

# Building a converged mining automation network

A communications blueprint for digital mines

White paper

To overcome immense challenges, mining companies are transforming by seizing technology advancements and adopting an automated, digital mine paradigm. Foundational to digital transformation is a converged communications and mining automation network (MAN).

This white paper, the second of two, explains how the Nokia converged MAN blueprint provides the attributes and benefits required for the mining industry to meet its challenges and continue to thrive.

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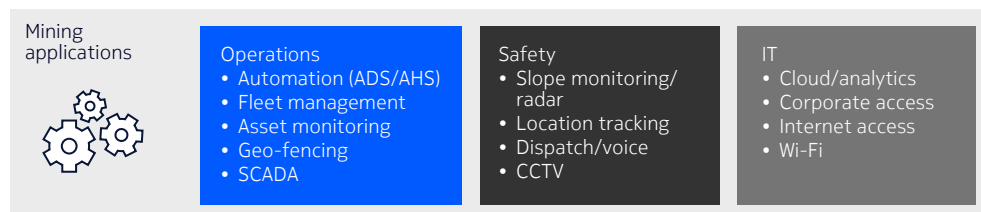
## Mining industry must transform to thrive

To satisfy the growing demand for mineral resources, mining companies have expanded in scale and grown in sophistication. They have transformed from small-scale manual labor to massive scale, heavily mechanized and capital-intensive corporate endeavors. Today, they are typically multinational firms operating globally, constantly exploring for new reserves as well as excavating, processing and transporting minerals worldwide to deliver profits to shareholders.

Despite past success, mining companies need to be better prepared for tomorrow. They operate with intensive capital in volatile political conditions and under stringent environmental regulations. They face the immense challenges of working in often harsh, remote and sometimes uninhabitable or hostile regions. In addition, they must deal with constantly fluctuating commodity prices affected by the global economic boom-bust cycle and political challenges. And they do all this while striving to deliver profitability and attain eco-sustainability.

To overcome these challenges and continue to flourish, mining companies are transforming by seizing technology advancements and adopting an automated, digital mine paradigm. They are embracing and investing in automation and other new mining applications such as predictive analytics to increase productivity, improve operational safety and attain environmental sustainability (see Figure 1).

Figure 1. Mining companies embracing digital transformation



Foundational to digital transformation is a converged communications and mining automation network (MAN) that can provide:

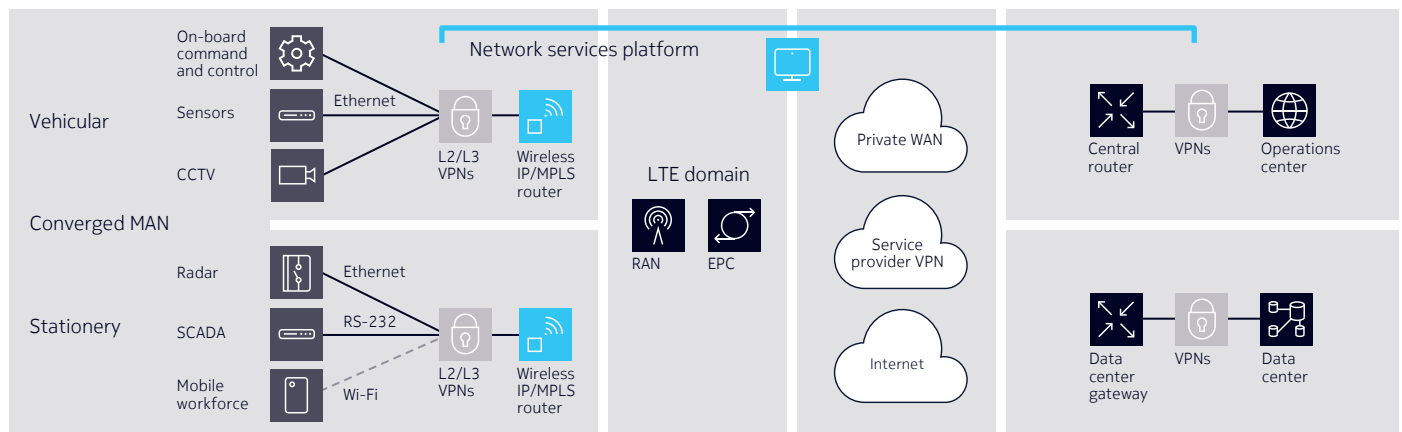
- Multiservice capability to provide converged communications for all applications
- Robust, cost-effective, everywhere broadband wireless connectivity
- Deterministic QoS capability and end-to-end redundancy protection to assure delivery of traffic for critical applications such as automation
- Flexible service capability to optimize machine-to-machine (M2M) application performance
- Simplified end-to-end network management
- Full interoperability with legacy applications and interfaces.

With these attributes, the converged MAN becomes the launching pad for mining companies' transformation journey. New mining applications can be deployed quickly with the network services platform rapidly provisioning new IP/MPLS VPNs. Through proper network dimensioning and QoS design, all applications can be assured of their required bandwidth. Mining companies can now fully harness the power of automation and other digital applications.

## Nokia converged MAN

As shown in Figure 2, Nokia offers a converged MAN blueprint that is grounded in two advanced and field-proven networking technologies: LTE and IP/MPLS.

Figure 2. The Nokia Converged MAN blueprint



### LTE

LTE is the 4G mobile broadband technology ideal for applications requiring low latency as well as broadband capacity. It has high spectral efficiency and uses advanced digital communications techniques such as orthogonal frequency-division multiple access (OFDMA), turbo coding and multiple-input and multiple-output (MIMO). It operates in numerous frequency bands and accommodates different channel sizes, catering to different spectrum availability situations and applications. It also continues to evolve to support emerging technologies, including the Internet of Things (IoT). Furthermore, with higher RF transmit power, better sensitivity and greater EIRP than other wireless broadband technology such as Wi-Fi® mesh, an LTE network can cover the same area with fewer base stations, attaining higher network efficiency.

While it is still a relatively new technology to the mining industry, LTE has been widely deployed by mobile network operators worldwide, offering data and voice communications for billions of subscribers. Critical infrastructure operators, including public safety agencies and railways, have also rolled out private LTE networks. With its flexible frequency band support, mining companies can either lease spectrum from mobile operators or gain access to a dedicated spectrum through government authorities to build their own private LTE networks.

With the preceding benefits, LTE is an ideal broadband radio networking technology to enable mining companies to reliably and cost-effectively cover hundreds of square kilometers.

### IP/MPLS

IP/MPLS can enable scalable, secure and flexible VPN services to converge numerous applications and connect to a multitude of devices. IP/MPLS VPN services support segregated, flexible, point-to-point and multipoint Ethernet and IP communications. Because of its deterministic QoS and encryption capabilities, with proper network engineering and design, IP/MPLS can assure timely and secure delivery of critical traffic from applications such as automation. It has been a technology of choice for modernizing mission-critical networks, supporting critical infrastructure such as electric grids, public transportation systems and public safety.

## Implementing the Nokia converged MAN with IP/MPLS

By innovatively merging IP/MPLS VPN services and LTE in a wireless IP/MPLS router, the Nokia converged MAN offers mining companies much more than just an LTE network. In addition to the robust, everywhere broadband wireless connectivity that a generic LTE network can provide, the Nokia converged MAN brings segregated and secure data communications for:

- Mining equipment and application devices (stationery or mobile)
- Control and monitoring applications
- The mining workforce.

In addition, the MAN can interconnect seamlessly with the operations center and data center via a self-built wide area network, a service provider VPN or the internet.

All of this is managed end-to-end by a network services platform.

The following sections describe the attributes of the Nokia converged MAN.

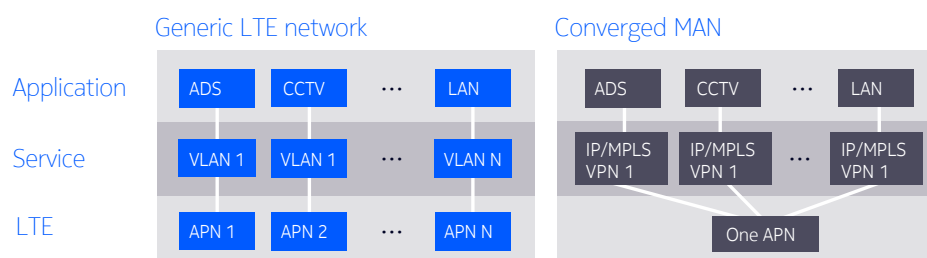
### Service convergence

Digital transformation ushers in many new, intelligent applications. As discussed in the white paper “The need for covered mining automation networks,” the purpose-built, application-specific network paradigm is costly and inefficient, impeding the pace of transformation. Therefore, it is imperative to move to a converged service network paradigm that can support numerous applications over a common network.

Even with new broadband wireless technologies such as Wi-Fi or LTE, the radio network sometimes still needs to be segmented by a service set identifier (SSID) or access point name (APN) that maps to different VLAN domains for individual mining applications in order to attain traffic segregation and QoS differentiations among applications. Every time a new application is deployed, in addition to a new VLAN domain creation being required, a new Wi-Fi SSID or LTE APN is required. This paradigm incurs significant wireless network management overhead.

By contrast, IP/MPLS provides a service convergence capability that requires only one APN at the LTE layer throughout the lifetime of the network because of the service-aware QoS capabilities. A new application requires only a new IP/MPLS VPN riding atop the same APN. This paradigm allows mining companies to build and configure the underlying LTE network only once and be ready for numerous mining applications—legacy, new and emerging—over a common communications infrastructure (see Figure 3). The result is optimal network operations efficiency and faster digital transformation.

Figure 3. Service architecture comparison of generic LTE network and converged MAN



Moreover, different mining applications have diverse communications requirements. With their full range of Ethernet and IP capability, IP/MPLS VPNs are capable of flexibly accommodating the various requirements (see Table 1).

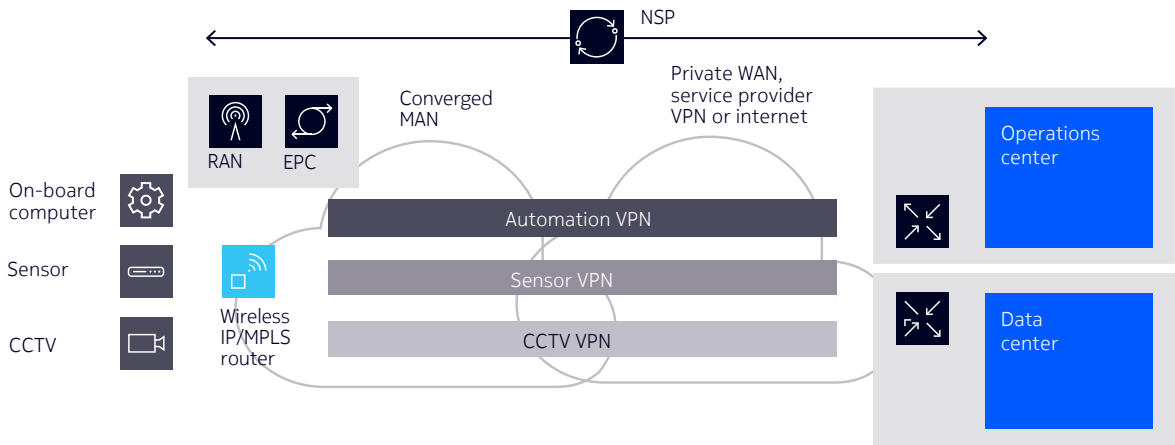
Table 1. IP/MPLS VPN can flexibly accommodate various requirements

Application	Traffic nature	Challenges	IP/MPLS VPN
Mining automation	IP any-to-any	Intra-subnet communications; low latency	Virtual private LAN service (VPLS)
Asset monitoring	IP point-to-point	Reliability	Ethernet pseudowire
SCADA	IP or TDM multipoint	Reliability; interoperability (for legacy systems)	IP VPN, optionally with raw socket for RS-232 interface
CCTV	IP multipoint	Multicast traffic	IP multicast and hierarchical VPN
IT Wi-Fi	IP multipoint	High throughput without impacting critical applications	IP VPN

## Seamless communications between mine, operations center and data center

It is imperative that the operations center constantly monitors mining activities. The introduction of mining automation and other digital applications also makes communications the with data center necessary. Therefore, extending connectivity beyond mines is essential. IP/MPLS VPNs can straddle the converged MAN and the corporate network seamlessly (see Figure 4).

Figure 4. IP/MPLS VPN supports seamless end-to-end communication

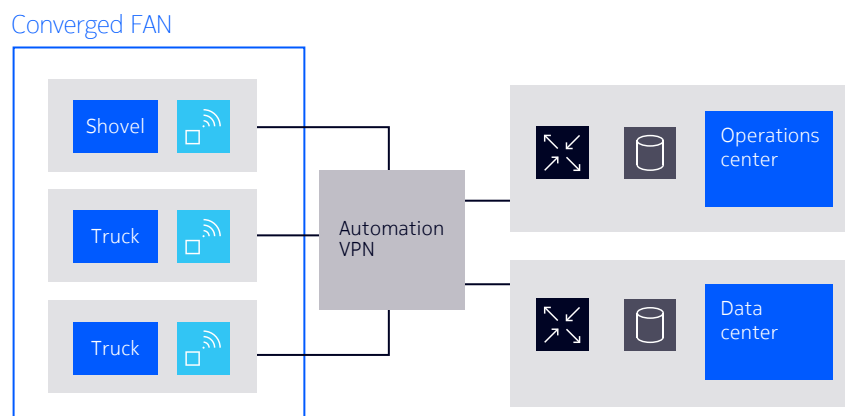


## Optimal M2M communications

M2M communication is fundamental to the mining automation that is crucial to the success of the mining industry. IP/MPLS VPN’s unique flexibility in point-to-point and multipoint Ethernet and IP services allows any-to-any direct communications over LTE among all necessary subsystem components anywhere: in the mine, the operations center or the data center, without needing to go through a central gateway. As an example, a VPN for automation allows all autonomous mining machines to respond to nearby mining vehicles while at the same time being monitored remotely, through stateless<sup>1</sup> meshed tunnels among all routers in the mines as well as the operations center and data center (see Figure 5). Dependent on the communications requirement, the automation VPN can provide Ethernet or IP connectivity among all application system components.

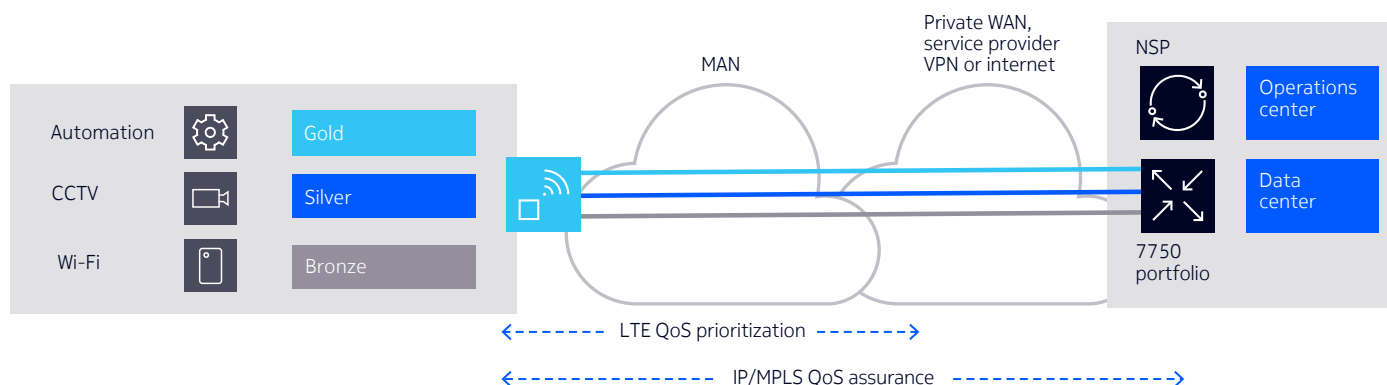
<sup>1</sup> An encrypted tunnel in a converged FAN is stateless, unlike a stateful IPsec tunnel. This makes tunnels simple to configure and efficient to maintain. For more details, read the Nokia application note “Network Group Encryption.”

Figure 5. Flexible IP/MPLSVPNs provide direct, optimal any-to-any communications



Automation applications also require real-time interaction with the surroundings. Assured delivery with strict communication delay is essential to ensure safety. Harnessing deterministic IP/MPLS QoS capabilities and LTE QoS prioritization, a converged field area network (FAN) provides assured QoS in the FAN and also extends QoS to the operations center and data center, provided that the interconnected network also possesses similar QoS capabilities (see Figure 6).

Figure 6. Converged MAN provides QoS and extends to operations and data centers



	Latency	Bandwidth	Reliability	Criticality
Automation	Low	Low	High	High
CCTV	Medium	Medium	Medium	Medium
Wi-Fi	High	High	Low	Low

## Robust broadband wireless connectivity

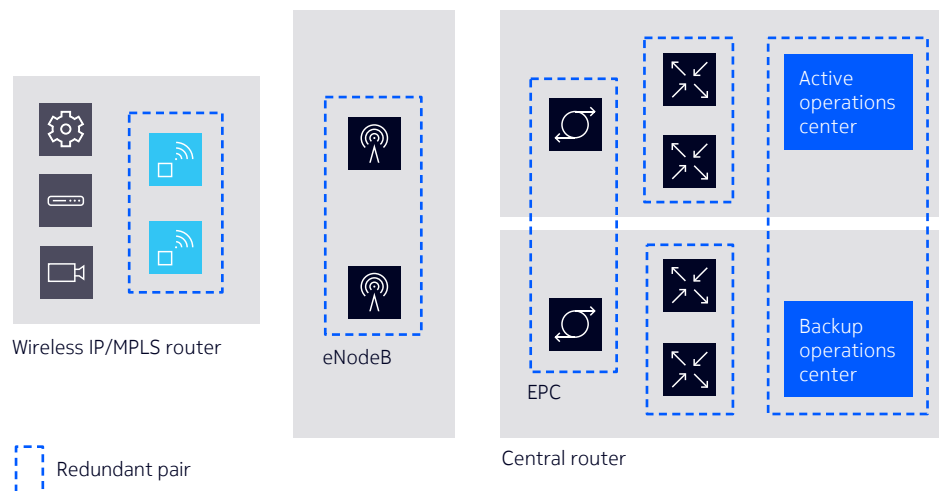
Mining communications take place over open field area, ranging from tens to hundreds of square kilometers, with people and gargantuan machines constantly on the move as activities are carried out. As mines are developed, the size increases and topography changes frequently with blasting, digging and other activities, requiring wireless coverage re-design, re-optimization and re-deployment which could last for days, if not weeks. This could bring mining operations to a halt, causing operations downtime and affecting productivity and profits.

To optimize operations uptime, the wireless connectivity needs to adapt quickly and continue to reach wherever people and machines are today and will be tomorrow despite shifts in the size and shape of mines. LTE broadband wireless technology has wide coverage and non-line-of-sight propagation characteristics, greatly reducing the need to re-deploy LTE base stations (eNodeBs) due to the changing form of mines, thereby minimizing extraction activities stoppage.

## Resilient end-to-end communication

As mines become automated and digital, communications with operations centers and control centers are more critical than ever before. Consequently, mining companies require more than just robust broadband wireless connectivity in their mines. The converged MAN needs to support high reliability in the end-to-end path from a mine to the operations center and data center. Pairing nodal redundancy protection with the full suite of IP/MPLS resiliency mechanisms, including pseudowire redundancy, BGP PIC/FRR, VRRP and MC-LAG, ensures that the whole communication path is resilient and can withstand network and equipment failures (see Figure 7).

Figure 7. IP/MPLS enables a fully-protected, end-to-end communication path



In addition, as natural disasters such as hurricanes and flooding become more intense and frequent, even in urban areas, it becomes crucial that there are redundant operations and data centers to ensure business continuity when disaster strikes. An IP/MPLS VPN can enable geo-redundancy protection by switching traffic from mines to the standby center pre-emptively or when failure occurs.

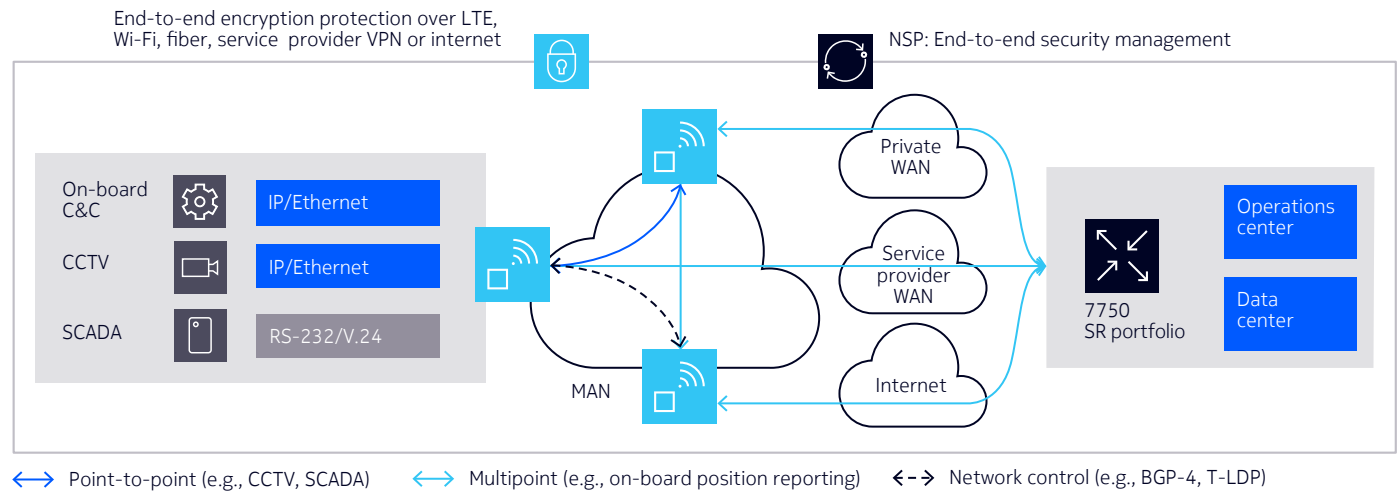
## Rigorous network security

Because of the importance of commodity trading on international markets and its impact on countries' economic development, mining companies are very often a valuable and important target for cyberattack. Exploration data and production data are sensitive information that can affect mining companies' success and future as well as commodity prices. With the extensive use of command and control systems and the introduction of automated hauling and drilling, it is also imperative to safeguard all communications to prevent mining operations from being compromised. Therefore, it is also imperative to protect data transmission from mines to operations centers and data centers.



As part of the defense-in-depth security framework,<sup>2</sup> IP/MPLS VPN restricts communications among an operator-defined set of subsystem components and devices, providing a formidable defense against cyberattacks. In addition, the use of Network Group Encryption (NGE)<sup>3</sup> can encrypt IP/MPLS VPN data and network control traffic, such as routing and signaling, flexibly over LTE and Wi-Fi radio links, optical fiber, service provider VPN and the Internet (see Figure 8).

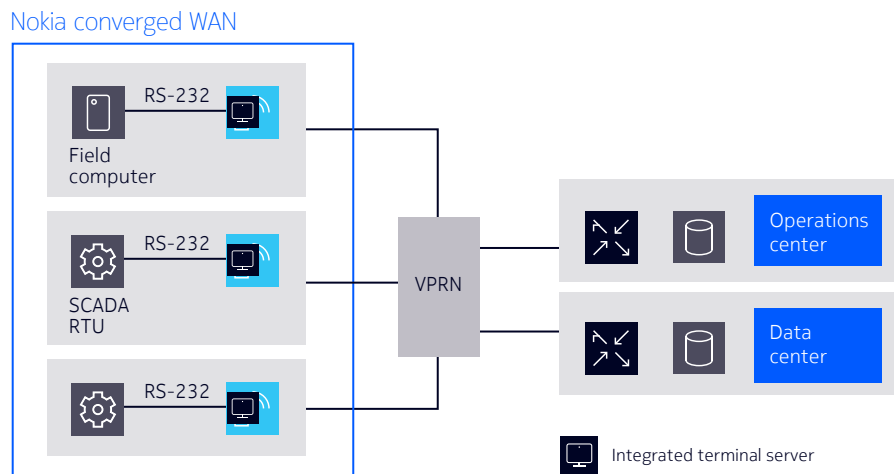
Figure 8. NGE safeguards all mining communications



## Bridging the past to the future

Serial interfaces such as RS-232/V.24 were commonly used in industrial and SCADA systems in the past and are still adopted by some field systems such as field computers today. With raw socket transport technology, IP/MPLS can gracefully adapt serial data over IP. Essentially, the IP/MPLS platform receives asynchronous characters and transports them by TCP or UDP sessions in IP packets with a Layer 3 IP/MPLS VPN (also known as VPRN) service.

Figure 9. Raw socket technology for serial-to-IP seamless adaptation



<sup>2</sup> For more information about network defense, read the [Nokia white paper](#).

<sup>3</sup> To find out more about NGE, read the [Nokia application note](#).

## Simplified network management

As more applications are in use, with a communications flow from the mine to the operations center and the data center, managing a reliable network has become a monumental task. A service-centric management platform can:

- Enable unified, end-to-end management including packet microwave and optical transport infrastructure
- Provides fast and easy configuration
- Support proactive service assurance and intelligent alarm correlations
- Simplify other network operations aspects, including configuration backup and upgrade
- Optimize network efficiency
- Maximize availability and performance.

The network services platform can also be a unified manager, extending management to include packet transport infrastructure with microwave and optical technologies.

## Conclusion

As mining companies face an array of constantly changing business conditions and more stringent environmental regulations, there is a pressing need to transform their mining operations so they can continue to thrive. The Nokia converged MAN provides the communications foundation for this transformation. Extending reliable and secure broadband wireless connectivity everywhere in the mine provides the necessary communications for automation, control and monitoring. Connecting the mine seamlessly to the operations center and data center facilitates the use of advanced data and predictive analytics applications to increase operational efficiency, make optimal business decisions and eventually boost profitability. As mining companies continue the modernization journey with IoT deployment, this converged MAN can evolve to support LTE Cat NB1, also known as NB-IoT, and will remain pivotal to profitable and sustainable operations.

With a broad communications product portfolio spanning IP/MPLS and LTE/5G to packet microwave and packet optical transport, along with cyber security, Nokia has the unique capability and flexibility to help mining companies transform their networks. This product portfolio is complemented by a full suite of professional services, including audit, design and engineering practices. With these products and services, Nokia can help mining companies transform and automate their mining operations and prepare for the future.

To learn more about Nokia solutions for mining, visit our [Mining web page](#).

## Acronyms

ADS	automatic drilling system
AHS	automatic hauling system
APN	access point name
BGP	Border Gateway Protocol
CCTV	closed circuit television
EIRP	Equivalent Isotropically Radiated Power
eNb	enhanced node-B



EPC	Evolved Packet Core
FAN	field area network
FRR	fast retransmit and recovery
IPsec	IP security
LAN	local area network
LTE	long term evolution
M2M	machine-to-machine
MAN	mining automation network
MC-LAG	Multi-Chassis Link Aggregation Group
MPLS	Multiprotocol Label Switching
NB-IoT	Narrowband - Internet of Things
P2MP	point-to-multipoint
PIC	prefix independent convergence
QoS	quality of service
RAN	radio access network
RTU	remote terminal unit
SCADA	supervisory control and data acquisition
SSID	service set identifier
TCP	Transmission Control Protocol
TDM	Time Division Multiplexing
T-LDP	Targeted-Label Distribution Protocol
UDP	User Datagram Protocol
VLAN	virtual local area network
VPN	virtual private network
VPRN	virtual private routed network
VRRP	Virtual Router Redundancy Protocol

## About Nokia

At Nokia, we create technology that helps the world act together.

As a B2B technology innovation leader, we are pioneering the future where networks meet cloud to realize the full potential of digital in every industry.

Through networks that sense, think and act, we work with our customers and partners to create the digital services and applications of the future.

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