well as speed. Wireline infrastructure will also require upgrades to provide adequate fronthaul, backhaul and power.

VIRTUALIZATION

MNOs will need to virtualize much of their 5G infrastructure to effectively manage spectrum—and efficiently manage costs. Several solutions and practices already exist to make this migration practical, including:

- **Centralized radio access networks (C-RANs),** which will be the precursor to cloud radio access networks (also known as C-RANs). Centralized RAN involves moving baseband processing units (BBUs) from cell sites to a central location serving a wide area via fronthaul. This practice not only reduces the amount of equipment at the cell site, but also lowers latency. In the coming evolution to cloud radio access networks, many BBU functions will be offloaded to commercial servers, essentially virtualizing the radio itself and greatly simplifying network management.
- **Network function virtualization (NFV),** which guides development of new core network architecture that will simplify the rollout of new services. NFV and software-defined networking (SDN)—deployed in conjunction with advanced analytic tools—will allow MNOs to automatically optimize their networks under policy control.
- **Cell virtualization,** which extends the concept of virtualization beyond the core network to the airwaves. Inside buildings, cell virtualization will enable MNOs to manage multiple radio points within the footprint of a single cell, boosting capacity and eliminating inter-cell interference. C-RAN-enabled cell virtualization also gives operators the ability to greatly increase spectrum reuse—hence, boosting overall efficiency.
- **Virtual service instances,** which reflect the need for 5G networks to support a diverse set of use cases. These virtual instances (or "network slices") can serve different customers with different Quality of Experience (QoE) levels even though they may be sharing common computing, storage or connectivity resources.

OPTIMIZATION

The third strategic component is to design and deploy for optimal performance. On a general level, this means increased efficiency throughout the converged network—from spectrum efficiency to implementation of virtualized load-balancing, and from space-efficient small cells to energy-efficient backhaul. These measures are seen in such solutions as:

- **Mobile edge computing (MEC),** which will serve the low-latency 5G IoT use cases such as augmented driving and the tactile internet. Placing cloud-computing capabilities at the edge of the mobile network involves many smaller data centers distributed closer to the cell sites—forming an edge cloud where intelligence can be placed closer to devices and machines. Content will become more complex and will require ultra-low latency—not just in the pathway (which 5G solves), but in the core data center. Moving all of this content to the very edges of the network solves the problem.

- **New power solutions,** which are needed by 5G networks that have targets for energy efficiency as well as spectrum efficiency. It will be essential to learn how to get this power to sites in a practical, cost-effective and environmentally-responsible way. Power over Ethernet (PoE) is a promising technology for 5G devices in the IoT.

- **Frequency management in shared site equipment,** which will require advanced self-organizing network (SON) capabilities in addition to core network architecture changes. New access network techniques such as massive MIMO (multiple input multiple output) are required to deliver the 5G experience; RF beamforming and interference mitigation technologies are also critical. Massive MIMO typically describes arrays of at least 64 antennas—often in bands above 2 GHz in the TDD spectrum. Massive MIMO will be deployed extensively in the centimeter and millimeter wave bands where the antennas become very small.

- **Time division duplex (TDD) modes,** which will play a significant role in growing 5G deployments. In 2015, about one in eight networks utilized TDD technology, and that ratio is likely to increase.[2]

- **Interference mitigation,** which is needed to ensure robust data services, as increased complexity demands increase signal-tonoise ratio (SNR). As stated in Shannon's Law, the level of noise and interference in a wireless network determines the throughput capacity. MNOs must focus on ensuring a clean RF path through new technologies that reduce cell border interference, carefully sculpted transmission patterns, and network optimization.

We're helping unlock the potential of 5G

CommScope has been a key player in virtually every major innovation in communications networks. With experience that informs and powers imagination, we've helped bring the world into the LTE era, and we are not slowing down now. CommScope's fundamental viewpoint about 5G is that it will be a "network of networks"—a convergence of wireline and wireless with deep fiber penetration in both to support the variety of 5G use cases. As a global leader in wireless network infrastructure solutions, we are actively participating in these key 5G organizations:

Platforms for Advanced Wireless Research

Platforms for Advanced Wireless Research (PAWR)—This US-based program is a joint effort by the National Science Foundation and a wireless Industry Consortium to create city-scale testing platforms to accelerate fundamental research on wireless communication and networking technologies. CommScope will contribute connectivity solutions such as antennas, RF cabling, cabinets, small cells, and fiber optics.

5TONIC

5Tonic—In this open research and innovation laboratory for 5G founded by Telefonica and IMDEA Networks, CommScope will be trialing cell virtualization with OneCell.

5GMF—CommScope is a long-time member of this forum, which conducts research and development of fifth-generation mobile communications systems.

5GAmericas—CommScope is a long-time member of the Board of Governors of 5G Americas (formerly 4G Americas), the influential industry trade organization composed of leading telecommunications service providers and manufacturers.

Next Generation Mobile Networks (NGMN) Alliance—CommScope is a key contributor to this group, which is focused on 5G and accelerating the development of LTE-Advanced and its ecosystem.

U5GIG—CommScope is a member of this forum, which is an initiative in developing 5G standards by 2020 inspired by the vision for UAE innovation.

As you explore your 5G options, consider how CommScope can help prepare for and discover its full potential. We can develop and participate in 5G workshops, requests for quote, information sessions and other partnership opportunities.

1 Gartner - https://www.gartner.com/imagesrv/books/iot/iotEbook_digital.pdf

2 GSMA - Mobile's Green Manifesto 2012 - http://www.gsma.com/publicpolicy/wp-content/uploads/2012/06/Green-Manifesto-2012.pdf

CommScope pushes the boundaries of communications technology with game changing ideas and groundbreaking discoveries that spark profound human achievement.

We collaborate with our customers and partners to design, create and build the world's most advanced networks.

It's our passion and commitment to identify the next opportunity and realize a better tomorrow.

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