PRIVATE NETWORKING 101

KEY CONSIDERATIONS, APPLICATIONS, AND USE CASES

EXECUTIVE SUMMARY

The fourth industrial revolution (Industry 4.0) promises to deliver quantum-level improvements in factory automation and efficiency with the capability to connect machines to machines as well as people to machines. Dangerous operations such as mining will be made safer through driverless operations. The acceleration of digital transformation that results from Industry 4.0 will also allow businesses of all sizes to reap the benefits of new-found agility for faster time to market, cost reduction, and improved customer experiences. Networking is at the heart of it all.

Consequently, there is high interest in deploying cellular telecommunications infrastructure within the enterprise to complement Wi-Fi installations. 5G promises to deliver ultra-low latency and significant throughput, unlocking transformative use cases across many industries. However, enterprises can still take advantage of 4G LTE today through private networking deployments that deliver time-tested secure and predictable wireless connectivity.

Where do enterprises start in the evaluation of private networking? There are many available solutions from infrastructure and managed service providers. Still, businesses of all sizes need education and guidance to ensure optimal fit, ease of deployment and ongoing management.

This paper will explore critical private networking infrastructure considerations to deliver an optimal balance of hardware and software. It will also educate readers on the use of licensed spectrum, target industries, and applications; how 4G, 5G, and Wi-Fi deployments will co-exist; and broader deployment considerations.

PRIVATE NETWORKING INFRASTRUCTURE

By definition, a private network allows a discrete number of devices to communicate with one another. Historically, cellular telecommunications infrastructure has been deployed for public wireless wide-area networking based on its high capital cost structure and licensed spectrum deployment requirements. Today, cellular infrastructure is a viable choice for any private enterprise to significantly accelerate digital transformation due to the following recent developments:

- The availability of disaggregated, industry-standard, telecommunications-grade hardware that delivers exceptional capital cost savings over traditional, single-purpose infrastructure.

- Software-defined networking (SDN) tools that can virtualize network functions in both the core and radio access network (RAN) domains, making deployment significantly easier, faster, and scalable to meet cost requirements and site needs.

- Expanded access to licensed spectrum once reserved to carriers and service providers as well as under-utilized unlicensed spectrum through emerging platforms, such as MulteFire that operate in the upper mid-band range.

- A growing ecosystem of industrial devices, including mining vehicles, robotics, Internet of Things (IoT) sensors, and machine tools that integrate cellular communication capabilities.

Private cellular networking has the potential to provide enterprise network operators with a compelling alternative to Wi-Fi in historically unconnected areas. Cellular can propagate over longer distances with fewer point-to-point handoffs. It is also ideal for use cases requiring a combination of indoor and outdoor connectivity and fine-tuning for specific latency or throughput requirements. Most importantly, cellular supports wider propagation more efficiently than Wi-Fi to facilitate use cases that involve high-velocity assets such as trucks, trains, cranes, and agricultural equipment.

Two domains comprise every private cellular networking deployment: core and RAN infrastructure.

First, core network components serve as the central part of a cellular network and knit together mobile, fixed, and converged connectivity to ensure a more consistent user experience. For 5G, this includes a higher degree of hardware disaggregation from a compute and storage perspective. The results include reduced operational expense, enhanced security through new 3GPP releases, and software programmability that extends infrastructure investment protection over legacy 4G networks.

Second, RAN comprises base stations and antenna arrays. Base stations are fixed points of communication within a cellular network designed to cover a specific geographic area. Based on the need for coverage, it can take the form of macro-cells that cover a wide area, micro-cells used for densification of coverage in highly

populated areas, and pico-cells that boost coverage within buildings. Antenna arrays are attached to base stations to amplify signal strength. For 5G, new requirements address the need to deliver significantly lower latency and improved throughput over LTE with massive MIMO factoring heavily. MIMO stands for "multiple-input, multiple-output" and combines many antennas to improve broadcast efficiency. Because 4G small cells, both micro and pico, act much like a Wi-Fi access point, they integrate similar functions into a compact form factor and only require an Ethernet cable to interface into an existing enterprise local area network. On the other hand, 5G radio systems rely on a more distributed architecture, and as a result, enterprises will need deployment guidance based on the added complexity.

Together, base stations and antennas constitute the radio access network connecting devices to a core network. Virtualization, telco cloud services, and multi-access edge computing (MEC) are already helping ease the deployment and improve private networking service quality with today's private wireless 4G LTE solutions. Cloud and MEC both deliver much-needed scale, performance, and private network deployment flexibility based on an enterprise's workflow and security needs.

LICENSED SPECTRUM

Historically, enterprises have relied exclusively on public access mobile radio (PAMR), digital private mobile radio (PMR), Wi-Fi and unlicensed spectrum for wireless communications given the lack of access to licensed spectrum. Governments worldwide have managed licensed spectrum like a rare commodity amongst network operators and, for a good reason, to mitigate broader telecommunications contention and its tremendous revenue potential. Case in point, the recent C-Band spectrum auction managed by the Federal Communications Commission resulted in a historic $81-billion payday for the United States government. On the table were prized 5G upper mid-band spectrum assets. Enterprises and municipalities bid alongside wireless operators AT&T, Dish, T-Mobile, Verizon, and others.

Prior to the C-Band auction, CBRS/OnGo's emergence paved the way for broader access to licensed spectrum in the United States, and other countries such as France, Germany, the United Kingdom, and Japan have already initiated similar scenarios by releasing unused bands. It is also worth noting that the CBRS Alliance recently rebranded itself as the OnGo Alliance in an effort to extend its learnings globally to facilitate spectrum sharing among regional Internet service providers, satellite communication companies, cable operators, the military, and other stakeholders.

What is driving the democratization of licensed spectrum? From our perspective, the potential to raise revenue and accelerate Industry 4.0 applications positively impacts the global economy. To understand what spectrum assets are ideal for private networking deployments, consider the pros and cons of each category:

- Low band is defined in the sub 1 GHz spectrum range and can transmit over long distances with better penetration but at lower throughput due to smaller bandwidth availability.

- Mid-band is defined in the spectrum range of 1-5 GHz and can deliver a good balance of transmission distance and high throughput.

- High-band or millimeter wave (mmWave) is defined in the spectrum range of 24-52 GHz and can deliver extremely high throughput and ultra-low latency but over much shorter distances with line-of-sight challenges.

Which licensed spectrum band is ideal for private networking deployments? From our perspective for industrial sites, mid-band provides a perfect balance of propagation and performance without the need to densify networks with potentially costly small cell infrastructure. For wide-area private wireless networks, low-band offers the maximum coverage area. It is worth noting that similar to public cellular networks, a combination of spectrum assets, if available, will increase coverage and capacity.

Another consideration factoring into a private wireless network is the choice of architecture linked to the 5G new radio (NR) standard: standalone (SA) versus non-standalone (NSA). 5G SA refers to an end-to-end network that leverages 5G NR core architecture to offer support for yet-to-be-defined industrial features and other enhancements of future 5G releases. 5G NSA is more of an intermediary step that allows operators to deploy 5G networks on some elements of existing 4G infrastructure. We believe that the widespread availability of 5G SA solutions in 2021, such as Nokia's recently launched platform, will catalyze private network adoption.

Target Industries and Applications

Will a 4G or 5G private network benefit all enterprises? Likely in some form since cellular infrastructure can deliver reliable ultra-high performance and extremely low latency over long distances. However, there are specific industries and applications that will benefit the most:

- Manufacturing for machine-to-machine communication and process automation.
- Energy and utilities for grid management.
- Transportation and logistics for ensuring chain of custody and autonomous operations of railways, airports, ports, and mining operations.
- Aerospace and automotive for autonomous vehicle and facility operation.
- Defense, government and public safety for national security operations, improved first responder communications and “smart” connected city deployments.
- Healthcare for enhanced telemedicine and telesurgical tactile distance procedures as an alternative to a public network slice.
- Retail operations supporting smart warehousing and replenishment.
- Farming and ranching to improve crop and livestock yields through the application of "AgTech" methodologies.

Broadly speaking, operational technology (OT) environments will benefit from the deployment of cellular infrastructure. Nearly 3/4 of these enterprise "non-carpeted" areas such as warehouses, manufacturing lines, and industrial control systems are not connected by Wi-Fi today.

The Co-Existence of 4G, 5G, and Wi-Fi

Enterprises have a number of choices with respect to wireless connectivity. Wi-Fi enjoys a broad install base and supports the basic connectivity and application needs of knowledge workers cost-effectively. However, private cellular networking is poised to meet the more demanding needs of industrial applications. Today, 4G supports a majority of industrial use cases, and 5G, with its improvements in throughput and lower latency, is poised to unlock new ones.

The hype around 5G has certainly reached its apex, but the new cellular standard will deliver on its full industrial potential with future 3GPP Releases 17 and 18 as well as the expected, widespread availability of device chipsets that support the aforementioned releases. In summary, 4G, 5G, and Wi-Fi will be better together to support enterprise carpeted and non-carpeted applications.

General Deployment Considerations

How do IT professionals deploy and manage cellular wireless infrastructure that is inherently different than anything in the past? 4G and 5G infrastructure are indeed new, but many private wireless platforms are focusing on easing the deployment and management experience for IT professionals. Operation and management (O&M) systems, customer portals, and self-organizing network (SON) topologies that automate the planning, configuration, management, and optimization of cellular networks are among some of the tools required to accomplish this objective.

Should businesses own its private networking infrastructure on-premise or consider SaaS/cloudified or managed service offerings? There are many pros and cons to owning versus a subscription, including the balance sheet treatment of capital versus operational expenses as well as the need for immediate upside capacity and access to the latest feature releases. The ultimate decision should be made based on enterprise needs and IT staffing levels.

Call to Action

The acceleration of digital transformation that results from Industry 4.0 will be transformative. Wireless connectivity, and in particular private cellular networking will serve as a critical lynchpin for many industrial applications. This paper explored a number of private networking considerations by defining core infrastructure requirements, decoding spectrum requirements, identifying target industries and applications, providing a rationale for the co-existence of multiple wireless modalities, and offering general deployment considerations.

It is Moor Insights & Strategy's opinion that there are only a handful of providers that can offer an end-to-end solution. We believe Nokia is well-positioned to deliver a robust private networking platform based on its broad portfolio, deep experience, and overall leadership in private networking relative to its traditional peers, as highlighted by more than 260 4G and 5G customer deployments to date.

To learn more, visit www.nokia.com/networks/solutions/private-wireless/

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