Synergistic Advantages of Private Cellular and Mesh

Secure, Flexible, and Reliable Connectivity for Enterprise, Industrial, Agricultural, and Outdoor Applications

Executive Summary

Enhancing Security and Connectivity

Private cellular network deployments are on the rise. The demands of automation and IoT, coupled with increasing focus on securing networks from intrusion—whether intended to disrupt business or access private data or trade secrets—have outstripped the capabilities of Wi-Fi when looking beyond the typical carpeted office areas where it excels.

Primary applications for private cellular, which offers better security, performance, and control, include manufacturing and industrial sites, warehouse and logistics, and expansive outdoor sites ranging from event venues to agriculture to shipping ports and railyards.

The GXC ONYX platform enhances the flexibility and value of private cellular networks through its patented cellular mesh approach, which increases the extensibility, coverage, and reliability of private cellular networks. Mesh can also dramatically decrease construction costs by extending cellular connectivity across distances reaching up to two miles.

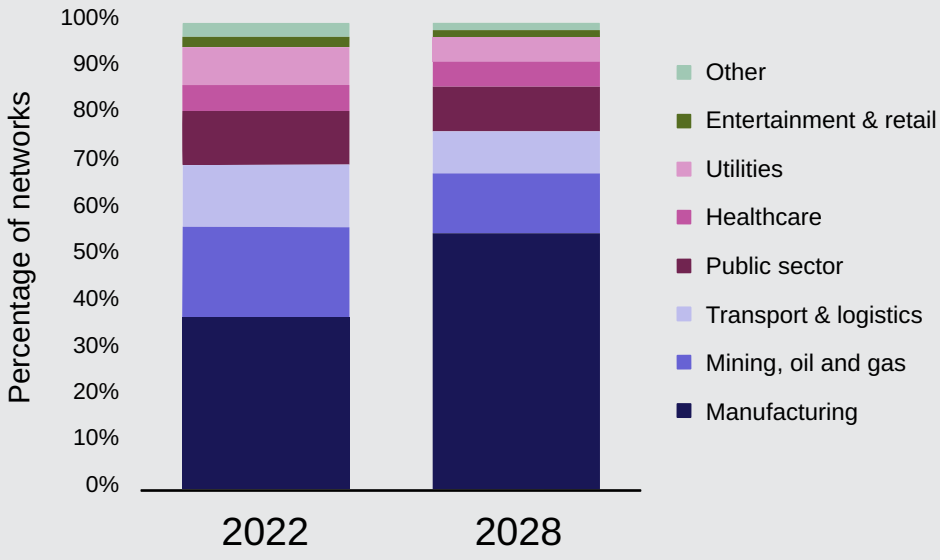
Synergistic benefits of private cellular mesh deployments include enhanced network management and control, flexible and simple deployment to meet customer needs, reliable connectivity throughout both indoor and outdoor environments, and significant construction and TCO cost reductions compared to using Wi-Fi for connectivity in industrial and outdoor sites.

> ... the global market is primarily driven by the growing need for ultra-reliable low-latency connectivity for Industrial Internet of Things (IIoT) applications, including collaborative robots, industrial cameras, and industrial sensors."

The Growth of Private Cellular

The adoption and deployment of private cellular networks are on the rise globally. According to Analysys Mason's Dec. 2023 report Private LTE/5G networks: world-wide trends and forecast, the number of private LTE/5G networks worldwide will grow from over 4,000 in 2022 to over 60,000 in 2028.

Figure 1: Share of private networks by sector, 2022 and 2028



> ... the global market is primarily driven by the growing need for ultra-reliable low-latency connectivity for Industrial Internet of Things (IIoT) applications, including collaborative robots, industrial cameras, and industrial sensors." – Grand View Research

Private cellular utilizes much of the same core technology as public cellular services, but does not carry the heavy application and cost profile required of network service providers.

What is Private Cellular?

Private cellular networks provide wireless connectivity utilizing radio frequency bands allocated for LAN deployments. At a high level, private cellular has similar characteristics to Wi-Fi technology that is utilized in nearly every enterprise around the world. However, Wi-Fi operates in a frequency band that is unlicensed and is easily disrupted by infrastructure—especially metal structures found in industrial settings—as well as radio interference from in-network access point (AP) signals and those from other networks and sources.

The table below highlights key advantages of private cellular over Wi-Fi in addressing comprehensive business needs.

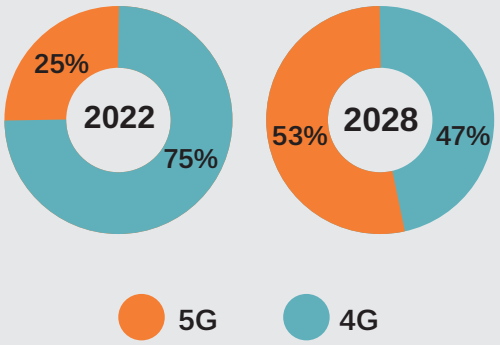
Key performance differences between GXC ONYX and Wi-Fi networks

	Wi-Fi	GXC
COVERAGE	3000-5000 sqft. per AP	16,000 sqft. per AP Indoor 500,000+ sqft. per AP Outdoor
ENVIRONMENT	Best suited for Indoor	Indoor + Outdoor
INTERFERENCE	Unlicensed / congested bands, only 3 non-over lapping channels available in 2.4GHz band	15 independent channel, managed network, cellular QoS
SECURITY	Vulnerable to intercept and impersonation attacks. Generally controlled by passwords	Employ carrier-grade, robust, protocols, end-to-end encryption. SIM-based authentication
LATENCY	Unpredictable latency	Consistent, lower latency
DEPLOYMENT	Designed for simpler radio environments, lower number of devices	Designed for complex environments, high (>200) number of devices supported per AP
HANDOVER	Best effort, proprietary solutions	Controlled handovers, decades of cellular development

Most current private cellular networks operate in the mid-band frequency band between 1 GHz and 6 GHz (commonly referred to as sub-6 GHz). Both 4G-LTE and 5G services use the Citizen Band Radio Service (CBRS) Channel 48, which operates at a carrier frequency of 3.5 GHz.

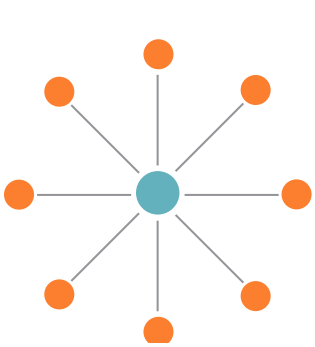
Selecting 4G-LTE or 5G private cellular is a business decision based on the required network bandwidth capacity and quantity of endpoint devices. There are currently fewer 5G endpoint devices in the marketplace, and unit prices are higher than those for 4G-LTE devices. However, as reflected in the Analysys Mason report, networks utilizing each option will reach parity by 2028, raising the likelihood that the 5G device costs will become more competitive. Platforms such as GXC ONYX offer simple in-situ conversion from 4G-LTE to 5G when needed.

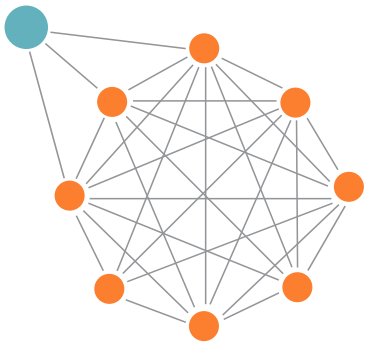
Figure 2: Share of private networks by technology, 2022 and 2028



Mesh Networks Extend the Value of Private Cellular

Before discussing mesh, it is important to understand how radio bandwidth is utilized in a typical wireless network—both Wi-Fi and cellular. Endpoint devices, whether a phone, computer, scanner, or robot, connect wirelessly to the access point (AP) with the strongest signal. In a traditional network configuration, each AP has a wired backhaul connection to the network uplink. When these physical connection points are not available or are too expensive to install, cellular mesh connectivity can be the answer.





GXC's core differentiating technology is its ability to connect Access Points wirelessly to provide ultra-dense, reliable networks without the need to build upon existing wired infrastructure.

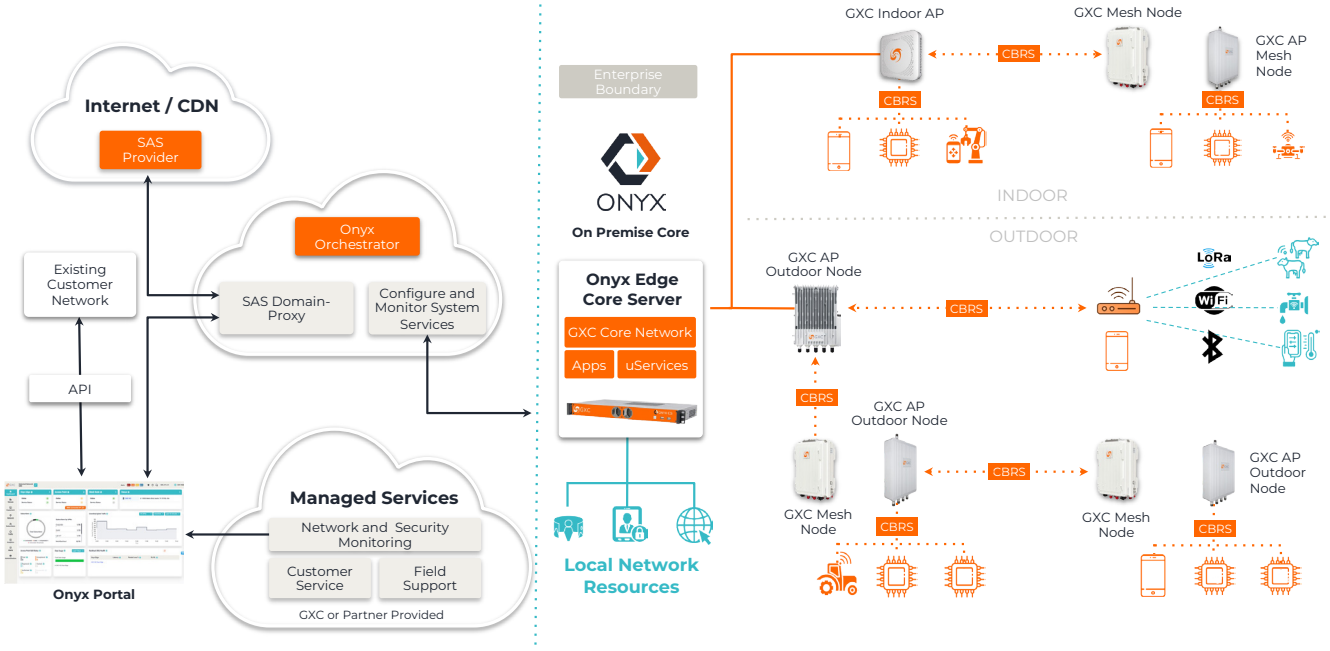
Hardik Jain
CTO, GXC

A cellular mesh network can reduce or eliminate cabled uplink connections by utilizing some of its bandwidth for backhaul and relayed connection to additional APs. GXC's Onyx Mesh utilizes its patented technologies, including dynamic interference cancellation and micro-second scheduling of transmit and receive functions, to potentially double the data capacity in each node and provide as much as 10x performance improvement in the network. In addition, its QoS-enforced, use-case driven performance flexibility is facilitated through the unique and enhanced transmit power management combined with directional antennas.

Operational Benefits of a Mesh Topology

Mesh deployments offer redundancy and mobility through the baked-in cellular features designed to hand off a device to the strongest AP signal. This enables the self-healing of a network in the case of an AP failure, as well as assuring that endpoints have reliable connectivity.

It is common for mesh and traditional wired AP networks to provide service in a complementary fashion. Selecting the best technology and AP modality to meet operational needs in each part of an industrial or remote site is simply good business. The Onyx network example (below) incorporates wired and wireless ethernet LAN elements as well as wired and private cellular mesh nodes.



Examples of Cellular Mesh Extension:

Revolutionizing Agricultural Research with Seamless Connectivity

An agricultural research center, spanning over 2,100 acres, needed a reliable wireless solution to support its advanced research in digital agriculture, precision farming, and autonomous equipment. The facility faced challenges maintaining connectivity across its vast area, impacting the efficiency of its research and data-sharing capabilities.

Challenges

The center's extensive size made it difficult to establish a stable connection between sensors, field machinery, and autonomous vehicles, hindering the seamless flow of critical data needed for ongoing research activities.

Solution

A private cellular network, enhanced with strategically placed mesh nodes, was implemented to optimize coverage and provide backhaul connectivity between key areas, including a repositioned Gateway AP at the main facility and a Mesh Node at the grain elevator. This configuration ensured consistent, high-speed connectivity throughout the site.

Results

The new network delivers reliable, high-speed coverage across the entire research facility, enabling real-time data collection, improved communication among devices, and advanced agricultural research. Its scalable design accommodates future research initiatives and evolving technology requirements.

Impact

The private cellular network has significantly enhanced the center's operational efficiency, supporting cutting-edge research and contributing to advancements in agricultural productivity and sustainability.

Enhancing Distribution Center Operations with Secure Private Connectivity

A distribution center and adjacent port terminal required a more reliable and secure network solution to support its inventory scanners and logistics operations across expansive outdoor areas. The existing public cellular network was inadequate for the facility's needs, leading to connectivity gaps and security concerns.

Challenges

The facility's remote location and extensive outdoor areas made extending the existing wired infrastructure prohibitively expensive. Inadequate public cellular coverage also posed challenges, while security requirements demanded a private network to protect sensitive data.

Solution

The deployment of a private cellular network with strategically positioned mesh nodes provided blanket coverage across the distribution center's parking areas and remote dock facilities. This solution delivered secure, high-speed connectivity for inventory management, eliminating reliance on public networks.

Results

The private cellular network was successfully deployed, meeting all performance and security criteria. It now supports reliable real-time data communication, enhancing inventory tracking and logistics efficiency while providing the flexibility to scale as needed.

Impact

The new network transformed connectivity at the distribution center and port terminal, improving operational efficiency, securing data, and enabling future expansion to accommodate additional devices and applications.

Flexible Mobile Network Solutions for Temporary and Emergency Connectivity

A mobile network solution was needed to extend reliable connectivity for various scenarios, including seasonal agricultural activities, large events, and disaster recovery. Traditional infrastructure posed challenges in deployment time and installation costs, making temporary or emergency setups impractical.

Challenges

Establishing connectivity in areas where fixed infrastructure is unavailable or cost-prohibitive required a flexible, quick-to-deploy solution that could deliver high-speed communication with minimal setup.

Solution

A vehicle or trailer-mounted cellular node access point was deployed to enable rapid network extension. The mobile solution supports seamless connectivity for managing autonomous farm vehicles, network extension at large events, and rapid recovery following a network failure.

Results

The solution offers quick deployment with minimal setup, ensuring immediate connectivity in critical situations. It supports a variety of use cases, from temporary setups to emergency responses, and eliminates the need for costly installations.

Impact

The mobile mesh solution significantly enhances operational flexibility and efficiency, providing a rapid deployment option for temporary and emergency scenarios, making it an essential tool for dynamic connectivity needs.

Private Cellular and Mesh Synergies Ease Enterprise Connectivity

Private cellular (4G-LTE and 5G) has been proven to solve real-world problems in applications where Wi-Fi is not a viable option, or in business environments that require consistent and cost-effective upload and download performance, which is challenging using public networks. By providing flexibility and local control through private cellular connectivity, the GXC ONYX Private Cellular Mesh solutions deliver unmatched extensibility and performance without incurring capital investment in construction and labor. In addition, GXC's Private Cellular Mesh gives enterprises the flexibility they need to quickly address evolving operational needs and confidently support the next generation of business applications that rely on consistent, secure, and cost-efficient connectivity.

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