Unleashing the potential of connected mobility for railways

White Paper

How the Internet of Things will transform railway operations and passenger experiences
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Collecting and making sense of data to improve railway operations

The railway environment is alive with data. Modern locomotives packed with sensors generate thousands of data points per minute. Trackside infrastructure fitted with sensors and environmental monitors is perfectly positioned to deliver vast amounts of information to help improve safety and operational efficiency. In stations, data from ticket gates, video surveillance, services, car parks, building monitors and ticket kiosks provide the basis for improving the efficiency of passenger flows and station operations.

The Internet of Things (IoT) is the key to making full use of this wave of data. The IoT interconnects physical things, such as vehicles, buildings and machines fitted with devices such as sensors, actuators and network interfaces, to collect and exchange data to enable them to be monitored or controlled remotely across existing communications network infrastructure. The Global Standards Initiative on Internet of Things (IoT-GSI) has defined the IoT as “the infrastructure of the information society.”

Innovative applications and advanced analytics capabilities promise to transform railway operations and the passenger experience. Safety is the prime benefit. Connected mobility will provide multiple ways to improve safety - from train control and traffic management, to more automated CCTV monitoring that can quickly highlight hazards such as platform crowding.

Operational efficiency is boosted by greater insights into how railway assets are performing, for example by monitoring not just trains, but the track environment for early detection and rectification of issues before they lead to failure and disruption.

More radically, IoT has the potential to alter the business model of railway operations. Instead of selling equipment to railway operators, manufacturers could lease it according to use, such as distance travelled or weight of cargo carried.

Deploying widespread infrastructure, platforms and applications to support IoT for railways, however, means that railway operators must navigate a complex technology landscape peppered with wireless connectivity technologies offering different performance parameters. They must work out the most economical way to connect all the deployed sensors and securely collect the data they generate.

The key is to avoid IoT deployments that fragment into siloes, each performing a specific use case, but all working independently. Vertical solutions are difficult to scale, challenging to manage cost effectively and hard to secure. Fragmentation also misses opportunities to create new insights by sharing data between applications.

A horizontal IoT platform sweeps away these barriers and opens up many new possibilities to use big data in more creative and effective ways.
IoT creates new ways to run railways

IoT has the potential to transform how many industries work. From manufacturing to public safety, transportation to utilities, and healthcare to city management, IoT will reshape business models, strengthen value chains and reset entire industry configurations.

The rail industry stands to gain substantially from the development of IoT technologies and ecosystems. Railway operators will be able to more easily convert the data flowing from their railway networks, trackside infrastructure, rolling stock and station real estate into valuable business benefits. These fall into three main categories – increased safety, higher operational efficiency and delivery of the best passenger experience.

**Increased safety**
Safety is top of the priority list for railway operators. While the value of train control systems to protect the movement of trains is well established, IoT can enable new applications to help protect passengers in stations.

For example, real-time video surveillance coupled with advanced analytics can provide automated monitoring of crowded platforms or trains to detect potential issues as they arise. Situations can include overly-busy platforms, criminal activity, crowds suddenly moving in unexpected directions or people approaching the platform edge. Such systems could monitor thousands of camera feeds and alert control room staff of potential situations, enabling action to be taken.

Figure 1: IoT enabled by secure and reliable network infrastructure and an adaptive, scalable horizontal platform, supports a wide sweep of applications to increase the safety and efficiency of railway operations, as well as provide new passenger services
**Improved operational efficiency**
Connected mobility will help to improve operational efficiency in many ways.

More effective and predictive maintenance is a major benefit. Today, 35 percent of initial delays are attributable to defective rolling stock and infrastructure components, while 80 percent of locomotives will typically be taken out of service for unexpected repairs within a four-week period.

IoT can address these issues through the monitoring and analysis of data collected by train-based and trackside sensors. Data flowing from locomotive and rolling stock sensors can be made available to workshop technicians to help analyze the train condition and prepare overnight maintenance and repairs during operations. Potential service interruptions can be detected by continuously monitoring tracks, overhead power lines and level-crossings. Environmental sensors that measure conditions such as water table levels, which can affect railway embankments should the ground become waterlogged, can be analyzed to enable early planning of repairs.

Combining and analyzing the mass of data from all these sources provides new, comprehensive insights that reduce the need for time-consuming routine maintenance checks of tracks and overhead lines. It also enables more efficient maintenance processes including preventative maintenance, to improve the reliability of rail services and reduce the cost of servicing and repairs.

Other ways to improve operational efficiency also become possible. Station staffing levels can be organized more efficiently to manage passenger flows at peak times. Integrated ticketless transportation can reduce the cost of revenue collection and cut the time for passengers to navigate through stations. New building efficiency can be achieved by analyzing heating and electricity consumption and through the supervision of alarms, doors and other areas.

**Better passenger experiences**
Data coming from a wide range of sources can be analyzed to find new ways to improve the passenger experience, even before they leave home. Based on ticket sales, CCTV information, live train times and car parking capacity, passengers can be advised on the best times to travel to enable them to better plan their journeys.

At the station and on board trains, IoT connectivity can provide monitoring of the status of facilities such as ticket machines, toilets, food chillers and ovens to help ensure the reliable delivery of all services. This can also cut costs by reducing the penalty costs of these assets falling out of service.

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*Source: T-Systems International GmbH*
Implementing the full capabilities of IoT

To gain the full benefit of IoT and ensure a secure and future-proof roll out, railway operators need to consider a range of requirements.

The first is to identify the target use cases and appropriate business models that will deliver the desired business benefits. The network performance needed to support these use cases helps to determine the technology requirements.

**Choices in connectivity**

Train and asset tracking applications are likely to need a mix of real-time and non-real-time data collection, and will have varying requirements in terms of bandwidth. Video surveillance and public Wi-Fi access in public transit systems will require substantial connectivity bandwidth, while sensing and metering applications involve only simple data communications. Different mobility requirements will apply - video surveillance of platforms, environmental monitoring, building management systems and digital signage are static use cases, while live video from moving trains and train system monitoring will require high mobility.

Clearly, IoT applications have highly diverse needs for network connectivity, reliability, security, latency, data rate, mobility and battery life. No single access technology can meet all these connectivity needs and it is likely that several radio technologies will co-exist for many years.

Connectivity technologies suitable for IoT fall roughly into two groups according to the signal range directly between the gateway and the endpoint. Low Power Wide Area (LPWA) generally reach further than 500m. Short Range Low Power (SRLP) technologies, such as ZigBee and Wi-Fi, have less than 500m range.

LPWA is split into two separate sub-categories. On the one hand, there are the current proprietary LPWA technologies, such as SigFox and LoRa, which typically operate on unlicensed spectrum. On the other hand, there are the forthcoming 3GPP standardized cellular IoT technologies, in short cellular IoT, which typically operate on licensed spectrum.

**The critical need for security**

As rail systems rely heavily on wireless connectivity, they tend to be more vulnerable to outside interference and intrusion. The threats are varied, ranging from data loss and eavesdropping to gain confidential business information, to a denial of service attack that could knock out applications, as well as data manipulation and fraud that could lead to direct monetary loss.

Cyber secure connections between applications and connected devices are critical to prevent hacking attacks and preserve passenger safety. A centrally managed horizontal IoT platform will always have the latest security patches and firmware updates, eliminating the risk of some systems not being updated regularly.
An integrated IoT deployment

While separate vertical solutions that address specific IoT use cases may offer fast and lean deployment, such an approach limits the true capabilities of IoT. In contrast, a horizontal platform approach will provide the greatest benefits and enable fast introduction of use cases. A platform that runs multiple use cases in parallel reduces the total cost of ownership.

The horizontal platform must integrate all standards and systems to enable data sharing between applications to create entirely new business propositions. It must also be capable of managing a wide variety of devices, from sensors to cameras, and the communications between the applications and devices. Interacting with devices and other systems to send and receive information, the platform will gather, verify, report, analyze, store and act on data.

Furthermore, a platform that can handle existing unconnected systems that have already been deployed eliminates the need for railway operators to rip out and replace infrastructure in order to realize the full benefits of IoT.

Nokia solutions for railway IoT

As an end-to-end IoT solution provider, Nokia takes a horizontal platform approach that simplifies the implementation and management of all IoT applications and use cases that railway operators can deploy.

The platform, Nokia IMPACT (Intelligent Management Platform for All Connected Things), is a cloud-based solution that enables services to be scaled to meet any demand. IMPACT provides data collection, event processing, device management, data contextualization, data analytics, end-to-end security and applications enablement, for any device, any protocol and across any application.

A good example of the advanced capabilities that IMPACT can encompass is video analytics. Powered by machine learning algorithms, video analytics can automatically detect anomalies in video feeds in real time, such as hazardous platform crowding, and then trigger alerts for further action.

Nokia also offers a wide range of licensed and unlicensed radio access technologies, an optimized core network to deal with the specific requirements of IoT traffic, and a Multi-access Edge Computing capability to meet the low latency requirements of some use cases.
IMPACT implements the latest Lightweight M2M (LWM2M) security model for IoT device management and is backed by network, cloud and end-point security. Nokia NetGuard Endpoint Security monitors IoT devices, detects malware, draws correlations between events in different parts of the network, and sets security parameters to minimize the chance of successful attacks. This network-based anti-malware solution analyzes traffic patterns from within the network, which is more efficient than traditional antivirus software, as it cannot be disabled and protects IoT devices without requiring any on-board security software.

IMPACT has gained industry recognition for its end-to-end capabilities in support of the mass adoption of IoT, winning the ‘Best IoT Innovation for Mobile Networks’ award at the Global Mobile Awards (GLOMO) 2017 in February. The award recognizes the full range of capabilities that the Nokia portfolio offers, from connectivity to security to analytics. The Glomo Awards are judged by world-leading independent experts, analysts, journalists, academics and, in some cases, mobile operator representatives.

The comprehensive Nokia IoT portfolio is supported by expert services to help railway operators implement IoT matched to their needs. Services experts design, plan, integrate and manage the device, connectivity, platform and application layers to meet the needs of railway operators.

One of the latest and most innovative additions to the Nokia IoT services range is Nokia worldwide IoT network grid (WING). This managed service simplifies global IoT connectivity by spanning technologies and borders, giving railway operators access to a global IoT connectivity grid with subscription and device management, security and analytics all included. The Nokia services approach opens up new business opportunities for railways, accelerates time to deployment of use cases, optimizes cost of ownership and enables new global revenue streams from IoT.

To facilitate the wider development of IoT applications, Nokia has also set up an IoT Community ecosystem, which has more than 70 partners (and growing) working in an open, collaborative environment.

Figure 4: Nokia offers a comprehensive IoT portfolio
Conclusion: Nokia is the leading partner for railway IoT

The railway industry has for many years used machine-to-machine technology and data analysis to improve the maintenance and performance of its assets. Today, as IoT technologies and businesses develop, railway operators have substantially greater opportunities to benefit in more creative and effective ways. The use cases and applications described in this paper are just the tip of the iceberg and many other areas that could offer potential cost savings have probably not even been identified yet.

Nokia offers a cost-effective and flexible approach to IoT for railway operators. Nokia IMPACT is a horizontal platform built on open standards and modular interfaces and which includes end-to-end security to protect the operator and its customers.

Nokia has established a strong record of success in the railway industry, providing mission-critical networks to more than 100 passenger and freight railway operators globally. With more than 30 years of experience in the sector and the most complete portfolio of products and services, Nokia is also a leading player in IoT and device management, supporting more than 1.5 billion devices and providing leading edge security.

Nokia is well-placed to help railway operators take full advantage of the growing opportunities of IoT, cost-effectively and securely.

Figure 5: Nokia has industry-leading credentials in IoT and has experience of applications and systems that are reshaping business models in many vertical industries

Acronyms

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<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>IoT</td>
<td>Internet of Things</td>
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<tr>
<td>IoT-GSI</td>
<td>Global Standards Initiative on Internet of Things</td>
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<td>LPWA</td>
<td>Low Power Wide Area</td>
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<td>SRLP</td>
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