Case Studies From 5G Wireless Private Networks in the Mining Sector

A Technical Paper prepared for SCTE by

Andy Striegler
Sr. Director, Enterprise Customer Solutions
Rogers Communications Inc.
8200 Dixie Road, Brampton, Ontario, Canada
+1 647-747-0644
andy.striegler@rci.rogers.com

Kamaljit Bal
WPN Architect, Enterprise Customer Solutions
Rogers Communications Inc.
8200 Dixie Road, Brampton, Ontario, Canada
+1 416-825-7084
Kamaljit.bal@rci.rogers.com

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1. Introduction

A new generation of private 5G networks is emerging to address critical wireless communication requirements in public safety, industrial operations, and critical infrastructure. Advanced network features and services are needed to serve mission-critical and business-critical use cases.

Within the industrial market segment, the mining sector has been an early adopter of wireless private technology and has been investing heavily in wireless private networks (WPNs) around the globe to enhance overall productivity, operational efficiency, and safety.

In recent years, Rogers has deployed multiple WPNs in the mining sector in Canada. In 2020, Rogers launched Western Canada's first private LTE network with one of the latest coal mine in British Columbia and later deployed 5G-Ready private network solutions at an Open Pit Gold Mine in Northern Ontario. The WPNs were designed to provide reliable, low-latency wireless communications primarily for autonomous haul truck operations and other critical in-pit applications.

On-premises deployment architecture model was chosen as a standalone private network. To enable a fully operational 5G Wireless Private Network at the mine, Rogers has deployed multiple cellular network towers with its full range of spectrum frequency bands to support a diverse set of use cases and applications throughout the mine site. Radio Access Network (RAN) Sites were configured to enhance efficiency, increase Bandwidth, reduce latency to less than 20ms. Wireless Private Network sites are connected to fully redundant High Availability (HA) Mobile Cores deployed locally on mines Data Centers. Each site has fiber transport backed up by Microwave link. The network has been built with a full failover backup system across the site. The system is designed to guarantee automated deployment and configuration, and efficient operation and maintenance throughout its life.
The authors of this paper and presentation will discuss the lesson learned, key system requirements, use cases, design considerations, operations, and network performance.

2. Private Network Definition

The definition of a private mobile network used in this report is a 3GPP-based 4G LTE or 5G network intended for the sole use of private entities, such as enterprises, industries, and governments. The definition includes MulteFire or Future Railway Mobile Communication System. The network must use spectrum defined in 3GPP, be intended for business-critical or mission-critical operational needs. Non-3GPP networks such as those using Wi-Fi, TETRA, P25, WiMAX, Sigfox, LoRa and proprietary technologies are excluded from the Private network list. Furthermore, network implementations using solely network slices from public networks or placement of virtual networking functions on a router are also excluded. Where identifiable, extensions of the public network (such as additional sites deployed at a location, as opposed to dedicated private networks), are excluded. These items may be described in the media as a type of private network.

3. Why Private Networks

The demand for private mobile networks based on 4G LTE (and increasingly 5G) technologies is being driven by the spiraling data, security, digitization and enterprise mobility requirements of modern business and government entities. Organizations of all types are combining connected systems with big data and analytics to transform operations, increase automation and efficiency or deliver new services to their users. Wireless networking with LTE or 5G enables these transformations to take place even in the most dynamic, remote, or highly secure environments, while offering the scale benefits of a technology that has already been deployed worldwide.

Private mobile networks are also often part of a broader digital transformation program in an organization. This could include the introduction or development of cloud networking and other digital technologies such as artificial intelligence and machine learning, and data analytics. More and more applications of the private mobile network will use these capabilities combined with mobile connectivity.

There are several reasons for the growing demand for 4G and 5G private networks. Here are some key factors driving this trend:

Enhanced Security: Private networks provide an extra layer of security compared to public networks. Industries that deal with sensitive data, such as government agencies, financial institutions, healthcare organizations, and critical infrastructure sectors, require robust security measures to protect their data and operations. Private networks offer increased control over network access and data management, reducing the risk of unauthorized access and data breaches.

Customized Solutions: Private networks allow organizations to tailor their network infrastructure according to their specific requirements. They can optimize network performance, allocate resources efficiently, and prioritize critical applications. This customization ensures reliable and predictable network connectivity, reducing latency and improving overall efficiency.

Industrial Internet of Things (IIoT) Applications: The rise of the Industrial Internet of Things has led to an increased demand for private networks. IIoT applications, such as smart manufacturing, autonomous vehicles, remote asset monitoring, mining, and precision agriculture, often require low latency and high bandwidth connections. Private networks can offer dedicated and reliable connectivity to support these demanding applications.

Mission-Critical Communications: Certain industries, such as public safety, defense, and emergency services, require uninterrupted and reliable communication for their critical operations. Private networks can ensure dedicated and prioritized connectivity, enabling real-time communication and coordination in emergencies or mission-critical situations.

Improved Performance and Capacity: 4G and 5G private networks offer superior performance and increased capacity compared to public networks. These networks can handle a larger number of connected devices simultaneously and provide faster data transfer rates, enabling bandwidth-intensive applications and services.

MEC: 5G Multi-Access Edge Computing (MEC) brings compute power closer to the network edge, eliminating the time it takes to run data to a centralized data center. This reduces communication latency, increases system performance, and leads to new business opportunities in the private network space.

Overall, the private network market will experience substantial growth over the next several years. These networks offer organizations greater control, reliability, and tailored services to meet their specific requirements. As a Canadian leader in 5G innovation, Rogers has been developing 5G use cases in several sectors in partnerships with the Canadian universities and industry consortiums. In these following sections, we will present case studies from two different private network deployments done by Rogers.

4. Private Networks Architectures

5G technology holds immense importance for industrial use cases due to its transformative capabilities that revolutionize the way industries operate. With its ultra-low latency, high data rates, and massive device connectivity, 5G enables a range of applications that significantly enhance productivity, efficiency, and safety in industrial settings. Multiple architecture and partnership options can be considered when implementing private wireless solutions. Choosing the best approach depends on multiple factors such as the character of various sites, the use cases, and the Private enterprise capabilities. In certain use cases, it is necessary for the data to remain within the confines of the organization to maintain privacy and allay security worries. In such cases, some (if not all) of the network entities need to reside locally in the organization's premise and/or be owned by the organization.

4.1. Standalone Private Network Deployment

In this model, a small standalone cellular network with associated management and operations tools and applications, user end points, and radios are integrated into the enterprise LAN and managed by the enterprise IT department or a service provider. The security and administration of this private cellular network are often handled separately, and there is typically little to no integration of this network with other enterprise network components. Figure 1 shows the high-level architecture of On-premises private network deployment. This concept has been used to create private 4G LTE networks in locations that require cellular access but do not have coverage from major providers, mining is a typical example.

In many new private 5G deployment scenarios, this model is being looked at as the first alternative. This model is typically used in early proof-of-concept and trial deployments to assess the maturity of use cases and deployment options. Larger more complex deployments, for example multi-site enterprises with multiple use cases for private cellular, may find this model limiting and too complex.

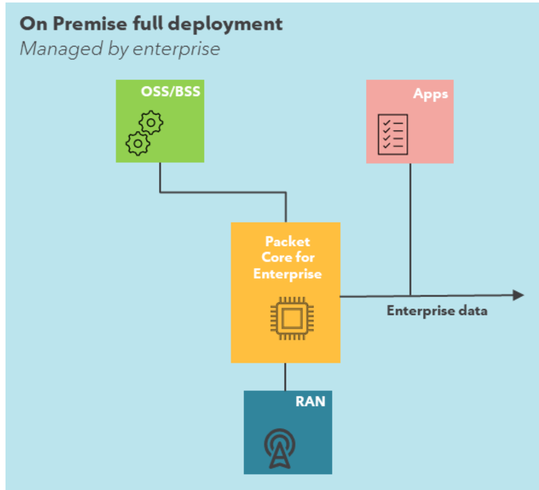

Figure 1- On-premises full deployment Model for WPN

4.2. Hybrid cloud private deployment

As a result of business demands for less complicated management of a stand-alone private cellular network, cloud hosted private deployment options have been emerging in recent years.

These models involve placing a portion of the private cellular network on the premises of the business, on an edge platform, and managing it remotely via the cloud. Depending on the architecture, the precise mix of on-premises to cloud infrastructure can change. In the simplest scenario, the radio and packet core are on-site at the enterprise, while the management applications are hosted in the cloud. Another option is to place the packet core, or key components of a virtualized packet core such as the User Plane Function (UPF), is on premise. The ultimate deployment architecture is determined by the demand for throughput and latency as data moves across the cloud. Figure 2 shows the high-level architecture of hybrid cloud private network deployment

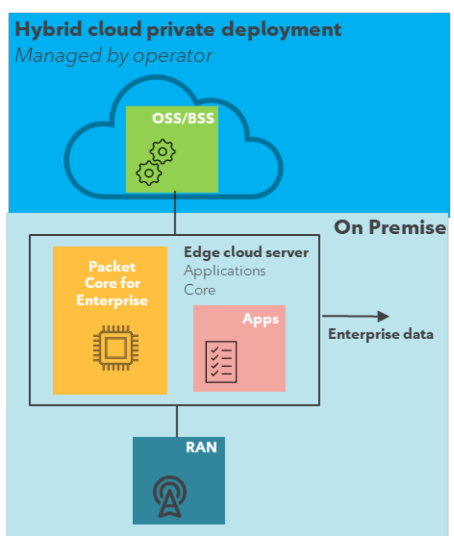

Figure 2- Hybrid cloud Model for WPN

These models can be created in novel ways thanks to the flexibility brought about by the 5G virtualized packet core and edge platform advancements. The cloud hosted options are attractive for enterprises as they can offload complexity of operations of a standalone cellular network to the cloud provider operator. However, they suffer from the same drawback as the standalone models, as they depend on leased or shared/local spectrum availability, unless enterprises or system integration partners own spectrum that can be used in these models.

4.3. Network Slice based private network deployment

The network slice deployment model is where a Mobile Network Operator (MNO) dedicates a “slice” of their existing commercial cellular network to an enterprise. A slice can include a set of radios, spectrum bands, fiber network capacity, 5G Core, and other collaterals as defined by the MNO. In this model, the operator will continue to operate the slice of the network that is dedicated to the enterprise for a cost and will integrate the slice into the enterprise network enabling the enterprise to co-manage the slice through MNO operations portal that will be made available. The minimum core elements and applications are deployed on the premises to ensure reliability, low latency, and preserve the confidentiality of the data. The rest of the core elements and applications run in the service provider cloud and rely on existing cloud core management.

Figure 3 shows the high-level architecture of slice based private network deployment

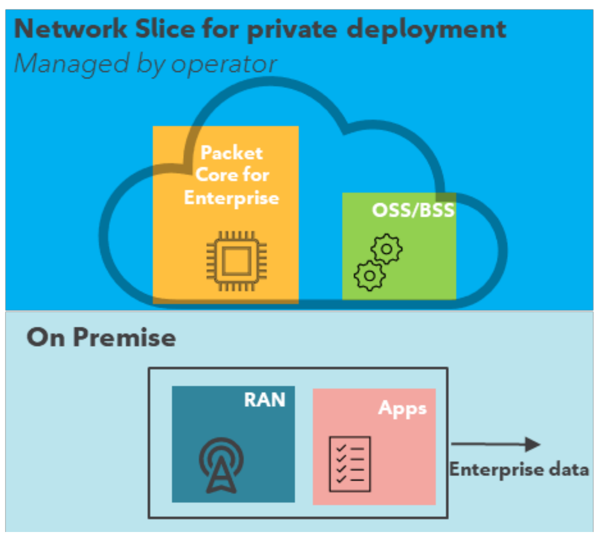

Figure 3- Network Slice Model for WPN

The level of control, security, and management of the slice is specified and agreed to through Service Level Agreements (SLA) that will be made between the provider and the enterprise. This network slice model is extremely appealing as it can open the vast resources of cellular providers: spectrum, footprint, coverage, & expertise, to enterprises. However, it remains to be seen how providers can successfully monetize this model as it might directly compete with the profitable consumer cellular use cases that providers have hitherto prioritized.

In conclusion, the complexity of implementation and operational costs are highest for autonomous private architecture and lowest for core slicing. Data confidentiality, security and reliability typically decreases with as-a-service and core slicing solutions. A hybrid private–public architecture could be a more appropriate choice if the operations are spread over a wider area, need connectivity with off-site and mobile assets, or prefer to outsource this part of the enterprise IT operation. Dedicated private wireless solution could be more suitable if enterprise need to have full control of their network and ensure the reliability and availability of the local operations when failures occur in the outside world.

4.4. Spectrum related requirements

Spectrum is crucial to any wireless network deployment. A key factor influencing the uptake of wireless solutions is the question of how to handle spectrum for industrial purposes, since reliable connectivity demands licensed spectrum. Some countries provide spectrum dedicated for industrial use, whereas others do not. Communication Service Providers (CSP) are in the prime position to optimally address these industrial connectivity needs with powerful 5G networks and business models focused on industries. There is a huge opportunity for CSPs to address industrial connectivity needs with 3GPP based cellular technologies. The opportunity encompasses a range of industries, including diverse segments with diverse needs, such as those in the manufacturing, mining, port, energy, and utilities, automotive and transport, public safety, media and entertainment, healthcare, and education industries, amongst others.

The more available spectrum, the more enriched use cases can be enabled. In this context, private mobility is an accelerator, as it allows service provisioning even before availability of the public network. Private mobility also enables tailoring an optimized wireless solution to match the target application requirements. Government officials and bodies recognize the benefits widespread 5G deployment can bring to various industries and public services. There has been a notable shift in focus towards dedicating spectrum for the deployment of private cellular networks.

5. Wireless Private Network: Coal Mine in British Columbia

5.1. Introduction

Customer has recognized that mining companies are at a tipping point. As they strive to boost productivity and efficiency, attain safety and eco-sustainability, and deliver higher shareholder value, customer reimagines their operations paradigms and embraces new digital innovations and technologies.

Customer has taken a giant step to modernize its company with a critical infrastructure upgrade built for demanding applications, including Autonomous Haulage Systems (AHS), Internet of Things (IoT), Push-to-Talk (PTT), advanced analytics and many more.

Customer's vision to create a genuinely Private LTE (pLTE) infrastructure to enable their digital transformation strategy called for an innovative partnership with Rogers. Since then, pLTE deployment has become a foundational component for customers digital transformation. By design, it is robust, scalable and application ready. pLTE is an enabler for various end devices, user equipment (UE) and sensors that will drive rich data analytics and decision support tools.

5.2. Solution Architecture

Rogers launched Western Canada's first private LTE network at one of the Coal Mine in British Columbia. This pLTE were designed to provide reliable, low-latency wireless communications primarily for autonomous haulage truck operations and other critical in-pit applications.

The Network design involves geo-redundancy to design highly available applications. Customer chose geo-redundant architectures to avoid downtime by distributing applications and infrastructure across significant distances. For improved reliability and capacity, the two identical systems are placed in a group, and their configurations are synchronized to prevent a single point of failure. A typical application of geo-redundant architecture is dealing with natural disasters, which may cripple certain areas and ensure 0% migration downtime.

The continuous terrain changes in mining industry makes design phase challenging. The design should consider Mine Evolution “terrain changes”. Reliable and real-time propagation loss modeling play a significant role in the efficient planning, development, and optimization of macro cellular communication networks in each terrain. Thus, the need to create/adapt or regularly tune an existing design to enhance its signal propagation accuracy in a specified terrain becomes imperative.

Below are pictures from the customer mine location showcasing the radio install and coverage plan using fixed communication towers and CoWs due to changing terrain.

Figure 4- Customer Mine Site

- On-premises deployment architecture model was chosen as a standalone private network to enable a fully operational pLTE Network at the mine.
- Rogers has engineered the network with dedicated multiple spectrums to address peak usage and future requirements.
- RAN Sites are designed to consider terrain changes, and configured to support enhance efficiency, increase Bandwidth, reduce latency.
- The Core sites are designed with fully geo-redundant HA architecture.
- The network has been built with a full failover backup system with the site.
- Considering the entire network is deployed behind the Customers LAN network which means, it is fully secured from application/IT/Management Perspective.
- Network support a diverse set of use cases and applications such as AHS, PTT
- Enable Customers digitalization innovation strategy which includes Autonomous Haulage System, PTT, manned mining apps and UE manufacturers (AVI).

Figure 5 shows the high-level architecture of Customer Ltd pLTE network deployment

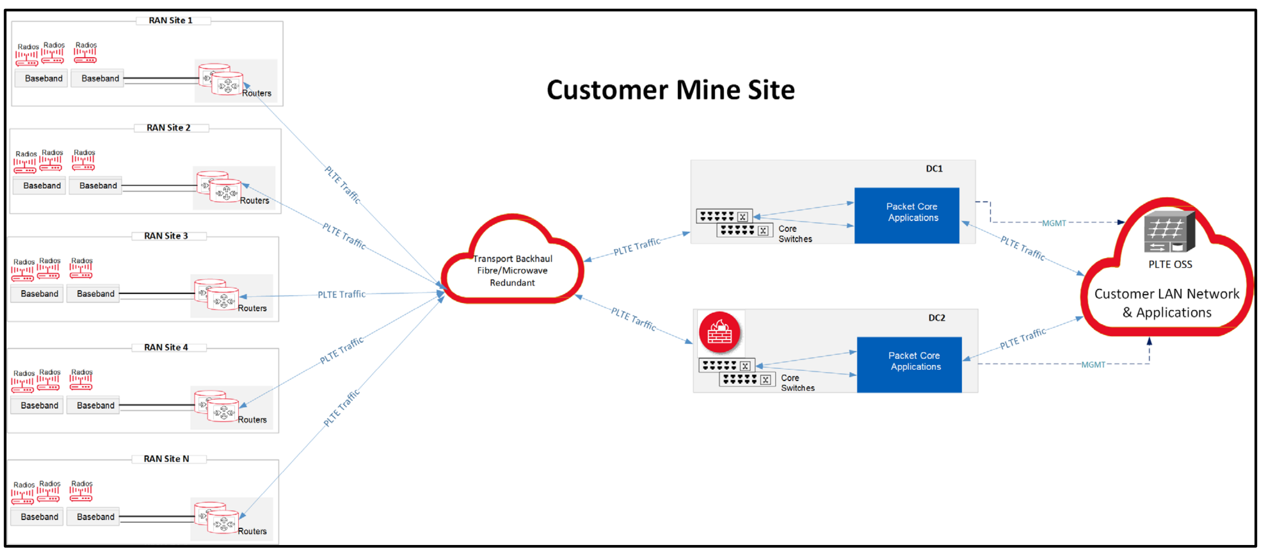

Figure 5- high Level Architecture

5.3. Outcome

- Considering the entire network is deployed behind the Customers LAN network which means, it is fully secured from application/IT/Management Perspective.
- Reliable and real-time propagation loss modeling play a significant role in the efficient planning, development, and optimization of Radio networks in different terrains.
- Enable customer's digitalization innovation strategy which includes Autonomous Haulage System, PPT, manned mining apps and UE manufacturers (AVI).

- Reliable coverage and backhaul connectivity increased the operational accuracy of the field assets and devices

- Production Process efficiency has improved by broader network coverage for assets and devices using fleet management application.

- Allow workers/miners to spend more time in the field and access/process applications data remotely hosted in the central facility.

6. Wireless Private Network: Open Pit Gold Mine in Northern Ontario

6.1. Introduction

The Rogers Wireless Private Network is deployed in Open bit Gold Mine in Northern Ontario, it is to provide the private LTE/5G coverage at the mine with high capacity, low-latency solution to improve Mine Safety & increase Mining Operations Efficiency.

6.2. Solution Architecture

Gold Mine becomes the first open pit mining operation in Canada to be fully connected over LTE/5G Wireless Private Network. Dedicated LTE/5G network key to transform into Smart Digital Mine of the future.

Rogers has deployed multiple cellular network towers with its full range of spectrum frequency bands to support a diverse set of use cases and applications throughout the mine site. RAN Sites were configured to enhance efficiency, increase Bandwidth, reduce latency to less than 20ms.

Wireless Private Network sites are connected to fully redundant HA Mobile Cores deployed locally on mines Data Centers. Each site has fiber transport backed up by Microwave link. The network has been built with a full failover backup system across the site. The system is designed to guarantee automated deployment and configuration, and efficient operation and maintenance throughout its life.

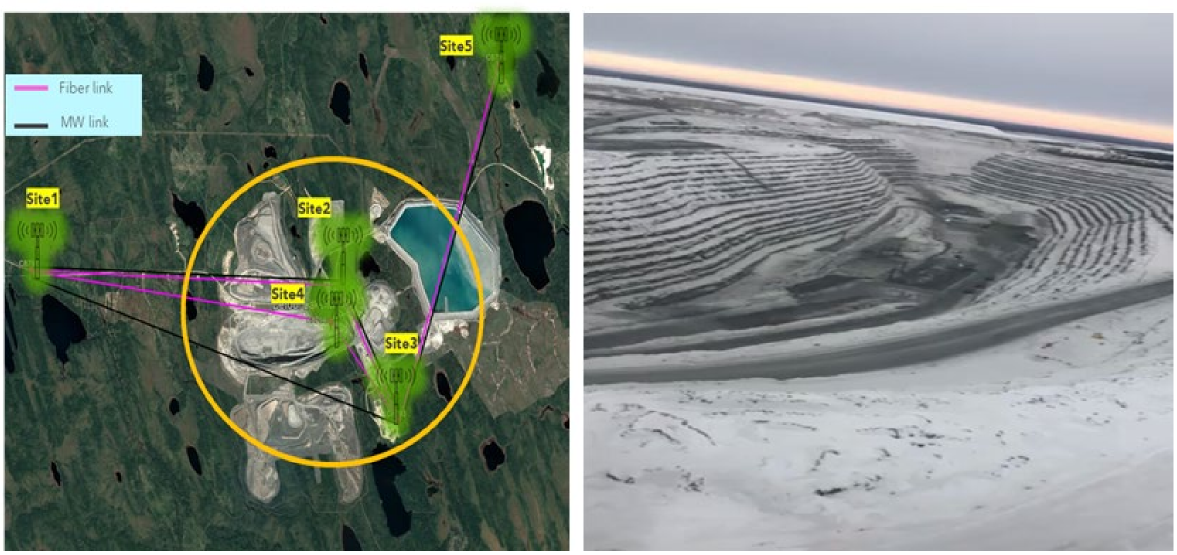

Figure 6- Customer Mine Site

- On-premises deployment architecture was chosen with Cloud based management network to enable a fully operational 5G Wireless Private Network at the mine:
- Rogers has deployed multiple cellular network towers with full range of spectrum frequency bands.
- RAN Sites were configured to enhance efficiency, increase Bandwidth, reduce latency to less than 20ms.
- Wireless Private Network sites are connected to fully redundant HA Mobile Cores.
- The network has been built with a full failover backup system across the site.
- Network support a diverse set of use cases and applications throughout the mine site.
- Enable digitalization of mining use cases such as Autonomous Haulage and Drilling System, teleremote operations which require low latency less than 20ms.

Figure 7 shows the high-level architecture of Open Pit Gold network deployment

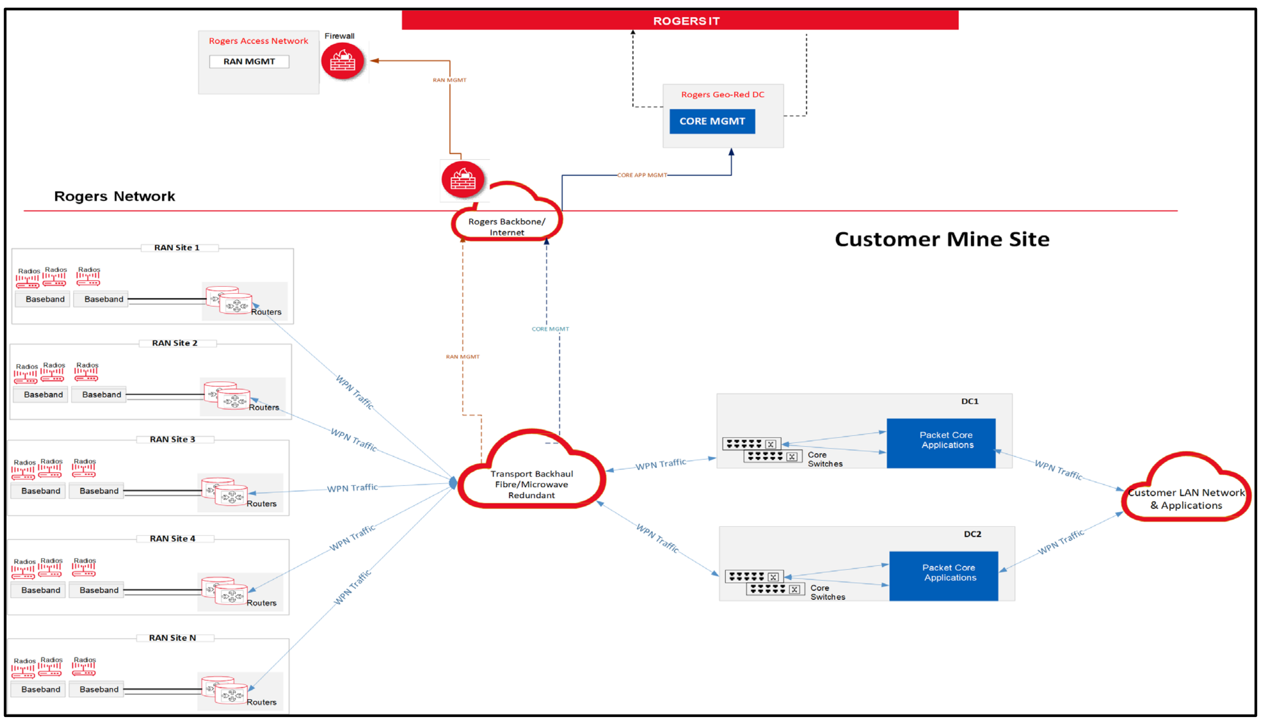

Figure 7- high Level Architecture

6.3. Outcome

- Production Process efficiency has improved by broader network coverage for assets and devices using fleet management application.
- Enable digitalization of mining use cases such as Autonomous Haulage and Drilling System, Blast loading SW which require low latency less then 20ms and some other high latency tire pressure sensor application.

- The round-trip latency between the devices and applications are measured less than 20ms.
- Wireless Private Networks enables high-capacity real time video surveillance system attached to Autonomous Haulage vehicles to upload around 60 Mbps data.
- Reliable coverage and backhaul connectivity increased the operational accuracy of the field assets and devices
- Allow workers/miners to spend more time in the field and access/process applications data remotely hosted in the central facility.

7. Conclusion

Wireless Private Networks resolve strategic challenges in the mining industry such as mine safety, operational efficiency, Mission Critical use cases, Data accuracy, Privacy, and capacity issue (Bandwidth/latency).

Canadian mining industry is gradually adopting the latest technology to deploying, integrating a managed, modular, and customizable Wireless Private Network to ensure that mining sector benefits from next-generation innovation

- Wireless Private Networks are key to the success of Mining Industrial evolution worldwide.
- Enable digitalization of mining use cases such as Autonomous Haulage System, and Drilling System, Blast loading SW and teleremote operations which require low latency less than 20ms and some other high latency tire pressure sensor application.
- The round-trip latency between the devices and applications are measured less than 20ms.
- Wireless Private Networks enables high-capacity real time video surveillance system attached to Autonomous Haulage vehicles to upload around 60 Mbps data.
- Considering Wireless Private Networks are deployed dedicated for the customer with industry grade HW, the packet drop within the network is less then 0.25%.
- Reliable and real-time propagation loss modeling play a significant role in the efficient planning, development, and optimization of Radio networks in different terrains.
- Production Process efficiency has improved by broader network coverage for assets and devices using fleet management application.
- Allow workers/miners to spend more time in the field and access/process applications data remotely hosted in the central facility.
- Wireless Private Network meet all the requirements laid by the mining industry such as operational efficiency/Mine Safety/coverage/Services Availability.
- CSP’s along with their vendor partners are contributing to the Wireless Private Network Market in Canada with innovation and research to help drive revenue

As mining industry continues to face multiple complex challenges, from uncertainty across geopolitical landscape to the disruption of digital economy, resulting in increased pressure as productivity in operation needs to improve. To capitalize on digital revolution, mining companies would benefit from 5G and be the catalyst for this transformation:

- Up to 25% increase production
- Up to 40% drill operations
- Up to 20% energy savings

5G networks have the potential to provide opportunities to the mining industry such as automation and remote operations due to improved coverage, lower latency, and higher reliability at every stage of its business operations.

Abbreviations

AP	Access Point
LTE	Long Term Evolution
IIOT	Industrial Internet of Things
MNO	Mobile Network Operator
CSP	Communications Service Provider
AHS	Autonomous Haulage System
IOT	Internet of Things
PTT	Push to talk
UE	User Equipment
COW	Cell on Wheel
RAN	Radio Access Network
HA	High availability
LAN	Local Area Network
Mbps	Megabits per second
HD	high definition
SCTE	Society of Cable Telecommunications Engineers

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