STRATEGIC WHITE PAPER

Highway-agency Communications

Decreasing traffic congestion and reducing greenhouse gases with the Alcatel-Lucent Mission-critical WAN Infrastructure

Highway agencies can no longer cost-effectively deal with traffic congestion by simply building new roads infrastructure. Traffic congestion is the single largest greenhouse-gas contributor in most urban areas, resulting in a reduced quality of life in downtown neighborhoods and increased commute times for people who live in the suburbs. A projected population increase in suburban areas over the next few decades is expected to cause traffic to double. There is no single solution to this problem. Mass transit, cleaner energy and telecommuting, all offer benefits. Still, traffic will increase. Fortunately, Intelligent Transportation Systems (ITS) technologies make existing transportation infrastructures more efficient, minimizing or eliminating new construction. Alcatel-Lucent provides a scalable and flexible Mission-critical WAN Infrastructure necessary to reliably enable ITS.

Table of contents

1. Introduction

The continuing trend of population movement further from the workplace and into suburban bedroom communities, combined with the projected overall increase in global population, will pose a significant challenge to urban planners and transportation agencies over the next few decades. Even with increases in telecommuting and use of public transportation, the number of vehicles on the world's roads is expected to more than double by 2030. Up until now, the solution has been to construct new roads and new lanes on existing highways. This is now proving impractical and threatens the very character of downtown neighborhoods, further impacting the situation.

Higher capacity, more efficient and more comfortable mass transit is clearly a component of the solution. However, the increase in traffic is inevitable and improved traffic management will be part of the solution. Advances in communications technology have enabled Intelligent Transportation Systems (ITS) to integrate sophisticated communications networks into the highway infrastructure. ITS applications can reduce traffic congestion, increase highway efficiency and lower levels of greenhouse-gas emissions.

Highway agencies are responsible for operating, maintaining and improving road infrastructure. A communications network supporting voice, video and data is critical in operations to improve travel. To support customer needs for improved road safety and reduced journey time, many agencies are deploying new roadside devices to support their operations. These additions require a communications network that can support various types of traffic between the operations center and the tens of thousands of devices alongside highways.

Reliable, scalable and flexible telecommunications is a key enabler. Alcatel-Lucent has dynamic communications platforms that allow these agencies to meet the performance requirements of all their applications, from cost-effective business applications to mission-critical services.

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 address these challenges with a converged backbone that enables always-on communications to securely interconnect highway 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.

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 applications 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 the resiliency, increased bandwidth capacity, effectiveness and flexibility to enable true and 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, Quality of Service (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 and applications necessary for implementing ITS. In the past, agencies' enterprise 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 corporate network to support ITS would not provide the same level of availability and stability. In addition, advanced end-to-end network and services management may yield the lowest total cost of ownership (TCO) of any available option.

2. Taking control

Highway authorities worldwide need to accommodate increasing demands on their roadways. In the past, governments simply built more roads and added new lanes to meet the demand. However, this is no longer viable on its own because as cities grow and suburbs sprawl, we are approaching the limit on the physical space available for additional roads. At the same time, funds are limited for the rehabilitation and replacement of existing roads and the construction of new ones. Fortunately, technology already exists to allow highway authorities to handle increased demand and operate even more effectively and efficiently, saving money in the process. Today's communications technology makes such advanced management techniques possible.

The communications infrastructure for most highway agencies is built as multiple network overlays, each supporting separate voice, video and data-services applications. With frequently limited interconnectivity and minimal flexibility to efficiently support other services, these networks were highly inefficient. The networks are normally each installed by different vendors, with proprietary extensions and high maintenance costs. Although the networks exist in an environment where asset life is measured in decades, holding to the status quo has become an increasingly high-risk proposition. For some applications, highway operators simply used point-to-point leased services from a service provider. The transformation challenges are to:

- Improve operational efficiency
- Improve vehicle-traffic flow
- Enhance safety and security

A growing number of newer applications are IP-based, and many are much more demanding in terms of bandwidth, availability and responsiveness. Rather than continue to manage separate networks and add another IP-based network to the mix, highway operators can improve the efficiency of their operations by adopting an IP/MPLS converged network. This approach provides operators

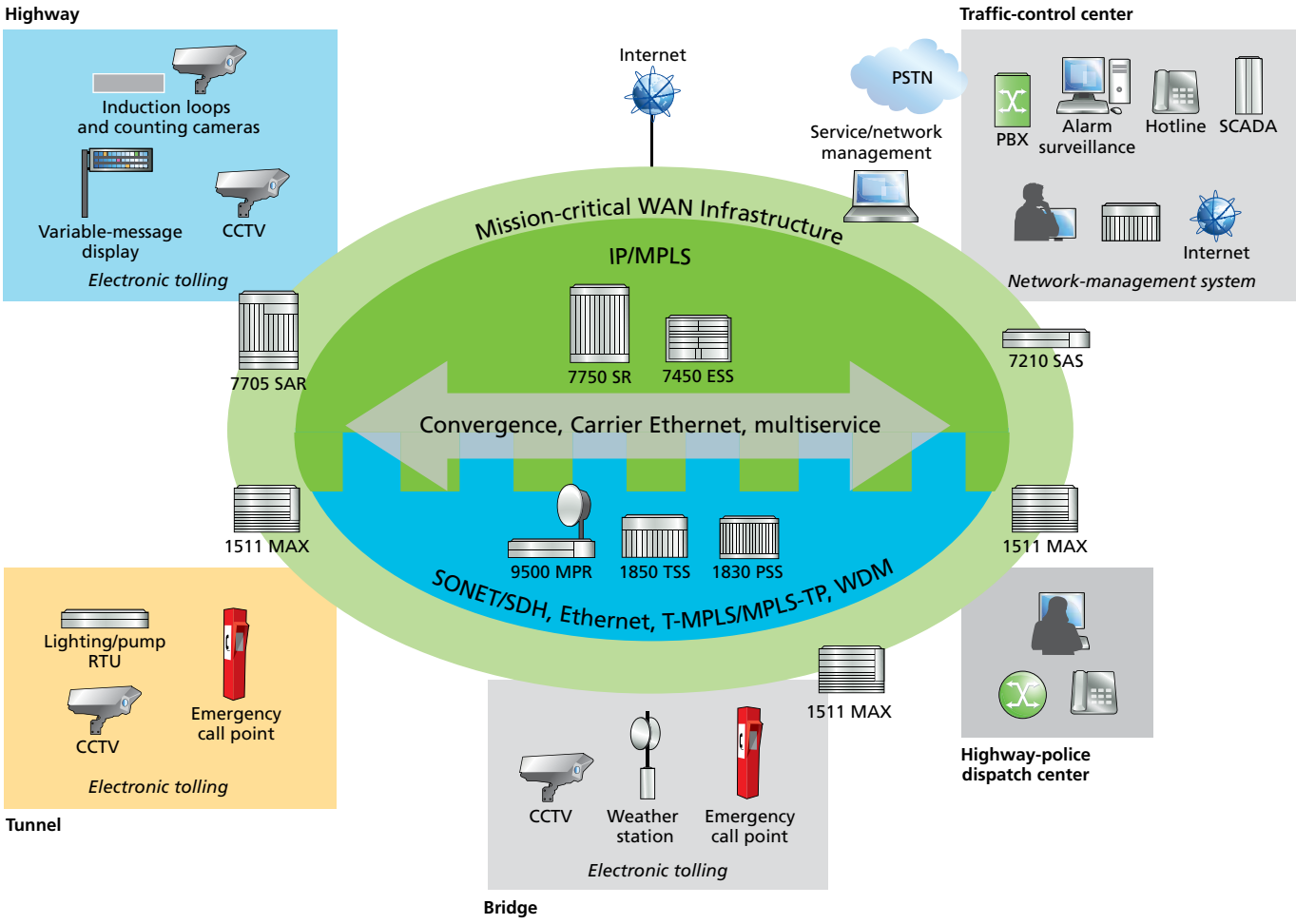
with an effective solution for managing IP video, voice and data applications while continuing to support their legacy systems. By enhancing microwave and optical transport technology and adopting IP/MPLS technology, highway agencies have the opportunity to converge these networks — their WANs — and enjoy a whole range of benefits, including greater flexibility, lower costs and improved security.

Mission-critical operations information can be rapidly communicated with extremely high reliability in such a converged environment. The physical connectivity of an agency's fixed sites with a common WAN for all types of communications — voice, data, video, and so on — provides a key communications foundation for improved intra-/interagency communications. At the same time, IP traffic associated with digital LMR/PMR, voice, data and other new applications, including voice collaboration and streaming video to improve productivity and security, is also supported. One network can host the full suite of applications traffic the highway agency requires while protecting critical traffic to ensure that it always receives priority treatment.

2.1 What the converged network looks like

The Alcatel-Lucent Mission-critical WAN Infrastructure uses a combination of IP/MPLS, SONET/SDH, Ethernet and MPLS-TP 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. This infrastructure, shown in Figure 1, builds on key elements of the Alcatel-Lucent High Leverage Network™ strategy for carriers and ensures the delivery of all essential information, when and where it is needed for a coordinated multi-agency response.

Figure 1. Highway-agency WAN-communications transformation with the Alcatel-Lucent Mission-critical WAN Infrastructure



The Alcatel-Lucent Mission-critical WAN Infrastructure delivers multiservice support, allowing the convergence of all traffic in a single reliable, secure and scalable Carrier Ethernet-based network. Ethernet, as a packet-based data-communications technology, has had appeal for WAN applications for several years now because of the desire to build Ethernet infrastructure based on Ethernet's attractive economics (high performance/price ratio and low cost per transported bit). Combined with Ethernet's ease of use, familiarity and virtual ubiquity in LANs, it is easy to see why highway agencies have attempted to capitalize on what was once a "best-effort," only-in-the-LAN technology.

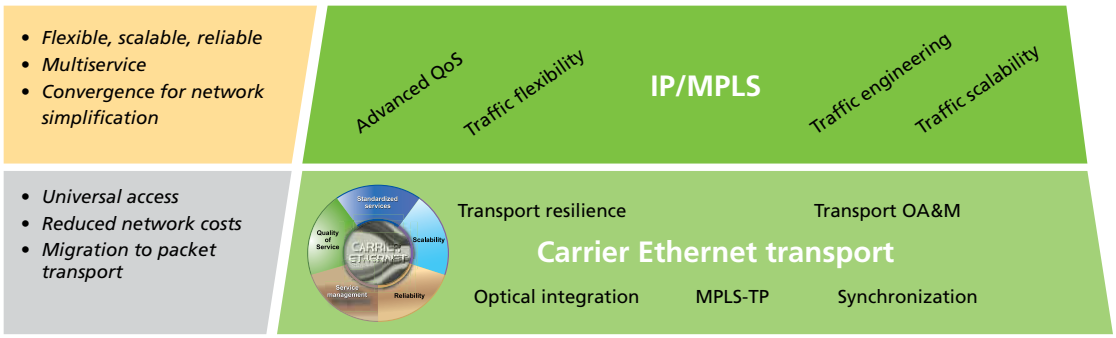
The term "Carrier Ethernet" was defined and promoted by the MEF (formerly Metro Ethernet Forum) to differentiate from traditional LAN-based Ethernet. This has helped take Ethernet outside the LAN to become more of a WAN technology. The benefits of Ethernet are combined with the reliability, protection and OA&M provided by technologies such as SONET/SDH, WDM and MPLS.

WHAT IS CARRIER ETHERNET?

Carrier Ethernet is a fundamental technology throughout the Alcatel-Lucent Mission-critical WAN Infrastructure. Carrier Ethernet consists of the following, as shown in Figure 2:

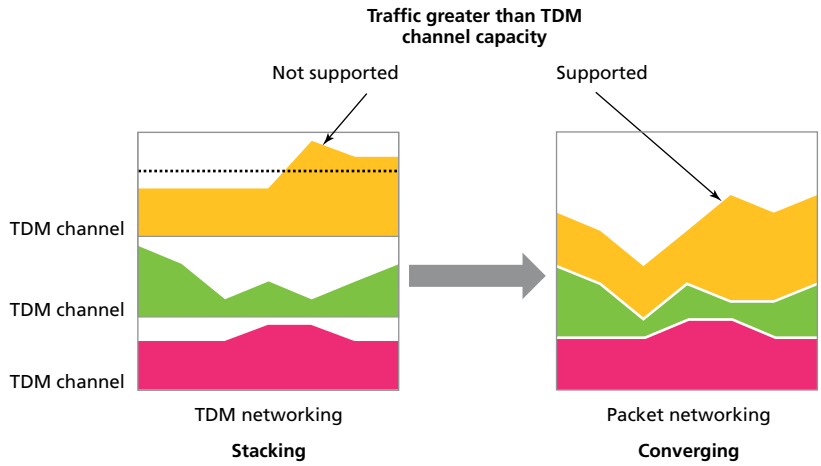
- *Carrier Ethernet transport* – Provides cost-effective, resilient, bulk transport, with:
  - ¬ Flexibility to route and monitor capacity where and when it is required
  - ¬ Operational efficiency
- *IP/MPLS* – Allows abstraction of the service layer from the transport layer, with ubiquitous, scalable, far-reaching and operationally consistent means of delivering mission-critical, legacy and new broadband-multimedia packet traffic and the associated attributes (for example, high availability, QoS, traffic engineering, ease of provisioning, flexibility)

Figure 2. Alcatel-Lucent Carrier Ethernet



Microwave and optical SONET/SDH transport evolve with the addition of Ethernet capabilities to provide Carrier Ethernet transport. This evolution is essential as IP traffic increasingly dominates the network with new applications for bandwidth efficiency and seamless traffic migration. Rather than stacking individual TDM channels to increase bandwidth for the support of increasing applications 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 of new bandwidth-intensive IP applications that include streaming video and digital imaging. 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



Efficient Carrier Ethernet transport can be realized with the SONET/SDH network support of increasing packet using Ethernet over SONET/SDH (EoS) while the majority of traffic is TDM. The packet traffic is supported using low-cost Ethernet interfaces while offering carrier-class capabilities for OA&M, manageability and protection. Because TDM traffic is still the majority of traffic on most highway-agency WANs, multiservice provisioning platforms (MSPPs) are well suited to provide Carrier Ethernet transport by adapting a Circuit-Switched technology, SONET/SDH, to transparently carry IP/Ethernet traffic.

A new category of transport devices, Packet Optical Transport, allows highway agencies to leverage their existing SONET/SDH networks while concurrently deploying and migrating to robust packet transport with feature-rich Ethernet — all using the same Packet Optical Transport platform. These platforms effectively support both TDM and packets in any ratio, SONET/SDH and Ethernet, and the emerging MPLS-TP. Seamless TDM-to-packet migration can be achieved with Packet Optical Transport while realizing the benefits of Carrier Ethernet transport.

Alcatel-Lucent was at the forefront of the development and delivery of the carrier-grade, always-on, IP/MPLS-based Mission-critical WAN Infrastructure. As a result, Alcatel-Lucent offers industry-leading Carrier Ethernet solutions over IP/MPLS that have been engineered for service reliability.

Many highway-agency networks consist of multiple service-specific overlay networks. The addition of new high-bandwidth, packet-based services is typically incompatible with existing network infrastructure and often require a completely new backbone network. If the majority of services become packet-based, an evolution to a High Leverage Network with transformation to the single, managed, fully converged IP/MPLS-based Alcatel-Lucent Mission-critical WAN Infrastructure may be the optimal choice. From a network-architecture perspective, these networks have a converged IP/MPLS-based core complemented by converged, IP/MPLS-based aggregation and access. The move to all IP also improves scalability, reliability and QoS while dramatically simplifying the network and lowering operating costs.

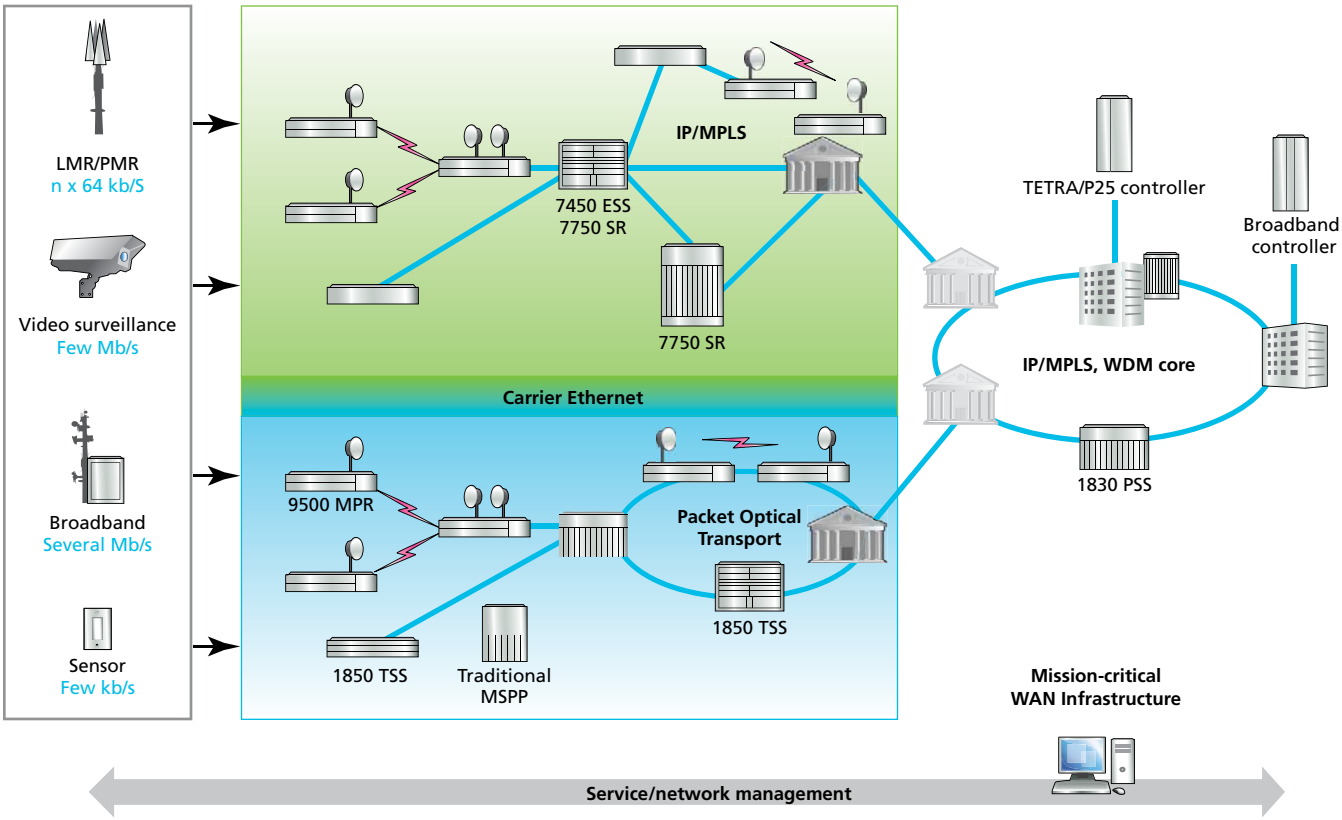
From a transport perspective, the use of more efficient packet-based transport instead of circuit-based transport helps improve efficiency and further reduces costs. A single converged, multiservice network that leverages the power and commonality of Ethernet and IP is application-aware and highly equipped to cost-effectively enable the creation and delivery of more dynamic, flexible and personalized services.

Convergence across the IP and optical layers in the backbone enables continuously scalable and dynamic bandwidth. By integrating the optical and IP domains using cross-layer automation, operational efficiencies are greatly improved while costs and carbon footprint are reduced.

End-to-end network and service management with tighter integration of the Operations Support System (OSS)/Business Support System (BSS) yield greater efficiency, improved visibility of network status, and faster time to repair.

The converged Alcatel-Lucent Mission-Critical WAN Infrastructure simplifies and reduces operating expenditures (OPEX) with end-to-end service and network management that includes integrated MPLS/microwave management and optical and microwave transport management (see Figure 4). This evolution to a converged network is essential for improving management efficiencies and lowers the skill barrier for staff. In addition, a converged network provides industry-standard interfaces for OSS integration.

Figure 4. Alcatel-Lucent Mission-critical WAN Infrastructure enables cost-effective, reliable IP transformation for a range of topologies



3. New applications, new capabilities

The majority of today's highway-agency communications networks are not equipped to support dynamic communications and real-time monitoring. Key capabilities that are driving changes in WANs include agency communications, LMR/PMR digital upgrades, monitoring, and access to new broadband applications that include new sources of streaming video and digital images such as electronic tolling, plate recognition and CCTV.

ITS provides for a large number of new IP-based applications, including:

- Mission-critical control applications signaling, supervisory control and data-acquisition technology with an Ethernet interface (eSCADA) and monitoring
- Security applications: IP-based CCTV, access-control, fire-detection and fire-control systems
- Communications applications: LMR, telephony, emergency telephones, wireless, and corporate LAN

- Information systems: dynamic information-display and lane-signaling systems
- Road-specific applications: weather stations, speed-enforcement systems, traffic-signal controllers, height and weight systems, traffic-counting systems, tolling (generic, congestion reduction, greening)

Converging legacy and new IP-applications traffic in a single network also improves productivity within agencies. Information previously available in only one system — for example, road-patrol reports and live roadside-surveillance feed — can be accessed at the same time in new combinations, improving rapid decision making and productivity.

Transformation by adding IP/MPLS and Carrier Ethernet transport capabilities typically occurs in phases that are driven by specific traffic growth and the existing WANs' 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/Ethernet service management and common optical and microwave transport management.

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.

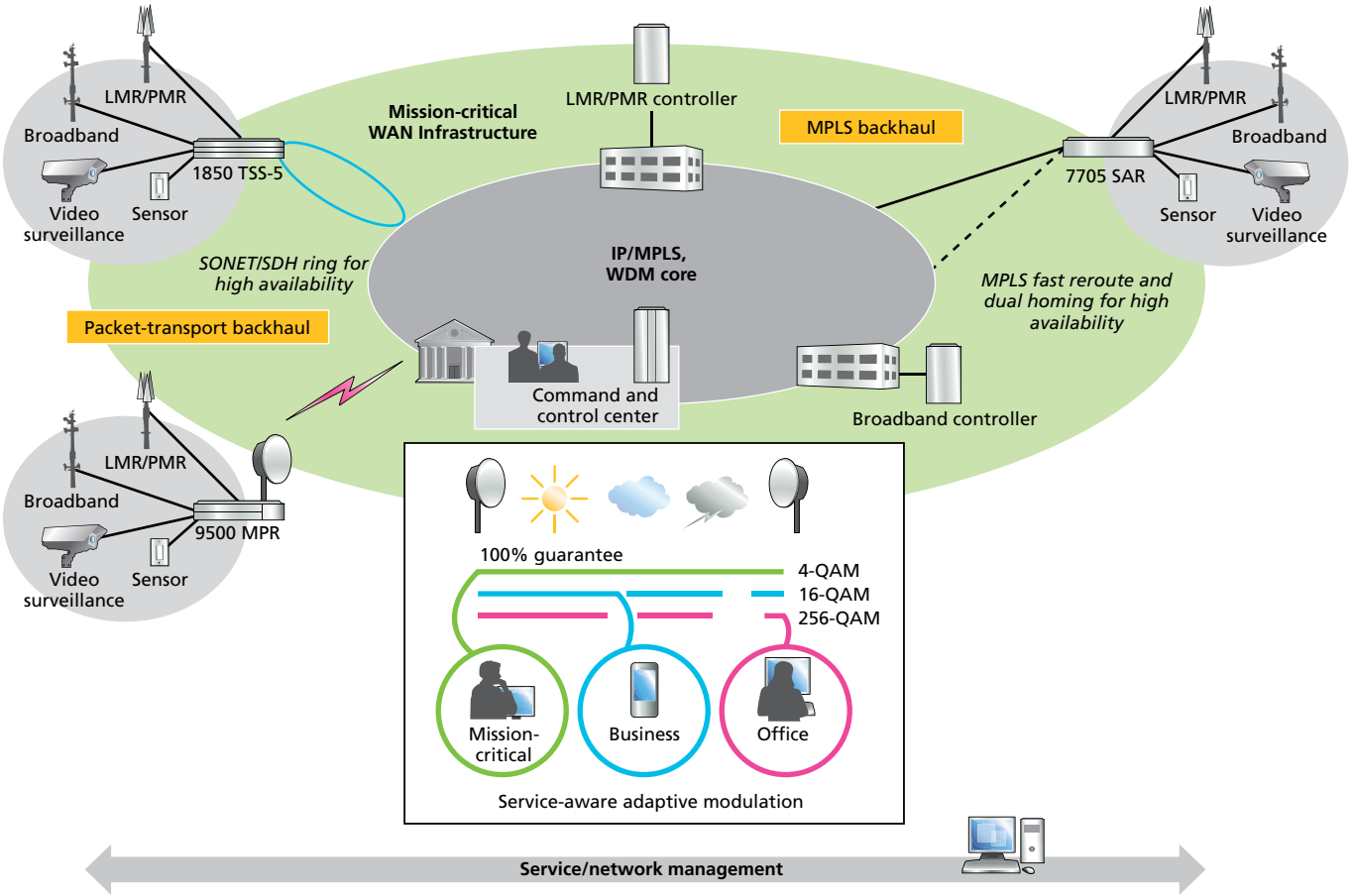
3.1 LMR/PMR upgrades

Agencies are evolving LMR/PMR networks based on industry-standard technologies such as Association of Public-Safety Communications Officials - International (APCO) Project 25 (P-25) and Terrestrial Trunked Radio (TETRA) to improve their capabilities and performance. The evolution includes upgrades of older analog radio-access systems to digital systems with improved voice quality, more advanced data capabilities, more efficient use of spectrum, and extended coverage to remote areas as well as inside buildings and underground. These advantages are triggering the need for a backhaul solution with an expanded bandwidth capacity and extended network footprint, equipped with Ethernet interfaces to support the increasing IP traffic.

As shown in Figure 5, the Alcatel-Lucent Mission-critical WAN Infrastructure delivers reliable backhaul for today's LMR/PMR traffic and cost-effectively scales for future broadband-wireless traffic support. The infrastructure includes Ethernet interfaces for new IP-based traffic and TDM interfaces for legacy radio-access systems at sites that multiple agencies share. The Alcatel-Lucent Mission-critical WAN Infrastructure leverages the globally proven Alcatel-Lucent Mobile Ethernet Transport Architecture, deployed for more than 150 mobile carriers.

To keep first responders connected, LMR/PMR coverage can be extended inside buildings and tunnels. Each building or tunnel is unique, and so are its radio frequency (RF) needs. Alcatel-Lucent has deployed purpose-built wireless solutions using a mix of technologies, including distributed antenna systems and radiating cable systems in more than 50 buildings and tunnels.

Figure 5. Reliable and scalable cell-site backhaul of analog and digital/IP LMR/PMR traffic



Microwave packet radio, which is capable of handling multiple packet types natively, introduces a new concept in backhaul applications: the ability to transport multimedia traffic efficiently and still support 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 the long-term enabler for highway agencies to smoothly transition their backhaul networks from TDM to IP and include broadband wireless, realizing dramatic reductions in operating costs: for example, up to 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 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.

IP-based mobile-radio access solutions for voice make it easier to patch together first responders with different radio systems as well as link them with personnel at fixed sites using Voice over IP (VoIP) using collaboration applications. Seamless handoffs between dispatch centers as a pursuit crosses a jurisdictional boundary are feasible with dual-mode phones and IP-based traffic supported on a common WAN.

3.2 Monitoring

CCTV provides multiple benefits for highway agencies. Security and safety of the traveling public and agency employees is improved, physical security in remote locations is vastly superior, and access to these locations can be monitored and controlled centrally. Congestion and traffic accidents are immediately visible to traffic authorities and emergency services. CCTV, combined with dynamic message systems, can alert drivers to congestion and suggest alternate routes well in advance, helping to reduce congestion. Physical assets can be protected and centrally monitored as well by extending WAN communications to these sites.

Video surveillance, which can help protect critical infrastructure and monitor high-crime areas, typically requires several megabits of bandwidth per site for solutions with enhanced capabilities such as high resolution and remote operation. The converged WAN can cost-effectively scale to deliver sufficient bandwidth. Using a combination of an IP multicast protocol and MPLS-based Virtual Private LAN Service (VPLS), video-surveillance traffic can be easily distributed to primary and secondary remote monitoring centers for increased reliability and flexibility. Remote sensors complement CCTV by providing for automated remote monitoring of traffic flows to enable rapid automated congestion-control mechanisms that can highlight problem areas to commuters.

3.3 Broadband applications

In-vehicle transponder systems, combined with automatic number-plate recognition systems and CCTV, can register drivers at highway speeds and remove the need for toll plazas at the entry and exit points of toll highways. These systems eliminate the queues, congestion, labor costs and delays often associated with toll highways. The technology also enables pay-as-you-go expansion of toll highways on a lane-by-lane basis. Commercial traffic often prefers a toll to tying up equipment and personnel on congested highways, and toll routes discourage non-essential use. Toll routes can provide commercial traffic that depends on access to the city core with a fast and cost-effective way to bypass commuter routes, thereby reducing congestion and heavy truck traffic on other routes.

Access to high-speed data and multimedia allows workers to have a virtual "desktop in the field" and enhances communication among first responders and remote emergency-response coordinators. Arming first responders with advanced multimedia capabilities allows them instant access to mission-critical data, giving agencies the ability to exchange information, such as surveillance and tactical video, digital imaging, 3-D mapping/geographic information system (GIS) and remote database access, across jurisdictional boundaries. This accurate, up-to-date information can reduce congestion and greenhouse gases.

Broadband wireless solutions supplement and enhance current LMR/PMR networks with advanced multimedia capabilities. Alcatel-Lucent broadband is based on standardized, commercial technologies, for solutions that leverage the economies of scale of Fourth-Generation (4G) networks and allow full interoperability between highway agencies' broadband and commercial wireless networks. These technologies typically offer engineering crews transmission rates of 2 Mb/s to 10 Mb/s or more.

Highway agencies must find cost-effective backhaul solutions that can match capacity requirements. 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, with more Ethernet and IP capabilities to transparently aggregate and switch growing volumes of packet traffic at a level of reliability that matches TDM. New Packet Optical Transport Systems and microwave packet radios offer the resiliency, increased bandwidth capacity, effectiveness and flexibility to enable 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.

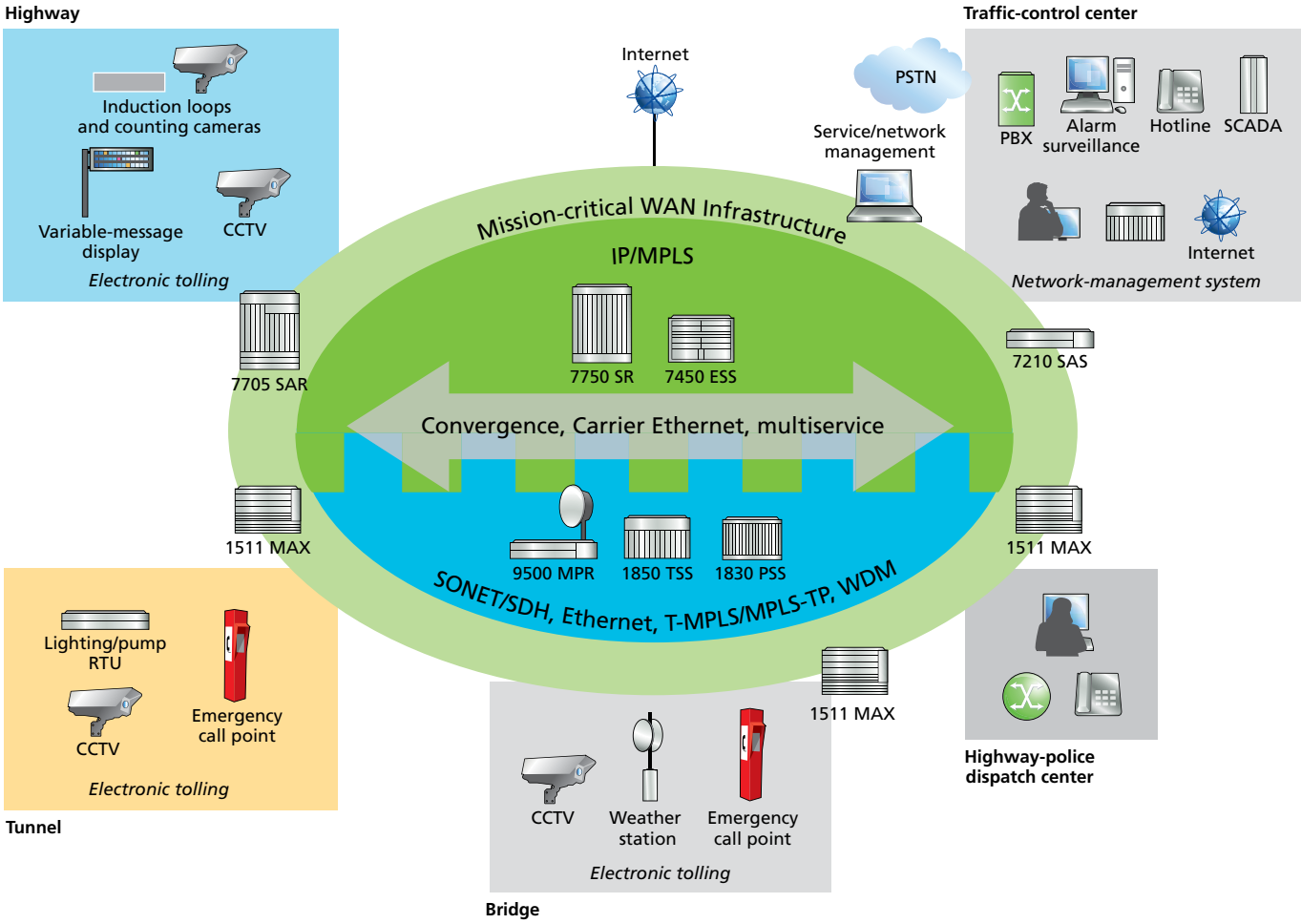
Capacity is just one element to consider in planning for the addition of broadband capabilities for mobile first responders. When broadband is added to existing voice, multiple traffic types are simultaneously introduced, with different requirements in terms of capacity, availability, quality and use of available resources. The Alcatel-Lucent Mission-critical WAN Infrastructure supports LMR/PMR traffic backhaul and cost-effectively scales with the addition of Ethernet interfaces to support this new, IP-based broadband multimedia traffic.

4. Enabling operational optimization

Service-oriented IP/MPLS and Carrier Ethernet transport networks are inherently able to support new applications, which provide new ways for employees to work efficiently, share information and interact responsively. New information systems provide the ideal opportunity for highway agencies to reclaim this knowledge, centralize it, and make it accessible to the whole organization. The appropriate WAN gives workers seamless and secure access to centralized information no matter where they are, helping to boost productivity.

It is ironic that, when all is calm, communications traffic is at a minimum and the highway-agency network is nearly idle aside from internal administrative applications. The Alcatel-Lucent Mission-critical WAN Infrastructure platforms, shown in Figure 6, have been designed from the ground up for high availability, using advanced hierarchical QoS technology that guarantees on-time delivery of the most critical and time-sensitive communications. Alcatel-Lucent Carrier Ethernet allows

Figure 6. Alcatel-Lucent Mission-critical WAN Infrastructure for highway agencies



specific application traffic to be optimized and guaranteed using service-adapter modules, within Ethernet service switches and service routers, that are targeted to enhance specific application flows. In this manner, intelligence can be applied only when needed and without burdening the remainder of the traffic.

The evolution of the WAN by adding IP/MPLS or a new microwave link often allows a highway agency 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 with Carrier Ethernet transport allows the reliable, scaled aggregation and transport of any 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 multiple-agency WAN.

5. Ensuring security

Securing critical infrastructure is of paramount importance to highway agencies worldwide, both from physical and electronic threats. New standards are quickly emerging.

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.

Within the Alcatel-Lucent Mission-critical WAN Infrastructure, a virtual private network (VPN) can be created with MPLS to securely transport an agency's traffic among sites and mobile first responders along with the flexibility for interagency sharing of specific information at designated times. Optical and microwave SONET/SDH networks are, by definition, carrier-grade, implementing security at the physical layer.

6. The Alcatel-Lucent offering

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

- *End-to-end, carrier-grade infrastructure* – Alcatel-Lucent provides a rugged, reliable, scalable and secure WAN built on innovative, high-reliability products and backed by our expertise in delivering complex, mission-critical networking to meet highway-agency requirements. Alcatel-Lucent solutions incorporate non-stop routing, redundancy, MPLS fast rerouting in IP/MPLS parts of the network, and ring protection for optical and microwave packet networks.
- *Cost-effective growth and convergence of growing packet (digital LMR/PMR, video surveillance, broadband 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 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 Highways solution.

6.1 Innovations in eco-sustainability

Innovations in eco-sustainable networks and applications can help highway agencies to reduce costs while dramatically reducing their environmental footprint. Key focus areas for Alcatel-Lucent are energy efficiency, a reduced carbon footprint and environmental sustainability. Alcatel-Lucent helps highway agencies 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, operating at voltages and frequencies that are no higher than necessary to achieve desired functionality and performance

7. Conclusion

Today's highway agencies are compelled to gain efficiencies in existing highway infrastructure to reduce congestion and greenhouse gases without spending public funds to lay more asphalt and reduce green space. ITS provides a clear and cost-effective alternative to construction. New ITS technologies exist as integrated, distributed applications, most requiring an IP infrastructure and large bursts of data throughput. Agencies' current networks are a collection of discrete overlay networks, each supporting a single application, with *ad hoc* additions when new applications are required. Most corporate IP-capable networks are enterprise-grade networks that work well for best-effort applications but are not scalable, reliable or robust enough to trust to mission-critical applications such as bidirectional lane control or emergency-services communications.

A transformation of today's agency-specific WAN is a typical first step in addressing these challenges and toward the 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 is driving the evolution and convergence of today's WANs with new IP/MPLS and packet transport standards and our Mission-critical WAN Infrastructure. The company is an expert multivendor integrator in mission-critical communications projects. With our broad microwave, IP/MPLS and optical portfolio, end-to-end management, transportation-industry experience and the Mission-critical WAN Infrastructure offering, Alcatel-Lucent has all the elements that highway agencies require to simplify and reduce WAN-transformation risks.

8. Acronyms

4G	Fourth Generation
1511 MAX	Alcatel-Lucent 1511 Media Access Cross-Connect
1830 PSS	Alcatel-Lucent 1830 Photonic Service Switch
1850 TSS	Alcatel-Lucent 1850 Transport Service Switch
5620 SAM	Alcatel-Lucent 5620 Service Aware Manager
7210 SAS	Alcatel-Lucent 7210 Service Access Switch
7450 ESS	Alcatel-Lucent 7450 Ethernet Service Switch
7705 SAR	Alcatel-Lucent 7705 Service Aggregation Router
7750 SR	Alcatel-Lucent 7750 Service Router
9500 MPR	Alcatel-Lucent 9500 Microwave Packet Radio
APCO	Association of Public-Safety Communications Officials – International
ATM	Asynchronous Transfer Mode
BSS	Business Support System
CCTV	closed-circuit television
EoS	Ethernet over SONET/SDH
eSCADA	supervisory control and data-acquisition technology with an Ethernet interface
GIS	geographic information system
IP	Internet Protocol
ITS	Intelligent Transportation System
LAN	local area network
LMR	land mobile radio
MEF	former Metro Ethernet Forum
MPLS	Multi-Protocol Label Switching
MPLS-TP	MPLS Transport Profile
MSPP	multiservice provisioning platform
OA&M	operations, administration and maintenance
OPEX	operating expenditures
OSS	Operations Support System
P25	Project 25 (APCO-25)
PBX	Private Branch Exchange
PMR	professional mobile radio
PSTN	Public Switched Telephone Network
QAM	quadrature amplitude modulation
QoS	Quality of Service
RF	radio frequency
RTU	remote terminal unit
SCADA	supervisory control and data acquisition
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical Network
TCO	total cost of ownership
TDM	Time Division Multiplexing
TETRA	Terrestrial Trunked Radio
T-MPLS	Transport MPLS
VoIP	Voice over IP
VPLS	Virtual Private LAN Service
VPN	virtual private network
WAN	wide area network
WDM	Wave Division Multiplexing

CPG0662091109 (01)

Alcatel·Lucent