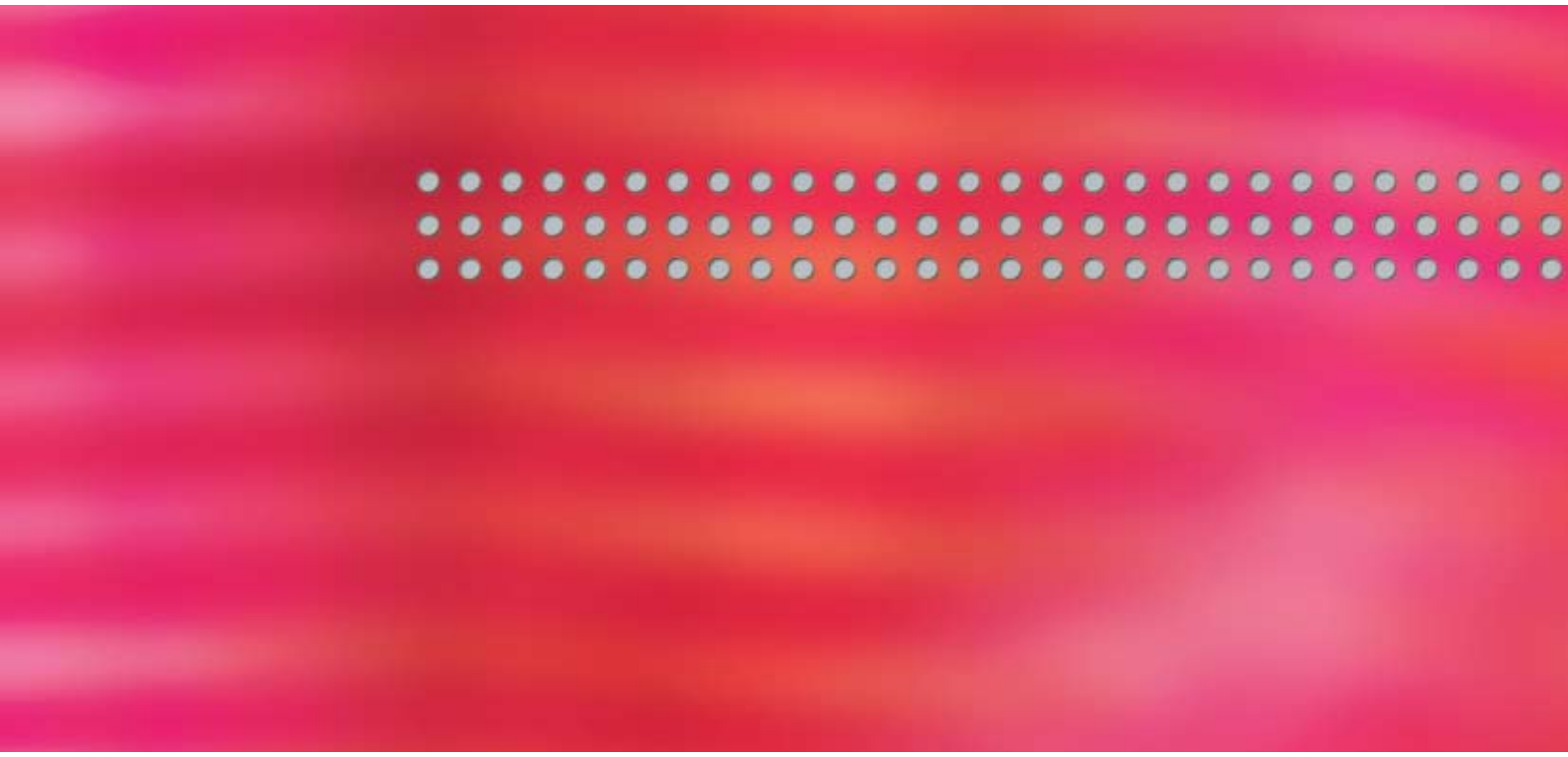
Alcatel·Lucent

APPLICATION NOTE

IP/MPLS Networks for Public Safety

Highly reliable mission-critical communications infrastructures



Abstract

Alcatel-Lucent delivers a converged IP/MPLS-based network for public safety using next-generation products and management tools. The Alcatel-Lucent IP/MPLS infrastructure supports network resiliency, quality of service, virtualization, convergence, and a management platform that automates and simplifies operations management. This highly available IP/MPLS network enables governments to effectively support performance guarantees on IP land mobile radio communications and a growing number of mission-critical applications. Reliable communication is essential to meet key objectives such as providing "always on" services, increasing security, and improving network efficiency and staff responsiveness while serving the public.

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Introduction

Communications infrastructure is very critical to the operation of public safety agencies. Their responsiveness depends heavily on maintaining emergency communication and the access to and sharing of information. With continued threats in terrorism and the demands for more effective cross agency coverage, the modernization of public safety networks is a priority of many state and local governments with funding being made available for network upgrades.

Traditional public safety communications infrastructure uses TDM technology. As technologies and requirements evolve, IP-based voice and data systems provide superior performance over traditional approaches to critical communications. Many public safety communications are evolving to IP solutions which utilize an IP backbone for first responder radio networks, video surveillance, improved interoperability, and better integration with growing IT functions. Many of these applications are resource intensive (bandwidth and availability). Governments can effectively address public safety IP communications requirements and control costs by deploying an IP/Multiprotocol Label Switching (MPLS) network.

An Alcatel-Lucent IP/MPLS network, over microwave wireless transport or fiber optics, provides a reliable infrastructure to support mission critical voice, video, and data communications. Performance guarantees for critical IP applications such as P25^{IP} and video surveillance are enabled with an IP/MPLS converged network. Alcatel-Lucent's management platform allows governments to improve efficiency by automating and simplifying operations management for IP and Ethernet-based services. An IP/MPLS network improves the bandwidth efficiency of a public safety network, saves costs, enables easier access to existing government databases, and enhances the safety of the general public as well as the safety of personnel delivering these services.

Public Safety Communications Challenges

The primary purpose of a public safety network today is to carry emergency Land Mobile Radio (LMR) traffic. The communications network must always provide services that can be shared among agencies, expandable into new areas, and easily managed from end to end. The emergence of new applications and the growing need for resiliency and interoperability between agencies are important reasons for change. Better communications and interoperability are now possible with the introduction of IP communication. TDM technology is limited in efficient bandwidth usage when handling IP-based traffic which is bursty and dynamic in nature. With a growing need to increase the efficiency of networks and allow more centralized high impact applications on the network, many governments are modernising their communications infrastructures by upgrading legacy LMR and microwave networks from the current TDM-based to IP-based networks.

Moving to IP-based solutions

IP-based solutions offer many benefits. For example, IP-based LMR voice messages can be sent in compressed and encrypted IP packets from end-to-end, providing a high level of security while maintaining voice quality. IP communication allows easier interoperability between agencies. For example, connecting a county's emergency center to the state police can help reduce isolated islands of communications. Other benefits include the integration of the network with off-the-shelf IP data applications and interconnection of peripherals such as scanners and video devices. This means firefighters will have higher speed access to many databases of critical information such as building plans and GPS coordinates. A successful implementation of IP-based solutions requires a highly reliable IP backbone network that can support a broad range of new applications from broadband data and video to voice interoperability.

Alcatel-Lucent has a highly reliable IP/MPLS network solution that enables public safety agencies to meet the performance requirements of all their mission-critical services and applications. An IP/MPLS implementation offers advantages and savings such as:

- Optimising the bandwidth available in the network to make possible the introduction of new applications
- Reducing the dependency on leased lines
- Extending services to remote areas,
- Satisfying the growing IT functions

These not only enhance the safety of the general public but also expand the use of the network and the investment of the government.

The Alcatel-Lucent IP/MPLS network

IP networks have grown significantly in recent years, but they often lack the necessary scalability to support traffic that requires QoS levels beyond best effort. Traditional IP and Ethernet networks also lack the ability to optimize the use of network resources. By using MPLS, a government will have an IP network with the same robustness and predictability of a circuit-based TDM network. This will allow the government to improve services to its agencies and users. With an MPLS-enabled IP network, the agency has a system that:

- Is highly scalable and reliable with redundancy and fast reroute (FRR) capabilities
- Addresses a range of QoS and service level agreement (SLA) requirements
- Optimizes bandwidth usage through traffic engineering

Each application on the network has unique requirements in terms of bandwidth, QoS, and availability. The IP/MPLS network enables the government to set service parameters for each service and traffic type (voice, data video) according to operational requirements. This network is also capable of supporting low jitter and delay to handle all traffic types effectively and reliably in real time.

In addition to standard MPLS advantages, the Alcatel-Lucent IP/MPLS network supports advanced MPLS capabilities (including non-stop routing and non-stop services) to provision virtual private networks based on Virtual Leased Line (VLL), Virtual Private LAN Service (VPLS) and IP virtual private networks (VPNs). This allows for virtualization of a single network infrastructure to carry different services and traffic types. One service is carried across one virtual private network while the traffic of different services is securely separated in their own private networks. The Alcatel-Lucent multiservice MPLS network can also support existing TDM traffic so a government can choose when to migrate some existing services to IP.

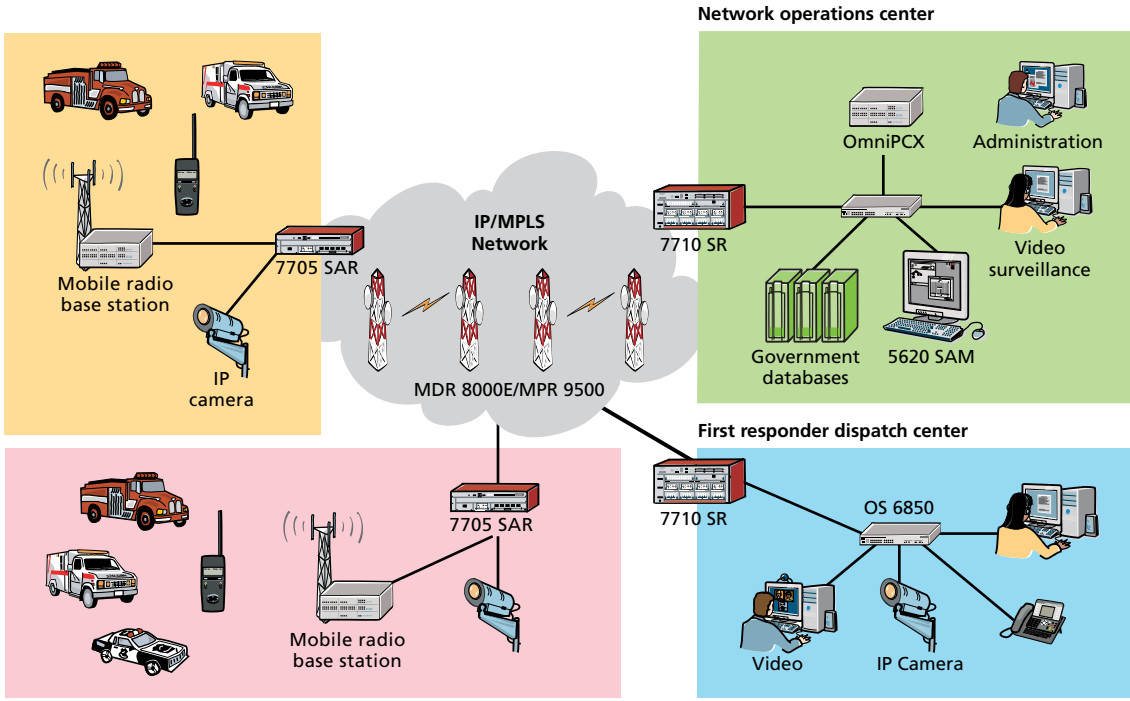
The Alcatel-Lucent IP/MPLS implementation provides a service-oriented approach that focuses on service scalability and quality, as well as per-service operations, administration and maintenance (OAM). With a service-aware infrastructure, the government has the ability to tailor services such that mission-critical applications have guaranteed bandwidth to meet peak requirements. The Alcatel-Lucent service router supports IP routing and switching which enables the government to support real-time applications with its non-stop services functionality thus providing superior reliability.

The main components of the Alcatel-Lucent IP/MPLS network include:

- 7710 Service Router (SR)
- 7705 Service Aggregation Router (SAR)
- 7450 Ethernet Service Switch (ESS)

In addition, the administration of the Alcatel-Lucent IP/MPLS network is handled by the Alcatel-Lucent 5620 Service Aware Manager (SAM), which automates routine tasks and makes it easy to provision new services, maintain operations and troubleshoot faults in the network (see Figure 1).

Figure 1. Alcatel-Lucent IP/MPLS Communications Network for Public Safety

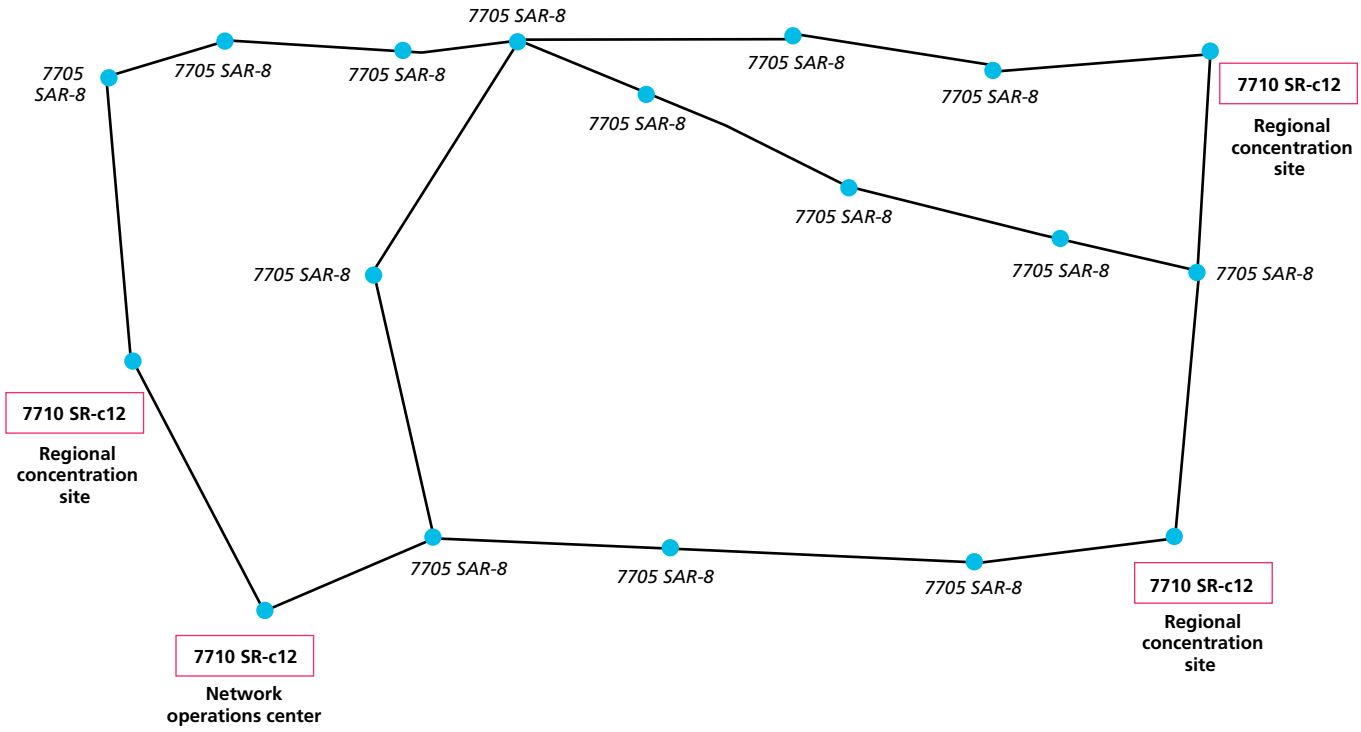


Land Mobile Radio Backhaul

LMR systems communicate between switching centers and the base stations, and microwave radios backhaul traffic to the dispatch center. With LMR systems becoming IP-based, an IP/MPLS backbone will provide the necessary reliability, quality of service, and bandwidth optimisation to the backhaul network. Unlike traditional TDM implementation, an IP/MPLS based network allows microwave radio bandwidth to be used in a dynamic manner such that network bandwidth is only consumed if user traffic is present. This means more applications with higher bandwidth can be converged and carried over the same network.

The general network architecture is an MPLS overlay on Microwave transport. Microwave provides a cost effective and reliable transport over different terrains while the MPLS layer provides the intelligence for network wide resiliency, QoS, and bandwidth optimisation. Figure 2 shows a typical topology of a backhaul network consisting of multiple rings.

Figure 2. Typical Alcatel-Lucent Backhaul Network Topology

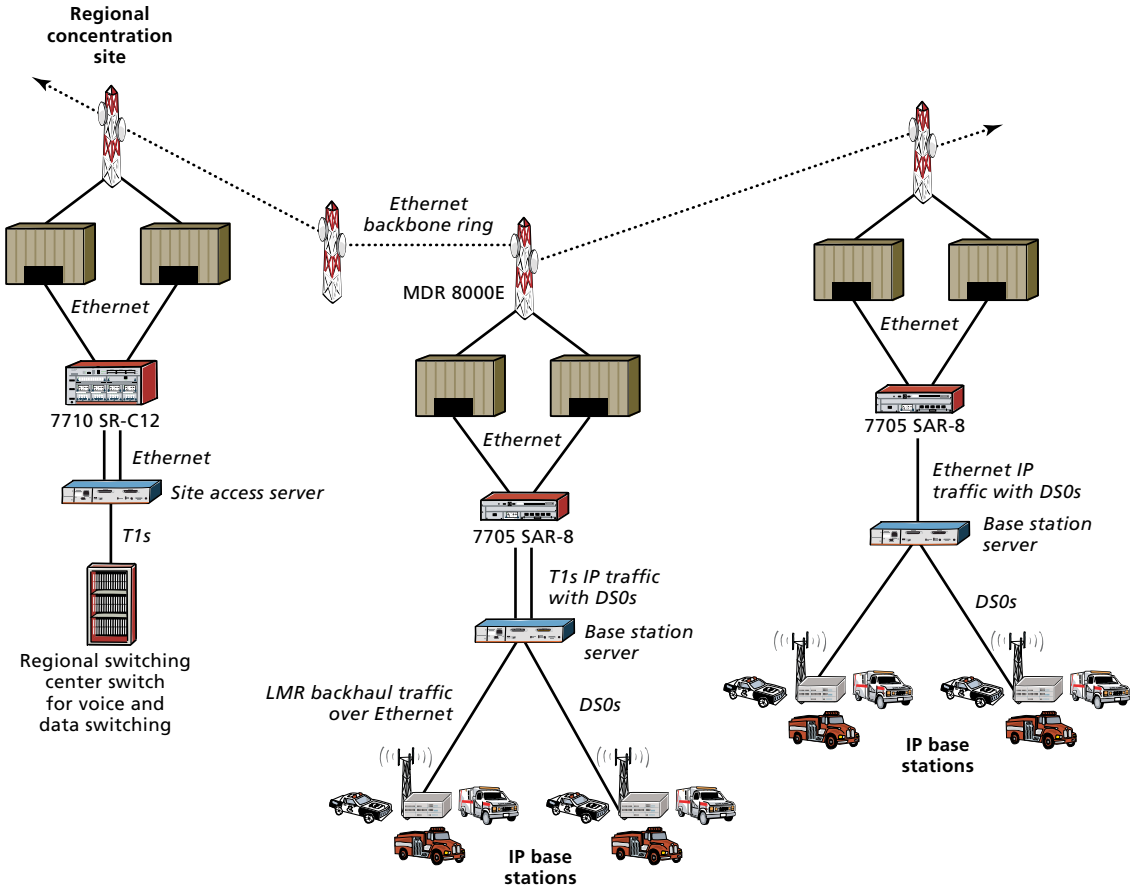


Network Resiliency

A ring topology provides a reliable architecture because traffic can be rerouted to the opposite direction if a failure occurs in a link connecting any adjacent sites. An Alcatel-Lucent IP/MPLS network uses the MPLS fast reroute feature for resiliency where traffic is rerouted around a failure with sub-50 millisecond restoration time. This ensures that services on the network are not affected.

Figure 3 depicts the site connections of a typical network. Traffic from the switching center is carried through the MPLS switch to the microwave transceiver and transported to the base station sites.

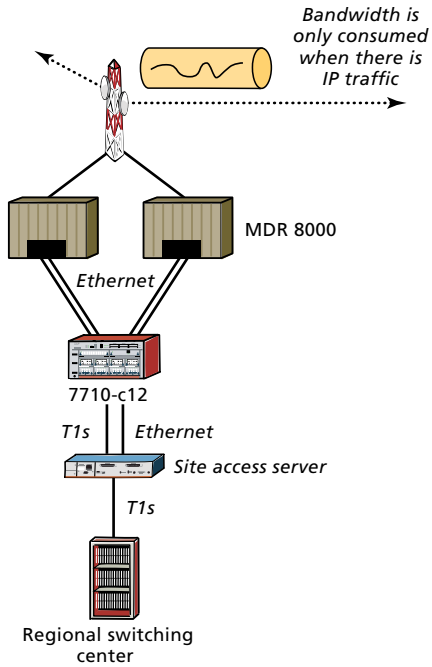
Figure 3. Alcatel-Lucent IP/MPLS LMR Backhaul Network



Bandwidth Efficiency

In a TDM approach, bandwidth is allocated and used as fixed bandwidth over the microwave links. In contrast, in an IP/MPLS network, bandwidth over the microwave links is consumed only if there is IP traffic transmitted from the switching center or base stations (see Figure 4). The physical interface connected to the MPLS router can be Ethernet or T1 with the layer 2 protocol being Ethernet, PPP, or HDLC. This approach saves bandwidth and allows more applications to be deployed and shared over a single network.

Figure 4. Bandwidth Efficiency with IP traffic



IP video surveillance

Video surveillance has become paramount for governments to safeguard critical assets and ensure the safety of their personnel and the public. The modern video surveillance system is now IP-based and is becoming integrated with the IP backbone networking of governments using network-based architecture. Managing video traffic can be a challenge for governments that are still using traditional networks. Adding closed-circuit television (CCTV) traffic onto an IP network unprepared for video traffic can adversely impact all services on the network. Therefore, it is critical for governments to select a network solution

that can adequately address their video surveillance requirements. They need a reliable, "always-on" network that can handle many high-quality video streams and accommodate the convergence of voice and data traffic. The network architecture must be capable of handling future growth, including significant increases in bandwidth.

Distributed video surveillance offers many advantages, including support for real-time video streaming to many locations and the flexibility to deploy video analytics software remotely. Because access and distribution of CCTV streams can be very dynamic and mission-critical in nature, the highly scalable and reliable Alcatel-Lucent IP/MPLS network is the ideal solution for handling thousands of video streams now required in modern physical security applications. This network solution is designed to deliver and maintain QoS for each type of application.

A modern video surveillance operation has many high-quality CCTV cameras generating multicast IP video streams. These video streams are transported in real time to multiple locations. CCTV cameras and CODECs have Ethernet and IP interfaces and support Internet Group Management Protocol (IGMP) to register these devices to a multicast group. Each CCTV channel belongs to a different multicast group; therefore, each has a different multicast IP address assigned to the packets carrying footage for the channel. IGMP is used by the operator's workstation to communicate to the edge routers for the channel the operator is requesting.

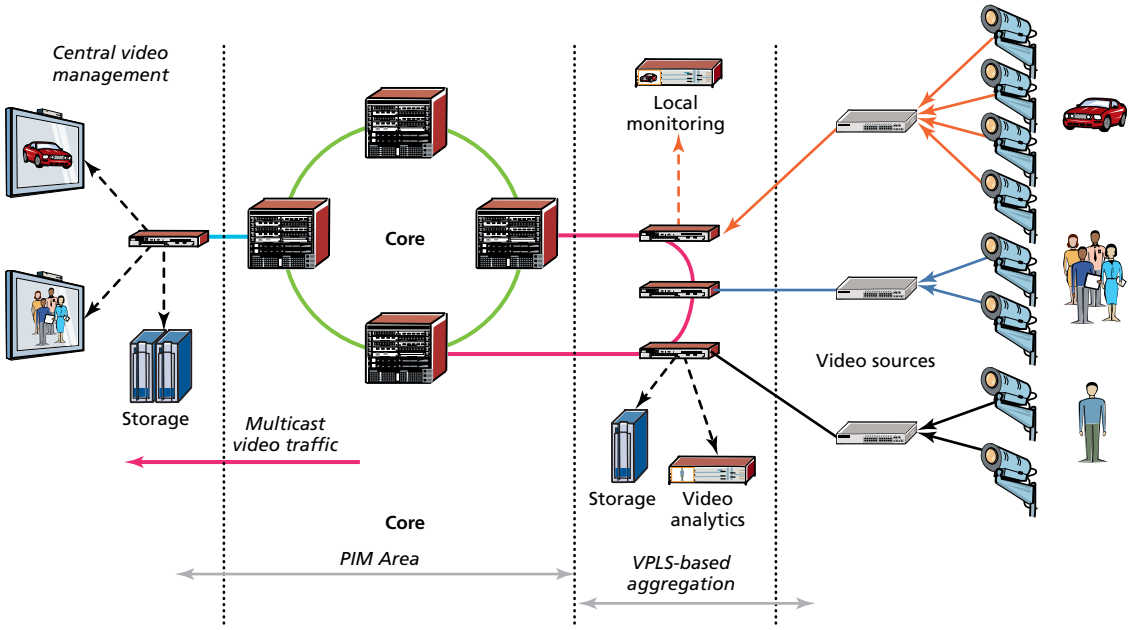
The simplest way to implement the delivery of CCTV traffic to the central video management and storage is to deploy an IGP, and an IP-multicast protocol, such as Protocol Independent Multicast — Sparse Mode (PIM-SM), in both the core and aggregation parts of the network. PIM is responsible for setting up individual multicast trees, one for each CCTV channel, to deliver the traffic to the devices in the aggregation network layer. A pure IP approach, however, has many issues, such as the lack of resiliency and long recovery time after failures in the network.

Using the multicast capabilities of VPLS technology in the aggregation network, provides a powerful and cost-effective solution for the delivery of CCTV traffic to the local monitoring stations and central video management. It also resolves several problems inherent in a pure IP PIM-based solution:

- VPLS is based on MPLS and therefore offers all the benefits of MPLS including sub-50 ms recovery times to dramatically improve recovery times after a node or link failure.
- Removing PIM from the aggregation network dramatically reduces the operational complexity of deployment, maintenance and debugging problems.
- Network scalability is increased as a result of an increase in the number of video streams served by each aggregation node.
- A reduction in resource consumption makes it possible to support different types of services concurrently.

Replacing PIM with VPLS in the aggregation network improves network resiliency and decreases complexity. The PIM multicast protocol can be deployed and limited to the IP/MPLS core by using VPLS in the aggregation network as shown in Figure 5.

Figure 5. Video surveillance with VPLS

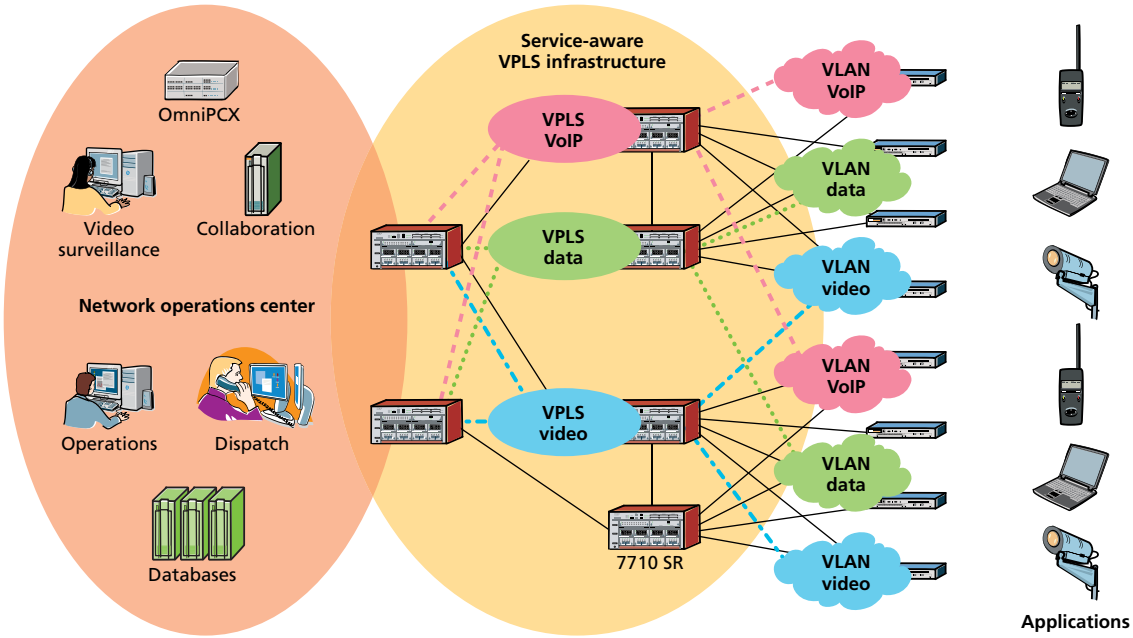


Converged voice, video and data communications

A service-aware IP/MPLS network supports convergence of voice, video, and data traffic on a single high-capacity network where different applications are managed through configurable QoS levels. This facilitates the deployment of advanced applications in video surveillance, collaboration and conferencing. Using MPLS, network virtualization is possible with separate virtual networks for different voice, video, and data applications such as VoIP and Video. These virtual networks are securely separated as if they were individual networks. Using MPLS VPN technologies, it is possible to provision virtual networks with controlled levels of security and QoS for different applications or agencies. For example, a VoIP service can be provisioned with reserved bandwidth to ensure the quality of the conversation, even during peak usage.

An Alcatel-Lucent IP/MPLS network supports advanced Layer 2 and Layer 3 VPNs that provide secure traffic separation and customized service levels for mission-critical services, while leveraging the common network infrastructure of the government.

Figure 6. Multi-service converged communications



Capitalizing on MPLS capabilities

An increasing number of governments are deploying their own MPLS-based networks. MPLS brings the advantages of a circuit-based network to an IP network, and enables network convergence, virtualization and resiliency.

MPLS is used to transport different types of traffic using VLL, VPLS and IP VPNs. In an MPLS network, Open Shortest Path First (OSPF) is commonly used as the Interior Gateway Protocol (IGP) supporting the setup of MPLS paths.

High availability through MPLS

The IP/MPLS network assures high availability through fast path restoration and network reconvergence within 50 ms. Network resiliency is achieved by means of the end-to-end restoration capabilities of the MPLS Fast Reroute feature. High availability is essential to a public safety communications network, which carries mission-critical voice, video and data information. With MPLS Fast Reroute, video, voice and data service interruption is minimized during network failures. To protect the network against node or interconnection failures, end-to-end standby MPLS paths are provisioned. MPLS offers the flexibility to provision hot or cold-standby paths to protect an active path.

The Alcatel-Lucent IP/MPLS implementation includes the unique additional high-availability features of non-stop routing and non-stop services supported on the Alcatel-Lucent service router portfolio. The benefits are unparalleled availability and reliability:

- *Non-stop routing* – ensures that a control card failure has no service impact. Label Distribution Protocol adjacencies, sessions and the database remain intact if there is a switchover.
- *Non-stop service* – ensures that VPLS and IP VPN services are not affected when there is a control fabric module (CFM) switchover.

MPLS traffic engineering

MPLS has a built-in mechanism, called traffic engineering, which allows for the selection of the best path across the network, taking the physical paths of the links and interfaces into account. This mechanism is used in networks to ensure that the best link is chosen to optimize network bandwidth.

Hierarchical Quality of Service

The Alcatel-Lucent implementation of Hierarchical QoS (H-QoS) is service-aware, allowing lower priority traffic to burst to fill available bandwidth when higher priority applications go idle. Typical routers offer QoS levels per port with either strict priority or weighted fair queuing. In contrast to this, the Alcatel-Lucent IP/MPLS network implements service-based queuing (For example, each logical port such as a virtual LAN or a virtual circuit, within a physical port has a dedicated queue). The Alcatel-Lucent solution also supports queues and QoS for traffic classes within the logical port, and provides each service with committed information rate and peak information rate type guarantees.

Effective management for easier day-to-day operation

A key element of reliable and flexible MPLS-based infrastructures are effective, simplified management tools that provide easy configuration and control of the network, fast, effective problem isolation and resolution, and support of new management applications. The Alcatel-Lucent IP/MPLS network supports OAM tools that simplify the deployment and day-to-day operation of a public safety communications network. For example, service tests, interface tests and tunnel tests allow for rapid troubleshooting and enable proactive awareness of the state of traffic flows to help minimize service down time.

The Alcatel-Lucent IP/MPLS network is fully managed by the industry-leading Alcatel-Lucent 5620 Service Aware Manager (SAM). The Alcatel-Lucent 5620 SAM is an integrated application that covers all aspects of element, network and service management on one platform. It automates and simplifies operations management on a converged MPLS network, driving network operations to a new level of efficiency. The Alcatel-Lucent 5620 SAM product suite supports element management, network commissioning, service provisioning and service assurance.

IP routing management control

The Alcatel-Lucent 5650 Control Plane Assurance Manager (CPAM) offers real-time control plane visualization, proactive control plane surveillance, configuration, validation and control plane diagnosis. In addition, it provides simplified diagnosis and intuitive visualization of the relationship between services, the MPLS infrastructure and the routing plane. Integrated control plane and service management is an innovative development in service routing. It enables network managers to overlay Layer 2 and Layer 3 services, MPLS tunnels and various OAM traces on the control plane map which simplifies problem resolution, reduces control plane configuration errors, and reduces troubleshooting time.

Summary

Only MPLS can provide the reliability that is needed for mission-critical services. To achieve this reliability, governments should ensure that their IP public safety networks are MPLS-based. A service-aware IP/MPLS network supports converged voice, data and video applications that are managed through configurable QoS levels. The Alcatel-Lucent IP/MPLS product portfolio leads the industry in reliability and OAM tools which are key enablers for meeting the "always-on" requirement for mission-critical operations. The Alcatel-Lucent solution helps address public safety communications challenges by:

- Optimizing the bandwidth available in the backhaul network
- Providing network virtualization with QoS guaranteed for priority traffic
- Improving agency interoperability and access to critical information
- Making possible the introduction of new applications

The Alcatel-Lucent advantage

Alcatel-Lucent has years of experience in the development of MPLS-based technologies and is a leader in IP/MPLS and VPLS networking. Alcatel-Lucent supports a complete MPLS offering, which includes solutions for Layer 2 (VLL, VPLS) and Layer 3 (IP VPN) services and a broad and scalable IP/MPLS portfolio, including the Alcatel-Lucent 7750 and 7710 Service Routers, 7705 Service Aggregation Router, 7450 Ethernet Service Switch, and 5620 Service Aware Manager.

With the broadest portfolio of products and services in the telecommunications industry, Alcatel-Lucent has the unparalleled ability to design and deliver end-to-end solutions that drive next-generation communications networks. Alcatel-Lucent is a leader in microwave wireless transmission, converged broadband networking, IP technologies, applications, and services. Alcatel-Lucent's Professional Services Portfolio includes Service and Solution Consulting, Network Build-Out, and Operations Support. Within the state and local government sector, Alcatel-Lucent is a proven and reliable partner with an excellent record for cooperation and communications throughout a project's life cycle. Alcatel-Lucent's high technical competence, consistently high-quality implementations, and solution-oriented project execution, ensure success.

Abbreviations

CCTV	closed-circuit television
CPAM	Control Plane Assurance Manager
ESS	Ethernet Service Switch
H-QoS	Hierarchical Quality of Service
IGMP	Internet Group Management Protocol
IGP	Interior Gateway Protocol
IP VPN	IP virtual private network
LMR	Land Mobile Radio
LSP	label switched path
MAC	Media Access Control
MPLS	Multiprotocol Label Switching
OAM	operations, administration and maintenance
OSPF	Open Shortest Path First
P25	Project 25 or APCO-25
PIM	Protocol Independent Multicast
PIM-SM	Protocol Independent Multicast – Sparse Mode
PPP	Point-to-Point Protocol
QoS	Quality of Service
SAM	Service Aware Manager
TDM	Time Division Multiplexing
VLL	Virtual Leased Line
VoIP	Voice over Internet Protocol
VPLS	Virtual Private LAN Services virtual private network