

Mavenir's Private 5G Networks Deliver Trust, Performance for Industry 4.0

As regulators free up spectrum for private networks, manufacturing organizations are ready to own and manage these networks. Private 5G enables industrial automation, edge analytics and a powerful technology ecosystem



Industry 4.0 represents the digital transformation of the physical infrastructure on the factory floor. Industry 4.0 systems draw on big data and data analytics, simulation, artificial intelligence (AI), robotics and other emerging technologies to carry out complex processes efficiently and accurately. These processes draw on AI to make judgment calls, which means manufacturing operations can be optimized for maximum output and profitability.



Industry 4.0 needs a network that offers predictable performance, with low-latency and high throughput with high reliability, and quality-of-service (QoS). Private 5G networks provide this connectivity, offering all the benefits of public 5G networks dimensioned to support manufacturing and enterprise uses.

Authors

Aniruddho Basu,
SVP and GM, Emerging Business,
Mavenir

Anil Keshavamurthy,
Principal Engineer, Intel Corporation

As regulators around the world designate segments of the spectrum for use in private implementations, Mavenir—an Intel® Network Builders ecosystem member—is stepping up with private 5G technology for enterprises and communications service providers (CommSPs). Mavenir's MAVedge end-to-end private 5G networks for enterprises and industry, coupled with Intel® Xeon® Scalable processors and Intel's suite of Intelligent Edge and 5G technologies, provides a complete solution for greenfield networks or to evolve existing wired networks to the benefits of 5G. Moreover, setting up and managing the cellular network is easy with the Mavenir/Intel solution.

5G is enabled by the Intelligent Edge, a distributed computing strategy that enables organizations to process application data in the location that delivers the most value—which is often not in a data center or the cloud. 5G connectivity makes this practical, enabling near-instant communications between computing at the edge and the devices within an industrial environment, while AI enables automated decision-making.

Industrial PCs provide built-in support for time-sensitive networking (TSN) and time coordinated computing combined with AI and functional safety. These platforms enable distributed intelligent nodes connecting to cellular base stations.

Private 5G For IIoT Market Landscape

The hard-wired connections that have historically kept industrial operations linked are not always capable of meeting the demands of Industry 4.0. They require fixed equipment locations and expensive cable connections. Both unlicensed Wi-Fi and licensed cellular networks provide much greater flexibility. Wi-Fi and 5G coexist in many enterprise environments, where organizations are using each technology to its best advantage. Advancements in Wi-Fi 6E supporting low-latency capabilities are making Wi-Fi more suitable for industry 4.0 use cases.

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Figure 1. 5G brings significant advantages for Industry 4.0.

The Manufacturing Leadership Council—part of the U.S.-based National Association of Manufacturers—lists six Industry 4.0 requirements that legacy communications cannot always easily meet at the necessary scale:¹

- **High data rate:** Uninterrupted throughput of at least 25 Mbps.
- **Wide coverage:** Must be able to accommodate complex environments, including metals and electromagnetic interference.
- **Low latency:** Real-time controls, machine-to-machine communications and autonomous operations are difficult to maintain unless latency is minimal.
- **High reliability:** Packet loss must be as low as possible.
- **High security:** Industry is an attractive target for cyberattacks. Communications must be tightly secured.
- **Scalability:** As the number of connected devices increases, scaling up becomes too complex for wired communications to meet in a cost-effective way.

5G provides the low-latency, highly reliable, secure and scalable networking that Industry 4.0 demands. Low latency is necessary for time sensitive networks (TSN) over 5G,

which enables distributed time-sensitive applications in new markets. A private 5G network also provides better device density than other alternatives.

5G supports both sub 6GHz and higher frequency millimeter wave (mmWave) transmission, making the protocol highly adaptable. Sub 6GHz, also called mid-band 5G, offers long range and high throughput (up to 900 Mbps), while mmWave's higher frequencies provide faster throughput but much shorter range. Industry 4.0 use cases can look to mid-band 5G for communications between facilities and mmWave for maintaining a powerful internal network. Specifically, mmWave's short range and ability to use multiple small cells to route signals around obstacles fits well within a manufacturing or other industrial environment.

Because 5G networks based on vRAN are heavily virtualized, hardware investments are significantly reduced compared to older network technologies, and network functions are easily scaled to meet increasing demands. The virtualization also enables managing the network as an IT workload, supporting cloud-native application deployment and orchestration.

Private 5G For Industry 4.0—Why Now?

The time is right for industries to begin or accelerate a transition to Industry 4.0 and private 5G, for several important reasons.

Industry 4.0 operations are proving their return on investment (ROI), measured by improved quality, lower costs of operation and safety assurance of the workforce. According to researchers for the European Center for Power Electronics in Nuremberg, Germany, Industry 4.0 could reduce costs of production and logistics by up to 30%, and quality management costs by up to 20%, achieving these metrics by lowering risks to workers. Industry 4.0 also enables shorter time to market for new products, and the ability to carry out custom mass production projects with no significant increase to overall production costs.²

In addition to the financial benefits, the possibility of converging fragmented industrial wireless communications networks, such as Wi-Fi, Bluetooth, Digital Enhanced Cordless Telecommunications (DECT) and Global Positioning System/Ultra Wideband (GPS/UWB), into a single seamless network appears easy to understand for some manufacturers as they examine the viability of private 5G in their factory to address the following challenges:

- Continuous information flow across the factory floor
- Uniform, fast and flexible data processing
- Real-time coordination

Moreover, regulators have begun opening broadband spectrum licenses to industries beyond mobile network operators (MNOs), a key step toward enabling Industry 4.0 to meet its potential.

The U.S. Federal Communications Commission opened the door to private 5G networks in 2015, when it adopted rules for shared commercial use of the 3550-3700 MHz band, also known as the 3.5 GHz band. In the process, it created the Citizens Broadband Radio Service (CBRS) and created a three-tiered access and authorization framework. Some enterprises bought licenses to use the spectrum in a 2020 spectrum auction.

German telecoms regulator BNetzA has reserved 100 MHz in the 3700-3800 MHz range for private networks and has awarded more than 120 licenses to industries.^{3,4} ARCEP, the regulator in France, has also begun granting licenses to companies interested in private networks.⁵ Japan's telecommunications ministry began accepting applications for private 5G spectrum late in 2019.⁶ Other countries are taking similar measures, finding strong interest from companies.

A third factor in 5G's readiness for Industry 4.0 is the July 2020 issuance of 5G Release 16 from the 3rd Generation Partnership Project (3GPP), which brought a long list of new capabilities that enable support for various vertical markets, including manufacturing. This is the first release that has empowered 5G support for license-exempt bands and private networks. Release 16 marks the 5G debut of Ultra-Reliable Low-Latency Communications (URLLC), which enables support for guaranteed levels of reliability and latency.⁷ This means 5G now provides low latency and ultra-reliable deterministic capabilities for industrial control systems and data traffic. Release 16 also brings precise location capabilities, enabling 5G networks to pinpoint the location of 5G-enabled devices to within 3 meters indoors, a key capability for Industry 4.0.⁸

Industrial protocol support is important for a successful network. There are at least 16 proprietary industrial protocols with more than 1% market share with the most popular protocol reaching 17% of the market.⁹

Companies build deterministic, industrial networking products and ecosystems around these protocols, but because they are not interoperable, customers are locked into that system. System and maintenance costs are high, and innovation is slow due to the small ecosystem. In response, TSN is becoming the standard Ethernet-based technology for converged informational technology (IT) and operational technology (OT) networks of Industry 4.0.

TSN together with 5G URLLC capabilities can provide low latency end-to-end deterministic connectivity over heterogeneous networks. Industrial protocols ported to run on top of TSN can co-exist and operate on common network infrastructure thus eliminating islands of proprietary networks.

The Open Platform Communications (OPC) Foundation has started work on the Open Platform Communications—Unified Architecture (OPC UA) protocol to establish an interoperable industrial networking protocol.

OPC UA utilizes a multi-layered architecture that is “future proof” by virtue of the ability to add innovative new technologies, transport protocols, security algorithms, encoding standards, or application-services. All of these can be incorporated into OPC UA while maintaining backward compatibility for existing products.

OPC UA is a platform-independent, service-oriented architecture that ensures that the many individually connected components in a factory can communicate seamlessly with each other. OPC UA also features a suite of security controls to allow firewalls to operate effectively in the connected environment. OPC UA working groups are preparing to support deterministic unified architecture and 5G transport mapping in future releases. This will enable wireless connectivity for machines using these protocols. The new PubSub extensions to OPC UA add the possibility of many-to-many communications based on publish / subscribe paradigm while providing end to end time-deterministic communication.

Figure 2 shows UE capable of supporting 3GPP Release 16 URLLC feature combined with TSN allows multiple real-time protocols such as Profinet, CC-LinkIE TSN and OPC UA all simultaneously operating on the same network providing the needed time-deterministic communication across heterogeneous networks. In this case, the 5G system is simply acting as a virtual TSN switch to either end of Ethernet TSN domains. Any real-time protocol optimized to run on an Ethernet TSN network runs unmodified with 5G network in between the Ethernet TSN domains.

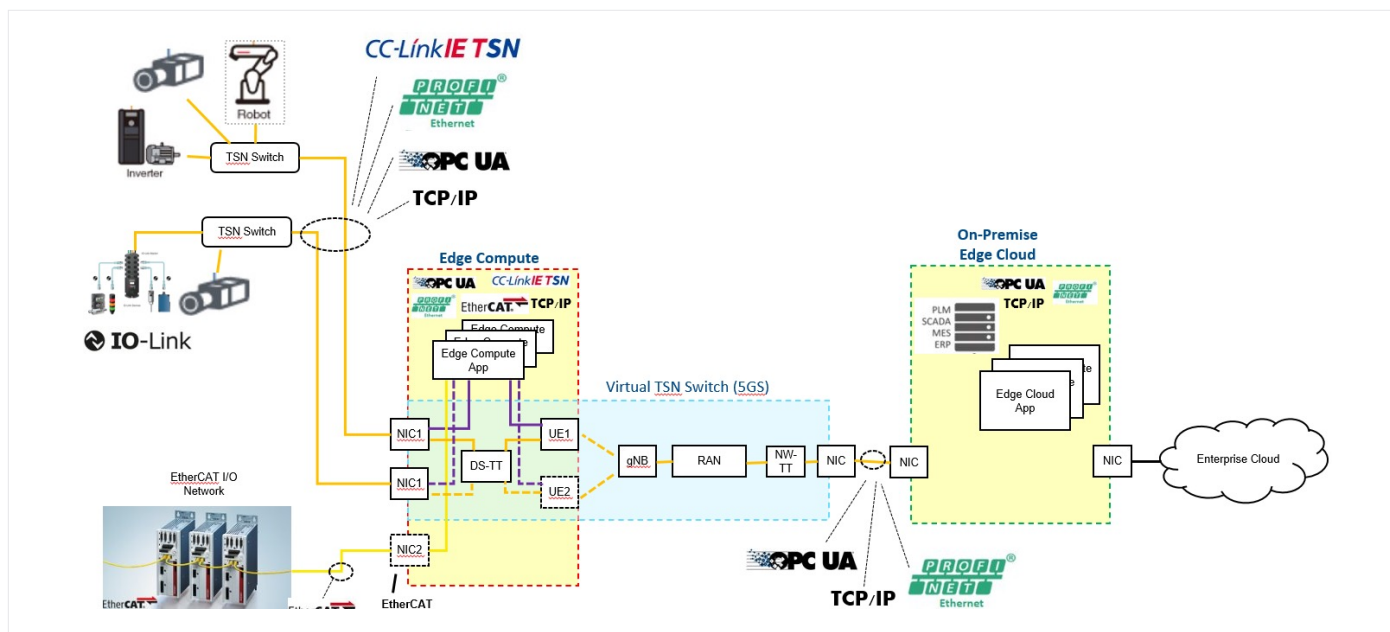


Figure 2. This diagram demonstrates how multiple real time protocols can reside on the common infrastructure reducing TCO and simplifying network complexity as both OT and IT traffic use same underlying infrastructure.

Mavenir Provides Complete Private 5G Solution

The vision of Industry 4.0 is a lively manufacturing environment that creates fast, efficient operations with high levels of quality assurance and worker safety. Edge AI enables advantages such as accurate supply and demand forecasting, operational process automation and automated field inspection using sensors, unmanned aerial vehicles and other tools. It's the intelligence that truly qualifies Industry 4.0 as a revolution, but it is networking and computing power that enables it.

Mavenir's MAVedge leverages this industry momentum with a complete system to enable private 5G for Industry 4.0 applications. It is a software-based private 4G/5G network solution running on Intel architecture commercial off-the-shelf (COTS) hardware.

Key elements of the MAVedge solution (see Figure 3) include O-RAN Alliance compliant virtual RAN, edge compute capabilities for high-performance user plane function (UPF) processing, a complete cloud native 5G core that can connect the private network to any network, and an ecosystem of applications such as in-stream video analytics, IoT, messaging

and others provided by both Mavenir and its partner ecosystem. This functionality is supported by a cloud-native web scale platform and complete management and analytics.

Mavenir's Open RAN radio units provide 4G and 5G radio access for outdoor, indoor, enterprise, and neutral host environments to address coverage needs for any private network deployment. The solution features a range of 5G standalone (SA) products that are Open RAN and Neutral Host compatible and cater to specific geographies and applications.

Mavenir's cloud-native 5G Packet Core, based on Mavenir's web scale container platform, gives enterprises the flexibility to deploy cellular networks on their existing on premises or cloud data center infrastructure. 5G service based architecture (SBA) allows instant scaling of compute, storage and network functions as the demands on the network evolve.

An ecosystem of applications caters to all use cases, allowing enterprises to gain insights from data to improve business decisions. Edge computing and ultra-reliable low latency unlock new enablers such as VR/AR and haptic feedback for remote expert inspection and maintenance, and new forms of entertainment.

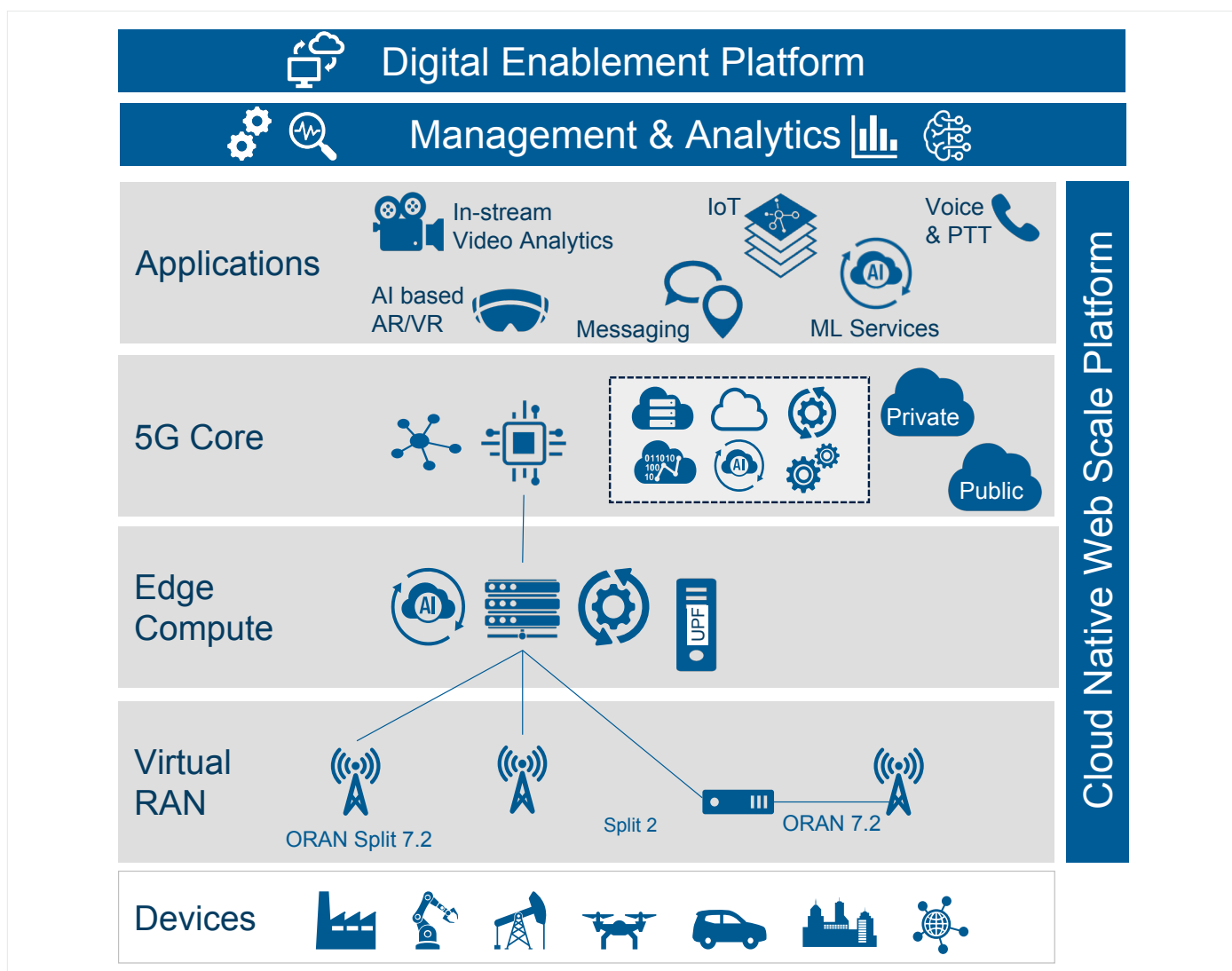


Figure 3. Mavenir MAVedge components, ecosystem and architecture.

Intel 5G Technology

Intel is a trusted partner in transforming the telecom network into a software-defined, agile and scalable infrastructure. The company has built on this expertise to deliver key 5G technologies including optimized private 5G vRAN solutions.

Servers based on 3rd generation Intel® Xeon® Scalable processors are an ideal complement for MAVedge in private 5G applications. This CPU family benefits from decades of innovation for the most common workload requirements, supported by close partnerships and deep integrations with the world's software leaders and solution providers. For organizations ready to drive 5G networking to the next level, 3rd generation Intel Xeon Scalable processors boost network performance with CPU models featuring up to 40 cores and a wide range of frequency, feature, and power levels.

The RAN is undergoing dramatic change from a closed to an open architecture. Intel has developed key technologies for very high RAN performance including FlexRAN™, Intel® vRAN Dedicated Accelerator ACC100, and enhanced Intel® Select Solutions server reference designs.

Intel offers the silicon, software and tools needed to bring the full performance and value of 5G to life.



Mavenir's fully automated network management system offers a single interface for all network management and analytics needs:

- Remote Radio Unit, O-RAN components of 5G NR, Cloud Native Packet Core Management
- Remote monitoring and remote debugging
- Fault monitoring and alarm notifications

In addition, zero touch provisioning simplifies the radio deployment, allowing the radios to autonomously connect to the network and retrieve their configuration information.

The system adheres to cloud native design principles for scalability and can be flexibly deployed on the edge or in the cloud, or on customer premises.

The private 5G network enables enterprises to strategically distribute computing power, applications and resources across the intelligent edge, ensuring that apps and resources are where they need to be at any given moment to efficiently handle demands. This reduces reliance on centralized data centers and facilitates the ultra-low latency the intelligent edge requires.

On-site management is greatly simplified in MAVedge, with fully automated deployment and management (see Figure 4). The MAVedge solution features an orchestration layer that provides zero-touch provisioning, automation and easy management. Global manufacturers that run multiple factories in multiple locations within a given geography can manage multiple instances of private network all from a single management interface.

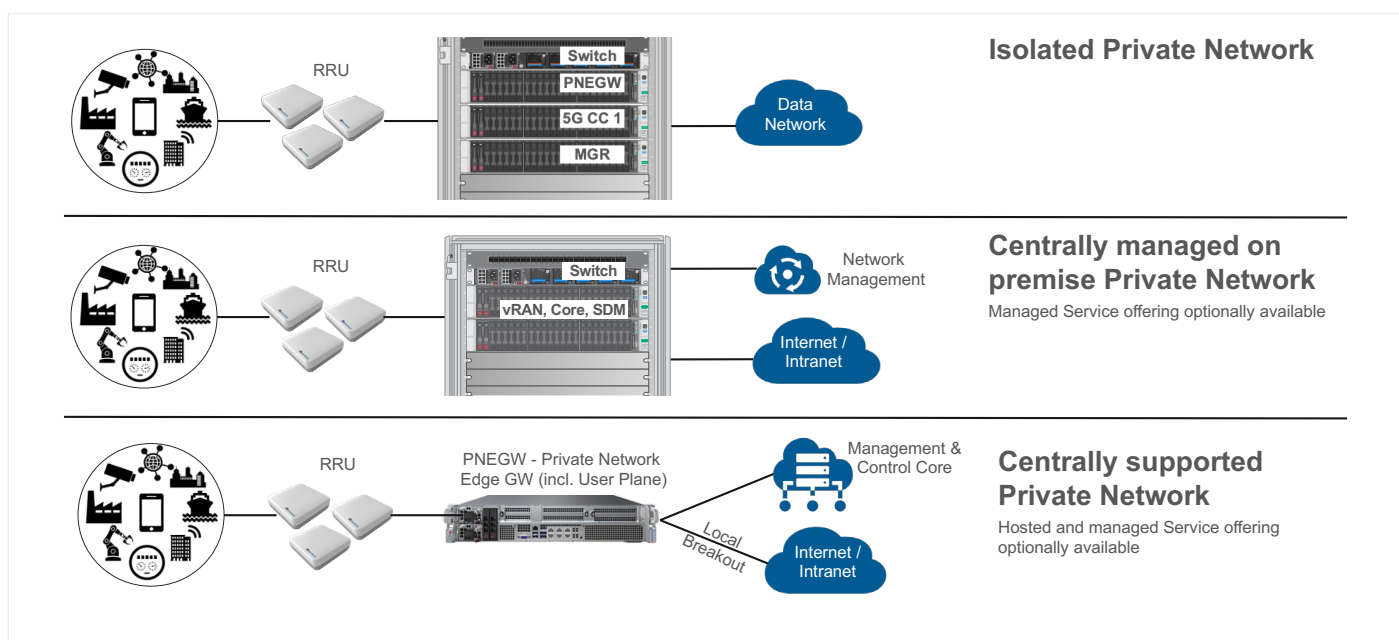


Figure 4. MAVedge deployment scenarios.

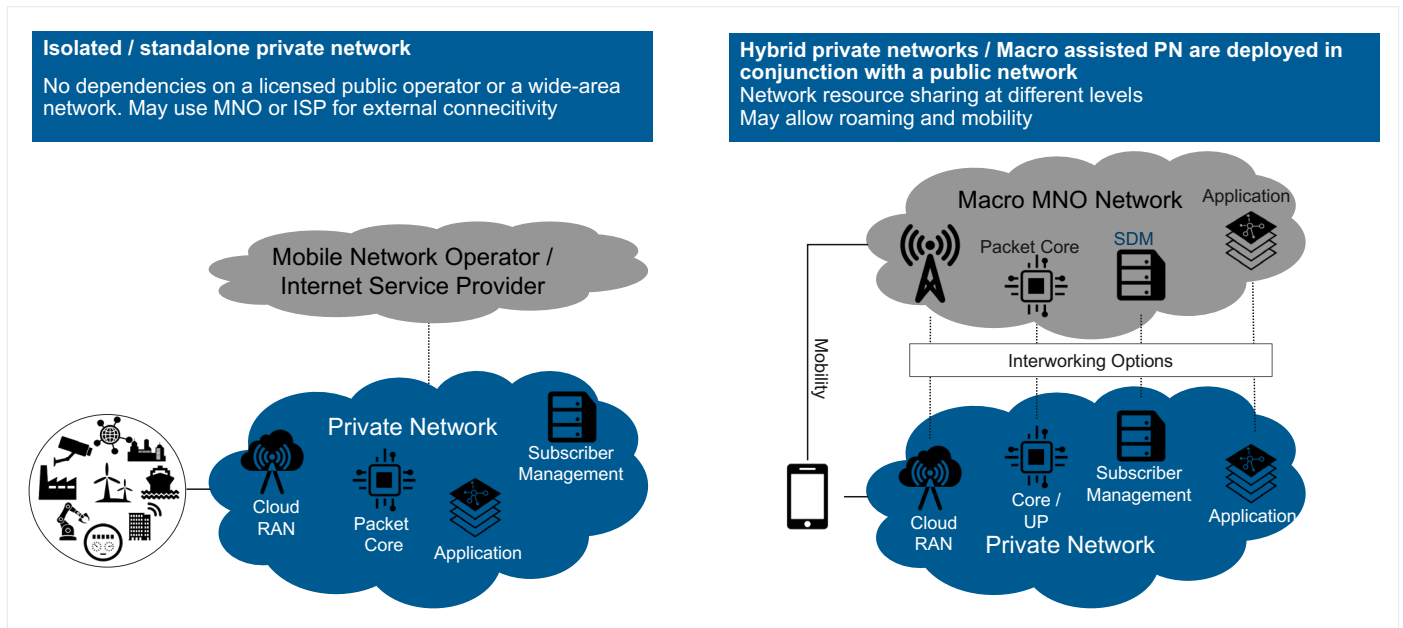


Figure 5. Independent private networks remove dependencies on outside providers, but an MNO model is still versatile and capable.

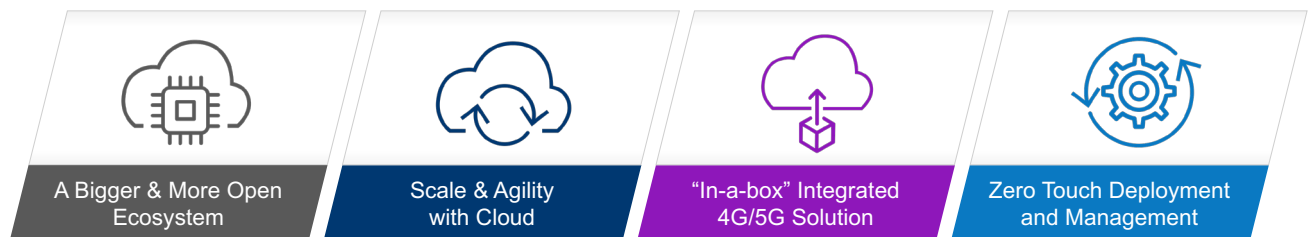
In geographies where enterprises own their spectrum, it is possible to deploy fully isolated private networks owned and operated by the enterprise. In other geographies, where a manufacturing owner obtains a spectrum slice from a carrier, infrastructure is shared with public network enabling the server and data to be kept within the factory where it is easily accessible and secure. (See Figure 5.)

An ever-growing number of Mavenir and third-party remote radio unit (RRUs) are available for the MAVedge solution covering radio frequencies for both frequency range 1 (FR1; 410 MHz to 7.125 GHz) and FR2 (24.25 – 52.6 GHz). Radios are also available for indoor and outdoor, and with enough power to allow the system to perform optimally even in environments with significant barriers to transmission, such as heavy equipment and electromagnetic signal interference.

Mavenir Four Architecture Pillars for Private Network Solutions

Mavenir has architected MAVedge, and its full portfolio of Multi-G solutions for private networks, based on four pillars:

- **Open architecture:** Supports broad ecosystems, including digital marketplace of device and application partners using OpenRAN. Supports multiple deployment topologies, including multi-access edge computing (MEC).
- **End-to-end distributed cloud-based capabilities:** Completely cloud native with fully open architecture. All elements are cloud enabled Kubernetes based containerized architecture.
- **In-a-box integrated solutions:** Mavenir's private 4G/5G networks can run in isolation, with no reliance on external data centers.
- **Fully automated deployment and management:** To save CAPEX/OPEX, Mavenir offers single pane of glass view of all solution components, remote monitoring, service assurance and diagnostics. Zero-touch network orchestration balances the needs of multiple micro services and applications within defined parameters and a given load.



Mavenir's Private Networks Value Proposition

Virtualization Provided by Mavenir Webscale Platform

Mavenir Webscale Platform (MWP) is a key element of MAVedge. 5G demands networks that are highly adaptable and scalable and that feature zero-trust security functionality, scalability and a high degree of automation. MWP is the component that powers those features in MAVedge.

MWP is a next-generation cloud-native solution that includes Kubernetes based containers as a service (CaaS), platform as a service (PaaS) and Mavenir's own telecom PaaS layer called Mavenir Telco Cloud Integration Layer (MTCIL). In addition, there's a management layer that includes full fault, configuration, accounting, performance and security (FCAPS), analytics, slice management and service orchestration.

Building An Ecosystem

MAVedge uses Open RAN open interfaces standardized by the O-RAN Alliance to enable an entire ecosystem of applications and devices. Open RAN allows different hardware and software providers to interoperate easily. Mavenir leverages this capability with its own roster of application and device partners, each of them contributing 5G or Industry 4.0 components that easily integrate into the network.

Mavenir's partner network spans a wide range of technologies, including Industry 4.0 and private 5G-enabled software, radios and devices. All of the ecosystem solutions are integrated with MAVedge to ensure interoperability and to simplify deployment.

Conclusion

Industry 4.0, powered by the secure, low-latency, high-reliability deterministic edge network, private 5G, robotics, AI, IIoT and other capabilities, promises to completely overhaul the technologies and processes that support industrial operations. This revolutionary manufacturing approach promises a positive return on investment driven by improved quality, manufacturing flexibility and reduced costs. Private 5G provides the pivotal connectivity that will enable Industry 4.0. Mavenir and Intel are leading the way with MAVedge private 5G network that provides deterministic and high-throughput connectivity, designed to drive Industry 4.0 initiatives.

Learn More

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¹ <https://www.manufacturingleadershipcouncil.com/5g-and-smart-manufacturing-16489/>

² <https://www.online-journals.org/index.php/i-jim/article/view/7072/4532>

³ <https://enterpriseiotinsights.com/20210607/5g/german-regulator-already-awarded-123-private-5g-networks>

⁴ <https://inform.tmforum.org/insights/2021/01/hard-talk-recap-the-private-5g-network-surprise/>

⁵ <https://5gobservatory.eu/5g-private-licences-spectrum-in-europe/>

⁶ <https://www.rcrwireless.com/20191219/5g/japan-award-licenses-local-5g-networks-soon-report>

⁷ <https://blogs.intel.com/technology/2020/08/realizing-the-promise-of-5g-via-release-16/#gs.5j49tq>

⁸ Ibid.

⁹ <https://www.hms-networks.com/news-and-insights/news-from-hms/2020/05/29/industrial-network-market-shares-2020-according-to-hms-networks>

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