GSMA Intelligence

RADAR

Private 5G networks: time to scale up

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Published September 2024

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This report was conducted by GSMA Intelligence and supported by sponsor Intel.

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Executive summary

There has been plenty of momentum for private wireless networks through to the middle of 2024. Not only are there now more deployments around the world, but there is also a healthy dose of realism that seems to have seeped into the industry. Several major markets are increasingly opening up spectrum access to enable private network deployments and new business models. That said, private 5G is still largely a local affair, as specific countries' policies will largely determine the momentum for private 5G and the flavour of private wireless that is finally deployed.

The market for private networks, and private 5G in particular, is growing at an impressive rate as enterprises increasingly engage ecosystem players, including telecoms operators and systems integrators, to set up private wireless networks. Industry attention is increasingly focused on filling the gaps in the private wireless proposition and, in this sense, this is also a maturing industry segment. Private 5G will continue to gather steam, with multiple vendors doubling down on their investments. But the value points are shifting away from the radios and mobile cores, which are now table stakes, towards the distributed edge and seamless orchestration of workloads across enterprise information technology (IT) and operational technology (OT) environments.

There is tremendous diversity among enterprises, not just in terms of their size and workloads but also the types of use cases that they are trying to enable. Increased coverage in enterprise sites has been a key unique selling point (USP) of private wireless networks. Ultimately, however, coverage will be a composite of cellular coverage as an overlay over existing networks, including legacy Wi-Fi that has been installed in certain areas. The private network will ideally cover all serviceable areas and manage diversity in networks.

There is also significant variation in the type of deployment models that are appearing around the world. Spectrum is still a critical building block, and how local regulators approach spectrum availability and licensing is playing a key role in shaping the pace and quality of deployments. But this diversity also means a lot of complexity and as a result there is a shift in the competitive landscape towards systems integrators as a key partner for enterprises. Systems integrators already have existing relationships with enterprises and are increasingly stepping up to lead on private wireless networks. There are, however, several larger telecoms operators that have made great strides in this regard, including the main Chinese operators and others such as Singtel, Telstra and Verizon.

The diversity of enterprise requirements also means that one size does not fit all cases. This has manifested in a few large vendors, such as Nokia and Ericsson, and a very long tail of smaller suppliers. One clear example is the vast number of providers for mobile core software, from industry pioneers such as HPE Athonet to companies such as Celona and Druid Software. Many of these players have based their solutions on Intel's FlexRAN reference architecture, which has been a key enabler of solutions catering to enterprise requirements.

The real value in private 5G will be in the edge cloud solution that gives enterprises the flexibility to deploy workloads and handle processing on-premises. In some cases, workloads will also be segregated for processing through multi-cloud connectivity to public or private clouds. In 2024, other key areas of innovation in the private wireless network space include seamless orchestration of workloads, increased focus on security to beyond access point names (APNs) and full visibility of connected endpoints.

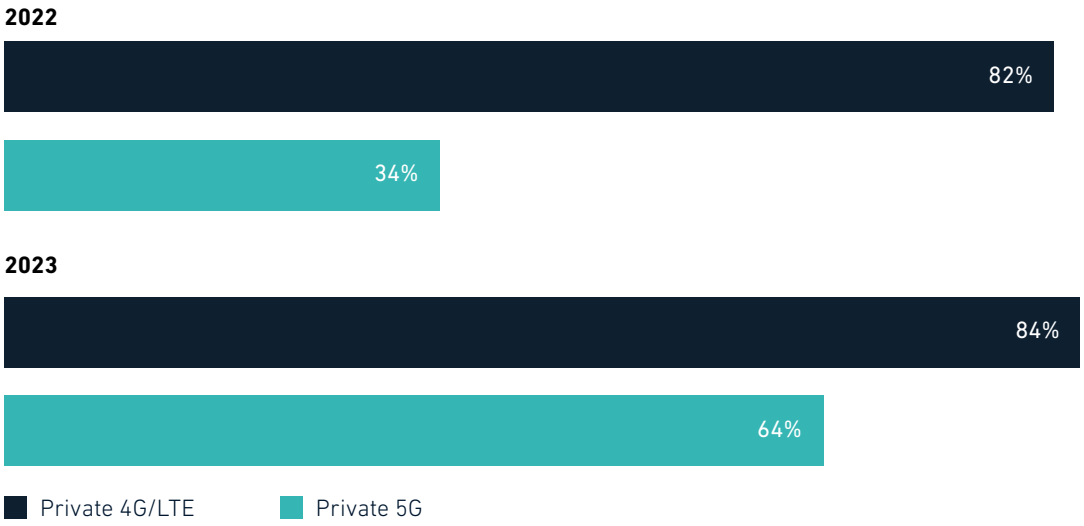
1 Market update: momentum continues, but scale is needed

There continues to be demand for private wireless deployments across a range of sectors, with companies seeking customised connectivity to meet bespoke needs. This means that operators with existing LTE-based private networks have a competitive advantage to the extent that they can rapidly deploy private 5G networks using a non-standalone (NSA) architecture, with 5G radios and an LTE core. Eventually, the NSA network can be upgraded to 5G standalone (SA) to provide end-to-end 5G connectivity.

The numbers tell a clear story. There is strong momentum for private 5G deployments, regardless of whether they are being deployed by operators, systems integrators or enterprises directly. The number of mobile operators deploying private 5G serves as a useful proxy for gauging momentum. While a strong majority of operators (84%) have private networks in operation, there has been a noteworthy change over the last 12 months in the proportion of those that have added 5G into the offering. Now just under two thirds of operators have deployed private 5G, which is double the comparable figure a year ago (see Figure 1). This has been helped by the growing share of 5G SA networks, which are required for the low-latency benefits of 5G, and growing amount of high-capacity spectrum.

Figure 1

Share of operators that have deployed private wireless networks



Source: GSMA Intelligence

Despite regional variations, several markets around the world have made significant progress in the development of private wireless networks:

North America:

- Each of the three major operators – Verizon, AT&T and T-Mobile – have live deployments in place and have made private wireless a priority as a means of selling 5G to enterprise customers.
- The market is bifurcated into two broad camps between those using licensed (run by the operators or vendors) and unlicensed spectrum. The latter model has heavily leveraged Citizens Broadband Radio Service (CBRS) frequencies.
- The outlook is buoyed by demand from defence (for example, the US military is required to install private networks at all bases worldwide, of which there are around 800), transportation and professional sports (such as Verizon's deal with the National Hockey League for private 5G within arenas).

Europe:

- Key markets for private wireless activity include Germany, France, the UK, Spain and the Nordic countries.
- While typical enterprise sectors such as manufacturing and services (financial services and media) exhibit the main use cases, larger deployments have been made in critical infrastructure projects such as in construction, mining, airports, ports, healthcare clinics and hospitals.

Asia:

- South Korea continues to be a leader in private network development, with the country's Ministry of Science and ICT (MSIT) reporting that private 5G is operational in 48 locations, marking a substantial increase from 2022. The main use cases in South Korea involve shipbuilding, logistics, healthcare, manufacturing and energy.
- In China, the three largest telecoms operators lead in the implementation of private networks, encompassing private 4G and 5G. Globally, China leads in terms of volume of private 5G deployments, with differing accounts from the regulator and other sources, putting the total number of deployments at over 30,000.

2 Do enterprises need 5G?

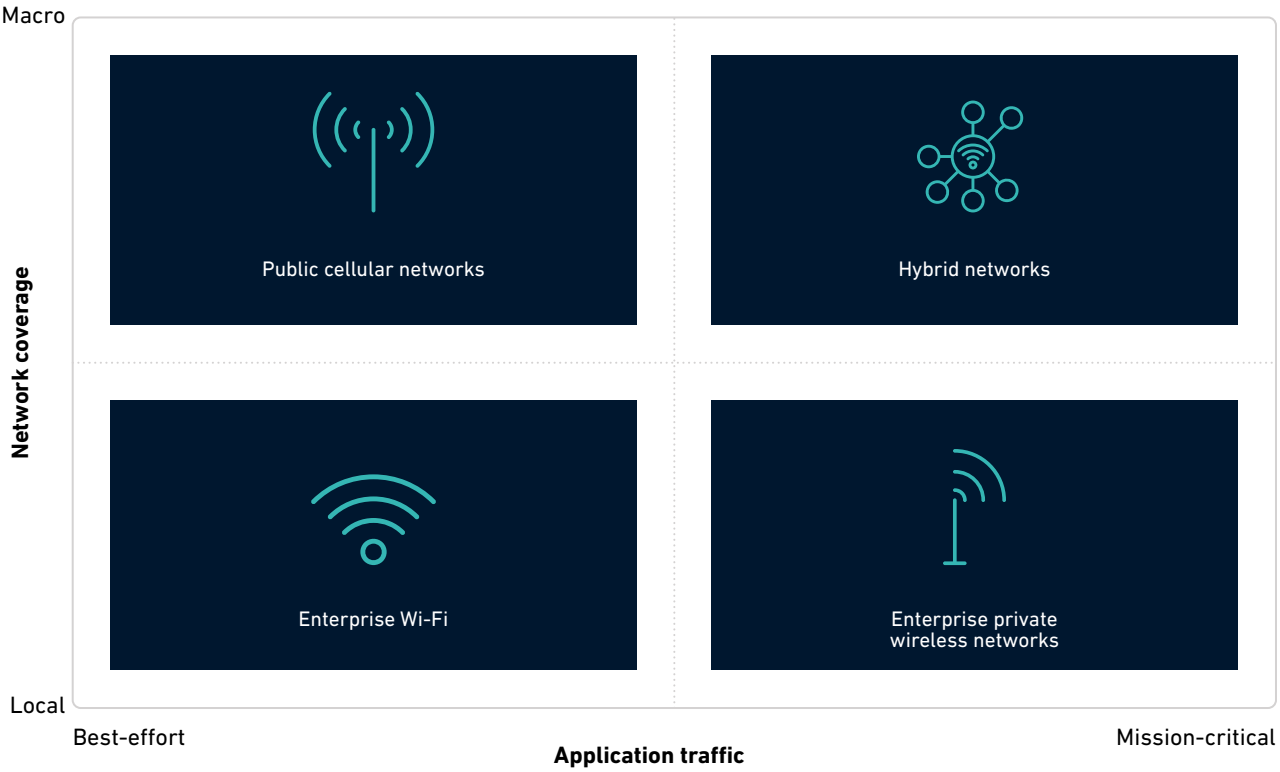
It is important to define private wireless networks, as they have existed for some time and are not always based on cellular technologies. For example, Wi-Fi networks are also private at their core, utilised for highly localised use cases in either residential or enterprise settings.

The 3rd Generation Partnership Project (3GPP) has defined private networks as non-public networks (NPNs), with the primary distinction that these networks would not operate on the 'public' wide-area network typically run by incumbent telcos but rather networks that are smaller in scale and for the 'private' requirements of an enterprise. Most private networks fall into the category of standalone NPNs (SNPNs): the GSMA defines this as "a self-contained standalone network, which is operated by an industrial operator with leased, unlicensed or privately licensed spectrum, which is blocked for access outside the enterprise". There are also other categories of private 5G networks that will feature integration between private and public networks.

Beyond the definitions, enterprise end users need to consider the number and category of use cases that might require a private wireless network. The first aspect is whether the use cases can be enabled with best-effort connectivity or require mission-critical connectivity. The second aspect that enterprises need to consider is whether these use cases can be serviced with network coverage that is 'local' or if they need macro networks to offer much broader coverage. Figure 2 presents a framework for analysing these choices and trade-offs for an enterprise.

Figure 2

Use case framework for private wireless networks



Source: Mandala Insights, GSMA Intelligence

Most enterprises with digital transformation projects underway will see emerging use cases in the lower right quadrant in Figure 2 ('local' networks and mission-critical use cases). However, use cases can also spread into wider mobility scenarios, which would push them into the upper right quadrant with hybrid network deployments.

2.1 The USP of private wireless networks

Private networks offer enterprises several key advantages and benefits over legacy cellular and Wi-Fi networks that have been deployed by enterprises.

Greater coverage with a smaller footprint

Private wireless networks help enterprises achieve nearly full coverage of their sites, across both indoor and outdoor scenarios. A given area can be covered with far fewer cellular radios (small cells) compared to Wi-Fi access points. An early example of this was Rio Tinto, a mining giant in Australia, replacing over 30 Wi-Fi access points with four LTE base stations. Similarly, Nokia's smart factory in Chennai replaced 52 Wi-Fi access points with two LTE base stations. With 5G private wireless networks, there will be a similar effect. The smaller number of base stations has significant implications in terms of a lower total cost of ownership for the enterprise. As the Nokia factory example suggests, the cost of 5G radios relative to Wi-Fi access points is significantly lower, especially when factoring in the added cost of fibre connectivity to the Wi-Fi access points.

Greater coverage enables more use cases at enterprise sites, including use cases with a high degree of mobility or stationary assets that are in hard-to-reach areas. Ultimately, though, coverage will be a composite of cellular coverage as an overlay over existing networks, including legacy Wi-Fi that has been installed in certain areas. The private network will ideally cover all serviceable areas and manage diversity in networks.

Handover capability to enable mobility use cases

One of the major challenges with legacy Wi-Fi coverage is the inability to track and communicate in real time with moving endpoints, whether these assets are products or people. Cellular technologies such as LTE and 5G provide handover capabilities for the endpoint as it moves from one area of the site to another, whether this is indoors or indoors to outdoors. Handover capabilities are enabling use cases such as asset tracking, inventory control and management and autonomous vehicles such as automated guided vehicles (AGVs). For example, an AGV requires latency of below 10 milliseconds as well as handover capabilities to enable seamless movement across a factory or premises floor. In a busy factory or warehouse, the volume of AGVs could number in the hundreds, making the latency and handover requirements paramount. These requirements can be much better serviced by 5G relative to Wi-Fi.

Configurable quality of service

Legacy technologies such as Wi-Fi are essentially best-effort connectivity and are a shared resource for all endpoints within the coverage area. 4G LTE is a step up from best-effort connectivity, but there is still no ability to 'configure' the network to enable differential access to different endpoints. For instance, a 5G network can allow CCTVs and 4K camera feeds to utilise a higher uplink data throughput. As another example, a 5G network can enable a worker safety use case that creates a geofence around a hazardous area that must be provided with the lowest latency possible to enable real-time warnings.

Operable in harsh environments

There are a number of industry verticals that are saddled with harsh environments. These include energy sectors such as oil and gas, transportation, aviation and mining, all of which frequently involve areas that are challenging for stable connectivity. Even manufacturing poses unique challenges for connectivity due to the existence of heavy machinery, no clear line of sight and obstructions, among other issues. 5G private networks can overcome these challenges by using techniques such as spatial diversity and coordinated multipoint (CoMP) to overcome blocking and achieve the demanding availability targets.

Localised control of assets and data

In combination with configurable networks, enterprises can also deploy compute resources on-premises and secure their networks at the local site level. The ability to do this in a secure manner allows enterprises to collect and analyse data and deploy new use cases. Use cases that are mission-critical and need low latency for real-time decision-making can be processed locally. This has the added advantage of keeping sensitive data on-premises, building security for devices and endpoints deployed on site, and saving significant costs related to data transfer to a centralised public or private cloud.

Improved cost effectiveness through productivity gains

Productivity enhancement has become an imperative for enterprises, especially those in verticals that have been disrupted by 'digital' players. Enterprises in manufacturing, for example, have been attempting to make their production lines smarter with a view to drive more efficiencies in assembly lines and broader factory operations. Having previously embraced wireless/mobile technology in a fragmented manner, enterprises are now aware of and evaluating the potential to enhance and extend their wide area networks with wireless connectivity technologies such as 5G, Wi-Fi 6 and even NB-IoT. Private wireless networks also generate savings in other areas. For example, manufacturing companies moving to private networks can eliminate the expensive cabling that is required for connectivity to each machine while also cutting down on energy consumption.

2.2 Key drivers for private 5G

Global momentum for private wireless networks has benefited from several key drivers and trends that have manifested both at a global level and at a local level within individual countries with their own contexts. Private networks are not a new concept and have been attempted before, but they have never scaled up beyond the point-solution level within enterprises.

Enterprise digital transformation

The post-pandemic enterprise landscape is increasingly defined by digital transformation, which is fuelling a productivity drive led by digitalising workflows and operational processes. The productivity imperative is even more acute when one considers the sharp dichotomy between traditional industrial enterprises and faster-moving industries led by technology and IT companies. There is also a prevalent between enterprises in developed economies and enterprises in emerging economies.

Digital initiatives within the enterprise segment are creating new use cases, which could not be implemented earlier for a variety of reasons. In some cases, this was an issue of coverage with either no cellular coverage or inadequate Wi-Fi coverage indoors. In other cases, it was an issue of specific features of existing technology that could not cater to the needs of the use case.

Increasing availability of spectrum

Spectrum allocation, or more specifically access to reliable spectrum, is the most essential and crucial building block for a private wireless network. Several countries have enabled private networks over existing cellular frequencies, while others have carved out frequencies for either dedicated use by enterprises (Germany) or shared access (the US with CBRS).

Germany has been notable in giving dedicated spectrum exclusively to enterprises. GSMA Intelligence research indicates that spectrum set-asides do not necessarily drive deployments and have unintended consequences on infrastructure development. The US has been the pioneer of enabling shared spectrum models with its CBRS frequencies in the 3.5 GHz bands. In Asia, countries such as Japan, South Korea and Taiwan have issued 5G licences for mobile operators in 3.5 GHz but have also allocated spectrum in the n79 (4.8 GHz) band for the deployment of private networks.

Increasing relevance of distributed cloud architectures

The highly centralised architecture of the cloud meant that it was suitable for workloads that did not need real-time processing. But a newer class of use cases is emerging that will need real-time compute and processing to enable truly digital workflows. Many of these use cases will cater to mission-critical requirements in industry verticals such as manufacturing, aviation, mining and energy that will need extremely low latency and deterministic data transfers.

The increasing demand from industry verticals for connected endpoints is driving a new trend – a marked shift from centralised towards distributed architectures and the emergence of the edge as a computing paradigm. The edge cloud, which has been a buzzword for several years now, is finally gaining traction and investments. As it scales up, the edge cloud will move the needle for digital transformation within the enterprise. There will also be scenarios where the enterprise adopts hybrid cloud architectures, with some workloads sent to one or multiple centralised public or private clouds versus other workloads that are kept on-premises and managed in the edge cloud.

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The evolution to 5G will enable new IoT devices, applications and use cases

Private 5G networks will ultimately enable a host of devices within the enterprise premises. An increasing volume of connected endpoints in a massive IoT deployment will collect data and transmit information to a cloud server, either at the enterprise site or a remote edge/public cloud location.

While most enterprise private networks to date have deployed private LTE, private 5G is being ramped up and more 5G devices and endpoints are coming to market. Enterprise-grade devices and endpoints will include smartphones, tablets and handhelds for workers, as well as multiple industrial devices (e.g. programmable logic controllers, cameras, sensors, tablets).

The reality of implementations on the ground mandate the ability to combine and integrate mobile technologies with other standards such as Wi-Fi and LoRa equipment using routers and gateways that connect multiple other devices to a private cellular network. Increasing the density of IoT devices will require device management, security and orchestration software that will increasingly be deployed on an edge cloud.

At the same time, a number of new use cases and applications are driving demand for private network connectivity within the enterprise. These include worker safety applications that deploy new technologies (such as augmented reality for field workers), inventory applications that utilise scanners and mapping/positioning technologies and AGVs that roam the premises carrying an assortment of materials and goods. All of these have different requirements in terms of latency, mobility, data throughput and more – but they can all be enabled under the umbrella of a private 5G system.

New ecosystem players are expanding the opportunity

The landscape for private wireless networks is much more fragmented and diverse than the traditional telecoms network. One of the biggest reasons for this is that enterprise networking requirements need a high degree of bespoke solutions. Moreover, enterprises rarely start with a full-blown deployment. Rather, they tend to do small trials and proofs of concept (POCs) before scaling up the network deployment.

In addition to investments from mobile operators, the private wireless space has been attracting network and technology vendors, and the number of available solutions has increased sharply through to mid-2024. This includes providers of traditional network equipment and enterprise networking software, systems integrators and more niche providers, as well as hyperscalers.

2.3 Private networks can benefit from upcoming innovations

Beyond the immediate benefits to be gained from a private wireless network compared to legacy technologies, there are a number of innovations coming down the line will would increase the attractiveness of private wireless solutions.

Advances in edge computing – The shift to distributed cloud architectures is driving investment in edge computing. This means new platforms and functionality designed to enable enterprise workflows to be conducted on-premises and in real time. Upcoming innovations in edge computing will boost the availability and capacity for compute. Edge computing platforms will increasingly incorporate AI, which in turn will benefit from the added compute resources available on the edge servers.

Open RAN – Open RAN has brought several important changes to the supply chain for radio equipment by giving operators and service providers increasing choice over the kind of tech stack they want to deploy as well as the ability to select best-of-breed components from different vendors. Open RAN has appeal for enterprises as well, which typically do not need the high-specification RAN that mobile operators do. With open interfaces and the ability to customise deployments to enterprise requirements, open RAN can make it easier for enterprises to source and deploy wireless networks.

Advances in small cells and access points – On both the cellular and Wi-Fi roadmaps, there are significant advances ahead. Enterprises will benefit from extended coverage as well as coverage for endpoints deployed within their sites. One example of innovation in this domain is CoMP, which can be described as an extension of multiple input, multiple output (MIMO) technologies, which greatly enhances the capacity in each cell. CoMP implementations in 5G networks increase capacity greatly through spatial multiplexing utilising antennas from small cells. CoMP deployments in indoor or industrial environments can help overcome signal strength challenges from blockages, interference and other scenarios.

Time-sensitive networking – Time-sensitive networking (TSN) in its original form was a standard developed by the IEEE, specifically the 802.1Q standard, which enabled deterministic messaging over Ethernet. The idea was to minimise jitter and offer guaranteed delivery within prescribed time limits for real-time communications. TSN has now been incorporated into the 3GPP roadmaps, and its eventual rollout promises to bring deterministic routing into wireless connectivity. This will have a positive impact on use cases that require determinism in communications.

Indoor/outdoor positioning – There are several use cases that require precise and low-latency mapping and positioning for assets on the move. These could be in the form of robots, AGVs, tagged goods or inventory that could be moving across a factory floor, at an airport or port, for example. Use cases are also being explored for outdoor mobility, with drones as the best example. All of these assets need to move around the facility in concert (keeping to their specified paths), arrive and depart on time, and avoid collisions and other incidents. In many cases, their paths may also need to be reprogrammed mid-route. 5G and Wi-Fi 6/6E can offer the high degree of positioning accuracy that is required. The 5G framework is also flexible enough to enable hybrid solutions, in which 5G positioning can be designed to work together with on-device GPS and other technologies.

Industrial metaverse – While the metaverse is not a connectivity technology based on cellular or Wi-Fi, it certainly benefits from secure, reliable and low-latency communications. It is important to note that while the metaverse has somewhat faded from the consumer consciousness, it is very much alive in an industrial context. This is evident in advanced industrial markets such as Japan, where heavy industry and other large enterprises across manufacturing and other verticals are identifying use cases that can benefit from the dynamic, connected representations of real-world things in the digital world. Digital twins are the clearest example. Private networks can enable metaverse requirements across the consumer, enterprise and industrial segments; all of these will require different integrations to provide a meaningful and holistic experience.

Roaming – There are an increasing number of scenarios that are forcing enterprises to examine how their connected endpoints will stay on the network as they move from place to place. Certain use cases will mean assets are on the move beyond the immediate site where a private wireless network is enabled. For example, an asset tracking use case would require 'roaming' between private and public cellular networks. To enable this, several initiatives are underway to facilitate the required interconnect functionality to the public network. In a similar vein, interoperability between legacy connectivity solutions such as Wi-Fi and the cellular-based private network with technologies such as 5G is also important. Enterprises will, in most cases, continue to operate their legacy equipment and overlay a cellular network on top. But for certain endpoints, connectivity must be enabled with handover to cellular when going out of range.

Network slicing – The most hyped-up feature of the evolution to 5G and 5G-Advanced is the ability for mobile operators to offer their enterprise customers differentiated connectivity 'slices' of a public network. Despite its promise, network slicing has been slow to take off, as it requires a baseline of 5G SA networks. 5G SA networks have only recently started to gain momentum as operators invest and upgrade. As a technology, network slicing would enable mobile operators to offer enterprise customers a fully managed private 5G network that is a 'slice' of their macro network capacity, as opposed to a local breakout scenario. This can be configured to suit the specific requirements of the enterprise, such as throughput and latency, among other requirements.

AI – While there is no direct causal linkage between generative AI and private wireless networks, there is much more applicability for AI within the distributed edge cloud that will become increasingly relevant for the enterprise segment. AI is being increasingly deployed to accelerate workloads on edge servers, as they will need to support a wide variety of endpoints, each with variable connectivity and latency requirements. AI will also become increasingly relevant for orchestration of services and workloads from the premises to the cloud and back. Over time, exposing the myriad data sets from sensors, devices and workers in industrial settings to AI/machine-learning models will improve business visibility and drive efficiencies.

2.4 Key industry vertical opportunities for private networks

All industry verticals can theoretically benefit from private networks, but there are some that stand out. For example, in oil and gas, mining and utilities such as energy transmission networks, the availability of wireless connectivity for sites that were previously unconnected can deliver significant efficiencies. In all of these verticals, enabling remote connectivity and ensuring worker safety, often in harsh conditions, make the private wireless value proposition (around coverage, reliability and security) very compelling.

Manufacturing is a fast-growing sector with particular interest in multi-site support, meaning private wireless networks operate in both indoor and outdoor locations – within the office, on the shop floor and in the warehouse or other sites that may be based elsewhere. While manufacturing may in practice be complex to deal with, there are numerous private wireless deployments already in place. Asia Pacific is leading the way here, with operators in the region having the highest number of private wireless customers in manufacturing. In China, Japan and South Korea, among other countries, manufacturing (automotive, steel, electronics etc.) and adjacent sectors of logistics, shipping, energy and oil and gas are a major part of their economies, and these are key targets for private wireless offerings.

Smart cities are also seeing momentum, with applications such as defence or the use of drones for emergency response. Citymesh in Belgium has completed several mobile private network implementations in the country to support mission-critical applications for city infrastructure and major transportation hubs such as airports and ports.

The media sector has been an interesting industry vertical that has been serviced by telecoms operators for revenue generation from private wireless. Media companies have long been affiliated or partners with telecoms operators, and broadcasting is an application area where private wireless has the potential to enable new, compelling use cases. These include multiple-camera broadcasting and video recording, live events coverage with the use of drones and immersive experiences thanks to the ability to customise and guarantee service levels over private cellular.

Additionally, operators have high expectations for experiences that leverage multimedia content in specially designed spaces such as venues, stadia, and retail stores (i.e. the retail and live entertainment verticals). Operators also see high demand for healthcare and logistics, where hospitals and airports need highly secure and reliable networking.

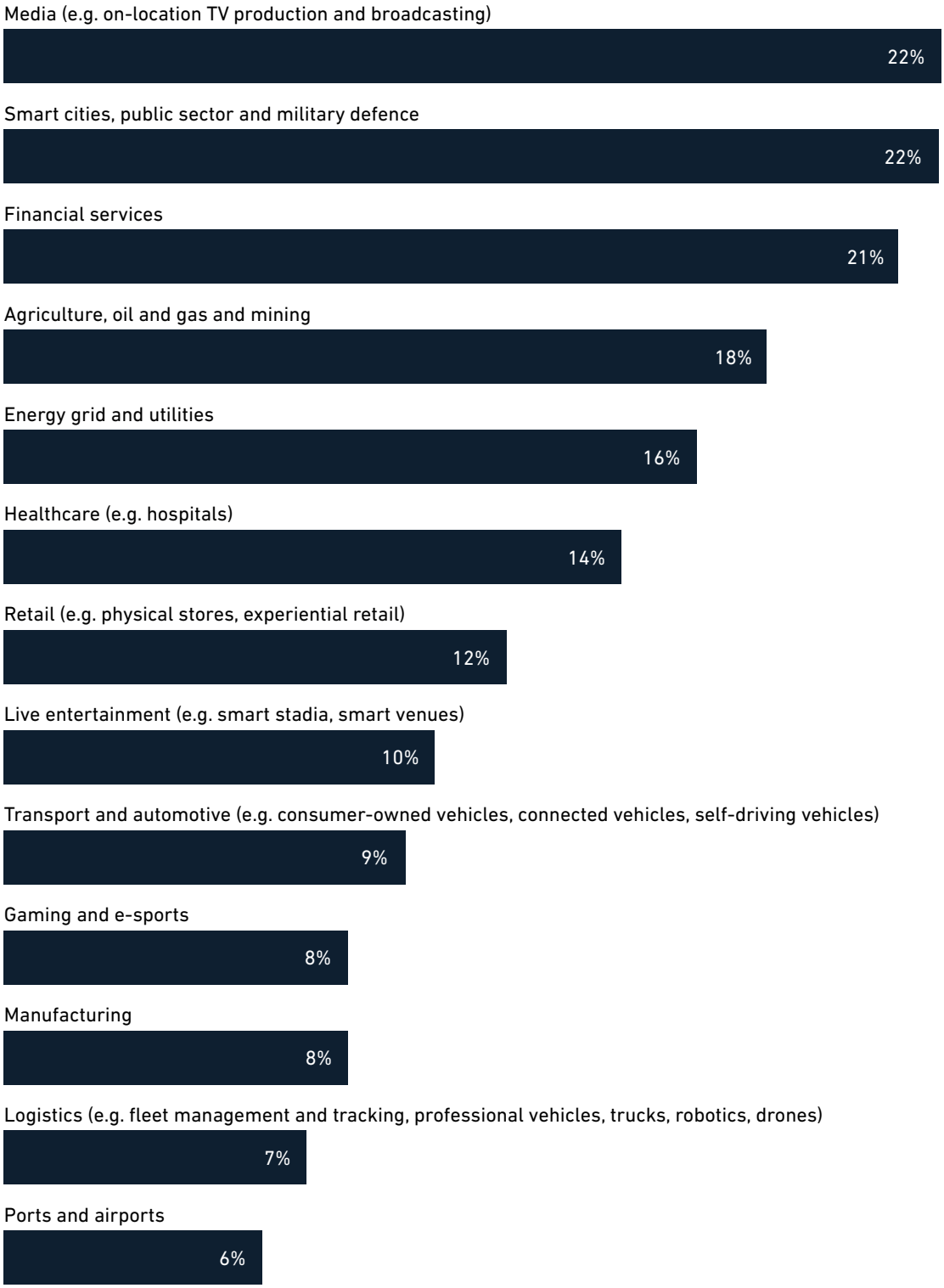
The category encompassing smart cities, public sector and defence almost doubled its score (weighted figure) compared to last year. This noticeable increase may reflect the growing appeal of citywide networks. This includes, for example, the implementation of first-responder programmes over public and private cellular networks with guaranteed service availability and network performance, as well as attractiveness of private networks in national defence applications.

Figure 3 captures some of the key verticals that operators are in discussion with for private wireless network deployments, based on GSMA Intelligence's operator survey.

Figure 3

What are the top-three industry verticals where you see the highest demand for private wireless networks (4G/5G)?

Percentage of operators



Note: Chart shows the overall weighted scores, calculated as ranked first * 1.00 + ranked second * 0.66 + ranked third * 0.33.
Source: GSMA Intelligence Operators in Focus: Enterprise Opportunity Survey December 2023

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Deployment scenarios for private 5G

Private network deployments that are based on LTE/5G include a combination of small cells, gateways, routers and a mobile core network that is usually deployed at the enterprise site. Increasingly, this includes an edge cloud deployment, either on-premises or at a far edge location, that enables hybrid multi-cloud connectivity for enterprise workloads. Enterprises have a variety of combinations available to them for deploying private wireless networks, depending on the level of control they want, the deployment model chosen and the type of spectrum available.

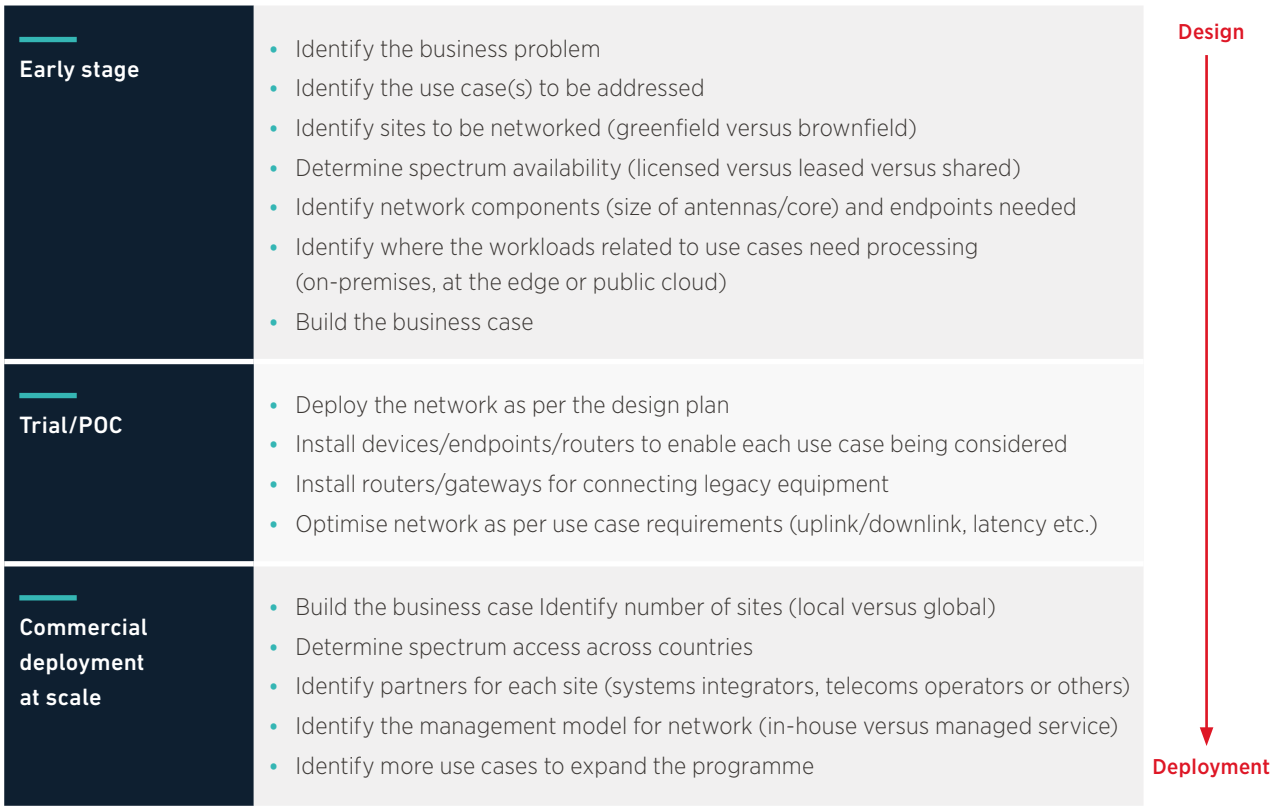
The specific deployment scenario will also depend on the type and volume of use cases and their specific requirements, such as the following:

- Are they mission-critical applications on a manufacturing floor or a mine, or are they best-effort connectivity use cases in a school district or campus?
- Does the use case require mobility within the enterprise site or beyond the site, which would mean that access and handover to a public mobile network would be needed?
- Does the enterprise have access to spectrum on its own or does it need to get access to leased or shared spectrum?
- Who does the enterprise contract with for the project? Is it a mobile operator, a neutral host provider, a systems integrator or another entity?

Typically, an enterprise goes through multiple stages, from the evaluation and initial design of a private wireless network through to the final deployment. The main considerations are illustrated below in Figure 4, though there are always variations depending on the type of business, industry vertical and location of the site.

Figure 4

Stages of private wireless network deployment



Source: GSMA Intelligence

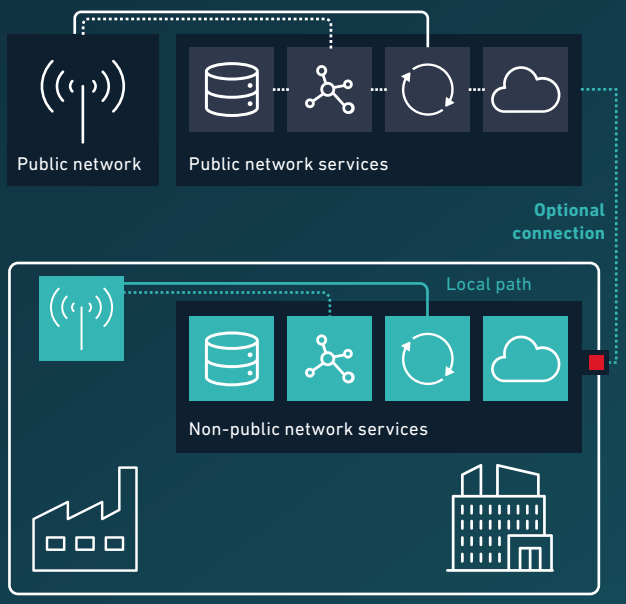
The specific requirements will be unique to each enterprise and these will determine the ideal deployment scenario to be adopted. While there are a number of models that have come into evidence over the last few years, they generally fall into one of the following categories:

- 5G private networks using licensed public spectrum, or public network integrated NPNs (PNI-NPN)
- 5G private networks using licensed dedicated spectrum
- 5G private networks using unlicensed, shared or leased spectrum.

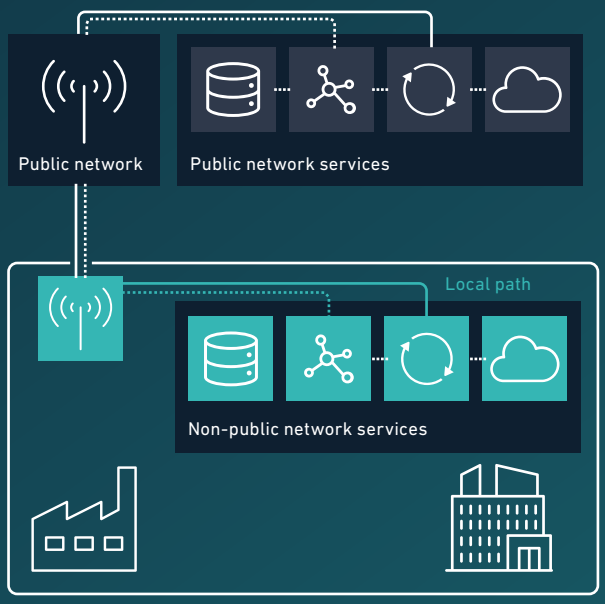
Figure 5 captures some of the main combinations and options that are available for an enterprise to choose from.

Figure 5

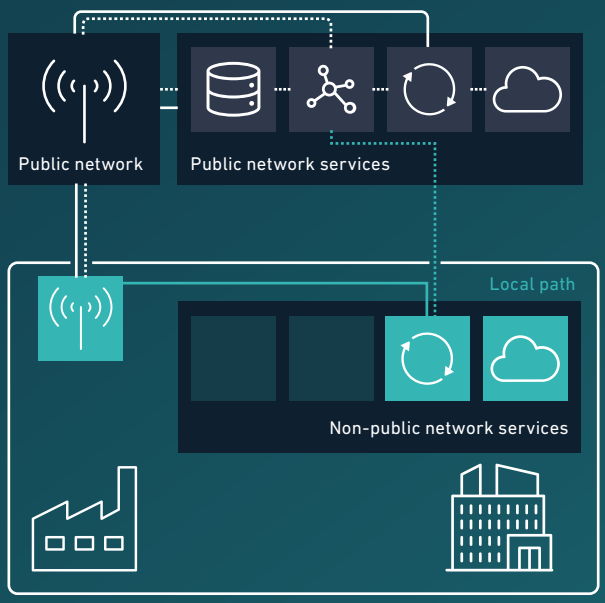
Deployment models for private wireless networks



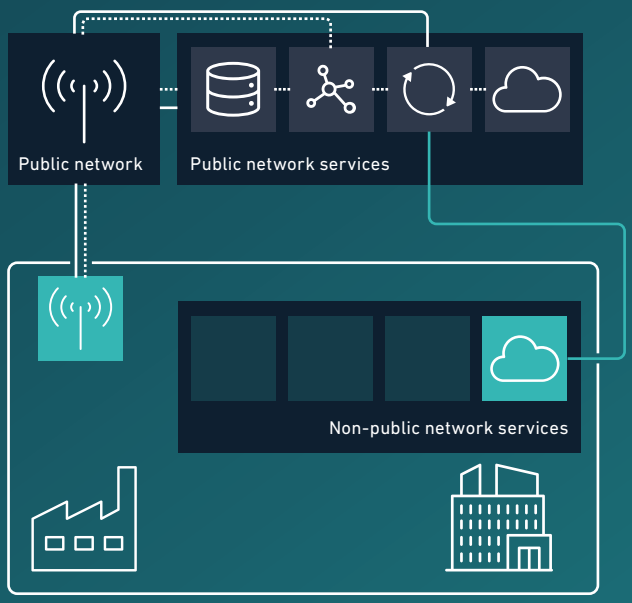
Deployment as isolated network



Deployment with shared RAN



Deployment with shared RAN and control plane



NPN deployment in public network

Source: 5G-ACIA

These private network deployment models can be provided by a number of different industry players (as detailed below in order of popularity today):

- **Systems integrators –** This is the most prevalent model in evidence today, as most enterprises are more likely to work with systems integrators and other third parties to build the network rather than adopting a do-it-yourself approach. Enterprises can choose large network vendors (e.g. Nokia, Ericsson, Cisco, HPE) to deploy the private network, or global systems integrators (e.g. NTT Data and Capgemini). There are also numerous systems integrators local to each market and, in some cases, to the specific industry vertical such as healthcare. In many cases, these systems integrators are already involved in the enterprise's ICT projects and have a high degree of familiarity with the context of the enterprise. Of course, there are a select few large enterprises that have the requisite expertise in-house and may opt to deploy a network on their own. An example of this would be Siemens, a large industrial manufacturer and solution provider, which developed a private wireless network solution on its own.
- **Public/edge cloud providers –** Enterprises can increasingly work with their cloud service providers, such as AWS and Microsoft, to deploy a 'localised' version of their clouds on-premises. For example, Microsoft offers Azure Private Edge, while AWS has Outposts: both of these solutions extend into the edge cloud that is located on the enterprise's site with small footprints. The advantage for the enterprise is that it can continue to use the tools that it's accustomed to with its primary cloud provider. In this scenario, the cloud provider would essentially act as a systems integrator, though access to spectrum is still necessary. In many cases, cloud providers would either partner with telcos for spectrum access or, where available, utilise shared spectrum like with CBRS in the US. Solutions are also available from new categories of edge cloud solutions. An example of a new solution is Nokia's MX Industrial Edge product, which is a standalone edge computing platform that enables enterprises to connect all of their OT assets at the site. Solutions from networking giants such as Cisco and Hewlett Packard Enterprise also provide performant edge cloud solutions for enterprises.
- **Telecoms operators –** In many ways, mobile operators are essential partners for enterprises to deploy a private network 'as a service', using licensed spectrum assets that they already control for a specific market. There are already a couple of approaches visible. First, operators such as Verizon have partnered with the likes of Nokia and Celona to offer a differentiated portfolio of solutions. Singtel exemplifies a second approach, where it deploys network slicing over its 5G SA network in combination with its Paragon edge platform for enterprise customers. A third approach that is taking shape is operators such as Telstra in Australia choosing to enable private networks but using public licensed spectrum; however, this is fairly unique to Australia given the relatively low population density, making plenty of spectrum available with minimal interference issues.
- **Neutral hosts –** Third-party neutral hosts that own or control real-estate assets can also develop a private network. Enterprises can approach them to strike an agreement, depending on the type of business and venue that is controlled by the neutral host. For example, a retail chain could tie up with a shopping mall, while a co-working space could tie up with the building management company on site. Another example of neutral host activity is in the healthcare sector in the US, where Stanford Medical has partnered with Celona and Critical Mobility to launch a CBRS-based neutral host network. There are also categories of digital infrastructure players that could set up private networks for shared or dedicated access. For example, Cellnex in Europe has built private networks for several customers and offers management services.

3.1 The competitive landscape is shifting towards systems integrators

In the early days of private networks, the sheer number of options available for enterprises complicated the decision-making process and held back the market opportunity. However, there has been a palpable shift from late 2023 onwards, with available solutions and business models showing signs of maturity. The fundamental challenges around spectrum access and business models persist, but there is a healthy dose of realism that has seeped into the industry. Private 5G is largely a local affair in the sense that specific countries' policies will largely determine momentum for private 5G.

The competitive landscape for private wireless network deployments is fluid and varies greatly between markets. But the majority of recent deployments have featured enterprise deals with systems integrators, compared to telecoms operators or hyperscalers. While operators and hyperscalers are important parts of the ecosystem and provide valuable building blocks that will underpin the eventual private wireless network, in most cases their core strength does not extend to putting all the pieces together and providing an enterprise with a managed solution. The key decision point for the enterprise buyer would be focused on which ecosystem player owns the contract and becomes the primary point of contact. In most cases, enterprise buyers already have deep relationships with their systems integrator partners and the deployment of a private network becomes an extension of the relationship.

A number of solutions have arisen in the competitive landscape for private 5G, from both incumbents and new entrants. Figure 6 shows a list of key stakeholders, though this is not an exhaustive list given the pace of industry development. The diversity of stakeholders has led to a range of industry partnerships aimed at providing enterprises with flexibility and choice.

Figure 6

Ecosystem for private wireless networks*

Operators
- Singtel
- Telstra
- Verizon
- Vodafone

Tower companies/ neutral hosts
- Cellnex
- Freshwave

Systems integrators (general focus)
- Accenture
- Capgemini
- NTT Data

Software vendors and specialists
- Aarna Networks
- Armis
- Celona
- Druid
- HPE Athonet
- OneLayer

RAN vendors and specialists
- Accelleran
- Airspan
- Ericsson
- Nokia

Public/edge cloud providers
- AWS
- Google Cloud
- Microsoft Azure

Network equipment vendors
- Ericsson
- Huawei
- Nokia
- Samsung
- ZTE

Network hardware vendors
- Cisco
- Dell Technologies
- Hewlett Packard Enterprise

Systems integrators (specialist focus)
- Amdocs
- Atos
- Kyndryl

Silicon and platform providers
- Intel
- Siemens

Device and router vendors
- Comba Telecom
- Cradlepoint
- Siemens
- Sierra Wireless

*List not exhaustive
Source: GSMA Intelligence

In business model terms, enterprises have to choose between selecting a partner to deploy a network and hand it back to the enterprise to operate or selecting a partner that offers a managed service. While some large enterprises have chosen to deploy private 5G on their own by leveraging in-house expertise, the majority of enterprises are more likely to choose a managed service offering, as they would incur less upfront capex on the network equipment, and management and maintenance would also be converted into an opex line item. In this model, the private network would be deployed 'as a service', with an upfront cost and then recurring costs, by a large network vendor, a global consulting giant, a sector-specific systems integrator or even a telecoms operator/hyperscaler working as a systems integrator. This model also has the added advantage of the systems integrator in question taking care of procurement of equipment and devices, procurement of spectrum, multi-cloud connectivity and maintenance.

During 2023, telecoms operators accelerated their commercial push for private networks. In a GSMA Intelligence survey of 100 telecoms operators globally, at the end of 2022, almost half of respondents claimed they had launched private 4G/LTE, and 34% had launched private 5G. A year later, the 5G figure had almost doubled to reach 64%. Mobile operators are strongly motivated to monetise 5G investments and to look for sources of revenue growth. The enterprise segment represents an incremental opportunity for operators to monetise 5G. Operators are increasingly seen as key partners in private wireless by other ecosystem players, including systems integrators, large network vendors and other private wireless suppliers. Examples include Verizon's partnership with Nokia and Audi to create a private network solution for Audi's automotive testing needs across sites in the US and in Germany, and Du and Ericsson's work in the UAE.

Hyperscaler cloud providers such as AWS, Microsoft and Google Cloud all have offerings for private wireless networks. These providers have robust enterprise customer relationships and manage an increasing range of workloads for these customers. They also have a strong interest in extending their cloud networks to the far edge, much closer to the enterprise site, or even within the site itself. On the enterprise side, deep familiarity with AWS Outposts or Azure Private Edge is a natural incentive for enterprises to partner with hyperscalers. However, there are notable gaps in this channel, as hyperscalers do not possess deep knowledge of cellular networking. Moreover, the sharp momentum shift towards deployment of AI models and computing resources has forced the hyperscalers to move their focus away from private networks in the short term.

3.2 A converged edge platform is foundational for enterprise digital agendas

Private networks are a key enabler for enterprise digital agendas, as they focus on new use cases and applications that will boost productivity and improve efficiency for mission-critical workloads. Increasing demand from industry verticals for connected endpoints is driving the advent of the edge as a computing paradigm. The emergence of edge compute is aided in large part by its increasing convergence with private 5G and IoT. While private networks and IoT have been around for some time, edge computing is a relatively new ingredient in the mix and is correlated with the momentum behind private wireless networks. Most enterprises have a large diversity of use cases that require some workloads to be kept on-premises and some in the cloud. Solutions based on purely on-premises or in the public cloud do not address the majority of enterprise requirements.

Industry attention has shifted to filling the gaps in the private 5G proposition. In 2024, the private network opportunity will become increasingly attractive while momentum continues to build, with multiple vendors further increasing their investments. But the value points are shifting away from radios and mobile cores, which are now table stakes, towards the distributed edge and seamless orchestration of workloads across enterprise IT/OT environments. For enterprises, radios and a mobile core of their choice is an incomplete solution with poor return on investment. The real value in private 5G will be in the edge solution that gives enterprises the flexibility to deploy workloads and handle processing on-premises or segregate some workloads to be processed through multi-cloud connectivity to public or private clouds.

Many of the latest use cases that require edge compute – such as defect detection and worker safety applications in factories, frictionless checkout in retail or emergency safety use cases in transportation/aviation – benefit from increased automation for fast and seamless data processing and transfer. This is where AI deployed on performant edge servers can make a significant impact on enterprise digital agendas. Private wireless networks will not be sufficient to enable digital transformation for enterprises without the availability of an open, scalable edge platform that allows developers to create edge-native AI applications. This will hold true whether these applications are created for new or legacy infrastructure.

4 Outlook

There is significant momentum for private networks around the world, with 2024 shaping up to be the tipping point. As private wireless networks gain momentum, a number of trends have taken shape:

- **Scaling up past trials/POCs –** Enterprises in leading 5G markets have moved past the early and trial/POC stages towards scaling up their deployments as they complete the initial evaluation phase. In many cases, early deployments were started with 4G LTE connectivity and devices, but these will be upgraded as an increasing number of 5G devices become available.
- **Increasing complexity –** With growing momentum behind private networks, several deployment scenarios are coming into play as enterprises grapple with their own specific requirements and use cases as well as the prevailing conditions for spectrum access in their respective markets. The increasing diversity in deployment scenarios is adding to the complexity that needs to be navigated by enterprises.

- **Systems integrators are taking the lead –** As a consequence of the increasing complexity of deployments, systems integrators (including major network vendors) have emerged as key players that will take the lion's share of enterprise spend on private 5G relative to telecoms operators and hyperscalers.
- **Rapidly growing ecosystem for private 5G –** In addition to operators, the private wireless space has been attracting network and technology vendors, and the number of available solutions has increased sharply through mid-2024. This includes providers of traditional network equipment and enterprise networking software, systems integrators and more niche providers, as well as hyperscalers. While some offer end-to-end solutions, many partnerships are being struck between industry players looking to not only scale up their solutions and improve positioning but also to offer greater flexibility to customers.
- **Converged edge platforms are the new value point –** As enterprises now have significant choice for mobile core and radio solutions, as well as increasing availability of devices, the focus is shifting rapidly towards the ideal way to enable new and existing use cases and orchestrate and manage the workloads associated with them. In most cases, enterprises are gravitating towards a hybrid approach, with a number of mission-critical and sensitive workloads staying on-premises, while others are being processed either at far edge locations or the public cloud. As a result, edge compute resources with AI-enabled platforms to drive efficient orchestration and management with multi-cloud connectivity are getting increasing attention and driving value.

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