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Saudi Arabia
Centre for the
Fourth Industrial
Revolution

5G Private Mobile Networks

Revolutionizing Industry with Private 5G Technology

Community Paper
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Contents

Abstract

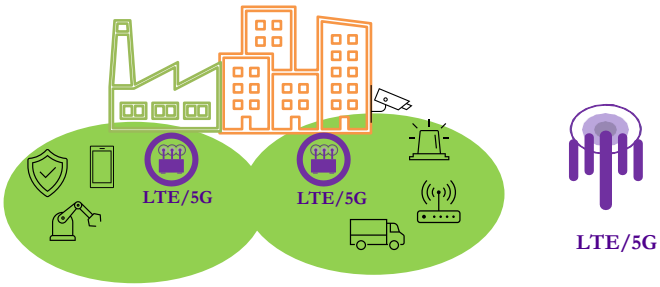
In this paper, we present one of the most recent innovations in mobile telecommunications that is mobile private systems (MPN). We highlight how businesses can take advantage and transform to digital using available choices. We present an overview of possible adoption options and assess it from technical and financial views.

Introduction

Recent advancements in Radio Access Networks (RAN) are Open RAN (O-RAN), 5G New Radio (NR), Mobile Private Networks, Network Slicing, Edge Computing, and Artificial intelligence and Machine learning. These innovations collectively contribute to the evolution of RAN, meeting the increasing need for connectivity and advanced services.

These innovations collectively contribute to the evolution of RAN, meeting the increasing need for connectivity and advanced services. Since MPN is a key enabler for organizations looking to embrace digital transformation, providing the foundation for enhanced connectivity, security, and efficiency, we tackle the MPN technology in this paper.

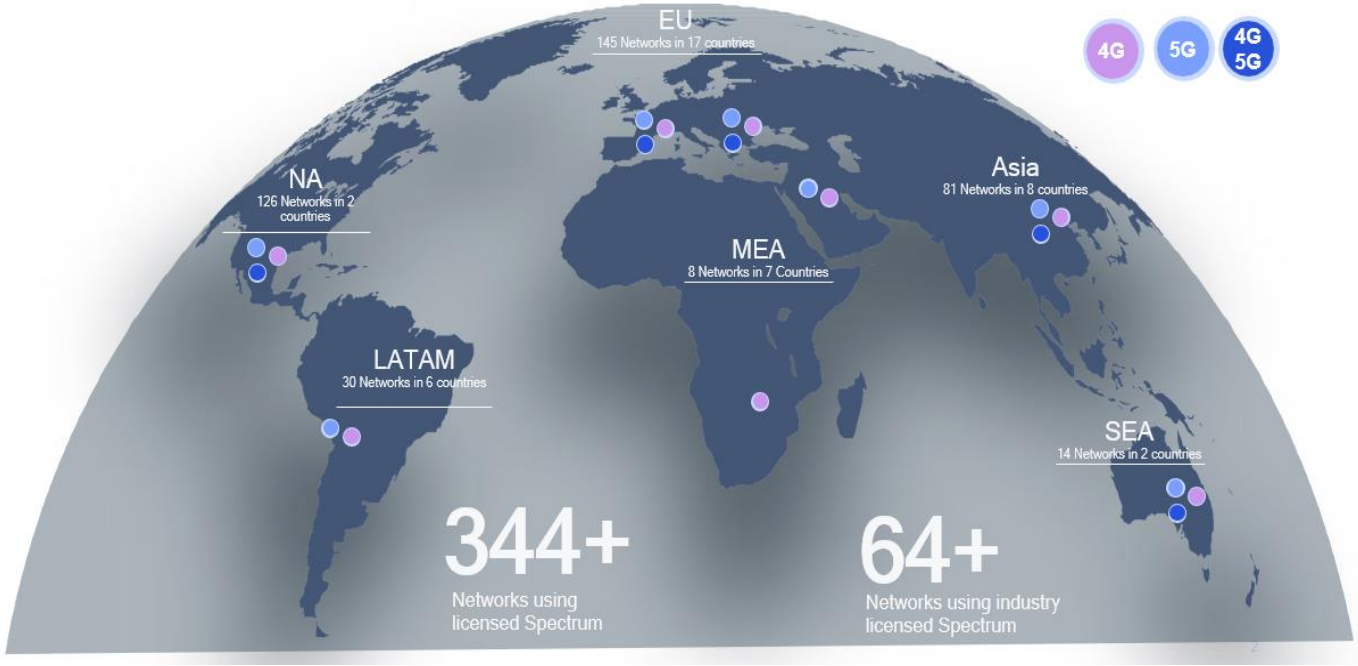
MPN shown in Figure (1) is targeted for business and industries to help in sitting the foundation for its digital transformation. It can serve as its new nerve system for their new setups.



Fig(1) Private Mobile Networks

MPN are built to give businesses devoted, customizable, and low-latency communication private networks. In this work, we'll dive into some key viewpoints of private 5G systems, their benefits, applications, and the transformative potential they hold for different industries.

MPNs can be classified as [1] Standalone where a business can have its complete isolated network from operators, Shared private network is an option for enterprises to have their own private networks but with sharing some parts with a operators, and Slicing private network that is expected to become a trend.



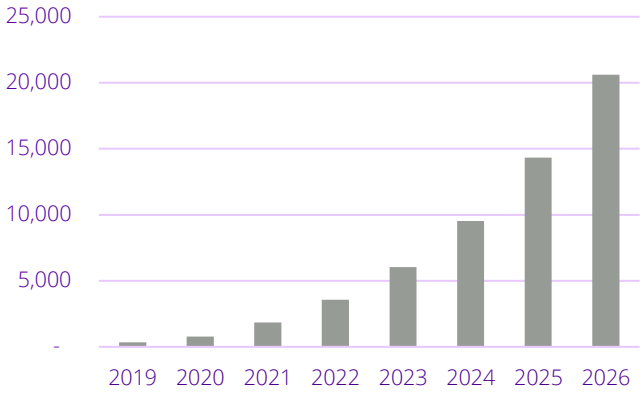
Fig(2) Global Deployment of Private Mobile Networks

Network Deployments

Number of private network customers by region (408 Network rollout, 483 Trials, and over 800 interested organizations) has been identified [2-4] as shown in figure (2).

The number of private LTE/5G networks worldwide as shown in figure (3) is expected to grow [3, 4] from 348 in 2019 to 20,600 by end of 2026. There is a trend of deploying private network in shared and unlicensed spectrum to reduce the cost.

In summary, a MPN is a key enabler for organizations looking to embrace digital transformation, providing the foundation for enhanced connectivity, security, and efficiency.



Fig(3) Number of Private LTE/5G Networks, Worldwide,

Transform industry and enterprise with 5G

Digital transformation using MPNs can bring significant benefits to organizations. Here's how they play a crucial role:

1. Enhanced Connectivity: MPNs provide reliable and high-speed connectivity across the enterprise. This is essential for implementing IoT devices, cloud services, and other digital technologies.

2. IoT Integration: MPNs can facilitate the network of IoT devices, allowing businesses for a real-time data gathering and analysis. Collected information can be later used to enhance its processes and implement automation.

3. Data Security: MPNs offers high levels of security which makes it very suitable for sending sensitive data. This is essential in industries such as but not limited to healthcare and finance.

4. Low Latency: MPNs can reduce communications latency which makes it suitable for industries and applications that requires fast data transfer, like augmented reality, virtual reality, and autonomous vehicles.

5. Customization: Organizations can customize its MPNs to meet its specific needs. requirements include coverage areas, capacity, and quality of service.

6. Cost Efficiency: Over time, MPNs can be cost-effective than traditional networks, especially for IoT deployments.

7. Increased Productivity: Employees can stay connected and work efficiently in both remote and mobile environments.

8. Remote Management: MPNs can be managed remotely, which simplifies the maintenance and monitoring activities.

9. Industry Applications: MPNs are beneficial for industries like manufacturing, logistics, agriculture, and healthcare, where the transformation of operations and decision-making are crucial.

In summary, a MPN is a key enabler for organizations looking to embrace digital transformation, providing the foundation for enhanced connectivity, security, and efficiency.

Use Cases

These networks are used in a variety of industries and applications to address specific needs as shown in Figure (4). Here are some key use cases:

Smart Construction

These networks ensure real-time monitoring for both workers and equipment in remote and hazardous places, and enhances the safety. It can also helps in tracking locations of equipment and vehicles.

Smart ports, Mining and Oil & Gas

Asset Tracking is essential in ports, and private mobile networks facilitate precise location tracking of goods and vehicles, optimizing logistics and reducing theft or loss. They enable real-time monitoring of inventory levels and the movement of goods within the port.

Manufacturing, Retail

These networks enable real-time communications between machines and robots, enhancing automation and efficiency on the factory floor. They support the collection and analysis of data from sensors and cameras to maintain high-quality manufacturing. It supports real-time inventory tracking and data exchange between stores and warehouses to optimize stock levels.

Education, Hospitality, Tourism, Government and Defense

It can be used as a reliable and secure network for remote lessons. Intelligent agencies can deploy it for secure and encrypted communications. Hospitality chains can have it as an alternative for its Wi-Fi network.

Fig(4) Advantages Across Various Industries

Deployments Options

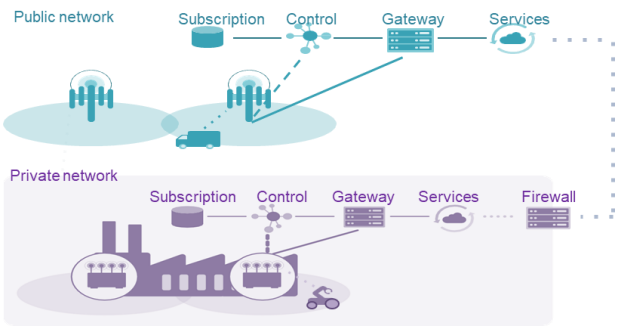
Stand-Alone

High Level Architecture

The Standalone network [1, 5] is a completely private network as shown in Figure (5). All functions happens within the boundaries of enterprise premises (such as a factory). It operates independently from the Mobile Network Operator (MNO) and has its own dedicated ID. An optional communication with MNO, if exists, is routed through a firewall. The operation of the network is exclusive responsibility of the enterprise owner.

Technical evaluation

Different choices are accessible to choose from within this classification. The preference lies in utilizing a private network with an MNO License to ensure Quality of Service (QoS) and meet the increasing demands effectively. For large enterprises, obtaining an industry local own license may be a suitable alternative. Another option is the utilization of shared spectrum, provided that regulators make this spectrum accessible for general use.



Fig(5) Standalone Private Mobile Networks

Option 1: MPN with MNO Spectrum License: Enterprises have the option to lease the spectrum from MNO for a fee. This licensed spectrum can have two scenarios: either MNO offers a private network-as-a-service (NaaS) using its spectrum, or it sub-leases the spectrum to the enterprise.

- Completely built and managed by the MNO.
- MNO must allocate a specific portion of its spectrum to ensure QoS, leading to reduced spectrum utilization.

Option 2: Communications, Space and Technology Commission (CST) has the ability to assign spectrum exclusively for industrial purposes through a Private Network with Industry Local License. This strategy promotes diversity in spectrum ownership, enables alternative providers to enter the market, and ultimately offers a wider range of network suppliers to choose from. Numerous countries have designated specific frequency ranges for utility operations, emergency services, and private mobile networks that cover local or wide areas within cities.

- Owning a license in the industry will enhance spectrum utilization. Without this ownership, companies may miss out on the advantages of economies of scale, potentially resulting in increased network development costs.

Stand-Alone

- Requires maintaining experts which is not non-MNOs core business.

Option 3: CST has the ability to assign spectrum for shared use between MNOs and businesses. Management of spectrum access can be handled by CST directly or through an authorized spectrum access system provider.

These solutions facilitate multiple organizations to utilize the same spectrum range within a single geographic area. Enhanced spectrum efficiency. MNOs are not required to allocate a specific portion of spectrum for enterprise use.

Financial evaluation

The majority of MPNs utilize licensed mobile spectrum, but an increasing number of private 5G networks are now utilizing locally licensed spectrum that has been made available by regulators.

Options	Option 1: Private Network with MNO Spectrum License	Option 2: Private Network with Industry Local License	Option 3: Private Network with Shared Spectrum License
Capex for network infrastructure	Cost paid by Enterprise to MNO suppliers.	Cost paid by Enterprise to MNO suppliers.	New cost paid by both MNO & Enterprise to suppliers.
Capex for spectrum	Lease fee paid by Enterprise to MNO for using its spectrum.	Cost paid by Enterprise to CST.	New fee paid by both MNO & Enterprise to CST.
Opex for support, services, and maintenance.	Cost paid by Enterprise to MNO managed service.	Cost paid by Enterprise to CST.	New cost paid by both MNO & Enterprise to managed service.

Table (1) Private Mobile Networks options

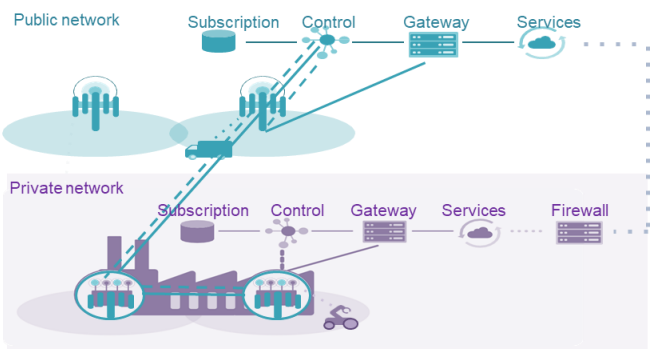
Network Sharing

High Level Architecture

In this case, it is hosted by a MNO network as shown in Figure (6). With this setup, MPN share elements of the MNO network , while some functions remain independent. The logical premises contains all data flows associated with private traffic.

Technical evaluation

Within this classification, there are various choices to choose from. The primary objective of Option-1 is to offer tailored services compared to Option-2. Sensitive and confidential information can be securely stored within the company's facilities under both options. Option-2 allows MNO to utilize its expertise, experience, and knowledge to oversee and manage the majority of the private operations.



Fig(6) Shared Private Mobile Networks

Option 1: Shared RAN: The private network is assigned a unique ID exclusively for its own use. Nevertheless, there exists a RAN sharing arrangement with a public network operator. This presents a significant chance for enterprises to tailor the network to its specific needs.
The personal data of private subscribers is securely stored within the defined premises, ensuring that the MNO has no access to this information. It is important for enterprises to have a skilled team to oversee the control aspect and database maintenance.

Option 2: The operator is responsible for managing and maintaining the control part and the database, which are no longer located within the enterprise. The operator has a highly skilled and knowledgeable team compared to enterprises, ensuring efficient management.
However, this shift also limits the customization opportunities for the enterprise. Additionally, private subscriber information, such as the number and location of their devices, is now accessible to the Mobile Network Operator (MNO) and is no longer stored within the enterprise's premises.

Network Sharing

Financial evaluation

Enterprises are driving network sharing by tailoring it to its specific needs and customization requirements. Both alternatives are doable, with a preference for the second option from MNO perspective. There are certain advantages for MNO in leveraging a few of its core assets

Options	Option 1: Shared RAN	Option 2: Shared RAN and control plane
Capex for on network infrastructure	New cost to MNO. Potential benefit for MNO in the presence of MNO clients at corporate locations.	Potential new benefit for MNO from utilizing some of its core assets
Capex for spectrum	Potential benefit for MNO in the presence of MNO clients at corporate locations.	Potential benefit for MNO in the presence of MNO clients at corporate locations.
Opex for support, services, and maintenance.	New cost to MNO. Potential benefit for MNO in the presence of MNO clients at corporate locations.	Potential new benefit for MNO from utilizing some of its core assets

Table (2) Networking Sharing options

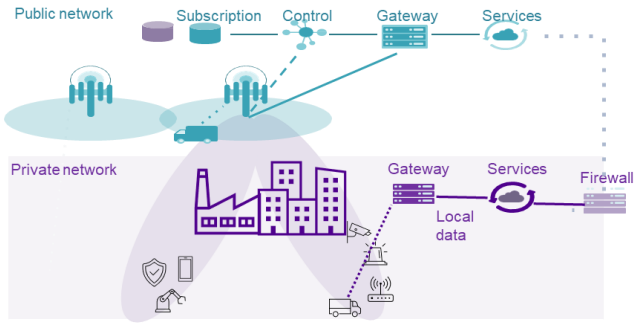
Network Slicing

High Level Architecture

Figure (7) illustrates the concept of slicing. In this scenario, the public and private traffic segments are considered separate entities within the network. This segregation is made possible by slicing network functions in a cloud setting. By directing all data through the public network, users can seamlessly access public network services and roam without any complications.

Technical evaluation

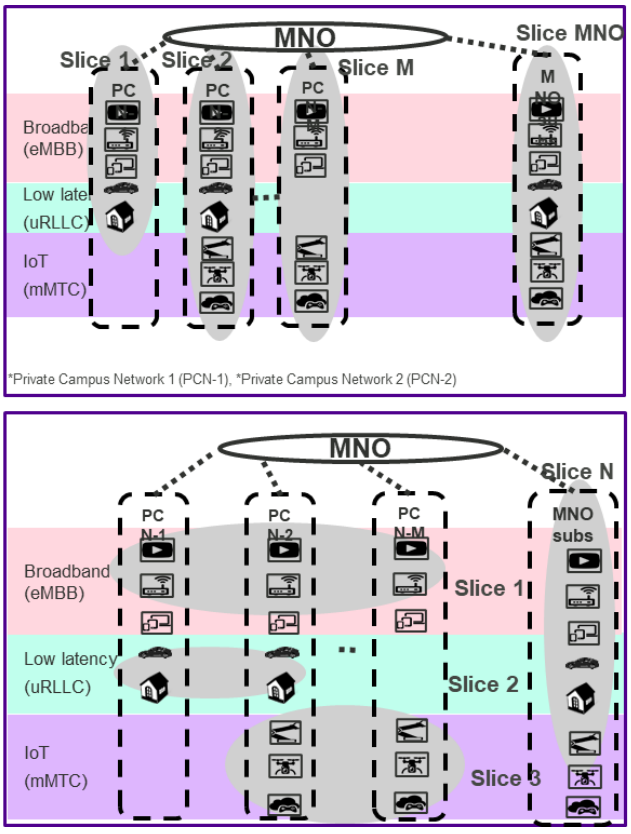
This is a novel addition to the 5G technology that enables specific clients to have exclusive access to network resources. Slices are tailored to specific industries [6], and the requirements for each industry vertical vary, resulting in multiple slices customized for different applications as depicted in Figure (8). Network slicing provides a form of 'virtual networking' that offers the advantage of customizing specific attributes.



Fig(7) Slicing Private Mobile Networks

Slices are specific to verticals, and slice requirements are different for each industry vertical, multiple slices customized to the various applications.

Option 1: One network slice for MPN: The number of network slices can be reduced by sharing the slice among the users. In this case, customization will become extremely difficult.



Fig(8) Slicing in Private Mobile Networks

Option 2: Multiple network slices for MPN: potentially delivering different network characteristics for different users or applications. If the number of network slices increases, the complexity increases.

Financial evaluation

While it is possible to have multiple slices using the network slicing approach, this introduces complexity and necessitates maintenance to ensure the quality of service for these applications.

Options	Option 1: One network slice for private campus network	Option 2: Multiple network slices for private campus network
Capex for on network infrastructure	No cost to MNO. Slicing fee paid by Enterprise to MNO.	No cost to MNO. High slicing fee paid by Enterprise to MNO.
Capex for spectrum	No spectrum cost to MNO. Slicing fee paid by Enterprise to MNO.	No spectrum cost to MNO. High slicing fee paid by Enterprise to MNO.
Opex for support, services, and maintenance.	No cost to MNO. Slicing fee paid by Enterprise to MNO.	No cost to MNO. High slicing fee paid by Enterprise to MNO.

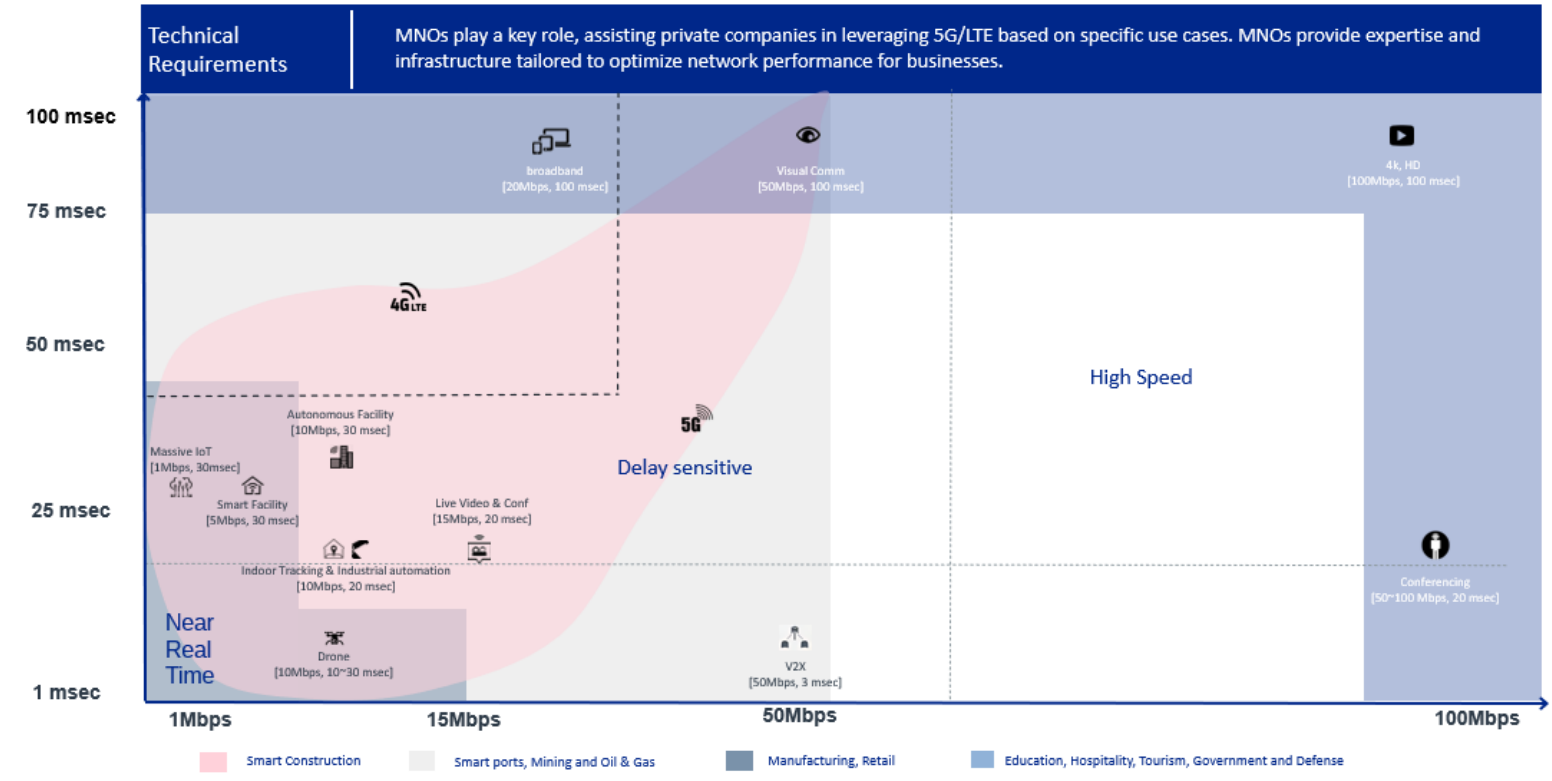
Table (3) Network Slicing options

Technical Requirements

Throughput & Latency Requirements

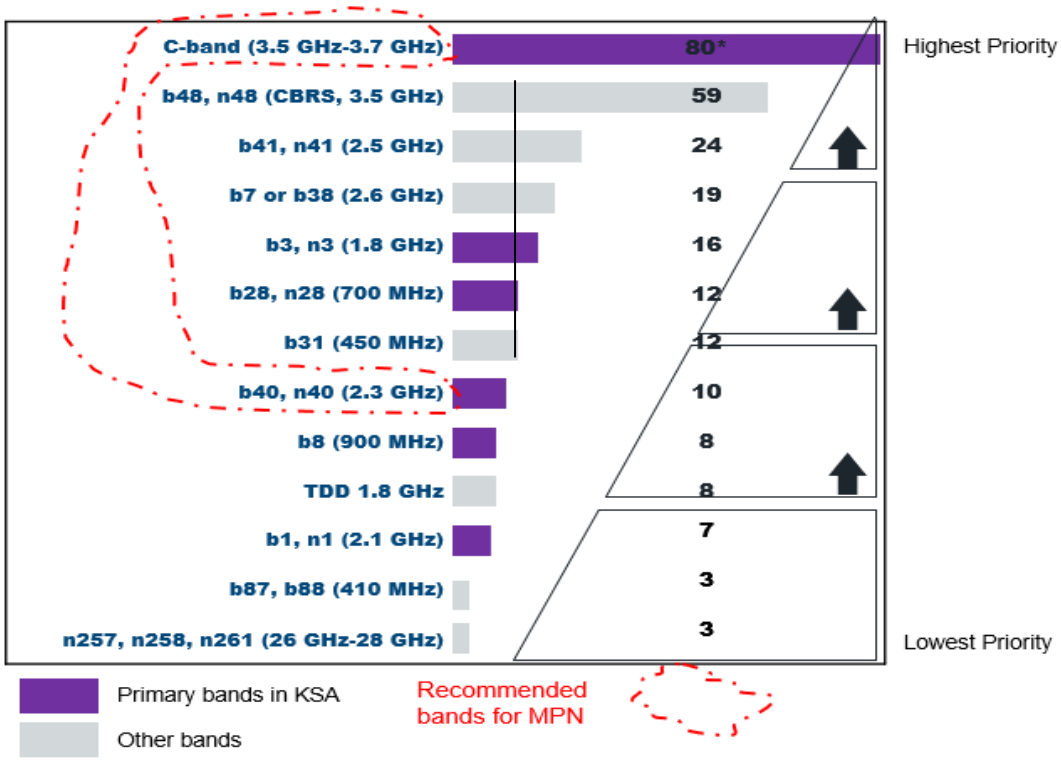
Based on collective sources (ITU Radiocommunication Sector (ITU-R), 5G Americas, Next Generation Mobile Networks (NGNM) Alliance). The three compilations provide a good sense of the possibilities enabled by 5G.

In Figure (9), requirements for throughput and latency are summarized for different industries. Note that some enterprises may have aggressive requirements than others. Resources again are tailored to meet use cases required by the enterprise.



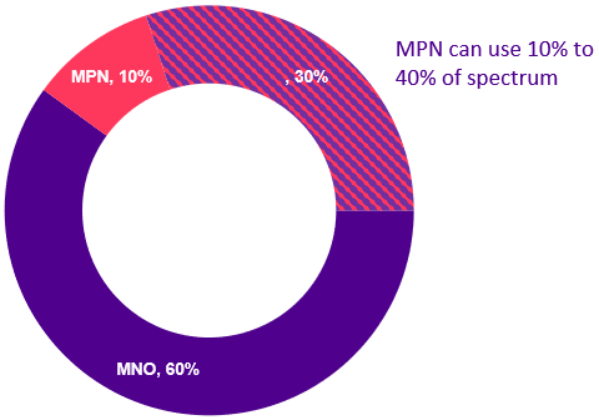
* Based on collective sources (ITU Radiocommunication Sector (ITU-R), 5G Americas, Next Generation Mobile Networks (NGNM) Alliance). The three compilations provide a good sense of the possibilities enabled by 5G

Spectrum Requirements



Fig(10) Spectrum for MPNs

Base on Private Mobile Networks GSA Nov 2023 report Figure (10) Spectrum bands used for MPNs; number of customer deployments identified using each band.



Fig(11) Spectrum Share

MPNs are often deployed using MNO or local spectrum. Network slicing in 5G is crucial and will evolve with technology. Spectrum bands used for private mobile networks; number of customer deployments identified using each band

In Figure (11), Use cases (type & quantity) are required to estimate the needed spectrum bandwidth. But, a good practice is not to exceed the 40% for MPN for a dedicate spectrum if required to ensure minimum impact of MNO consumers.

Challenges

MPNs are gaining popularity because of their advantages, however, they also have obstacles. Here, we summarize some of its challenges.

1. Initial Investment: Setting up a MPN can require a significant initial investment for infrastructure, including base stations and network equipment. The cost should be low in any case.

2. Operational Costs: MPNs may involve operational costs for maintenance, monitoring, and support, which can be a problem for some organizations. MPNs require regular maintenance to ensure their performance and security. This maintenance can be resource-intensive.

3. Spectrum Availability: Securing the necessary radio spectrum can be a challenge, particularly in regions with limited available frequencies.

4. Regulatory and Compliance: Obeying regulatory requirements, licensing, and compliance standards can be an obstacle.

6. Expertise: Managing a MPN requires specialized knowledge and expertise, which might be lacking within the organization. Finding and keeping skilled staff can be a challenge.

7. Interoperability: Interoperability with existing systems and networks, as well as integration with third-party services, can be complex.

Future Outlook

6G is still under research and expected to be an extension to 5G. At this point, it is expected that options would remain the same and follows the models of 5G. Moreover, AI is applicable to both private and public networks. All technologies in core and cloud that fits the public mobile network are applicable to private ones.

Conclusion

We presented one of recent advances technologies in telecommunications that is MPNs. We showed how firms can transform their businesses with private mobile networks. We present an overview of options available.

Despite private mobile networks challenges, they are increasingly adopted by industries and organizations where security, reliability, and low latency are dominant. As technology and standards evolve, some of these challenges may become less significant, making MPNs even more attractive for various applications.

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Endnotes

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