Optical networks deliver big benefits to public transport operators

Extensive high-definition CCTV networks, ultra-broadband passenger communications, real-time passenger information, and mission-critical signalling, as well as voice networks all promise to help deliver the safe and effective transportation services wanted by operators and passengers in the 21st century.

CUSTOMER VIEW

Public transportation industry realizes the benefits of optical networks

Recent projects undertaken by Eurotunnel, STIB/MVIB in Belgium, Highways England and Railway China show how more operators are realizing the benefits of optical networks ...

EXPERT VIEW

Using optics to manage and secure a converged transportation network

A single, converged network architecture based on IP/MPLS in combination with WDM/OTN (Wavelength Division Multiplexing/Optical Transport Network) is considered the optimum solution to meet transportation operators desire to introduce more and more bandwidth-hungry applications ...

But what is the best way of hosting all of these applications so they can work effectively? And do transport networks have the infrastructure to cope with the demands of multiple bandwidth-hungry applications working at the same time?

This edition of TrackTalk aims to answer these questions and more by looking in depth at the optical networking solutions deployed by Highways England, Brussels metro operator STIB/MIVB, Eurotunnel, as well as the Beijing and Nanning Railway Bureaus in China. Each of these operators has deployed an optical networking solution to meet a variety of challenges specific to them. They are now reaping the rewards of greater operational efficiency, which has helped to reduce costs and improve passenger service.

We also consider the contributions of Alcatel-Lucent to this field by looking at the advantages of its Agile Optical Network solution. This is considered the optimum solution to support high-bandwidth applications and build highly scalable networking infrastructure. What’s more, when combined with an IP/MPLS solution, it offers a unified and converged network. In this issue, we look at how this solution works, and how it benefits networks — now and in the future.
The Channel Tunnel is the world’s longest underwater tunnel and has provided a critical transport link between Britain and mainland Europe since it opened in 1995. More than 355 million passengers and 320 million tons of freight have now travelled through the 50.5 km tunnel and traffic is continuing to grow.

Eurotunnel manages the tunnel’s infrastructure, including its communications networks. This currently consists of a Synchronous Digital Hierarchy (SDH) network for mission-critical operations, including railway signalling. The tunnel also offers 3G/4G mobile coverage to the 21-million passengers travelling on trains running 100 m below sea level every year. But with Eurotunnel wanting to introduce new enhanced mission-critical services, including GSM-R radio coverage throughout the tunnel and its 150 km of galleries and 250 control rooms, a network upgrade is required. This upgrade will need to deliver the desired performance without impacting existing operations.

For Eurotunnel and other transportation operators facing the challenge of securing the bandwidth necessary to cope with new services, such as CCTV, traffic management, advanced signalling functions, VoIP and back-office applications, the solution of choice is a WDM optical network architecture.

This optical networking solution can support legacy and new services, and its ability to scale lets operators add new applications as they become available. For Eurotunnel, Alcatel-Lucent is delivering a WDM network based on its 1830 Photonic Service Switch (1830 PSS) and network management through its 5620 Service Aware Manager (5620 SAM). The project encompasses the installation of 20 1830 PSS-4s in technical rooms in the two tunnels. Plus, once installed, all rail operational services and applications will be consolidated onto a single network while leveraging the existing SDH optical network.

While the Alcatel-Lucent optical network is tailored to meet Eurotunnel’s requirements, including uninterrupted operation in the difficult tunnel environment, it is not a bespoke solution. Indeed railway networks in China, the metro in Brussels, and Highways England are also benefitting from this and other optical network technologies and solutions. These will prove critical in helping these operators deliver effective services, as demand increases.

The new solution will provide 10G-speed technology and support enhanced signalling, surveillance, and telecommunications. It will also lay the foundations for future 100G services.

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**Highlights**

- Many transportation operators and agencies deploy fractured communications networks and services, which are expensive to maintain and don’t meet current needs.

- IP/MPLS (Internet Protocol/Multiprotocol Label Switching) over WDM (Wavelength Division Multiplexing) provides the optimal network solution that can meet transportation communications needs — now and in the future.

- Intermediate optical networking solutions as deployed by Eurotunnel, Brussels metro and networks in China are helping operators to realize improved mission-critical network performance before a complete network upgrade is possible.

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Intermediate solution

Like Eurotunnel, China’s Beijing and Nanning Railway Bureaus are benefitting from improvements in speed and reliability offered by a WDM optical network while, at the same time, retaining their legacy SDH architecture. In Beijing, Alcatel-Lucent is installing the 1830 PSS on the 623km Ring 3 line, which connects neighboring cities with the Chinese capital. The new solution will provide 10G-speed technology and support enhanced signalling, surveillance, and telecommunications. It will also lay the foundations for future 100G services. In Nanning, the project encompasses an upgrade of the SDH architecture used on the 200 km Guilin-Liuzhou line to advanced multiservice switching.

Brussels metro operator STIB/MVIB is similarly transitioning to an optical WDM network to support its upgrade to automated operations grounded on communications-based train control (CBTC).

With passenger numbers rising by 70 percent in the past 10 years, STIB/MVIB is preparing for further growth by installing a new driverless system to increase its service capacity from 24 to 40 trains per hour. As a result, the network is expected to carry 415 million passengers per year by 2017 – a 20 percent increase from the 348.8 million served in 2012.

A successful transition to a fully automated system requires special safety measures. STIB/MVIB is consequently installing a new CBTC signalling system, automatically-controlled platform screen doors, and more than 10,000 interconnected video-protection cameras.

To deliver these services, STIB/MVIB tasked Alcatel-Lucent to deploy a WDM network based on the 1830 PSS to interconnect the metro network’s 70 stations and support mission- and non-mission-critical communications. The substantially increased bandwidth offered by the new network enables STIB/MVIB to host signalling, as well as passenger information, a real-time LAN network connecting all ticket machines and offices, its office communications, and an interconnected data center on a single converged network. The network is fully redundant, consisting of two parallel loops, which can easily take over from one another to provide continuous availability. And with more than 140 Reconfigurable Optical Add-Drop Multiplexer (ROADM) nodes, it is the largest installation deployed by any metro operator in any city in the world.

Fiber backbone

The 5260 SAM provides integrated network and services management while the project also includes the installation of a new fiber optic backbone. This has substantially increased the availability and resilience of STIB’s infrastructure. The fiber network’s robust design means that, if the fiber is cut, there is only a minimal effect on performance, with failover mechanisms able to restore service in only 50 ms. Fiber is also less attractive to thieves than networks that use copper. It also eliminates problems caused by electromagnetic interference, which is particularly problematic in tunnels.

These upgrades in Brussels, China, and in the Channel Tunnel will provide the respective networks with the flexibility to support high-bandwidth services. They also lay the groundwork for a future unified IP/MPLS network and ultra-broadband mobile infrastructure, demonstrating the capability of WDM to act as an intermediate solution before a complete network transition takes place.

An operator that has taken this step already is Highways England, which oversees England’s road network. Its network has evolved as new technologies have become available in the past 40 years. The result is more than 30 different voice, video, and data networks – from 1970s weather equipment to modern-day CCTV. This has led to a patchwork of different systems and applications, which rarely interact with each other and suffer from high maintenance and operations costs.

For Highways England, Alcatel-Lucent was tasked with the delivery of an end-to-end communications network, which could provide a platform for in-car driver information. The network would also need to offer minimal network latency, a single network for legacy and new services, network scalability and adaptability,
network intelligence, and state-of-the-art operational control and highway asset maintenance.

The selected solution is IP/MPLS over WDM. The core network is built around 10GB/s Ethernet connected by Dense Wavelength Division Multiplexing (DWDM) technology. The edge of the optical network will run at 2.5Gb/s, continuing to offer high reliability and high capacity. In addition, the core and edge IP/MPLS network will provide an IP transport mechanism for triple-play services using the Alcatel-Lucent 7750 Service Router, and its high-density 10/100MB/s Ethernet aggregation will meet all network edge performance and IP security needs.

Converged optical networks like Highways England’s, which support multiple applications through high-bandwidth – in addition to having the ability to scale – are the future of transportation communications. IP/MPLS over WDM is the next step to secure an optimal solution – with fiber, not copper, being the preferred backbone to support high-speed services and applications.

As Highways England upgrades its complete architecture, intermediate solutions can provide immediate improvements in performance. These intermediate solutions can serve as the first step to a complete overhaul at a later stage. Recent projects undertaken by Eurotunnel, STIB/MIVB, and in China show how more and more operators are realizing the benefits of improved communications and delivering enhanced services to their customers. To do this, they are beginning the transition from existing fractured and expensive solutions with WDM – the optical solution of choice.
Transportation operators have traditionally built single-purpose networks to support specific applications, such as signaling, traffic control, operations communications, highway tolling and CCTV. But with skilled employees retiring and suppliers ending their support, operating and maintaining multiple legacy networks has become increasingly complicated and costly.

Moreover, with railways, highways agencies, airport and port authorities all looking to use the latest technologies to enhance operations, security, and passenger services, the bandwidth burden from applications that use IP-based communications is growing beyond the capabilities of existing networks. Legacy networks were simply not built to handle high traffic and provide little flexibility for integration of the services, which operators and their passengers now demand. And with cyber security threats becoming ever more sophisticated, along with potential Layer 1 security interference issues, the time is right for operators to consider upgrading their network infrastructure to a solution that will meet not only today's demands but also easily actuate, integrate, and manage tomorrow's mission-critical and non-mission-critical applications.

The Alcatel-Lucent blueprint architecture is built around a single, converged communications infrastructure based on IP/MPLS. This creates a strong foundation for integrated communications and applications across all areas of transportation operations.

Various optical technologies are now available and offer certain benefits, depending on their application and use. This issue of TrackTalk focuses on the added value that an additional WDM/OTN optical network layer can bring to a single, converged IP/MPLS network.

WDM is a technology that multiplexes optical carrier signals and transports them at speeds of up to 500Gb/s. Capacities of 24Tb and more on a single optical fiber use different wavelengths or colors of laser light up to several thousand kilometers without signal regeneration. WDM technology is agnostic to the electrical client signal protocol and adds end-to-end low latency. It is therefore compatible with mission-critical communications, providing transportation operators the flexibility to add new applications and services to their network as and when they wish – without compromising the integrity of existing services.

OTN technology allows the switching of electrical client signals in order to optimize wavelength bandwidth filling. Defined by the ITU, it includes a payload encapsulation of digital clients, such as Ethernet and SDH-based interfaces, OAM overhead, forward error correction (FEC), and multiplexing hierarchy. OTN is specifically designed as a multi-service transport container for any type of service from TDM to packet – one of the technology’s greatest strengths.
As Eurotunnel, STIB/MIVB, and Highways England demonstrate, leading transportation operators recognize the benefits of an additional WDM/OTN layer, and equally appreciate the benefits that WDM provides during the transition from existing SDH legacy optical infrastructure to the final converged IP/MPLS infrastructure. In this scenario, WDM supports a temporary hybrid communications platform, allowing the various subsystems to migrate at their own speed.

**Benefits of WDM/OTN**
Transportation operators currently considering network upgrades are all looking to benefit from improvements in capacity and safety, as well as increasing customer satisfaction. A unified IP/MPLS single, converged network can certainly cope with the increased complexity of hosting multiple bandwidth-hungry applications. But, in a climate where the reduction of costs is a major concern, introducing an additional WDM/OTN optical layer is also beneficial because it provides long-term economic benefits.

DWDM’s high-bandwidth flexibility, which can increase from just a couple of wavelengths up to 88 when required, can meet the demands of future traffic growth and maximize fiber usage.

The key to the effective deployment of this additional WDM/OTN layer is to control and optimize the total cost of ownership (TCO). As a result, deploying a single Network Management System (NMS) is critical. Whereas in the past a dedicated management system was required to manage the optical layer, today’s solutions can leverage multi-domain and multi-layer management systems spanning both IP and optical domains. This helps to unify workflows and achieve maximum efficiency across all layers of the mission-critical network.

**Segregation and multi-tenancy**
While IP/MPLS clearly provides options to segregate different traffic types and can even introduce different levels of Quality of Service (QoS), for many transportation customers it is critical to increase the physical segregation between their mission-critical and user-connectivity traffic. Both WDM and OTN deliver on this key requirement. With WDM able to allocate different wavelengths to different types of traffic, segregation is achieved on an optical level using different frequencies. OTN optimizes usage by using sub-wavelength optical containers, which are also known as ODUs (Optical Data Units) within a certain wavelength, while the different sub-wavelengths are fully segregated by means of Time Division Multiplexing (TDM), which is similar to the SDH principle.

**Safety and security**
Mission-critical sectors, such as railways, highway agencies, and airport controllers, stress safety and security in all aspects of operations. As a result, signaling and operations data is no longer the only traffic considered as mission critical. Data from various sensors, video cameras, and fire protection devices is now viewed as integral to operations; consequently, it requires very high availability. The WDM optical layer provides this availability by incorporating several protection and restoration mechanisms on a per-wavelength service basis — in addition to the protection mechanisms available in the higher IP/MPLS layers.

Deploying a powerful Operations, Administration, and Management (OAM) toolkit at the photonic level to fully monitor and maintain an optical fiber network is a second key element:

- **Wavelength Tracker implements photonic OAM** with a patented technology enabling end-to-end power control, monitoring, tracing and fault localization for each individual wavelength. It also pro-actively detects service degradation, allowing railway operators to maintain a healthy network. Optical Intrusion Detection (OID) continuously checks the status at different points in the network elements. OID monitors changes in optical loss and generates an alarm when it identifies a possible optical intrusion along the fiber between two nodes.

- **Optical Time Domain Reflectometry (OTDR)** – a built-in feature – instantly detects and localizes the location of the fiber cut with high precision and monitors and detects in real-time any unexpected interventions on the fiber from a non-authorized third party.

The WDM layer is also a key element in cyber security. By offering scalable encryption, it provides a reliable encryption solution to fully secure specific data streams. This optical encryption solution works at a 10Gb/s line rate using robust Advanced Encryption Standard AES-256. On top of that, it introduces a latency of less than 1µs into the end-to-end data stream. At the same time, a dedicated software tool manages encryption keys in a simple, secure, and scalable way.

**Generating revenue**
A WDM/OTN layer maximizes the use of the fiber infrastructure. This implies that, even in instances with limited fiber availability, it is possible to offer bandwidth-consuming applications, such as Wi-Fi Internet. In addition, these opportunities open up the possibility of generating more revenue. In many countries, railways and utilities own a significant fiber infrastructure in both distance and area coverage, which, depending on an individual country’s regulations, presents a significant opportunity to resell bandwidth to third parties. For example, Paris Transport Authority (RATP) is exploring this possibility as part of its Grand Paris project, while Trafikverket in Sweden has looked at using its infrastructure to improve connectivity in rural regions.

**Move to metro layer**
As IP/MPLS becomes an integral part of our customers’ networks, we also see WDM/OTN technology usage extending from core to the metro and aggregation layer. The Alcatel-Lucent 1830 PSS-8 and PSS-16II extensions to the 1830 PSS product
family are designed to serve this need. The new compact shelves offer low-power architecture for maximum network operational efficiency and integrate OTN and photonic scalability with Layer 2 IP capabilities in a single, compact platform. A variety of packet – sub-10G, 10G, 40G or 100G services – over 10G/100/200G xWDM channels are supported, while distributed switching enables cost-effective network designs.

The latest WDM/OTN technology, which features OADM (Optical Add-Drop Multiplexers) and optical encryption technologies, offers key elements in building next-generation transportation communications networks. Transportation operators increasingly need to incorporate new services to meet their own operational, as well as customer requirements. This demands more and more bandwidth, which is beyond the capabilities of their existing networks.

If and when an operator decides to converge its existing networks, WDM/OTN technologies offer the flexibility to add these easily to a single converged architecture based on IP/MPLS. By providing tools to monitor the fiber plant and by providing greater infrastructure security, it is also possible to ward off sophisticated cyber attacks. This is crucial given the growing numbers of applications that transportation operators now consider mission critical.

Panel 1

WDM is defined by the following principles:

- Wavelengths (sometime called lambdas, colors or channels) correspond to different frequencies of light.
- In WDM technology, several incoming signals are transmitted simultaneously through the use of different wavelengths on the same fiber.
- Coarse WDM (CWDM) is a cost-effective option and supports eight wavelengths to a distance of 80 km. The usual incoming bandwidth is limited to a few 10Gb/s signals.
- Dense WDM (DWDM) enables long-distance reach and high-capacity transmission. As many as 88 wavelengths can be added to a single fiber, each of them allowing high bit rates of 100Gb/s since 2014, and even allowing 200Gb/s through the latest solution from Alcatel-Lucent. [http://www.alcatel-lucent.com/solutions/100G-200G-optics](http://www.alcatel-lucent.com/solutions/100G-200G-optics)

Panel 2

Optical Add-Drop Multiplexers (OADM) are key components of WDM networking. They enable a switch between wavelengths without converting back to the electrical signal. Tunable and reconfigurable OADM (T&ROADM) is a state-of-the-art OADM technology, which provides flexibility by using a Wavelength Selective Switch (WSS), which can individually switch any wavelength in any direction.

Panel 3

OTN switching offers several additional key benefits:

- OTN switches operate at the ODU layer. Because they are independent of the traffic type carried within the payload, the network becomes transparent to any underlying services and protocols.
- Using standard OTN mapping and aggregation structures, OTN switching allows efficient physical segregation (optical and via time division) of traffic.
- Switching at the ODU layer maintains the end-to-end optical performance and alarm monitoring.