5 Challenges Facing Service Providers

Evolving LTE to 4.9G

WHITE PAPER

Implementing new capabilities of 4G LTE helps meet customer demands today. Addressing 4.9G implementation challenges now means you're a step function closer to 5G.

Two major factors drive the development of telecommunications networks: the insatiable demand for download speed and the desire to connect everything, everywhere, all the time.

According to Ericsson's Mobility Report, monthly data traffic demand per mobile device growth will triple from 17.3 GB today to 56 GB in 2023. This dramatic increase has been trending steadily since 2011 and is driving a 34% compound annual growth rate (CAGR) increase in per-subscriber traffic by smartphone users – and about half as much for tablet and mobile PC users. The cellular network is becoming the central platform for connecting everything to everyone. The Internet of Things (IoT) and machine-to-machine (M2M) communications are helping drive this trend. Gartner predicts nearly 21 billion connected IoT devices by 2020.

The evolving capabilities of 4G LTE-Advanced Pro (dubbed 4.9G) can help meet subscribers' demand for data and fulfill their desire to connect everything. Incremental improvements to your existing 4G network can be a testing ground for technologies, applications, use cases, and business models in preparation for widespread deployment of all new 5G networks, without the outsize early adopter infrastructure investment.

Maximizing 4G LTE Performance

Realize the full potential of 4G LTE by addressing these 5 challenges:

1. Network speed – future-proof your platforms
2. Network virtualization – embrace cloud as an initial step
3. New business models – start by piloting IoT now
4. Spectrum usage – implement trials with current spectrum holdings
5. Infrastructure hardware upgrades – consider short- and long-term impacts

Required network configuration: LTE-A, LTE-A Pro

KEYSIGHT TECHNOLOGIES

Maximizing 4G LTE

Baseline 4G LTE networks can be upgraded to 4.9G by implementing LTE-Advanced (LTE-A) and LTE-Advanced Pro (LTE-A Pro). LTE-A adds power-saving features, carrier aggregation for increased bandwidth, and MIMO enhancements that improve capacity and throughput. LTE-A Pro adds improved carrier aggregation, full-dimension MIMO (FD-MIMO) to increase performance and cell density, and license-assisted access (LAA) to leverage unlicensed spectrum for even higher capacity and throughput.

The result is better performance for a broad range of connected devices and platforms and extended battery life (Table 1).

	Peak Transfer Rate	Maximum User Bandwidth	Connected Devices	Latency (Radio)	IoT Battery Life
LTE & LTE-A	Up to 1 Gbps	100 MHz	<100/cell	10 ms	Minimal due to lack of power saving
LTE-A Pro	1-3 Gbps	640 MHz (LAA)	50K/cell (NB-IoT)	<10 ms	Up to 10 years (NB-IoT/eMTC)
5G	10 Gbps	1000x higher bandwidth per unit area than LTE	10x-100x number of connected devices versus LTE	1 ms	Up to 15 years (mMTC)

Table 1: LTE, LTE-Advanced, LTE-Advanced Pro, and 5G performance parameters

5 Challenges for Service Providers

To evolve an LTE network to 4.9G presents challenges in 5 areas: network speed, network virtualization, new business models, spectrum usage, and infrastructure hardware upgrades.

To maximize the capabilities of a 4G LTE network, service providers need to overcome the challenges within each of the 5 areas.

Challenge 1 – Network Speed

Technology advances are closing the gap between 4.9G's performance capabilities and those envisioned for 5G. Gigabit LTE is essential as both a bridge to 5G and a mechanism to ensure that fallback from a 5G coverage area is not an unpleasant user experience.

Getting closer to the 1 Gbps threshold means taking full advantage of 4.9G technology options. Focus on optimizing spectrum usage and network capacity with carrier aggregation and license-assisted access (LAA), and rolling out pre-5G FD-MIMO.

Depending on spectrum holdings, testing of carrier aggregation will need to be performed for up to 32 component carriers with combined maximum aggregated bandwidth of 640 MHz (LTE-A Pro).

Ensure that networks are optimized for 4.9G by working with network equipment manufacturers (NEMs) on an upgrade path that supports these areas to provide a state-of-the-art platform using software-defined capabilities where applicable.

Telstra has already begun to roll out what it claims is the world's first commercial 1 Gbps LTE network, working with vendors Ericsson, Qualcomm, and device provider Netgear.

Challenge 2 – Network Virtualization

Telecommunication networks must be flexible, highly scalable, and cost efficient, while consuming minimal energy. A major enabler is implementation of network functions virtualization (NFV), which is the decoupling of software and hardware functionality instead of cyclically adding or upgrading purpose-built hardware.

Core Network

Many service providers are already implementing aspects of NFV, primarily with a virtual evolved packet core (vEPC) network. The benefits of using a virtualized core include a smaller footprint, reduced costs, a wide range of features, improved scalability, and dynamic resource allocation. NFV enables a 5G-ready platform, which supports future services such as network slicing.

To implement a virtualized core network requires supporting a broad range of fixed and mobile applications and access options, separating control plane and user plane, and migrating applications to the vEPC where appropriate, allowing for efficient deployment of network resources.

Radio Access Network (RAN)

Evolving the RAN to maximize performance of a 4.9G network is also important. By implementing LTE-A and LTE-A Pro, 4G LTE networks can evolve in terms of FD-MIMO, LAA, and NB-Iot/eMTC to offer more capacity, lower latency, more connections, and more flexible architecture. Major vendors have recently introduced new platforms that increase performance for their current LTE networks and get them started on the path to 5G by being more easily upgradeable. Examples include Nokia's AirScale platform, Ericsson's Radio System, and Huawei's 5000 series base station.

Korean service provider SK Telecom (SKT) has implemented a cloud RAN model with Nokia, in what is claimed to be the world's first commercial deployment. This approach, which SKT describes as a software-defined RAN, scales traffic more effectively and provisions network resources in the cloud according to demand. It also provides third-party access to the SKT network for users to develop their own applications.

Both the RAN and the core will need to be functionally tested and load tested to determine how the infrastructure handles the massive amounts of data driven by

4.9G technologies.

LTE Support for Future 5G Architectures

These virtualization measures enable new architectures such as mobile edge computing (MEC) and network slicing. Both can be implemented in a 4.9G network, although network slicing is only possible with a more limited set of attributes in 4.9G networks.

MEC moves processing, storage, and management to the base station or small cell, closer to the RAN edge, to support low latency, on-demand, and optimized services. As a local content cache, it works with MIMO to provide improved service to users.

Network slicing uses virtual network functions to potentially slash service provider capital equipment expenses (CapEx) and operating expenses (OpEx). By segmenting one physical network into multiple virtual networks, service providers can deliver different applications, levels of latency, throughput, and security, based on the service level agreement (SLA) between the providers and various classes of subscribers. The partitioning of multiple network "slices" can take place in both the core network and the RAN (Figure 1).

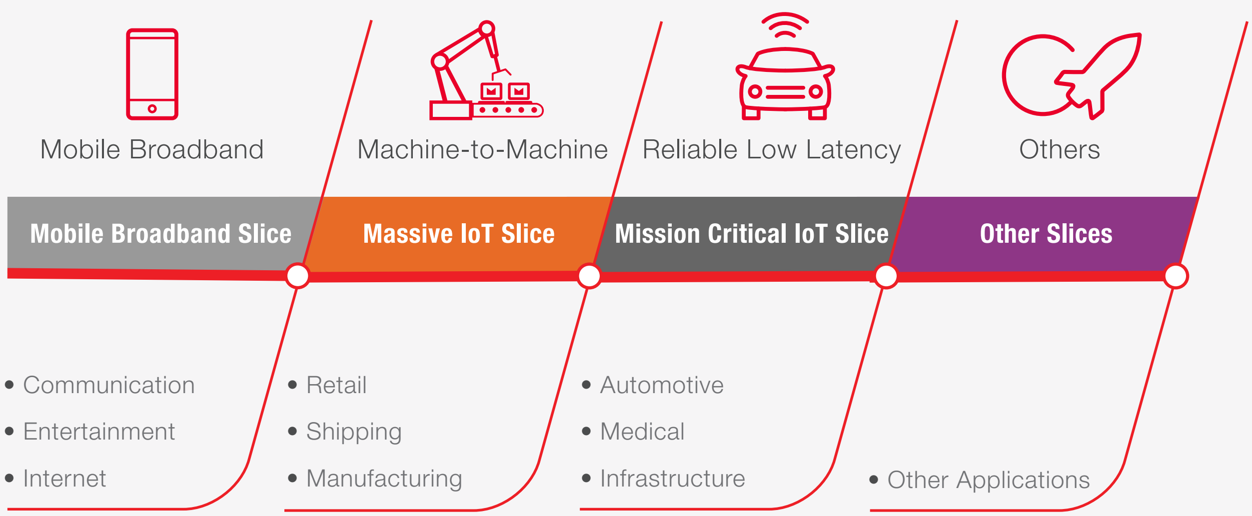

Figure 1 - Network slicing

A critical indicator of performance is network latency of less than 10 ms. This is especially important in slices that support real-time traffic and mission-critical applications.

Challenge 3 – New Business Models

5G promises to support a broad range of use cases, with the focus on three primary areas: enhanced mobile broadband, ultra-reliable low-latency communications, and massive machine-type communications. Implementing 4.9G brings service providers a step function closer to 5G.

Current 4G technologies such as CAT-M1 and NB-IoT are the basis for IoT services in 4.9G, and provide a foothold in this expanding market. They offer experience in operating the kind of network required to support wide-area, low-bandwidth, low-power consumption services. This is an opportunity to build a customer base, explore potential use cases in vertical industries, and engage in large scale IoT initiatives such as smart grid/smart city prior to the release of 5G standards and technologies.

Public safety networks provide communications for services like police, fire, and ambulance. Mobile broadband can help with situation-aware dispatching, remote diagnostics, and live mobile video. The US has dedicated a 700 MHz band to public safety, while the United Kingdom is using the 800 MHz band.

Consider the opportunities for new subscriber services given network virtualization, the transition to a cloud-based network model, and the introduction of new capabilities such as network slicing. Opportunities include virtual private network (VPN) and software-defined wide-area network (SD-WAN), as-a-service (XaaS) and hosted type offerings, augmented/virtual reality applications and services, and security.

Analyze business and financial impacts as services and applications are planned or rolled out. Perform cost/benefit analysis, compare revenue-per-bit and cost-per-bit of data consumed, and calculate average revenue per user.

While many of these new services and applications are often considered features of 5G, 4.9G means you can pilot business models and develop a 5G-like ecosystem ahead of the curve. 4.9G and NB-IoT support up to 50K devices per cell. Understanding how low-throughput, delay-tolerant devices impact the network through coverage and battery life testing will provide valuable experience as 4.9G is rolled out.

Challenge 4 – Spectrum Usage

Given the massive cost of spectrum, a 4.9G strategy must be planned out, including 5G coexistence. In the US, T-Mobile is using the 600 MHz spectrum and Sprint is using its 2.5 GHz holdings for 4.9G.

Spectrum holdings should be used now to gain experience with technologies such as MIMO, carrier aggregation, unlicensed shared spectrum using license-assisted access (LAA), and small cells. Consider spectral efficiency (i.e., the number of bits that can be transmitted over a given bandwidth). Characterized as the number of bits per second per hertz (bit/s/Hz), better spectral efficiency is achieved with higher scales of MIMO implemented, higher orders of modulation used, and in the least amount of bandwidth. Now is the time to test and gain experience with 4.9G technologies before the step function to 5G.

The decision whether to employ new or existing spectrum depends on various factors. Do you want to address coverage or capacity or both? Consider whether the band characteristics (i.e., bandwidth, channel capacity, propagation and susceptibility to weather conditions, mobility support) match the services rollout strategy for current 4.9G and anticipated 5G usage. All of these factors contribute to the quality of service (QoS).

Challenge 5 – Infrastructure Hardware Upgrades

4.9G shares many performance attributes with 5G, and requires similar infrastructure hardware upgrades when considering sub-6 GHz frequency bands. Consider antenna modernization, cell densification, and installing and activating fiber. Upgrade the RAN, data centers, and central offices. To meet capacity and coverage needs, consider a range of locations for cell sites, including rooftops, small cell backhaul locations, leased light poles, and other creative and "permittable" space. Site acquisition can take up to six months and construction can last 12 months. However, in most areas, existing towers can be used.

Understanding channel performance with new frequencies, new modulation techniques, and new antenna designs will provide a boost for mobile users while giving key insights into how these technologies will perform with 5G.

Underneath all of this is the requirement for a reliable, secure network. 4.9G technology investments include maximizing 4.9G capabilities supported by carrier aggregation (up to 32 carriers), MIMO (up to 64 transmit antennas), and higher-order modulation (up to 256 QAM). To support this, fiber networks can be built out, creating the enormous "pipe" that runs backhaul from every macrosite, tower, and rooftop. According to a recent report from Strategy& (formerly Booz & Company), by 2030 the winners will be those service providers with the largest installed base of fiber. They will be able to use their fiber bases to connect mobile base stations serving their own mobile operators and offer backhaul to other operators as they get ready for 5G.

Equally important will be the ability to build and validate a high performance network on top of those fiber resources. With up to 50 1 Gbps clients per tower and substantial amounts of function virtualization in the network, an end-to-end test strategy to validate network performance is essential.

Moving Forward

Evolving to 4.9G by implementing LTE-Advanced and LTE-Advanced Pro means meeting customer demands as technology and standards advance towards 5G. Service providers who address implementation challenges now, position themselves to take advantage of these technical evolutions.

- Be gigabit ready. Refresh or replace network equipment to accommodate the upgrades necessary to achieve gigabit LTE performance and low latency, and invest in platforms that offer software-defined capabilities to future-proof network upgrades.
- Network virtualization is integral to 4.9G. Migrating to a cloud-based, virtual evolved packet core (vEPC) platform is an initial step that allows more efficient deployment of network resources and prepares the infrastructure for future advances in mobile edge computing (MEC) and network slicing—this means depending more on data center functionality and less on purpose-built hardware.
- Gain experience in new business models with 4.9G today. For example, introducing a technology such as narrowband IoT (NB-IoT) can open new revenue streams such as machine-to-machine (M2M) communication and build a customer base prior to the release of 5G.
- The key to efficient spectrum use is flexibility. Since multiple radio access technologies can be supported within the same frequency bands, the options for repurposing existing spectrum resources are increased. Optimize bandwidth that's available now for 4.9G and develop a long-term plan that fits your technology strategy for 4.9G and 5G coexistence, including considerations for new bands below 6 GHz as well as those at mmWave.
- Invest now in infrastructure hardware that provides capacity for the future. The short-term winners will be service providers who can fulfill the bandwidth demand of their customers at the lowest deployment cost and develop new revenue streams. Longer term, the winners will be service providers with the largest installed base of fiber.

Working with a fast-paced partner with expertise in end-to-end telecommunications design, test, and measurement can help you maximize your 4.9G deployments and lay the groundwork for future technologies. Keysight Technologies is working closely with companies, consortia, and university researchers to develop the next generation telecommunications technology.

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