STRATEGIC WHITE PAPER

Rail-system Operator Telecommunications

Enhancing security, boosting efficiency and increasing passenger services with the Alcatel-Lucent Mission-critical WAN Infrastructure

Rail operators require a mission-critical communications network, which must be up and running 24 hours per day, 7 days a week. Safety and security are the primary concerns, especially when transporting people and dangerous commodities. Poor communications can bring trains to a halt, delay the resolution of security breaches, and result in lost revenue or even life-threatening disasters.

New regulatory requirements and enhanced vigilance have increased the number and types of applications necessary for safe, secure rail operations. These operational applications, along with new passenger-communications services that enhance satisfaction and drive new revenues, are placing incremental demands on existing networks that they were not designed to meet.

Rather than continuing to add a network for each new application and manage these along with the existing application-specific networks, rail operators can improve their efficiency by evolving to a single converged communications network. This approach provides rail operators with an effective infrastructure for enabling new applications, such as IP-based video surveillance for enhanced security, internal corporate-office voice and data applications, and new passenger information and communications services, while continuing to reliably support rail operators' legacy operational traffic.

The Alcatel-Lucent Mission-critical WAN Infrastructure helps rail operators to address these challenges with a communications foundation that enables always-on, secure communications while cost-effectively expanding to new areas and scaling bandwidth to accommodate new applications and boost employee effectiveness. Built-in application awareness, traffic optimization and end-to-end management boost overall effectiveness and flexibility.

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1. Introduction

Today's rail operators require advanced communications. The challenge of managing operations and services over a wide and geographically dispersed region as well as heightened security concerns, combined with the need to generate additional revenue streams by adding new media-rich communications services for passengers and enhancing services to compete with the airlines, can only be cost-effectively addressed with efficient communications networks. Applications for security, such as video surveillance and business continuity, and travelers' information and satisfaction — for example, messaging, mobile communications, and video content delivery — require reliable, specialized networks that run advanced communications across an entire transportation infrastructure.

Rail-transport operators, including inter-regional, regional and urban rail systems, are focusing on communications investments that increase security, decrease rising labor costs by increasing workforce efficiencies, improve asset tracking, and compete with airline-service short-haul flights for passenger fares. These operators are undertaking network transformation to increase the efficiency of their communications infrastructures and capitalize on technological innovations.

Traditionally, rail operators have managed multiple overlay networks, each supporting discrete applications. These networks often use a transport technology, such as TDM, ATM and/or Frame Relay, that is best-suited to the specific application. A growing number of applications are now IP-based. Many of these IP applications are much more demanding in terms of peak bandwidth, availability and responsiveness. Rather than continue to manage separate networks and add a separate IP network, rail operators can improve their efficiency and flexibility by evolving to a single, highly reliable converged network. This network transformation approach provides rail operators with an effective communications infrastructure for managing new IP video, voice and data applications while continuing to support their legacy systems.

A transformation of today's application-specific wide area network (WAN) is a typical first step in addressing these challenges and realizing new application benefits. The transformation includes expanded bandwidth and network reach along with new capabilities to cost-effectively address the increasing IP-based application traffic.

The Alcatel-Lucent Mission-critical WAN Infrastructure helps rail operators address these challenges with a converged backbone that enables always-on communications to securely interconnect agencies. This infrastructure connects existing mobile-radio cell sites, buildings and video-surveillance sources and cost-effectively allows the inclusion of new sites and bandwidth scaling to accommodate new applications that boost first-responder mission effectiveness. Built-in application awareness, traffic optimization and end-to-end management enhance effectiveness and flexibility. For the backhaul of land mobile radio (LMR)/ professional mobile radio (PMR) and future broadband wireless traffic, this infrastructure leverages the globally proven Alcatel-Lucent Mobile Ethernet Transport Architecture, which has been deployed with more than 150 mobile carriers.

Carrier Ethernet is a fundamental technology in the multiservice Alcatel-Lucent Mission-critical WAN Infrastructure. The benefits of Ethernet are combined with the reliability, protection and operations, administration and maintenance (OA&M) provided by technologies such as SONET/SDH, Wave Division Multiplexing (WDM) and Multi-Protocol Label Switching (MPLS). Within the WAN Infrastructure, Carrier Ethernet consists of IP/MPLS and Carrier Ethernet transport.

WHAT IS IP/MPLS?

IP/MPLS uses multiprotocol label switching to deliver IP-based applications traffic and services. MPLS is designed to achieve high reliability in converged WANs and has the ability to assign and guarantee Quality of Service (QoS) for specific traffic. IP/MPLS is particularly valuable for its openness and interoperability, bandwidth efficiency, and flexibility for supporting mission-critical operations and IT voice/data applications.

To capitalize on the wide range of new time-critical applications that increase efficiency, IP/MPLS capabilities are being added to WAN communications. IP/MPLS provides the efficient foundation for the increasing IP-based application traffic as well as multiservice flexibility to deliver mission-critical and legacy traffic in an operationally consistent manner.

Increasing packet traffic, with applications such as video surveillance and graphic-rich web-site content, is triggering change to facilitate efficient WAN transport. This shift often begins with evolution to a hybrid packet and circuit transport, with increased capacity, and then full packet convergence as packet traffic begins to dominate. MPLS Transport Profile (MPLS-TP) is the evolution of SONET/SDH to better accommodate native packet applications while retaining Carrier Ethernet transport performance. New Packet Optical Transport Systems, microwave packet radios and Zero Touch Photonics offer resiliency, increased bandwidth capacity, effectiveness and flexibility to allow true, smooth network convergence.

In a greenfield situation or when packet traffic is the dominant traffic type, an IP/MPLS backbone may be the appropriate architecture for offering carrier-grade Ethernet services and ensuring that new services, such as packet-based closed-circuit television (CCTV), are efficiently transported with the reliability, QoS and bandwidth necessary for a quality user experience. IP/MPLS and Carrier Ethernet transport support the full range of new IP-based applications coming down the pipe: applications that current networks simply do not have the bandwidth and flexibility to handle efficiently. IP/MPLS and Carrier Ethernet transport also provide the required foundation for broadband streaming video, imaging and video-surveillance capabilities to enhance mission effectiveness.

Although an existing corporate WAN may be sufficient for providing legacy services such as e-mail, voice and database access, the WAN may not be flexible or scalable enough to support the new services, such as packet-based CCTV, and passenger information and communications services. In the past, the agencies' internal corporate networks did not carry mission-critical traffic and were therefore not designed to provide the reliable, always-on capabilities of the Alcatel-Lucent Mission-critical WAN Infrastructure. Even if it were possible, extending the internal corporate network to support these new applications would not provide the same level of availability and stability. In addition, advanced end-to-end network and service management may yield the lowest total cost of ownership (TCO) of any available option.

2. Network transformation

By enhancing optical and microwave transport technology and adopting IP/MPLS technology, rail operators have the opportunity to converge their application-specific networks — their WANs — and enjoy a whole range of benefits, including greater flexibility, lower costs and improved security.

Mission-critical operations information can be communicated with extremely high reliability in such a converged environment. This is essential for the new capabilities used to manage rail traffic. At the same time, IP traffic associated with surveillance, upgrades to IP-based digital LMR/PMR, Voice over IP (VoIP), and passenger Internet-access applications to improve security, productivity and new revenue is also supported. One network can host the full suite of operations and corporate/passenger applications that a rail operator requires while protecting critical traffic to ensure that it always receives priority treatment.

In addition, centralization allows greater information sharing and compilation, which is key for rail operators preparing to contend with a mass exodus of baby boomers from the workforce. As individuals of the "boom" generation retire and take valuable technical knowledge with them, their knowledge must somehow be captured, preserved and easily distributed to other workers.

2.1 What the converged network looks like

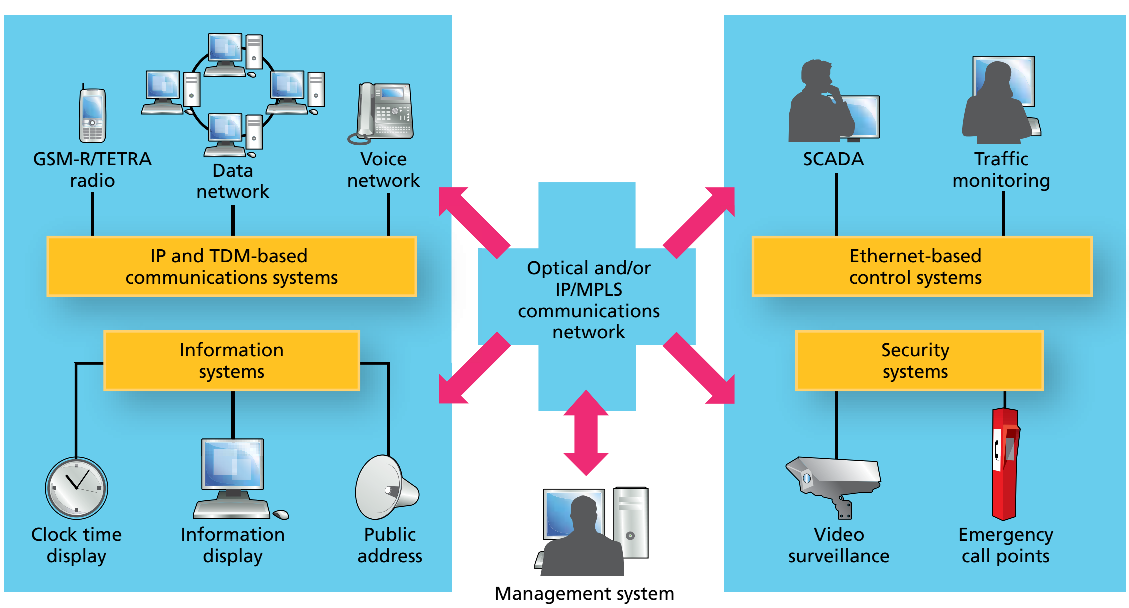
The proposed converged WAN, the Alcatel-Lucent Mission-critical WAN Infrastructure, leverages a combination of IP/MPLS, SONET/SDH and Ethernet capabilities to support the convergence of legacy and growing IP traffic reliably, flexibly and cost-effectively in a broad range of applications. Microwave transport is deployed where fiber connectivity between sites is not available, and WDM is used to scale fiber capacity. Microwave and optical SONET/SDH transport evolves with the addition of Ethernet capabilities to provide Carrier Ethernet transport. This is essential as IP traffic comes to dominate the network, with new applications for bandwidth efficiency and a seamless traffic migration.

WHAT IS CARRIER ETHERNET TRANSPORT?

Carrier Ethernet transport combines the traditional efficiencies of Ethernet with the carrier-class transport capabilities of OA&M, manageability and protection. With low-cost Ethernet interfaces, EoS efficiently delivers Carrier Ethernet transport for the increasing packet traffic while the majority of traffic is TDM. As packet traffic begins to dominate, MPLS-TP becomes the choice for Carrier Ethernet transport. This connection-oriented packet-transport technology, based on MPLS frame formats, provides resiliency and OA&M capabilities similar to SONET/SDH while maintaining the benefits associated with packet-based networking. MPLS-TP evolves to allow operational convergence with IP/MPLS domains.

Combinations of IP/MPLS and Carrier Ethernet transport are flexibly deployed in the WAN to cost-effectively support the specific traffic mix, topology and leveraging of investments, accommodating the changing traffic mix and required bandwidth growth in response to the new IP-based application deployments.

Figure 1. Rail-operator WAN communications transformation with the Alcatel-Lucent Mission-critical WAN Infrastructure



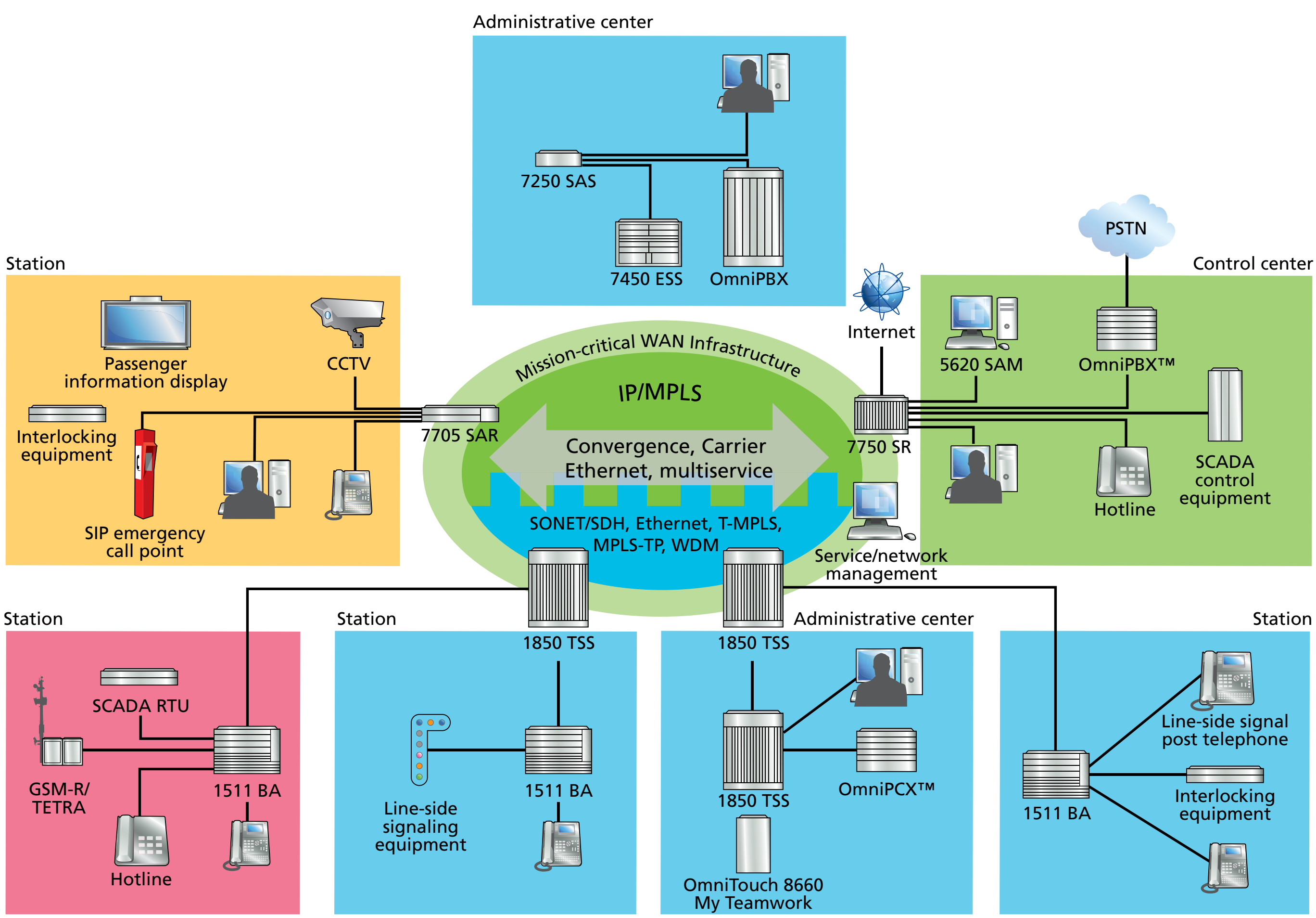
Such a converged network simplifies and reduces operational expenditures (OPEX) with end-to-end service and network management that includes integrated MPLS/microwave management and optical/microwave transport management. This evolution to a converged network is essential for improving management efficiencies as baby boomers with application-specific network knowledge retire. In addition, a converged network provides industry-standard interfaces for Operations Support System (OSS) integration.

The Alcatel-Lucent Mission-critical WAN Infrastructure, shown in Figure 2, builds on key elements of the Alcatel-Lucent High Leverage Network™ strategy for carriers. Real-time operations as well as smart and mission-critical operations and corporate information are reliably communicated in this converged environment. High availability, scalability and application awareness advance the delivery of all information needed to safely and securely keep trains on time and satisfy passengers with an enhanced level of service.

WHAT IS THE ALCATEL-LUCENT HIGH LEVERAGE NETWORK?

The Alcatel-Lucent High Leverage Network is a fully converged network that provides continuous scaling of bandwidth across multiple dimensions, from access to transport, at the lowest TCO. At the same time, the network is equipped with built-in application awareness, QoS and traffic optimization to provide the appropriate levels of network intelligence at the optimum cost. In addition, the High Leverage Network offers high reliability and availability, improved security, application assurance and enhanced policy management.

Figure 2. The Alcatel-Lucent Mission-critical WAN Infrastructure enables cost-effective, reliable IP transformation for a range of topologies



3. Rail-applications challenges: enabling new capabilities in a 200-year-old industry

A rail operator's communications system supports a broad range of applications, including those related to the internal operations of the rail system and those that support passenger-communications services.

Key applications include:

- Access control
- Alarms
- Cargo tracking
- Corporate LAN
- Mobile radio
- Passenger information display
- Public address
- Public Internet access
- Signaling
- Automation controls
- Telephony
- Ticketing
- Videoconferencing
- Video surveillance
- Wireless LAN (WLAN)

Each of these applications has a unique set of requirements in terms of bandwidth, QoS, availability, latency, and so on. The ideal communications infrastructure supports all these requirements and allows the rail operator to set service parameters for each service and traffic type — voice, data and video — according to operational and business needs, and to assign levels within each service type (for example, for critical, priority and best-effort data).

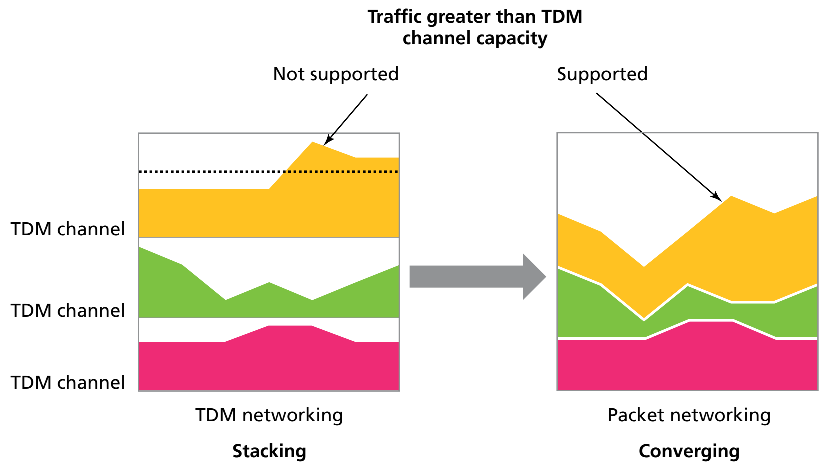
To transport all traffic types effectively and reliably in real time, a rail operator needs a WAN that supports low jitter and delay in a point-to-point or point-to-multipoint topology. The WAN must address key service areas, including data services, voice services, video surveillance, cargo tracking, intranet and Internet access.

Superior bandwidth utilization for increasing IP traffic improves worker productivity by allowing more flexible combinations of information: by converging legacy and IP traffic in a single network, information previously available in only one system — for example, engineering diagrams and customer-specific network details — can be accessed at the same time, improving the productivity of remote workers, repair teams, and so on. An IP/MPLS WAN also can efficiently replicate and send traffic to a second operations center to increase reliability and help address security regulations.

In such a network, carrier-grade optical and microwave transport continues to serve as the foundation, supporting a mixture of TDM and IP/Ethernet traffic with high availability and scalability. This SONET/SDH-based transport continues to evolve to Carrier Ethernet transport, with more Ethernet and IP capabilities to transparently aggregate and switch increasing volumes of packet traffic at a level of reliability that matches TDM.

Rather than stacking individual TDM channels to increase bandwidth for the support of growing application traffic, TDM, IP and ATM are converged and packetized for more efficient support while providing priority to mission-critical traffic (see Figure 3). This is particularly important for cost-effective support as IP traffic begins to dominate with new bandwidth-intensive IP applications that include video surveillance and public Internet access. With constrained funding, current investments must cost-effectively scale to address many years of new applications traffic growth.

Figure 3. Transforming to packet networking to optimize overall bandwidth



New Packet Optical Transport Systems and microwave packet radios offer resiliency, increased bandwidth capacity, effectiveness and flexibility to allow true network convergence. WDM is added in areas where fiber capacity is exhausted to cost-effectively increase bandwidth capacity. The addition of Zero Touch Photonics capabilities further simplifies WAN operations.

Microwave packet radio, which is capable of handling multiple packet types natively, introduces a new concept in transport applications: the ability to transport IP-based multimedia traffic efficiently while still supporting legacy TDM traffic. Microwave packet radio aggregates packet and legacy TDM traffic, increases bandwidth utilization, and optimizes Ethernet connectivity, enabling the non-linear cost-capacity model required to support broadband traffic. Microwave packet-radio technology is a long-term enabler for rail operators to smoothly transition their networks from TDM to IP, realizing a dramatic reduction in operating costs; for example, a 40-percent TCO reduction with the Alcatel-Lucent 9500 Microwave Packet Radio (MPR) compared to a TDM current mode of operation.

WHAT IS MICROWAVE PACKET-RADIO TECHNOLOGY?

Alcatel-Lucent microwave packet-radio technology uses a multiservice aggregation layer to provide the capacity to use Ethernet as a common transmission layer to transport any kind of traffic. All traffic is converged over a single packet-transport layer using industry-standard pseudowire and circuit-emulation technologies. Service awareness supports different traffic types with different requirements and priorities, optimizing bandwidth with the option of overbooking radio capacity for non-real-time traffic and variable bit-rate traffic.

Transformation by adding IP/MPLS and Carrier Ethernet transport capabilities typically occurs in phases that are driven by specific traffic growth and the existing WAN's capacity, reach and lifecycle stage. Managing the whole is simpler and less expensive than managing current application-specific networks because of the addition of end-to-end IP/MPLS and Ethernet service management and common optical and microwave transport management. The advantages are amplified because there is a single network to manage instead of multiple, application-specific networks, each of which could require separate management. Security policies can be centralized, ensuring their application and improving their enforceability. IP-address management is also centralized, along with distributed protection, for a truly secure, scalable solution.

IP transformation is bringing together dozens of applications. The required number of IP addresses can be doubled when the additional IP data devices are combined with a new VoIP network — a potential danger to corporate networks that can harm their user communities and introduce potential error to service provisioning. A centralized IP address-management capability can protect these business systems and make them more reliable, helping organizations to configure, automate, integrate and administer IP services efficiently across their entire networks locally or globally.

4. Critical schedules require a mission-critical WAN

Signaling is an important real-time service that needs to be treated as a mission-critical priority. It is used to convey critical information about the state of a rail line, control traffic flow, and generate alarms.

High availability is essential to a rail communications network. An IP/MPLS backbone network ensures high availability using fast path restoration and network reconvergence within 50 ms. Network resiliency is achieved with the end-to-end restoration capabilities of the MPLS fast-reroute feature. MPLS fast reroute minimizes service interruption to signaling as well as all other voice, video and data services during network failures.

The Alcatel-Lucent product platforms have added high-availability support for non-stop routing and non-stop services. For example, individual control-card failures have no service impact because Label Distribution Protocol (LDP) adjacencies, sessions and the database remain intact. As a result, services running over IP/MPLS-based virtual private networks (VPNs) that consist of Alcatel-Lucent product platforms are not affected when there is a control-fabric module switchover. Control-fabric switchovers may be caused by hardware failures or may be intentionally initiated during software updates. WAN products without this feature may cause service outages for as long as several minutes, and during this time, critical services could be down.

5. Enhancing safety and security

Incidents in London, Tokyo, Madrid and elsewhere have reminded us that passenger rail service is a highly visible, attractive target for terrorist groups. Security has become paramount for rail operators: critical assets, personnel and passengers must be protected against life-threatening disasters. Legacy technologies such as fire, intrusion and proximity alarms and proprietary CCTV systems once operated over separate overlay networks whereas CCTV and alarm systems with IP and Ethernet interfaces are now commonplace commercial off-the-shelf (COTS) products. The use of the COTS IP-based components and applications, combined with the real-time software analysis of video streams over a single, converged IP/MPLS network, has increased rail operators' ability to cost-effectively monitor and proactively detect potential threats to their vast, geographically dispersed infrastructure and rolling stock.

A rail infrastructure is often administratively divided into several regions. Each region is controlled by a Network Operations Center (NOC), and the regions are supervised by a single central operations center, which also serves as a backup of each regional NOC. Within this structure, a typical rail operation has many stations, and at each station high-quality CCTV cameras generate multicast IP video streams. A relatively large bandwidth is required to transport these video streams in real time to multiple operations centers. To make this possible, rail operators need a cost-effective, reliable high-capacity communications network that can transport multicast streams in a many-to-few topology.

Evolving from many application-specific networks to a service-oriented IP/MPLS network allows for centralized security-policy enforcement and the implementation of sophisticated electronic security measures that protect internal and external communications, operational data and customer information from being compromised. Optical and microwave SONET/SDH networks are, by definition, carrier-grade, implementing security at the physical layer.

Physical assets can also be protected and centrally monitored using the IP/MPLS network. To improve security at unstaffed and staffed stations, digital video-surveillance tools can be deployed. These tools typically require bandwidth of 64 kb/s to 384 kb/s for solutions involving compression and 1 Mb/s to 2 Mb/s for solutions with enhanced capabilities: bandwidth that the converged network can deliver. Video-surveillance traffic can easily be distributed to a primary and secondary remote-monitoring center for increased reliability and flexibility using a combination of an IP multicast protocol and MPLS-based virtual private LAN service (VPLS).

5.1 Ensuring safety with automated control systems

Modern metro trains are typically controlled by two separate signaling-based systems:

- Cab signals, which protect the trains by advising the operator of safe operating speeds on each track segment
- Centralized speed-control system for automated operation to ensure the proper separation of trains

Both systems typically work using a series of track-mounted — mechanical, radio frequency (RF), magnetic, current or inductive — beacons or transponders, which transmit a code to the train as it passes overhead. Metro rail authorities need to guarantee that these signals get through reliably to ensure the safety of its passengers and employees.

The cab signals are a mission-critical system that provides a continuous stream of information to the train regarding the maximum safe speed of the rail segment. Speed commands are designed to allow train operators to maintain a safe stopping distance and be advised of the safe speed limit for a given track segment. Operators have visual indicators of the cab signals on their control panels. Depending on the system, the cab signals may be integrated with the speed control to govern the speed of the train such that it can override the operator commands to stay within safe limits. Speed-enforcement systems may also be combined with the cab signals to apply brakes and halt the train.

For many metro systems, there is also an automated control system, called Automatic Train Control (ATC), run by a central computer. ATC speeds up or slows down trains to ensure that they keep a predetermined distance/time between them. The ATC system cannot override the maximum speed limit enforced by the cab-signal system. During normal operation, trains are controlled by the ATC, which accelerates and brakes the train automatically without operator intervention. An enhancement to ATC is the fully automated, driverless train.

Mainline rail signaling is a traffic-control system whose primary purpose is to avoid train collisions. Trains cannot stop quickly due to their high speed, low friction wheels and great mass. These characteristics, combined with the inability of trains to deviate from their path because of their fixed-track system, makes trains susceptible to collision with other trains using the same tracks. Signaling systems are typically managed on a section-by-section basis. The local segment authority generates movement-authority signal information to the train crews passing over these sections.

Automated control systems can provide enhanced control for railways, ensuring the safe operation of rail vehicles using data communication between the various control entities that make up the system. Types of automated control systems are automatic train protection (ATP), automatic train operation (ATO), and automatic train supervision (ATS). All these applications require a high-availability, scalable network to avoid collisions and ensure operational efficiency.

6. Enabling operational optimization

Maintenance personnel rely heavily on voice systems to stay in contact with co-workers while they perform routine duties. Voice communications can be within a station or span several stations. The transmission media may be wired or wireless and often are being upgraded to an IP-based system along with an expanded wireless coverage area. Whatever the requirements, high-quality voice communications must be supported to provide an efficient work environment and keep staff informed in the event of an emergency.

Rail operators are continuing to improve their ability to track cargo. A tracking system, such as one using radio-frequency identification (RFID) tagging or another new RFID technology, can be used throughout a rail network, increasing shipping efficiency and on-time delivery. To support this activity, shipment-data traffic must be handled by the communications network with the required priority.

In addition, rail company personnel working in operations centers and administration buildings need regular access to their intranet and the Internet. A WLAN allows a rail operator's mobile workforce to easily access information, such as schedules, cable identification, maintenance zones and work orders, from anywhere and at any time.

Service-oriented IP/MPLS and Carrier Ethernet transport have the inherent capability of supporting new corporate appli¬cations, such as unified communications, multichannel contact center, corporate resource planning and customer relationship management. These applications provide new ways for employees to work efficiently, share information and interact responsively with customers. New information systems provide the ideal opportunity for rail operators to reclaim this knowledge, centralize it, and make it accessible to the whole organization. The appropriate WAN gives workers seamless, secure access to centralized information no matter where they are, helping to boost productivity. With the sophisticated Alcatel-Lucent Mission-critical WAN Infrastructure in place, rail operators continue to realize high communications reliability, flexibility with fiber and fixed wireless topologies in the WAN, QoS, and as previously mentioned, scalability to meet changing and growing traffic needs.

The evolution of a rail operator's WAN by adding IP/MPLS often allows the operator to cost-effectively introduce a higher level of redundancy to parts of its network where SONET/SDH is not present, making extensive use of Ethernet interfaces to reduce costs. The continuing evolution of current optics and microwave technology allows the scaled aggregation and transport of any client traffic type, at the lowest cost per bit. The widespread value that next-generation SONET/SDH and WDM are bringing to TDM support has emerged during the lengthy TDM evolution. The addition of MPLS-TP extends this value as packet traffic dominates and provides further evolution toward operations consistency across transport and IP/MPLS domains, simplifying operations and cost. These technologies can simultaneously handle both TDM and IP, reducing investment risk and allowing seamless switching between the two depending on the traffic mix.

Advanced service- and network-management systems allow for centralized network management and advanced diagnostic capabilities, minimizing TCO and reducing down time. A Forrester® Research, Inc. study identified a 75-percent increase in provisioning productivity and 25 percent fewer dispatches with Alcatel-Lucent 5620 Service Aware Manager (SAM) management of four carrier networks, with infrastructure similar to that of a large rail-operator WAN.

7. Enhancing passenger services

Deregulation in the European airline industry 12 years ago created 5-percent annual growth in air-passenger traffic over the past decade, compared to a 1-percent annual increase in rail-passenger travel. Deregulation in the rail industry, beginning in December 2009, is expected to spark competition from private rail upstarts and newly deregulated state-owned railways from other European Union (EU) states. Enhanced service, in conjunction with reduced fares, is expected to draw passengers away from the airlines and other rail operators. The airline industry is expected to lose considerable business on routes of less than three hours in duration. Time spent commuting to and from the airports, mandatory early-arrival times, moving through ever-vigilant airport security, and congestion delays at major airports make it difficult for airlines to provide satisfactory service on these routes. Rail operators are leveraging the comfort of spacious cabins, rapid city-core-to-city-core service, and new revenue-generating communications services to attract new customers.

The provision of regular and ad hoc announcements and passenger information at station terminals and on trains increases convenience for the traveler. This content may be generated at a central operations center or at a regional center and may be specific to one station or broadcast to all stations. The inclusion of advertising content in these messages has the potential to generate new revenues. At the same time, passengers also expect Internet access in rail stations and continuous mobile voice and data service along the entire rail route. It is difficult for an airline to offer similar service at competitive rates. An IP/MPLS converged network offers an ideal infrastructure for adding these services.

8. The Alcatel-Lucent offering

As a proven telecommunications partner, Alcatel-Lucent understands rail operator-specific communications requirements. The company's market-leading communications portfolio delivers solutions for mission-critical communications in complex customer environments. With the Alcatel-Lucent Mission-critical WAN Infrastructure, rail operators gain the benefit of:

- *End-to-end, carrier-grade infrastructure solutions* – Alcatel-Lucent provides rugged, reliable, scalable and secure solutions built on innovative, high-reliability products and backed by our expertise in delivering complex, mission-critical networking to meet rail-industry requirements. Alcatel-Lucent solutions incorporate non-stop routing, redundancy, MPLS fast rerouting in IP/MPLS parts of the network, and ring protection with optical and microwave packet networks.
- *Guaranteed QoS for mission-critical legacy signaling and automated control systems* – Signaling and automated control systems in metro and mainline rail systems are critical to maintaining their safety and efficiency. The Alcatel-Lucent Mission-critical WAN Infrastructure ensures that the signaling and automation telemetry is always on.
- *Cost-effective growth and convergence of growing packet — supervisory control and data-acquisition technology with an Ethernet interface (eSCADA) and video surveillance applications — and legacy traffic* – Alcatel-Lucent solutions deliver a flexible, scalable WAN with carrier-grade IP/MPLS and Ethernet capabilities, leveraging our broad, industry-leading access, IP, optical and microwave portfolio for cost-effective support of a range of applications.

- *Simplified mission-critical WAN transformation and reduced OPEX* – The Alcatel-Lucent MPLS/Ethernet solution provides end-to-end IP/MPLS and Ethernet service management and integrated optical/microwave transport management, which cost-effectively address a range of applications with common management to simplify the network and reduce costs. Centralized security-policy administration and distributed protection simplify, scale and enhance security.
- *Packet evolution of transport networks* – The long-standing leadership of Alcatel-Lucent in optical SONET/SDH and WDM technologies provides the right solutions to evolve and transform current optical and microwave networks, supporting increasing packet-based traffic with Carrier Ethernet transport.
- *Reduced risk and WAN transformation costs* – The Alcatel-Lucent Mission-critical WAN Infrastructure incorporates our experience from more than 20 rail deployments worldwide. The Alcatel-Lucent Worldwide Services team provides end-to-end solution support with multivendor capabilities.

The Alcatel-Lucent Mission-critical WAN Infrastructure is a key component of the Alcatel-Lucent Dynamic Communications for Rail solution.

8.1 Innovations in eco-sustainability

Innovations in eco-sustainable networks and applications can help rail operators to reduce costs while reducing their environmental footprint. Key focus areas for Alcatel-Lucent are rail-industry efficiency, a reduced carbon footprint and environmental sustainability. Alcatel-Lucent helps rail operators realize benefits by reducing TCO and CO_2 emissions with a holistic approach across each network layer. Some proof points include:

- Packet microwave and optical transport platforms that use 62 percent to 65 percent less power per transported bit than traditional platforms by forwarding traffic to the most efficient and economic layer: packet, circuit or optics/wavelength
- IP/MPLS platforms that leverage intelligent dynamic powering methods and operate at voltages and frequencies that are no higher than necessary to achieve the desired functionality and performance

9. Conclusion

Rail operators are driven in part by regulatory requirements, but also by competitive pressure to increase security, optimize internal communications and introduce differentiated passenger services. New IP-based systems and applications are challenging to support with existing networks but offer the promise of the incremental revenues and reduced operating costs that are necessary for increasing competitiveness in a deregulated environment.

Rail operators know they cannot afford to shut down existing networks and experiment with new technologies at the risk of passenger safety and the bottom line. However, many rail operators have already recognized that those who choose to ignore this new era of competition risk losing a significant potion of their already-eroded market share to more nimble competitors. Their shareholders demand that current business levels and margins increase while the high level of security expected by rail travelers is maintained. Trains must offer more efficient, increasingly attractive services and comfort as well as on-time guarantees to gain passenger confidence.

A transformation of today's agency-specific WAN is a typical first step in addressing these challenges and toward realization of the benefits of new applications. The transformation includes expanded bandwidth and network reach along with new capabilities to cost-effectively address the increasing IP-based application traffic. A transformed WAN also provides the required foundation for broadband streaming video, imaging and video-surveillance capabilities. Any capital investment is significant, and the solution needs to be flexible, proven and reliable. Carrier-grade is the only acceptable level of quality to bring to mission-critical infrastructure such as this.

Alcatel-Lucent drives the evolution and convergence of today's WANs with new IP/MPLS and packet transport standards, and our Mission-critical WAN Infrastructure has been deployed by major rail companies worldwide. The company is an expert integrator in mission-critical communications projects. Rail operators can reduce risk and WAN-transformation costs with an end-to-end solution backed by multivendor Alcatel-Lucent Worldwide Services capabilities. With our optics, microwave and IP/MPLS portfolio, rail-industry experience and the Mission-critical WAN Infrastructure offering, Alcatel-Lucent has all the elements that rail operators need to simplify their WAN transformations and reduce OPEX while increasing competitiveness and achieving greater control over their business.

10. Acronyms

1511 BA	Alcatel-Lucent 1511 Business Access Multiplexer
1850 TSS	Alcatel-Lucent 1850 Transport Service Switch
5620 SAM	Alcatel-Lucent 5620 Service Aware Manager
7250 SAS	Alcatel-Lucent 7250 Service Access Switch
7450 ESS	Alcatel-Lucent 7450 Ethernet Service Switch
8660 My Teamwork	Alcatel-Lucent OmniTouch 8660 My Teamwork
7705 SAR	Alcatel-Lucent 7705 Service Aggregation Router
9500 MPR	Alcatel-Lucent 9500 Microwave Packet Radio
ATC	Automatic Train Control
ATO	automatic train operation
ATP	automatic train protection
ATS	automatic train supervision
ATM	Asynchronous Transfer Mode
CCTV	closed-circuit television
COTS	commercial off-the-shelf
eSCADA	supervisory control and data-acquisition technology with an Ethernet interface
EU	European Union
GSM-R	Global System for Mobile Communications - Railway
IP	Internet Protocol
LAN	local area network
LDP	Label Distribution Protocol
LMR	land mobile radio
MPLS	Multi-Protocol Label Switching
MPLS-TP	MPLS Transport Profile
NOC	Network Operations Center
OA&M	operations, administration and maintenance
OmniPBX	Alcatel-Lucent OmniPBX™
OmniPCX	Alcatel-Lucent OmniPCX™ Enterprise Communication Server
OPEX	operating expenditures
OSS	Operations Support System
PMR	professional mobile radio
PSTN	Public Switched Telephone Network
QoS	Quality of Service
RF	radio frequency
RFID	RF identification
RTU	remote terminal unit
SCADA	supervisory control and data acquisition
SDH	Synchronous Digital Hierarchy
SIP	Session Initiation Protocol
SLA	Service Level Agreement
SONET	Synchronous Optical Network
T-MPLS	Transport MPLS
TCO	total cost of ownership
TDM	Time Division Multiplexing
TETRA	Terrestrial Trunked Radio
VoIP	Voice over IP
VPLS	virtual private LAN service
VPN	virtual private network
WAN	wide area network
WDM	Wave Division Multiplexing
WLAN	wireless LAN

11. References

1. Forrester Research, Inc. *The Total Economic Impact Of Alcatel-Lucent's 5620 Service Aware Manager (5620 SAM)*. December 10, 2007.

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