The mining industry faces immense challenges, from harsh operating conditions to global economic fluctuations and stringent environmental regulations. To overcome these challenges and continue to flourish, mining companies are investing in automation and other new mining applications, with special focus on productivity, operational safety and environmental sustainability. This white paper, the first of two, explores the challenges and explains the communications network transformation required for the mining industry to thrive today and tomorrow.
The need for converged mining automation networks

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Mining through time

Mining is one of the earliest human activities. Throughout history, mining operations have evolved and adapted constantly to the changing demands of society. From the Bronze Age to the Middle Ages and the Industrial Revolution, mining has contributed significantly to the progress of society by extracting valuable minerals—such as copper, iron, nickel, silver and gold—to make tools, utensils, machines and currencies.

Today, minerals such as lithium and cobalt plus rare earth metals such as indium are critical for green energy technologies as society strives to become green and sustainable. At the same time, to satisfy the increasing demand for mineral resources, mining operations have expanded in scale and grown in sophistication. To optimize efficiency and production costs, operations have transformed to become massive-scale, capital-intensive and heavily mechanized corporate endeavors. Mining companies today are typically multinational firms operating mines around the world. They explore, extract, process and transport minerals worldwide for industrial use.

Challenges for the mining industry

Despite past success, few industries need to be better prepared for tomorrow than mining. Mining companies operate capital-intensive businesses in volatile political conditions and under stringent environmental regulations. They face immense challenges, often working in 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 they do all of this while striving to deliver profitability and attain eco-sustainability.

To overcome these challenges and continue to flourish, mining companies are seizing technology advancements and adopting an automated, digital mine paradigm. They are embracing and investing in automation and other new mining applications (see Figure 1) with special focus on productivity, operational safety and environmental sustainability.

Figure 1. Applications used by mining companies

Productivity

To thrive and deliver consistent profitability amid fluctuating commodity prices and demand, mining companies need to constantly optimize productivity in a volatile market. They are increasingly evaluating, trialing or introducing automation applications such as autonomous haulage systems (AHS) and autonomous drilling systems (ADS) to increase equipment utilization and optimize efficiency, and asset health monitoring applications to improve equipment performance and reduce downtime. Combined with the power of data analytics, there is an opportunity to proactively tune the mining workflow, from extraction to processing to freight transport, based on worldwide supply and demand forecast. In this way, mining companies can attain optimal throughput.
Operational safety

Mining, a perilous business due to often challenging and harsh operating conditions, must strive to attain always-safe operations. Whether it is collapse of pit walls following heavy rains, uncontrolled explosions or heavy equipment operating errors, hazards abound if safety practices are not strictly followed. Consequently, mine safety has become a paramount priority. From slope monitoring systems to high-precision GPS-based location tracking systems and collision avoidance applications, new technologies are introduced to avoid accidents and fatalities as well as prevent injuries. The introduction of automation applications will also further strengthen safety records.

Environmental sustainability

Mining companies also need to demonstrate high environmental sustainability to gain social acceptance from local communities and to operate with responsible and sustainable mining practices. They can become more eco-friendly by reducing the environmental impact on the surroundings. These practices include close monitoring of the condition of tailings or mine waste dumps with CCTV, use of improved processing technology, reduced consumption and recycling of water, minimized land disturbances and waste production, and leakage early warning and prevention. At the mine closure stage, they can also strive to reclaim and restore land to attain high environmental sustainability.

Need for network evolution

Open-pit mines, with an expansive surface, have a long history of deploying discrete private wireless networks with various technologies in the mine to satisfy communications needs. The various mining applications have included dispatch and SCADA. As a result, mines today have a combination of technologies, including land mobile radio, microwave, Wi-Fi®, and wireless mesh technologies. It has become costly and consumed a lot of technical resources just to maintain and operate this assortment of wireless networks.

More critically, as mines move to digital transformation and start to introduce automation and intelligent applications, current wireless infrastructures are challenged to meet new communications requirements for:

- Service convergence
- Broadband connectivity
- Reliable communications
- Optimal, secure, machine-to-machine (M2M) communications.

Service convergence

As the number of applications grows, there is a pressing need to converge and carry them over a common wireless network infrastructure with no performance compromise. Older proprietary, narrowband wireless technologies such as land mobile radio were not designed for service convergence and offer no path for technology evolution.

Even newer broadband wireless technology such as Wi-Fi mesh lacks the required QoS capability and robustness. Its low transmit power means a multitude of mesh nodes are needed to cover the whole mining area. Line-of-sight reception requires frequent antenna adjustment as mine topography changes and equipment moves around. Furthermore, operators often need to resort to an application-specific
Wi-Fi access paradigm. Typically they need to segment the Wi-Fi network with the creation of an application-dedicated SSID that is tied to an application-specific VLAN to treat traffic from different applications such as automation, CCTV and IT with the appropriate priority.

Even with the use of LTE, the fourth generation cellular technology, a different access point name (APN) may be required for each mining application to support traffic prioritization.

Broadband connectivity
In the past, mining communications were mostly about dispatching and voice. To improve safety and efficiency, SCADA systems were introduced in mines, generating data at a rate of tens of kb/s. To boost productivity, remote control capabilities have been ushered in. New applications such as fleet management, telemetry, CCTV and automation generate data at tens of Mb/s or more. Older wireless technologies in use today cannot provide the bandwidth required or an upgrade path to offer broadband connectivity.

Moreover, as mines are developed, the size increases and topography changes frequently with blasting, digging and other activities. This requires wireless coverage re-design, re-optimization and re-deployment, which could last for days or even weeks—bringing mining operations to a halt, causing operations downtime and affecting productivity.

Accordingly, the wireless connectivity needs to be robust and able to continue reaching wherever people and machines move, 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; this minimizes stoppage of extraction activities.

Reliable communications
Tele-remote mining operations allow mine personnel to work in the comfort of an operations center, either right at the mine or in a city remote from the mine. An operations center can boost efficiency and safety significantly. However, it requires constantly fast response times (tens of milliseconds) to have real-time interactions with the surrounding environment. Therefore, consistent low latency has become a critical communications requirement. Today’s wireless technologies do not have the necessary QoS capabilities to classify critical applications and ensure they meet the latency requirement constantly.

Furthermore, because an operations center becomes the nexus of a mine, it is crucial to keep it up and running at all times. As a result, geo-redundancy protection for an operations center has become critical to ensure maximum mine operations uptime. Without this protection, mining operations could halt for days or even weeks when severe storms or other natural disasters affect the city where the operations center is located.

Optimal, secure M2M communications
Traditional mining applications employ hub-and-spoke communications. Field devices such as SCADA remote terminal units or CCTV cameras transmit data to centralized servers or controllers. As applications such as fleet management become more intelligent and operations become more automated, real-time, secure communications among mining equipment such as hauling trucks, shovels and graders become essential. Consequently, M2M communications start to become a prevalent form of communications.

To support M2M communications in today’s wireless network, the traffic needs to either travel to a hub location via a L2TP tunnel or an IPsec tunnel (if encryption is required) first or hop on a mesh of tunnels, which requires substantial efforts to manage, before arriving at the destination router. The complexities and inefficiencies incurred by the tunnels impede the adoption and performance of mine automation.
Nokia converged mining automation network

As mining companies start to introduce automation and other digital applications, their wireless network infrastructure has quickly become a congestion point. They need to re-think the infrastructure to prepare for converged automated communications. They need a new private wireless network—a converged mining automation network (MAN) as shown in Figure 2.

Figure 2. Nokia converged MAN blueprint

To meet the requirements discussed in the preceding sections requires two global standards-based networking technologies—LTE and IP/MPLS—together with an agile network services platform. By fully exploiting the capabilities of these technologies, the converged MAN has the following essential attributes:

- 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 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.

Conclusion

The mining industry is at a tipping point. A confluence of continued commodity market fluctuations, close public scrutiny of ecological impacts and safety records, as well as new green environmental and health regulations are compelling mining companies to move toward digital transformation and use automation and data analytics to boost productivity, enhance safety, make better business decisions, and become more
sustainable and socially responsible. Grounded in LTE and IP/MPLS, the Nokia converged MAN brings reliable and secure communications everywhere in the mine. It will be an integral foundation of this transformation, enabling a whole set of applications, from AHS and ADS to location tracking, telemetry and SCADA.

With a broad communications networking portfolio spanning IP/MPLS and LTE/5G, packet microwave and packet optical transport, complemented by a full suite of professional services, Nokia has the unique capability and flexibility to help mining companies transform their communications networks, preparing for the future.

To learn more about Nokia solutions for mining, visit our Mining web page.

**Acronyms**

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<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>ADS</td>
<td>automatic drilling system</td>
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<tr>
<td>AHS</td>
<td>automatic hauling system</td>
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<tr>
<td>CCTV</td>
<td>closed circuit television</td>
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<tr>
<td>EPC</td>
<td>Evolved Packet Core</td>
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<td>IPsec</td>
<td>IP security</td>
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<tr>
<td>L2TP</td>
<td>Layer 2 Tunneling Protocol</td>
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<tr>
<td>LTE</td>
<td>long term evolution</td>
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<tr>
<td>M2M</td>
<td>machine-to-machine</td>
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<tr>
<td>MPLS</td>
<td>Multiprotocol Label Switching</td>
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<td>QoS</td>
<td>quality of service</td>
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<tr>
<td>RAN</td>
<td>radio access network</td>
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<tr>
<td>SCADA</td>
<td>supervisory control and data acquisition</td>
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<td>SSID</td>
<td>service set identifier</td>
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<td>VLAN</td>
<td>virtual local area network</td>
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<td>VPN</td>
<td>virtual private network</td>
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**About Nokia**

We create the technology to connect the world. Powered by the research and innovation of Nokia Bell Labs, we serve communications service providers, governments, large enterprises and consumers, with the industry’s most complete, end-to-end portfolio of products, services and licensing.

From the enabling infrastructure for 5G and the Internet of Things, to emerging applications in digital health, we are shaping the future of technology to transform the human experience. networks.nokia.com

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