Sweden's transport operator builds a nationwide GSM-R & IP/MPLS communications network to enhance safety and efficiency

NOKIA

Sweden's national transportation agency, Trafikverket, is responsible for long-term infrastructure planning for road, rail, shipping and aviation. It owns, constructs, operates and maintains all state-owned railways and roads, as well as a large number of ferry services. Since 1990, Trafikverket has utilized a national transmission network for all communications critical to the safe operation of transportation traffic in Sweden. In recent years, train signaling, alarm systems, ticketing, video surveillance, traffic management and increasing volumes of corporate and passenger voice, video, and data traffic were placing substantial demands on communications services, while many older network components were becoming difficult to maintain. Trafikverket selected Nokia to lead the transformation of its communications infrastructure to a future-ready digital solution. By deploying GSM-R and IP solutions, Trafikverket is now managing a ground-to-train radio network and a unified IP/MPLS infrastructure for supporting all critical data and services, including support operational voice and train signaling communications – all with high availability, security and cost efficiency.

Challenges

- Build a mission-critical ground-to-train radio network to meet the operational requirements of train operators, dispatchers and on-board personnel for 11,000 km of railroads.
- Meet international standards for ERTMS, ETCS L2 and GSM-R.
- Simplify a complex networking infrastructure encompassing a range of technologies.
- Prepare for the end of life of discontinued products.
- Deploy new services and applications requiring higher bandwidth.
- Address a continuous increase in passenger and freight traffic.
- Provision new business applications requiring Ethernet services.
- Reduce TCO by converging all legacy communication networks.
- Achieve more flexibility in the deployment of new operational services.

Solutions

- Intelligent network platform, GSM-R nationwide network to carry signaling data of the ERTMS standard and operational communication to the train driver, including a geo-redundant GSM-R core network across two locations.
- General packet radio service (GPRS) packet core, short message service center (SMS) and subscriber data management (SDM).
- Unified and multiservice IP/MPLS network supporting all mission critical services (Signaling, GSM-R), operational applications (CCTV, SCADA), Business applications (LAN, telephony) and passenger services (PIS, PAGA).
- Single management platform for microwave, optic and IP/MPLS.

Benefits

- Future-proof, flexible networking solution, including GSM-R, for operations, business and passenger services.
- Compliance with ERTMS standard.
- Smooth migration of legacy applications to the new network.
- Ultra-high reliability and redundancy.
- Reduced TCO, with a single-management platform for all transmission network elements.
- New revenue-generating opportunities for selling excess capacity to enterprises, service providers and cable operators in Sweden.

The challenges

For most transportation agencies, a reliable telecommunications network is essential for conducting safe, efficient operations. However, train signaling, alarm systems, ticketing, video surveillance, traffic management and increasing volumes of corporate and passenger voice, video, and data traffic are all placing substantial demands on aging networks, requiring new communication infrastructures.

In 1998, Sweden's transportation agency, Trafikverket, needed to deploy a signaling application to control trains and improve safety. This led to the requirement for building a ground-to-train GSM-R network to support mission-critical voice and data communications when the standard was finalized in 2000. By 2007, Trafikverket, faced with the end-of-life of its equipment, still was using its legacy network, which included many synchronous digital hierarchy (SDH) and time-division multiplexing (TDM) products that were difficult to get, or discontinued by vendors. Reinvesting in this antiquated network was not an attractive option, given the exponential growth in demanding IP-based applications, such as closed circuit television (CCTV). Moreover, the network was made up of various technologies provided by a number of equipment vendors, making it increasingly difficult and costly for Trafikverket to efficiently operate and maintain.

Trafikverket also wished to transition its SDH-supported global system for mobile communications – railway (GSM-R) to a single, unified network in order to improve capability, reliability and cost efficiency for train operators, dispatchers, station operators and onboard personnel. And, this network needed to conform to the European Rail Traffic Management System (ERTMS) signaling standard, which requires high availability and robustness.

Additionally, Trafikverket recognized the opportunity to generate additional revenue by selling its unused next-generation network (NGN) capacity to ISPs, private industries and cable operators in Sweden. Utility and transport companies that invest in a state of-the-art transmission network with high quality of service (QoS) and network virtualization can more effectively generate extra revenues through bandwidth resale.

By 2010, Trafikverket wished to increase the capacity and extend the coverage of the GSM-R network, as well as implementing geo-redundancy of the GSM-R core network to further improve the resilience of the signaling service.

All of these issues, coupled with an overriding need to ensure public safety, motivated Trafikverket to look at a converged network transformation for all business communications including critical operations such as GSM-R and signaling.

Partner selection criteria

Trafikverket selected Nokia as its NGN transformation partner primarily due to its ability to offer a turnkey GSM-R and Internet Protocol /Multiprotocol Label Switching (IP/MPLS) solution that would simplify network operations while reliably transporting mission- and safety-critical traffic. Decision criteria for the entire solution required that the partner meet all the safety and security requirements by optimizing the implementation of all fail-over, back-up and redundancy mechanisms along the end-to-end network. The solution also had to meet the necessary requirements for high-availability and redundancy.

The solution

From 2002 to 2008, Nokia implemented a nationwide GSM-R network to carry ERTMS-standard signaling data and operational communication to train drivers. The solution was further upgraded between 2010 and 2015 with the implementation of a geo-redundant core network to improve the resilience, and additional radio base stations to extend the coverage. Globally, in addition to this geo-redundant core across two locations, the solution includes base transceiver stations (BTS/ FlexiEDGE) covering 11,000 Km of rail tracks, base station controllers (BSC/ FlexiBSC), an intelligent network (IN) platform, a general packet radio service (GPRS) packet core, a short message service center (SMS-C), subscriber data management (SDM) and an operational support system (OSS).

This GSM-R radio network design uses an interleaved model, which avoids having two consecutive BTSs connected to the same BSC. In fact, thanks to the FlexiBSC unique features, only every fourth BTS is connected to the same BSC.

The entire radio network was successfully migrated from the old R99/ R4 core in one night, thanks to coordination, teamwork and execution from both Trafikverket and Nokia resources.

From 2010 to 2014, the Trafikverket's advanced communications network has been completed. Deployed across hundreds of sites, this unified, multiservice IP/ MPLS platform supports all mission-critical services (signaling, GSM-R), operational applications (CCTV, SCADA), business applications (LAN, telephony) and passenger services (PIS, PAGA). If offers high availability and security, and supports new and future applications for mission-critical traffic

Trafikverket's advanced network includes 7750 SR-7 service routers for the core network (supplying 10G connectivity), the 7450 Ethernet service switch (ESS) for the aggregation layer; 7705 SAR-8 service aggregation routers for the access layer; and LAN switches for the distribution layer.

These are supported by the 5620 service aware manager (SAM), the 5650 control plane aware manager (CPAM). The unified IP network with its management platform enhances simplicity, efficiency and reduces the total cost of ownership.

Network exceeds synchronous Ethernet specifications

To assure IP/MPLS support of critical GSM-R base stations, Trafikverket sent an evaluation team Nokia's R&D facilities in Ottawa, Canada for a series of rigorous synchronous Ethernet tests encompassing numerous scenarios of up to 24 nodes, pulling of links, alternate routing, and forced network failures to ensure that the synchronization met the stringent ITU-T specifications including G.8261/8262 and G.823/824/825. These tests confirmed that the 7705 SAR, 7750 SR and 7450 ESS products meet or exceed ITU-T recommendations for Ethernet protection switching and effectively close timing-related performance issues between Ethernet and traditional synchronous optical networking (SONET) and synchronous digital hierarchy (SDH), Asynchronous Transfer Mode (ATM) and time-division multiplexing (TDM)-based networks for reliably backhauling mission-critical and safety-critical data.

Next steps

Further capacity and coverage deployments for Trafikverket are ongoing. The main rollout of the radio network has been completed, and currently is overseeing coverage improvements to eliminate any possible gaps or interference issues. Major deployment for the core network is complete, with certain elements expected to undergo upgrades in the next two years.

The benefits

Trafikverket's nationwide backbone now supports deployment of ERTMS, ETCS L2 and GSM-R, while converging several legacy infrastructures into one, reducing costs. This allows Trafikverket to take its operations to the next level of efficiency and safety while adapting international safety standards, resulting in an overall lower TCO.

The new network offers a solution to deliver Layer 2 and Layer 3 VPNs, using Ethernet as the access. It meets the performance requirements of all applications; supports advanced MPLS capabilities such as virtual private LAN service (VPLS) and IP virtual private networks (IP VPNs), and provides cost-effective support of Trafikverket's existing TDM traffic until it is migrated to the new IP-based network.

The converged network enables cost sharing between layers, integrated operational efficiency, comprehensive monitoring and a uniform provisioning and repair process. It provides an industry-leading set of network and services management tools for end-to-end visibility, fault detection/correction, service enabling and more. It also guarantees high QoS for various rail applications, including access control, alarms, cargo tracking, corporate LANs, mobile radio, passenger information displays, high-speed passenger Internet access, signaling, video surveillance and other services. Trafikverket also can now distribute real-time applications to any point on the national network with unparalleled reliability.

Summary

Trafikverket's project demonstrates that GSM-R is a key technology to guarantee the safety of the train operations. It also shows that operators of mission-critical networks can benefit from the cost efficiency and ease-of-use that are hallmarks of a unified IP/MPLS network, and still get the reliability and stability of traditional SDH, ATM and TDM networks.

The new network enables Trafikverket to support various IP-based applications including GSM-R, CCTV, SCADA, LLPA (Long Line Public Address system), CIS (Charging Information System), and others. In addition, Trafikverket can harness its NGN transmission and distribution systems to deliver new revenue-generating telecommunications services with high QoS to customers, ISPs and cable operators, and is well positioned to increase its bandwidth resale.

Overall, the new technology provides a reliable, yet cost-effective, fully managed end-to end transport solution for mission- and safety-critical communications such as GSM-R and signaling traffic. This yields a first-class national rail network communications system ready for the challenges of today and tomorrow.

Glossary

BSC: Base Station Controller

BTS: Base Transceiver Station

CCTV: Closed Circuit Television

CIS: Charging Information System

CPAM: Control Plane Aware Manager

ETCS L2: European Train Control System Level 2

ERTMS: European Rail Traffic Management

GPRS: General Packet Radio Service

ICT: Information Communication Technology

IP: Internet Protocol

IP/MPLS: Internet Protocol / Multi Protocol Label Switching

LAN: Local Area Network

LLPA: Long Line Public Address system

LTE: Long Term Evolution

MPR: Microwave Packet Radio

ODU: Outdoor Unit

OSS: Operational Support System

PAGA: Passenger Announcement General Announcement

PIDS: Passenger Information Display System

SAM: Service Aware Management

SAR: Service Access Router

SCADA: Supervisory Control and Data Acquisition

SDM: Subscriber Data Management

SMS-C: Short Message Service Center

TCO: Total Cost of Ownership

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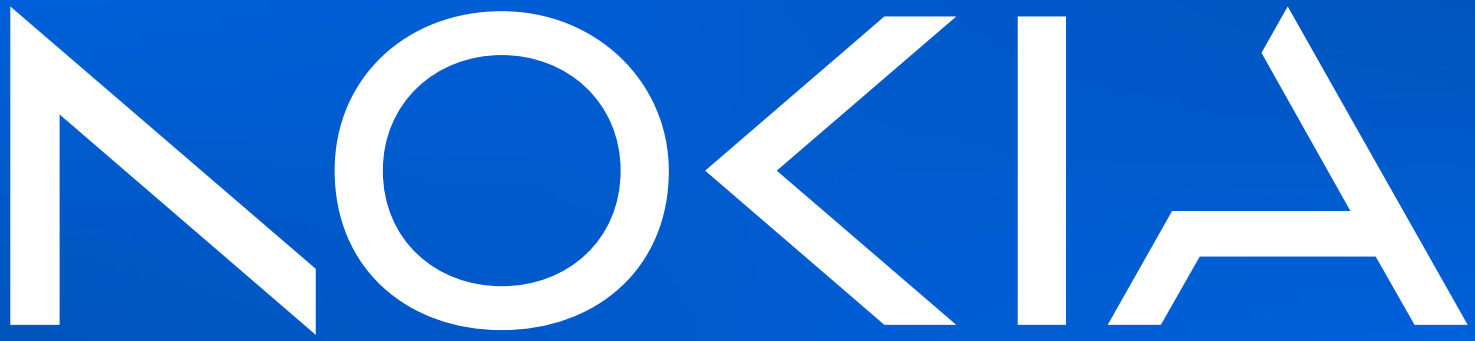

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Service providers, enterprises and partners worldwide trust Nokia to deliver secure, reliable and sustainable networks today – and work with us to create the digital services and applications of the future.