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Private LTE Enterprise Networks Using OnGo Technology

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PRIVATE LTE NETWORKS FOR ENTERPRISE USERS

Wireless networks are essential to many industries. In a world where new software-driven operating processes have the potential to revolutionize productivity across virtually all sectors – from primary industries to manufacturing, distribution and consumers – it is becoming ever more important to connect people, machines and assets to business logic.

In the enterprise today, WiFi is the dominant wireless technology, with private land mobile technologies, such as Integrated Digital Enhanced Network (iDEN), also frequently used. However, in some highly demanding sectors where range, robustness, mobility and quality of service (QoS) are critical, private LTE networks are gaining traction. Examples include power generation, utilities, campuses, theme parks, warehouses, factories, ports and logistics, as well as extractive industries such as mining, oil and gas. These private LTE networks are based on technology developed for high-performance public networks, optimized for deployment and operation in enterprise contexts.

LTE is an extremely successful technology, used to connect more than a billion customers worldwide. There is an opportunity to take advantage of this R&D investment and ecosystem scale and apply it to private networks. To date this has tended to mean working in partnership with mobile operators in licensed spectrum; now, for enterprises that want to control their own network, for performance, security, resiliency or other reasons, private networks using LTE-based OnGo technology are emerging as attractive.

This white paper discusses why LTE-based technology – specified by the CBRS Alliance and branded as "OnGo" – should be under consideration by enterprise CIOs with business-critical use cases as they seek to refresh their existing WiFi or private land mobile deployments, or install new networks to automate and optimize their operations. The CBRS Alliance and OnGo are focused on the U.S. market in the first instance, but as experience with the technology and spectrum-sharing model increases, there will be the potential to apply it internationally.

CBRS for Private Enterprise Networks

In 2015 the U.S. Federal Communications Commission (FCC) approved the allocation of 150 MHz of spectrum in the 3.5 GHz band – identified as the Citizens Broadband Radio Service (CBRS) – for mobile use by public and private networks. The allocation is governed under a three-tiered spectrum-sharing arrangement, with incumbent users (i.e., federal agencies and fixed satellite services), priority users and general-access users able to operate in the band in descending order of priority, according to various regulatory criteria.

The industry consortium the CBRS Alliance has been created to encourage the development, commercialization and adoption of LTE solutions for this spectrum. The CBRS Alliance is a non-aligned organization funded by a wide range of members from the vendor, operator and integrator communities.

Deploying OnGo in this spectrum band is attractive for private enterprise networks because governing standards allow for advanced LTE technology to be used without the need to strike agreements with licensed mobile operators. Enterprise users can instead take advantage of the General Authorized Access (GAA) element of OnGo, expected to be available from the fourth quarter of 2018, or wait to acquire exclusive-use Priority Access Licenses (PALs) at the FCC auction expected in 2019.

Private networks are deployed where the user has specific requirements, such as for coverage or more deterministic performance. Organizations that control their own networks can more easily modify the technology and optimize it for their own purposes. They can determine which users connect, how resources are utilized and how traffic is prioritized. If needed, parameters in the LTE radio can be customized to optimize reliability and latency in challenging physical environments (e.g., warehouses or oil/gas facilities with lots of metal), which is unthinkable on the public network. Companies with private networks also control their own security and can ensure that sensitive information doesn't leave the enterprise network, which can be essential to high-tech, R&D-driven businesses.

Private LTE should also be simple to deploy and operate – at least as simple as WiFi – and shouldn't require large numbers of specialist staff. To help address this, the CBRS Alliance has created the "OnGo Certification Program" to ensure that networks can be built using equipment from multiple vendors. This interoperability will encourage innovation and competition.

Private Network Use Cases

There are many use cases for private LTE enterprise networks. They often have a mobility component (one of the key advantages of LTE), but can also include fixed links to equipment or buildings. These networks can be designed specifically for outdoor operation over a large coverage area, such as in heavy industry (oil/gas extraction and mining), utilities and transportation; or for indoor operation with a constrained service area in mind, such as in warehouse or factory automation, or healthcare; or for something in between, such as in logistics/distribution, shipping ports or campuses (stadiums, universities, etc.). **Figure 1** categorizes these use cases.

Figure 1: Example Users of Private OnGo Networks

Use Case Type	Description
Automation & Industry 4.0	• Factory-floor robotics – e.g., wireless robots introduce much greater flexibility to reconfigure production lines • Logistics and warehousing – e.g., pick-and-pack machines; often considered under the banner of "Industry 4.0" • Typically focused, very dense deployments with low latency requirements
Production-Critical Networks	• To monitor and control critical infrastructure – e.g., electricity distribution grids, power plants, etc. • Automate processes and connect machinery at venues such as ports and transportation hubs • Often hazardous environments with requirements for employee safety
Primary Industries	• Locations often not covered by public wireless infrastructure • Very diverse sector from mining and oil/gas to agriculture, making increasing use of automated machinery • Often requires hardened equipment with good link budget for low-density long-range coverage
Venue Services	• Public venues such as airports, theme parks, stadiums, hospitals, ports • These venues have many users (internal, contractor, public), some of which have requirements for fast, highly secure access • Private network can be "sliced" (configured) for different user groups

Source: Heavy Reading

ONGO FOR ENTERPRISE NETWORKS

So-called "CBRS spectrum," like much U.S. mobile spectrum, is actually a technology-neutral allocation that can be used for many types of wireless technology, within the regulatory limits on power output, out-of-band emissions, etc.

However, the band plan, comprising multiple 10 MHz channels, does lend itself to LTE. Moreover, LTE already operates commercially at 3.5 GHz in Japan and a few other countries. Internationally, it is also one of the lead frequencies for 5G; in the U.S., there is an expectation that 5G will be deployed in CBRS spectrum, and in the adjacent 3.8-4.2 GHz bands over time.

What Makes LTE Attractive

Beyond the spectrum alignment, there are several reasons why LTE, packaged as OnGo technology, is attractive for high-performance enterprise networks in the "CBRS spectrum band." Three important reasons are:

- **LTE Technology Properties:** Designed for wide-area mobile networks, LTE offers an array of advantages over WiFi for enterprise and industrial use cases, including range, robustness, QoS and multi-service voice and data. LTE incorporates a full system architecture that includes a core network and associated services, such as authentication, policy, voice, video, etc. The LTE radio and system properties are discussed in more detail below.
- **Diverse, Large-Scale Ecosystem:** The mobile network equipment market is worth around $50+ billion per year and is highly competitive. There are many LTE small cell vendors and even more suppliers of devices, Internet of Things (IoT) modules and other terminal equipment. 3GPP standards and industry interoperability programs ensure that multi-vendor networks and devices work together "out of the box." Core networks, planning tools, self-organizing network (SON) software, and operations support systems (OSS) are also commercially available. These ecosystem attributes are now being extended to OnGo.
- **Roadmap to 5G:** One reason that LTE is suitable for industrial and enterprise use cases is that it is a proven, mature technology. It has active feature developments, such as low-latency radio, gigabit downlink and various types of IoT. From a system perspective, it also has a roadmap to 5G, with radio access network (RAN) and core products emerging that will make it possible to transition elegantly from 4G. For now, however, 5G is too new for industrial applications where stability and predictability are important. LTE is a proven technology with several years of development lifecycle remaining, and longer still for operation "in the field."

The LTE-based OnGo network products that are currently under development are designed to work with the spectrum-sharing databases, known as the Spectrum Access System (SAS), that are required to operate in CBRS spectrum. The SAS maintains a database of all OnGo radio base stations, including their tier status, geographical location and other information to coordinate frequency and transmit power, and to monitor and protect the band from potential interference. The SAS is mandatory for users of this spectrum under the FCC's Part 96 rules, and its integration into OnGo products illustrates the close link to LTE technology.

Diverse Enterprise Use Cases

Industrial users of wireless networks have a wide range of requirements, from wide area to local area, to low-power sensing and actuation, to high-speed mobility. Even within a specific vertical sector, the needs are diverse and are supported by many device types.

Figures 2 and **3** show examples of private network use that require multi-device and multi-service capability. In each case, these voice and data services should be delivered to hand-held devices, sensors, vehicles (drones, delivery robots heavy machinery, etc.), machines, cameras and robots, and increasingly to wearable devices such as watches, augmented-reality headsets and body-worn cameras.

In **Figure 2**, a wind farm operator uses wireless connectivity to improve the efficiency of its turbines and associated field operations. Low-power sensors are deployed on the turbine to monitor operating performance and for predictive maintenance alerts (especially useful for offshore wind farms). High-speed mobility is needed for drone-mounted video cameras. Employee connectivity and vehicle tracking are also supported.

Figure 2: Field Services & Private LTE Networks

Source: Qualcomm

In **Figure 3**, from the Port of Rotterdam in the Netherlands, one of Europe's largest container shipping hubs, the port operator must integrate supply chains served by intercontinental shipping, including connections to trains, trucks and river shipping to in-land terminals. As shown, these networks must support a range of endpoint devices to move containers between transport modes, and for employee use within the facility. Previously using a mixture of TETRA land mobile radio and WiFi, this port operator began a migration to private LTE in 2017. This European network uses the 3.7 GHz band (via arrangement with the local regulator), which is close to CBRS frequency bands.

Figure 3: Private LTE Networks for Shipping Container Terminal

Source: Hutchison Ports, Rotterdam

The types of use case, and the endpoints that need to be connected, are diverse within and across industry verticals. The opportunity is to consolidate services onto a single high-performance OnGo network.

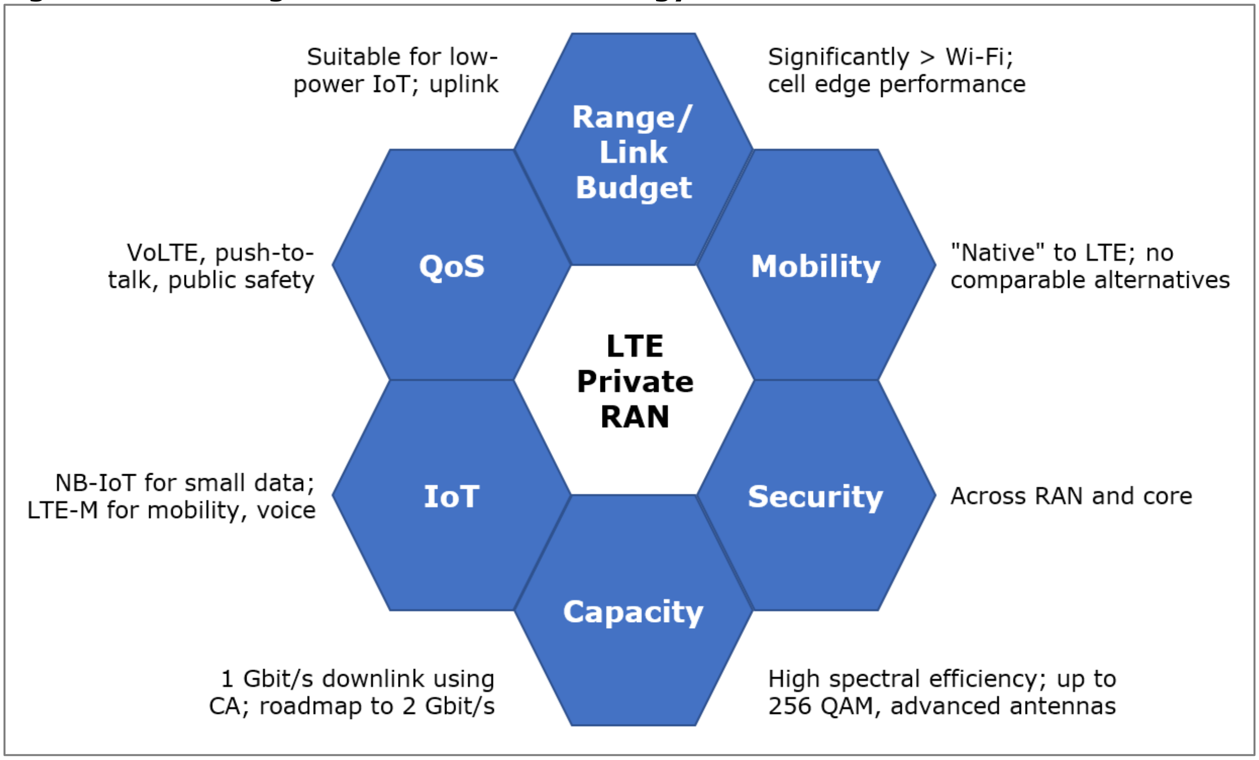
Some private LTE examples include:

- **LTE for campus operators:** Large campuses, such as theme parks, race tracks, stadiums, universities, etc., have requirements for many safety-critical and business-critical services, such as mobile voice, CCTV and point-of-sale terminals. These are often served by a mixture of legacy technologies, such as WiFi (data) or iDEN (voice), that have limited capability and can become costly to maintain.
- **LTE for warehousing and logistics:** The drive for efficient operations means this sector is automating rapidly. Private LTE networks can be used to connect and control "pick-and-pack" machines or automated guided vehicles (AGVs), to maintain records of equipment inventory and location, and to track goods into the supply chain.
- **LTE for manufacturing facilities:** Factory networks need to support different types of devices, including formats such as mini PCIe that can be added to existing equipment, or modules that can be integrated into new equipment. The factory of the future will evolve from today's demanding services, such as AGV control, to even more critical real-time processes, such as robotic motion control.

LTE RADIO PROPERTIES

The LTE radio design, from the protocol stack through to deployment architectures and products, is well suited to enterprise users operating in challenging physical environments. Key properties such as the use of OFDMA, the scheduled MAC, and the Hybrid ARQ re-transmission scheme, enable a very robust radio link, relative to WiFi. The properties that make LTE radio suitable for private networks are shown in **Figure 4**.

Figure 4: Advantages of LTE Radio technology for Private Networks



Source: Heavy Reading

Range/Link Budget

As a cellular technology, LTE is designed to operate under fading channel conditions, providing good cell edge performance. This is a decisive advantage over competing technologies in many enterprise use cases, especially for industrial users or outdoor networks. Of course, actual range is variable according to factors such as cell density, antenna system, terminal capabilities, etc. LTE systems generally use high-specification RF equipment, which helps to extend the link budget in scenarios that are challenging for WiFi, such as uplink, low-power IoT, non-line-of-sight and mobility scenarios.

As a very approximate rule of thumb, one LTE small cell will cover about the same area as two to three WiFi access points at equivalent power output and frequency. LTE in CBRS at 3.5 GHz spectrum, therefore, offers significantly greater range than WiFi at 5 GHz. In the Port of Rotterdam example (see **Figure 3** above), which has a requirement for outdoor connectivity of a large facility, the expectation is to replace 150 WiFi access points with just 15 LTE access points using 3.7 GHz spectrum, to achieve the equivalent coverage.

Spectral Efficiency/Capacity

Many of the concepts that improve range and reliability also increase spectral efficiency. LTE is more spectrally efficient than WiFi because of higher efficiencies at both link and MAC level, using concepts such as hybrid automatic repeat request (ARQ) with channel state information, more granular modulation and coding schemes and more adaptable schedulers (again compared to WiFi) to maximize channel capacity. Moreover, because LTE is designed for mobility and outdoor operation, and with concepts such as long cyclic prefix, it can support larger delay spreads, which also contributes to overall spectral efficiency.

More recently, 256 QAM has been introduced to commercial products, further increasing capacity in good channel conditions. Private networks have generally been less capacity-challenged than public networks, because they typically have fewer simultaneously active users per service area. Nevertheless, capacity is useful for services such as 4K video (e.g., CCTV) or, in future, for machine-vision applications or mobile virtual/augmented reality use cases. As more and more equipment is instrumented and connected, greater device densities mean enterprises will require more service-area capacity over time.

Quality of Service

The LTE QoS model allows for multiple layers of prioritization. For example, guaranteed bit rate bearers, known as GBRs, can be used to provide predictable latencies and priority access for certain users or services in loaded cells. The classic use case for QoS is voice-over-LTE (VoLTE) and push-to-talk services, which are often important to industrial and enterprise users. The same mechanisms are also being used to extend LTE lifeline services such as public safety. QoS is also one of the reasons why LTE is being proposed for critical automation tasks such as railway signaling or warehouse robotics. In public networks, QoS is an engineering feature that generally requires expertise and extensive testing to deploy; for enterprises to take advantage of it will require OnGo products with user-friendly management systems, controlled via user consoles.

Mobility

LTE is a natively mobile broadband technology, without comparable alternative. Mobility includes intra-network mobility using standard cell handover mechanisms and inter-network mobility – for example, "roaming" from private LTE to the public RAN, or even to WiFi. Where needed, LTE can also support high-speed mobility, which can be useful for machinery, drones, robots and aircraft, for example.

Internet of Things

LTE has two major ways to support IoT: narrowband IoT (NB-IoT) and LTE-M. LTE-M offers data rates of 1.4 Mbit/s and supports VoLTE and full mobility. It can be used for vehicle tracking/telemetry, including various fixed applications. It is already specified for TDD and can therefore be used with OnGo systems. There is a decent device ecosystem in the U.S. for LTE-M, due to the backing of the major mobile operators. It is deployed "in-band" (i.e., in the same spectrum as other access types). The primary trade-off compared to NB-IoT is power consumption and battery life.

NB-IoT is for low-cost, low-power devices that are static or nomadic, such as meter-reading, environmental sensors, asset tracking, etc. The link budget should allow these devices to operate even in severe non-line-of-sight installations, such as garages and basements, with very long battery life. At the time of writing, NB-IoT is only specified for FDD operation; however, it is likely to be extended to TDD in later 3GPP releases and may be available in OnGo products in time. NB-IoT can be deployed "in-band" and in guard band spectrum.

Security

It is never wise to be overconfident about security. Nevertheless, LTE benefits from a proven security model that applies to the radio link itself, and to core network services such as the Evolved Packet Core (EPC), IMS/VoLTE, subscriber data and policy. Classic SIM-based security can be used, as well as eSIM for embedded devices. There is deployment flexibility, allowing for local credential management on premises with a locally deployed core, or in wide-area network, data center or cloud. Generally speaking, private network operators will also use additional transport security, such as IPsec, and application layer security (TLS, etc.) over and above the standard LTE security.

A MULTISERVICE SYSTEM ARCHITECTURE

An LTE network includes RAN, core and services. It is, by design, a multiservice architecture that can support broadband, narrowband data, a range of voice, video and messaging services, and multicast emergency alerts. This is a useful set of attributes for enterprise networks that will often need to support several types of end-user device and services. An industrial facility, for example, may need high-bandwidth video feeds, low-bandwidth monitoring (e.g., sensors such as smoke alarms and motion detectors), mobile asset tracking and communication services for personnel, including voice and push-to-talk features.

Equipping personnel, as well as machines, with communications devices is important to productivity and critical to employee safety. Many of the innovations in this area are being driven by, or co-developed with, the public safety market, where LTE is also making in-roads. This includes hardened communication devices designed for use in challenging physical environments, as well as associated communication services such as mission-critical push-to-talk (MCPTT) and multicast video.

As with RAN equipment, there are several suppliers of small-scale, full-featured, standards-compliant core network systems designed specifically for enterprise and public safety LTE networks that work in the CBRS bands without needing any significant modification. From a core perspective, only the spectrum-sharing database elements need to be added.

SUMMARY & RECOMMENDATION

For enterprise CIOs seeking to refresh existing WiFi or private land mobile deployments, or preparing to install new networks to automate and optimize their operations, OnGo technology is a compelling proposition. Available from 4Q18, the combination of high-performance LTE, spectrum and certified products will enable enterprises, and their integrator partners, to build and operate private mobile networks that can support diverse business-critical use cases.