Building a converged oil and gas field automation network

A critical communications blueprint to embrace Industry 4.0

White paper

NOKIA

Contents

Executive summary

To overcome immense challenges, oil and gas companies are embracing Industry 4.0. They transform by seizing digital technology advancements and adopting an automation paradigm. Foundational to this transformation is a converged communications and field automation network (FAN).

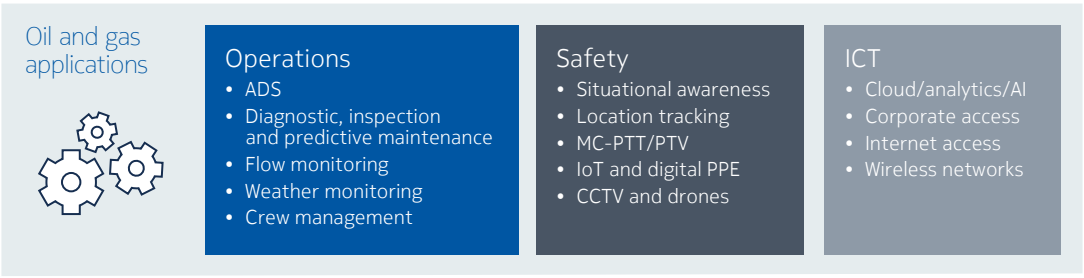
This white paper explains how the Nokia converged FAN blueprint, by innovatively merging private wireless networks with IP/MPLS, can provide benefits for oil and gas companies to overcome their challenges, enable digital transformation, and continue to thrive.

Oil and gas industry must transform to thrive

In a volatile global energy market, oil and gas companies are facing momentous challenges amid turbulent times today. They need to continue to drill and produce to satisfy the demand for petroleum and natural gas amid constant price movement affected by the global economic boom-bust cycle. At the same time, they are venturing further and deeper, operating in remote, inclement areas under hazardous conditions to reach untapped reserves. And they do all these while striving to deliver profitability, improve safety, attain eco-sustainability and prepare themselves for the energy transition.

To overcome these challenges and continue to flourish, oil and gas companies are embracing Industry 4.0[1]. They transform by seizing digital technology advancements and adopting an automated operational paradigm. They are investing in digital technology such as predictive analytics and AI to cut costs, and introducing automation for processes such as drilling to increase productivity, improve operational safety and attain environmental sustainability (see Figure 1).

Figure 1. Oil and gas companies embracing digital transformation



Foundational to digital transformation is a converged critical communications and field automation network (FAN) that can provide:

- Robust and predictable wireless communication to support a broad range of use cases at various operation sites and across the entire value chain – offshore and onshore, upstream, midstream and downstream
- Multiservice capability to provide converged communications for real-time data, voice, video and Internet of Things (IoT) 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
- High scalability and flexible service capability to optimize Industrial Internet of Things (IIoT) applications
- Simplified end-to-end network management
- Full interoperability with legacy networks, applications and devices, including SCADA, TETRA and P25.

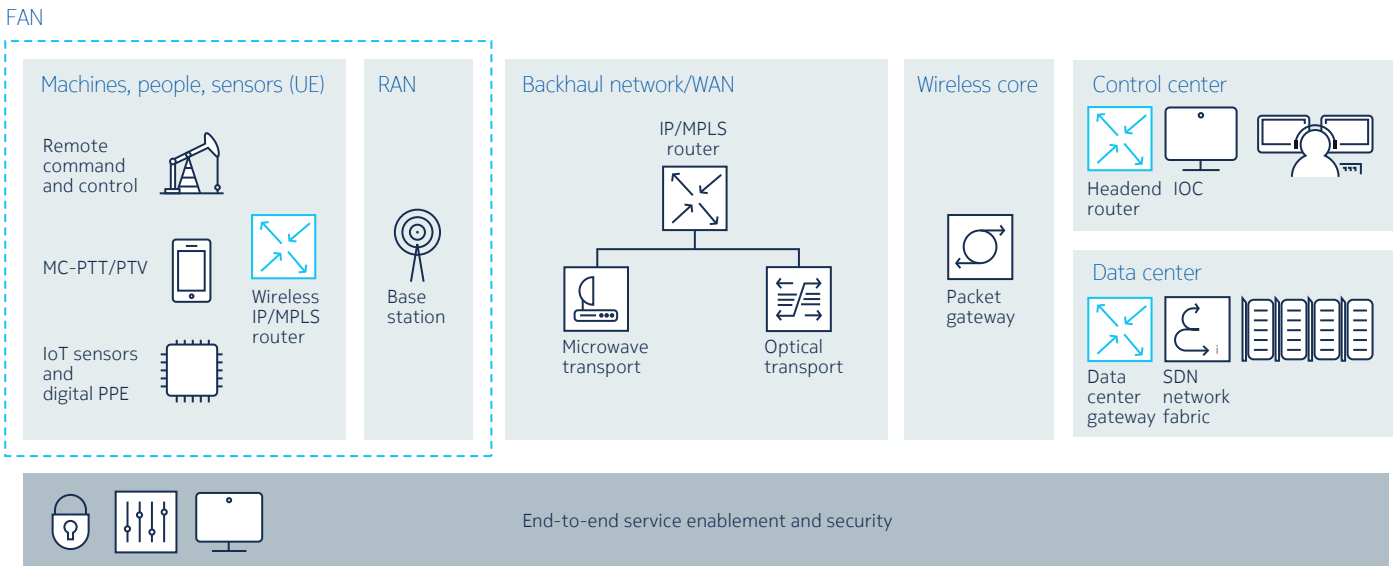
With these attributes, the converged FAN becomes the launching pad for oil and gas companies' digital transformation journey. New oil and gas applications can be deployed quickly with the network services platform rapidly provisioning new IP/MPLS VPNs. Through proper network dimensioning and QoS design,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

1 To learn about Industry 4.0, read "Industry 4.0: The revolution is here"

Nokia converged FAN

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

Figure 2. The Nokia Converged FAN blueprint



Industrial-grade private wireless

LTE is the 4G mobile broadband technology ideal for applications requiring low latency as well as broadband capacity.

Private wireless networks based on 4G/LTE standards can support all applications on a single industrial-grade infrastructure. They can provide true mobile coverage, with predictable quality of service (QoS) and support a massive number of active device connections per access point with far greater reliability and security than legacy network technologies. They can also support a smooth evolution to 5G.

Private LTE offers 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 oil and gas 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, railways and mining companies, have also deployed private LTE networks. With LTE's flexible frequency band support, oil and gas companies can either lease spectrum from mobile operators or gain access to a dedicated (licensed or unlicensed) spectrum through government authorities to build their own private LTE networks.

As such, LTE is an ideal broadband radio networking technology to enable oil and gas companies to reliably and cost-effectively cover areas of hundreds of square kilometers. With Nokia 4.9G/LTE private wireless solutions, they will benefit from applications such as mission-critical push-to-talk (PTT) and push-to-video (PTV) services, high-definition video, low-latency edge computing for remote and automated operations and camera surveillance, low-power sensor networks, telemetry and IoT – onshore and offshore.

Nokia industrial-grade private wireless solutions meet the connectivity challenges of the O&G industry by providing better coverage than Wi-Fi and offering a single network for all voice, data and video services. This network can connect thousands of devices for handheld, vehicle and machine use with greater predictability and performance under high load.

Nokia has deployed private wireless networks for more than 340 industry customers around the world in the transport, energy, manufacturing, logistics, and public sector segments.

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 mining, power grids, public transportation systems and public safety.

Implementing the Nokia converged FAN with IP/MPLS

By innovatively merging IP/MPLS VPN services and LTE in a wireless IP/MPLS router, the Nokia converged FAN offers oil and gas 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 FAN brings segregated and secure data communications for:

- Field equipment and application devices
- Control, automation and monitoring applications
- The field workforce

In addition, the FAN can interconnect seamlessly with the operations center and data center via a private 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 FAN and explain how it can benefit the oil and gas industry.

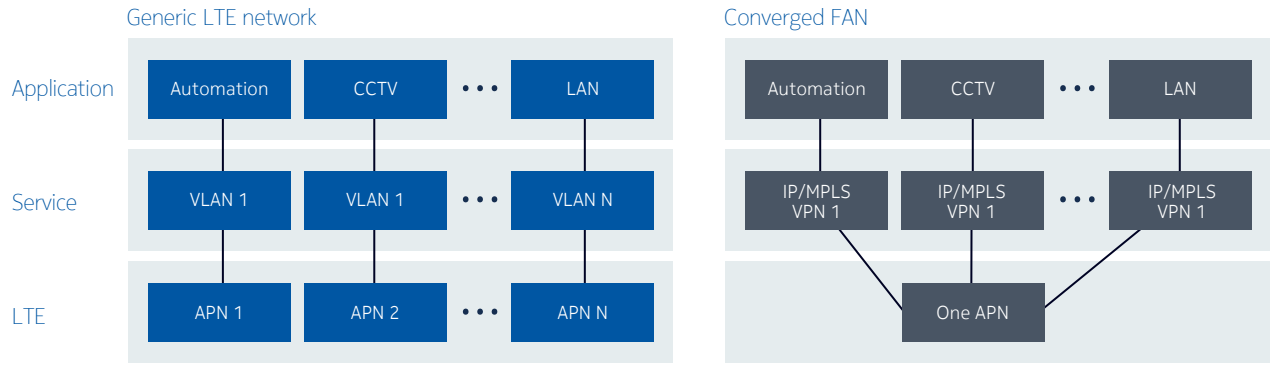
Service convergence

Digital transformation ushers in many new, intelligent applications. 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 oil and gas applications in order to attain traffic segregation and QoS differentiations among applications. Every time a new application is deployed, in addition to configuring a new VLAN domain , 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 needs only one APN at the LTE layer throughout the lifetime of the network because of the service-aware QoS capabilities of IP/MPLS. A new application requires only a new IP/MPLS VPN riding atop the same APN that hosts other application VPNs. This paradigm allows oil and gas companies to build and configure the underlying LTE network only once and be ready for numerous oil and gas applications—legacy, new and emerging—over a common communications infrastructure (see Figure 3). New application adoption no longer requires a new network. The result is optimal network operations efficiency and faster digital transformation.

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



Moreover, different oil and gas 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).

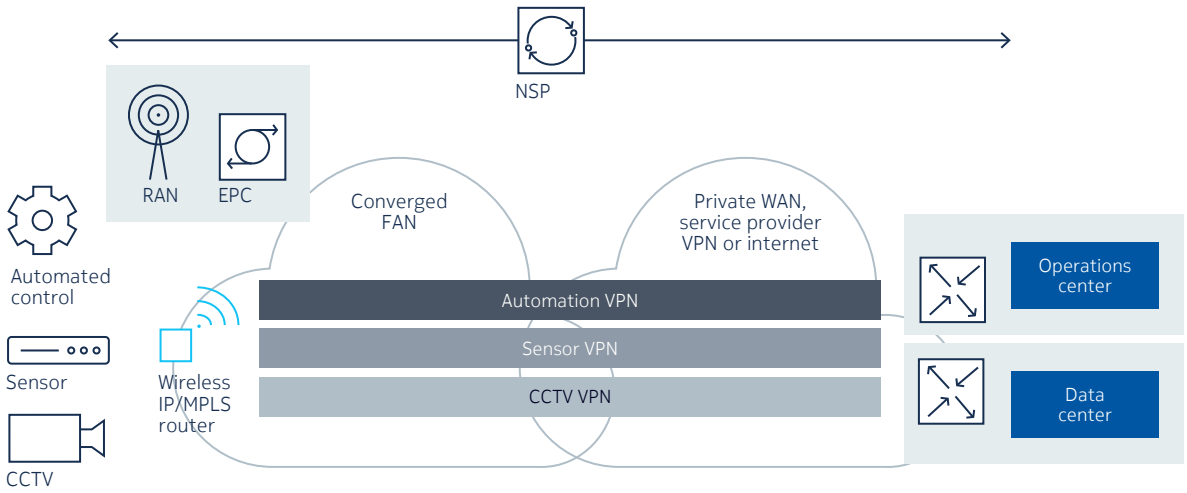
Table 1. IP/MPLS VPN can flexibly accommodate various requirements

Application	Traffic nature	Challenges	IP/MPLS VPN
Drilling automation	IP any-to-any	Intra-subnet communications; low latency	Virtual private LAN service (VPLS)
Flow 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

It is imperative that the operations center constantly monitors exploration and production activities from anywhere in the field, on the platform and inside the operations center. The introduction of predictive analytics also makes communications with the data center necessary. Therefore, extending connectivity beyond oil fields is essential. IP/MPLS VPNs can seamlessly straddle the converged FAN and the fixed network (see Figure 4), eliminating the need to stitch discrete circuits together, easing the trials and adoption of new applications.

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



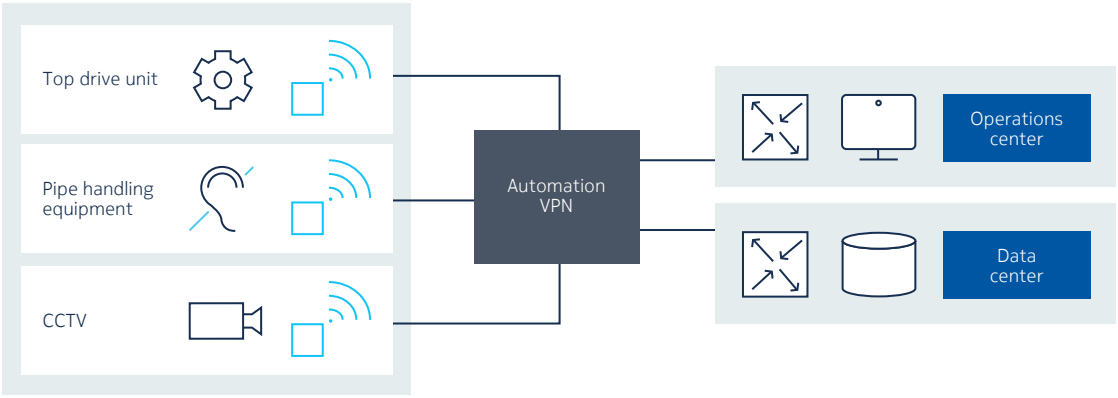
Optimal, assured IIoT communications

Industrial Internet of Things (IIoT) communications are fundamental to oil and gas field automation that is crucial to the future success of the oil and gas industry. IP/MPLS VPN's unique flexibility in multipoint Ethernet and IP services allows any-to-any direct communications over LTE among all necessary automation subsystems anywhere – in the oil field, the operations center or the data center – without needing to go through a central gateway.

For example, a VPN for ADS enables different subsystems (including the top drive unit, the pipe handling equipment, the sensors monitoring drill bit depth and penetration rate) as well as the automation controller to communicate in real time via stateless meshed tunnels[2] among all wireless IP/MPLS routers in the fields as well as the operations center and data center (see Figure 5). The automation VPN can provide layer 3 IP communications or layer 2 Ethernet communications which is ideal for control applications using Profinet, an industrial Ethernet-based communication standard.

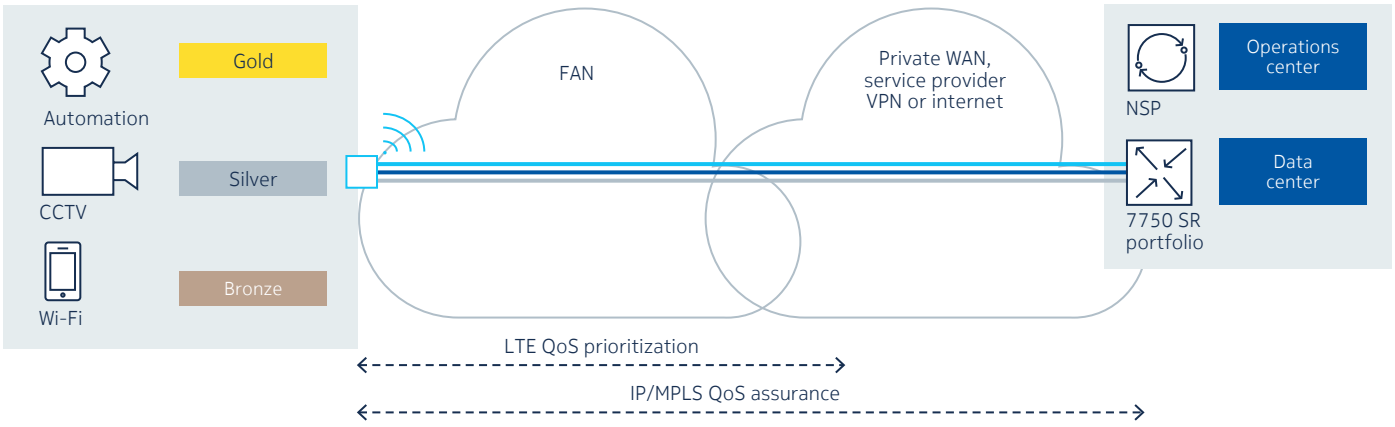
2 An encrypted tunnel in the Nokia converged FAN is stateless, unlike a stateful IPsec tunnel. This makes tunnels simple to configure and efficient to maintain. For more details, read the Nokia application note "Network Group Encryption."

Figure 5. Multipoint IP/MPLS VPNs provide direct, optimal any-to-any communications



To ensure safety and high performance, automation applications also require assured delivery with strict communication. Harnessing deterministic IP/MPLS QoS capabilities and LTE QoS prioritization, a converged FAN provides assured QoS in the FAN with extension to the operations center and data center, provided that the interconnected network also possesses similar QoS capabilities (see Figure 6).

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

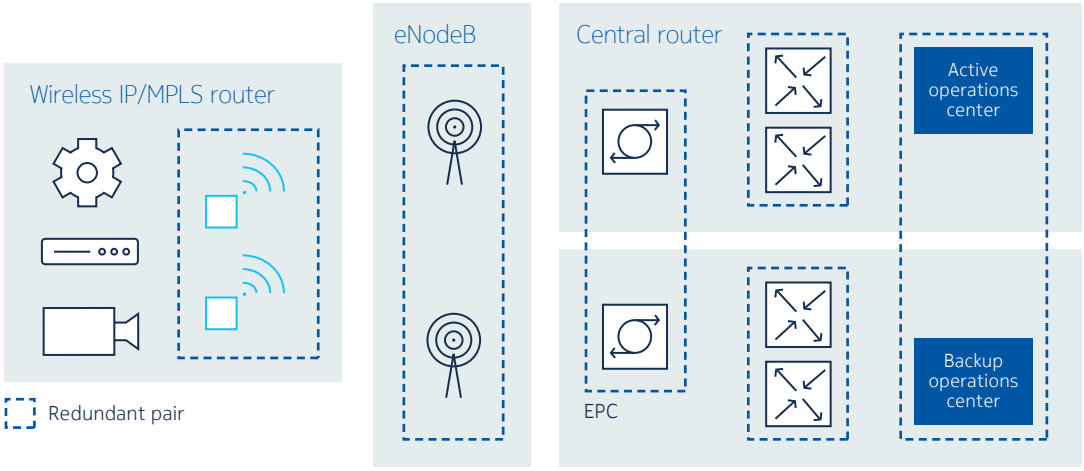


	Latency	Bandwidth	Reliability	Criticality
Automation	Low	Low	High	High
CCTV	Medium	Medium	Medium	Medium
Wi-Fi	High	High	Low	Low

Resilient end-to-end communications

As oil fields become automated and digital, communications with operations centers and control centers are more critical than ever before. When communication stops, production stops, affecting productivity. Consequently, oil and gas companies require more than just robust broadband wireless connectivity in their oil fields. The converged FAN needs to support high reliability in the end-to-end path from an oil field to the operations center and data center. Pairing nodal redundancy protection with the full suite of IP/MPLS resiliency mechanisms, including pseudo wire 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 data from fields to the standby centers preemptively or when failure occurs.

Rigorous network security

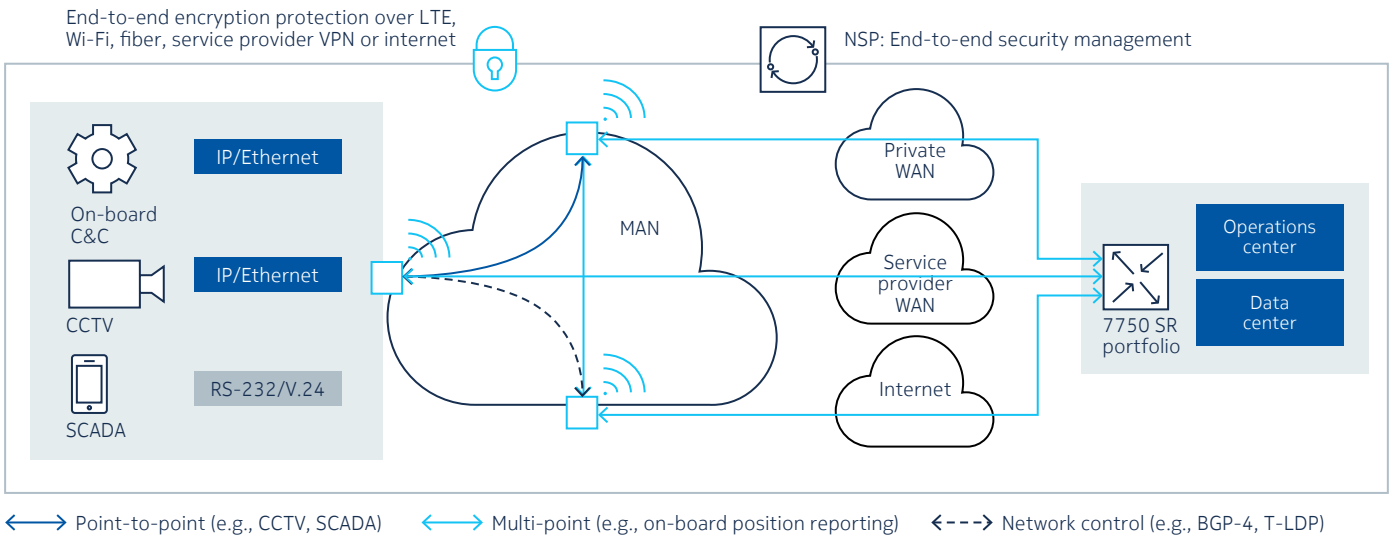
Because of the importance of commodity trading on international markets and its impact on countries' economic development, oil and gas companies are very often a valuable and important target for cyberattack. Exploration data and production data are sensitive information that can affect oil and gas companies' 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 oil and gas operations from being compromised. Therefore, it is also imperative to protect data transmission from oil fields to operations centers and data centers.

As part of the defense-in-depth security framework,[3] 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)[4] 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).

3 For more information about network defense, read the white paper "Nokia security for mission-critical networks"

4 To find out more about NGE, read the Nokia application note

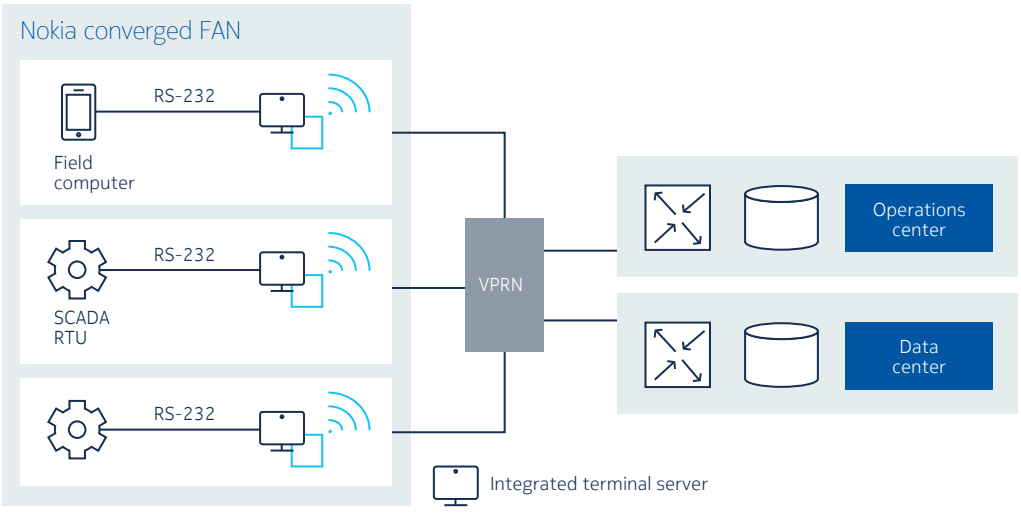
Figure 8. NGE safeguards all oil and gas communications



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 (see Figure 9).

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



Simplified network management

As more applications are in use, with a communications flow from the oil field 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
- Provide 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.

E&P use cases supported by a converged FAN

A converged FAN provides a robust, industrial-strength network infrastructure for oil & gas exploration and production (E&P). It is the foundation of a broad variety of use cases and applications and serves as a unique industrial wireless connectivity platform for supporting digital transformation.

Search and prospection

Search and prospection are nomadic and isolated exercises placing teams and equipment in remote areas that are under-served by communications networks. Exploration teams communicate using expensive and bandwidth limited satellite phones. Prospectors and field engineers are forced to carry laptops, hard disk drives and USB dongles to collect, transport and deliver the data manually.

A portable LTE configuration, serving up to hundreds of users, can be set up in minutes. Even in the most extreme conditions where there is no existing coverage. Paired with a satellite or microwave link, this solution can provide high bandwidth mobile connectivity in even the most remote locales for sensors, field workers and drones, both for collecting data, as well as providing field workers with access to remote data and remote processing capacity.

Drilling and extraction

Although mostly manually operated today, companies are pursuing a strategy of extreme autonomy to automate drilling and extraction, where all manually operated equipment will eventually be replaced with their autonomous counterparts. Remote operations will further supplement automation, allowing personnel to monitor automated processes and operate machinery at a distance using virtual telepresence.

Robot and drones can replace the manual inspection of facilities including offshore si tes, inside tanks and pipes, along with platform parts, and in areas subject to corrosion and complex or hazardous access points. Thousands of manual operations and processes can be transformed into a small number of automated processes, controlled with an industrial joystick and managed by the touch of a button.

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Worker safety and mission-critical communications

Safety incidents can delay or shut down operations, sometimes for days, while investigations are made — resulting in considerable loss of productivity and efficiency. Personal protection equipment (PPE) is the last line of defense for workers. It has traditionally meant equipment such as hard hats, earmuffs, face masks, steel-toed boots.

Smart technologies are now being integrated into PPE creating Smart PPE. This new class of equipment includes integrated communications in earmuffs and helmets, heads-up displays, and embedded environmental sensors to monitor heat, sound, chemicals, and impact. Or to keep workers out of no-go zones.

On top of this, TETRA and P25 communication networks, which are widely used for critical person-to-person and group communications, can also be fully replaced by LTE/4G, offering mission-critical Push to Talk (PTT) and Push to Video (PTV) services. A single button-push could make the difference between life and death.

Situational awareness

Situational awareness through video coverage and massive sensing is key to the safety, sustainability and security of future oil & gas operations. To achieve 360-degree situational awareness, the wireless network must be able to meet the excessive bandwidth demands of video cameras across an entire coverage area spanning onshore and offshore assets. Many of these cameras may be mounted on mobile vehicles or drones.

It must be also be able to manage and link thousands of IoT sensors providing machine health and diagnostics, position reporting, process monitoring and control, and environmental monitoring. Add to this growing list, digital PPE for mobile workers, smart tools, and communication devices.

Predictive maintenance using IoT and analytics

Maintenance and repair of vehicles and machines poses challenges in planning the use of repair equipment and teams. Breakdowns and unscheduled maintenance of aging assets can wreak havoc with even the best maintenance and repair planning. Predictive maintenance applications leverage pervasive LTE coverage to collect data from IoT sensors to feed asset management and advanced data analytics.

Predictive, condition-based maintenance solutions improve on today's preventive and calendar-based maintenance. Many assets fail during operations when using calendar-based maintenance schedules from the equipment vendor. Yet too-frequent maintenance leads to waste by refurbishing or replacing assets that are actually in serviceable condition.

Digital Twins, drones and Augmented Reality

A digital model of the physical environment, constructed using geological, engineering and asset information, can be continuously updated with data from sensors, cameras, drones and location-aware mobile devices. By using virtual simulations of the work environment operators will be able to create long-term and short-term schedules, make accurate estimates for personnel and machine efforts, and predict what the end-product results will be.

Drones can automatically survey, map and take volumetric measurements of a site to construct a 3D digital image of it. In oil & gas, for example, these technologies can be used for monitoring, inspecting and mapping wellheads, pipelines and storage tanks

AR/VR systems will use this Digital Twin to provide off-site and on-site staff with real time information and scenario simulations, while AR glasses will provide step by step instructions to service engineers.

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Accelerating the energy transition

Renewable energy technologies have experienced a spectacular growth in recent years and the oil & gas industry is feeling pressure from investors, consumers and governments to accelerate the energy transition and contribute to the climate targets set by the Paris Agreement. As a result, O&G companies have started decarbonizing and defossilizing their business and repositioning themselves in the energy industry. They are making investments in sustainable energy sources like biofuels, solar panels and wind turbines, as well as in energy efficiency technologies.

Actually, with decades of offshore experience and with proven operational practices, many fossil energy players have the capability to become sustainable energy innovators. Wind farm management, operations and maintenance challenges, for example, are similar to the ones related to offshore platforms. To succeed with remote wind farms, operators need a reliable FAN infrastructure to keep vessels, workers, sensors and operations centers connected in a reliable and cost-effective way and that enables additional use cases similar to the ones listed in this paper.

Conclusion

As oil and gas companies face an array of constantly changing business conditions and more stringent environmental regulations, there is a pressing need to transform their oil & gas operations so they can continue to thrive. The Nokia converged FAN provides the communications foundation for this transformation. Extending reliable and secure broadband wireless connectivity everywhere in the oil field provides the necessary communications for automation, control and monitoring. Connecting the oil field 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 oil and gas companies continue the modernization journey with IoT deployment, this converged FAN 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/4G/5G to packet microwave and packet optical transport, along with cyber security, Nokia has the unique capability and flexibility to help oil and gas 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 oil and gas companies transform and automate their oil & gas operations and prepare for the future.

Abbreviations

ADS	automatic drilling 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 automation network
FRR	fast retransmit and recovery
IIoT	industrial internet of things
IPsec	IP security
LAN	local area network
LTE	long term evolution
MC-LAG	Multi-Chassis Link Aggregation Group
MPLS	Multiprotocol Label Switching
NB-IoT	Narrowband - Internet of Things
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

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We create technology that helps the world act together.

As a trusted partner for critical networks, we are committed to innovation and technology leadership across mobile, fixed and cloud networks. We create value with intellectual property and long-term research, led by the award-winning Nokia Bell Labs.

Adhering to the highest standards of integrity and security, we help build the capabilities needed for a more productive, sustainable and inclusive world.

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