



# THE RISE OF LTE ADVANCED PRO



## THE ADVANCEMENTS IN 3GPP RELEASE 13+ THAT WILL NOT ONLY PAVE THE WAY TOWARD 5G BUT ALSO PROVIDE MANY ESSENTIAL SERVICES AS PART OF THE 5G PLATFORM FROM DAY 1

We are on our way toward the 5th generation (5G) of mobile networking, and the world is already preparing for an era of unified connectivity that will be like nothing we've experienced before. The 5G world will encompass an all-new kind of communications network, connecting not only users but machines, devices, and objects. Markets are already bracing for higher quality, higher speeds, higher capacity, and lower latency, as a bonanza of new devices and use cases are appearing on the horizon—widespread virtual reality (VR)

and augmented reality (AR), more autonomous transportation, smart cities, and the industrial Internet of Things (IoT), to name only a few.

The rise of 5G will change the trajectory of our connected lives. The market has been undergoing significant expansion of the use of mobile technologies in its leap toward 5G, already growing into new verticals and new areas, from machine-to-machine (M2M) use cases to mission-critical services where failure is not an option. The coming

5G landscape promises applications that we have not even dreamed about. Such as the overall propagation of mobile technologies into connected things such as vehicles, robotics, drones, and other machines. The future is a limitless confluence of intelligence, creativity, and connectivity.

The evolution of the 5G platform is occurring along two paths: first, the continued evolution of LTE, including fundamental services the market needs for 5G from Day 1; and second, the path of the 5G New Radio (5G NR) standard—coming in 3GPP Release 15—which will introduce new levels of flexibility and significantly improve performance, energy efficiency, as well as drive down cost per bit.

To that point, it's important to understand that 5G is not a magical standalone technology that will suddenly spring to existence on Day 1 and take off under its own power. Rather, it will require a strong, established foundation of existing technologies that are already primed to take on the heavy work of the 5G promise. In particular, LTE-Advanced Pro (LTE-A Pro)—standardized by the 3rd Generation Partnership Project (3GPP) and included in Release 13 and beyond—will be an essential pillar of the 5G platform.

LTE-A Pro is already improving the LTE mobile broadband experience by vastly enhancing performance and efficiency, further reducing latency to provide a seamless user experience, and embracing a wide range of connected devices and platforms under a single standard. The advancements in LTE-A Pro are essential to the 5G future, both from a mobile broadband perspective (Gigabit LTE and other advancements) and from the perspective of new verticals such as connected vehicles, IoT, drones, and broadcast TV.

## CONTINUING A STRONG LTE EVOLUTION

The experiences that the 5G mobile broadband effort is envisioned to enable will require ubiquitous coverage, even as users move beyond the reach of 5G. These users must be able to retain a consistent



broadband experience. However, as 5G deployment begins, the world will not immediately enjoy such coverage. Therefore, LTE will be indispensable to the success of the 5G platform, providing an essential anchor for the mobile broadband experience. Just as LTE relied heavily on 3G coverage for voice, 5G will rely heavily on Gigabit LTE. Advancements in LTE are particularly important in this respect, allowing multi-mode devices to be seamlessly connected to Gigabit LTE and 5G, thanks to Multi-Connectivity. Rather than providing a traditional handoff, Multi-Connectivity gives users simultaneous access to data from technologies such as 4G, 5G, and even Wi-Fi—a significant aspect of the 5G experience.

We are primed for 5G, but as excitement for the new era grows—5G does promise to be the unifying fabric for this array of technology, after all—it's important to remember that 4G LTE is still evolving and reaching. LTE-A Pro, in fact, provides a rich roadmap of LTE technologies that will underpin many of the technology innovations that will characterize 5G. LTE will continue to evolve beyond 3GPP Releases 13, such that its most powerful advancements—including, in particular, Gigabit LTE—will lead the way to 5G by pioneering many of the aforementioned 5G NR technologies and use cases in advance of commercialization starting in 2019 (with trials and interoperability testing anticipated in second half of 2017).

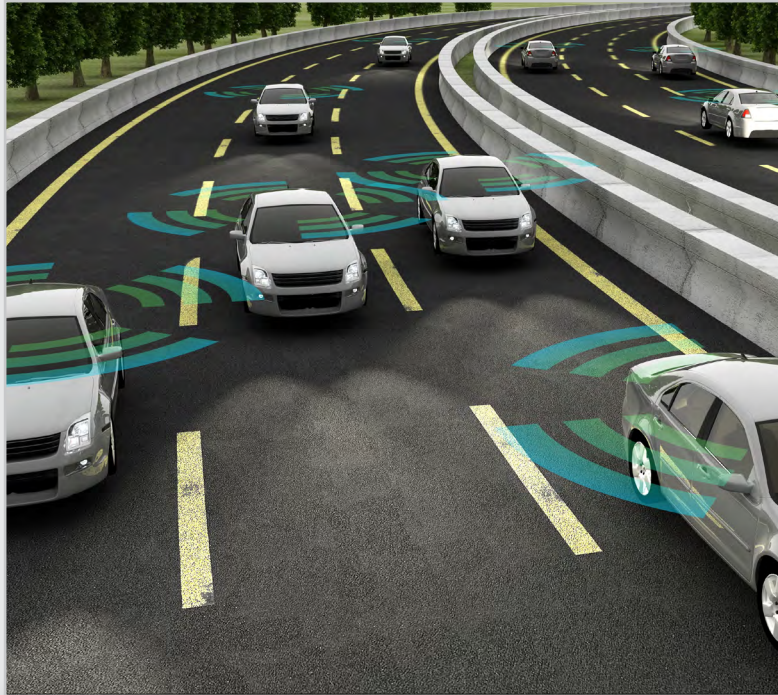


The key attributes defining Gigabit LTE in LTE-A Pro are data speeds initially reaching and then exceeding 1Gbps (vs. hundreds of megabytes per second in today's LTE network). Gigabit LTE is also evolving further in four main dimensions in Release 14 and beyond: even higher peak rate (up to 1.6Gbps defined so far in standards), ultra-lower latency (down to the 1ms range), more capacity (supporting more simultaneous users who use large amounts of bandwidth—for example, for mass VR/AR deployment), and better uniformity (for a more consistent experience anywhere in the network, even at the cell edge). A capacity and uniformity enabler is further advanced Multiple Input Multiple Output (MIMO) techniques, moving in the direction of massive MIMO by using many more antennas at the base station exploiting 3D beamforming. In these ways, Gigabit LTE will be the anchor of the 5G mobile experience—providing ubiquitous coverage and a consistent user experience.

## 5 ESSENTIAL SERVICES FOR 5G DAY 1

The LTE advancements on the horizon—both from the mobile broadband perspective (Gigabit LTE and other advancements) and in terms of new verticals such as LTE IoT (eMTC, NB-IoT), cellular vehicle-to-everything (C-V2X), drone technology, and other new areas—will be a critical part of the 5G platform. LTE-A Pro as a technology platform is going to provide many services from Day 1. In particular, it will enable the following five essential services that will complement what 5G offers.

- ***The Evolution of LTE IoT (eMTC, NB-IoT) Establishes the Foundation for 5G's massive IoT.*** LTE-IoT is designed for those use cases in which traditional LTE connectivity is not cost-effective or fails to meet certain application requirements. Operating in licensed spectrum, it boasts stability, reliability, and security for the future. The benefit of LTE IoT is that it works anywhere—particularly in remote and hard-to-reach areas—enabling low-power communication, reducing cost and complexity, extending battery life, deepening coverage, and enabling large numbers of devices. It connects devices efficiently on established
- mobile networks, providing security and reliability. LTE IoT—which will also make many new applications a reality—is perfect for applications communicating small amounts of data over long periods of time. Commercial networks supporting these narrowband devices will start to roll out in 2017.
- ***The Dawn of Cellular V2X (C-V2X).*** V2X is the foundation for the safe, connected car of the future, complementing Radar, Lidar, and other sensors to enable vehicles to communicate with one another, the pedestrians around them, and the roads upon which they travel. In the coming years, autonomous vehicle technology will continue to evolve to accommodate new safety requirements and use cases. C-V2X—an aspect of the 5G evolution that is part of 3GPP Release 14—enables connected vehicles to directly communicate with each other and exchange critical information to avoid collisions, see beyond corners, and communicate directly with infrastructure (e.g., traffic signals). C-V2X can also communicate alternative routing and send alerts about distant traffic accidents. C-V2X being defined in Release 14 is a mission-critical control service that will complement and coexist with future enhancements in Release 15 and beyond—all being part of a common C-V2X evolution that leverages the benefits of cellular technologies.
- ***The Continuing Importance of Voice and VoLTE.*** In its initial deployment, 5G will not offer a new way to deliver voice services; rather, it will depend on LTE for voice—just as the world depended on 3G and even 2G (e.g., circuit switched) voice services during the transition to LTE, bringing stronger data services and mobile broadband. VoLTE will serve as the foundation for 5G voice from Day 1, and in fact those technologies will provide voice services for years to come, enabled by a seamless multi-connection between 5G NR and LTE.
- ***Coverage for Drones.*** Today's drone regulations typically require a visual line of sight, and LTE is an obvious solution for overcoming the necessity for beyond line of visual line of sight operation.



The goal is to optimize the LTE network, to promote the use of cell networks for drones without impacting terrestrial devices, to ensure that networks can support devices at all altitudes, and to work with regulators to achieve positive developments in drone regulations on a large scale. Doing so will help accelerate 5G deployments, with LTE providing the foundational wide area coverage, specifically for massive deployment of drone use.

- ***The Approach of LTE Broadcast.*** The evolution of LTE Broadcast promises to make digital broadcasting dynamic and more scalable, ushering in a new solution for next-generation TV. Cellular networks rather than traditional high-powered towers can be introduced to power a converged, unified network—for both unicast and broadcast—that can address any device, from radio/TV devices to mobile devices and tablets. LTE Broadcast also has the side benefit of enabling new business models (e.g., using cellular as a content delivery platform that widens the space by supporting OTT content providers) and freeing up valuable spectrum (e.g., Europe is freeing up spectrum bands in the 470MHz-to-700MHz range for enhanced broadcast and new use cases such as 5G).

## QUALCOMM LEADS THE WAY

Qualcomm has consistently led the industry in its embrace of LTE-A Pro technologies. Just as it paved the way with 3G and 4G, the company is illuminating the path toward 5G. Qualcomm launched the world's first Gigabit LTE solution last year, enabling mobile operators to launch commercial network services in 2017. Recently, the company announced its newest premium-tier mobile platform—the Qualcomm Snapdragon 835 processor supporting Gigabit LTE—allowing for breakthrough performance and superior power efficiency. Such leadership is pushing LTE functionality toward a feasible 5G reality.

Qualcomm is also broadening the ecosystem by pioneering new verticals, enabling new services, and empowering new user experiences toward the 5G horizon. In the realm of LTE IoT, Qualcomm took a leadership position and harmonized the industry on the NB-IoT specification in 3GPP Release 13, then announced product support for NB-IoT that will be in time for commercial network launches in early 2017. Qualcomm continues to build on its leadership in C-V2X specifications and use cases as a co-founding member of the 5G Automotive Association (5GAA), recently announcing trials with Audi (and partners) to demonstrate the benefits of using a unified C-V2X connectivity platform during 2017. Finally, Qualcomm has announced trials with AT&T to prepare for large-scale drone deployment. Qualcomm's work in this area now will accelerate 5G deployments, specifically for massive deployment of drone use.

In addition to delivering Gigabit LTE and pioneering a new class of services, Qualcomm is innovating the use of LTE in multiple spectrum-focused efforts that pave the way toward new 5G spectrum sharing paradigms, making more spectrum available and increasing utilization but also bringing new deployment opportunities.

- ***Licensed Assisted Access (LAA).*** Introduced in 3GPP Release 13, LAA uses carrier aggregation to combine LTE in unlicensed spectrum (e.g., 5GHz) with LTE in the licensed band. Most of

the industry now focuses on LAA—a technology that will be deployed globally during 2017—using unlicensed spectrum as a supplementary link to add bandwidth to a licensed connection. Qualcomm offers LAA product support in Snapdragon 835 with X16 LTE and has performed trials for LAA with various network operator partners.

- **Citizens Broadband Radio Service (CBRS).** Last year, the FCC opened up 150MHz of spectrum in the 3.5GHz band, introducing new methods of sharing spectrum with existing incumbents and unlocking more spectrum for wireless communication. Qualcomm is a co-founder of the CBRS Alliance and a key contributor to coexistence.
- **MulteFire.** MulteFire is a new, LTE-based technology that operates solely in unlicensed spectrum or shared spectrum like CBRS,

combining the performance benefits of LTE with the simplicity of Wi-Fi deployments. Qualcomm is a co-founder of the MulteFire Alliance and is instrumental in driving the standardization of MulteFire technology. Qualcomm also demonstrated the first over-the-air connection in October 2016, and the MulteFire Alliance published its first specifications in January 2017 to pave the way for trial and commercialization.

Qualcomm is enmeshed in all aspects of LTE-A Pro, which in all these cases is an essential part of the 5G future. Although 5G is the talk of the market, not many companies have a history of successfully bridging the gap from potential to reality. Creating something new requires an incredible amount of complexity, and the new 5G landscape is going to require the leadership of an established leader in LTE. Qualcomm is that company, already working and succeeding on the LTE front lines to make 5G a reality. ●



Qualcomm's technologies powered the smartphone revolution and connected billions of people. We pioneered 3G and 4G – and now we are leading the way to 5G and a new era of intelligent, connected devices. Our

products are revolutionizing industries, including automotive, computing, IoT, healthcare and data center, and are allowing millions of devices to connect with each other in ways never before imagined. Qualcomm Incorporated includes our licensing business, QTL, and the vast majority of our patent portfolio. Qualcomm Technologies, Inc., a subsidiary of Qualcomm Incorporated, operates, along with its subsidiaries, all of our engineering, research and development functions, and all of our products and services businesses, including, our QCT semiconductor business. For more information, visit Qualcomm's [website](#), [OnQ blog](#), [Twitter](#) and [Facebook](#) pages