

APPLICATION NOTE

Next-Generation Oil and Gas Company Networking

Building a Better Network with IP/MPLS



Abstract

Oil and gas companies are experienced at building and operating reliable and effective networks to ensure the delivery of essential information and maintain flawless service delivery. The Alcatel-Lucent IP/MPLS solution can enable the oil and gas company to extend and enhance its network with newer technologies like IP, Ethernet and MPLS. These technologies will enable the company to optimize its network to reduce capital and operating expenditures without jeopardizing reliability. Advanced technologies also allow the introduction of new applications that can improve operational and workflow efficiency within the oil and gas company. Alcatel-Lucent leverages cutting edge technologies along with the Company's broad and deep experience in the energy sector to help oil and gas companies build better, next-generation networks.

Table of contents

1	Introduction
1	The traditional oil and gas networking infrastructure
2	Bandwidth and quality of service
3	CAPEX/OPEX and scalability
3	Next-generation oil and gas company network requirements
5	Bandwidth
5	Security
5	Reliability
5	Mobility
5	Manageability
6	The Alcatel-Lucent next-generation oil and gas company network solution
7	Alcatel-Lucent IP/MPLS solution building blocks
8	The network topology
9	CAPEX/OPEX and scalability
9	Multiservice support
9	Reliability
10	Bandwidth efficiency
11	Quality of service
11	Virtualization
11	Mobility
11	Synchronous Ethernet
12	Manageability
12	Summary
12	The Alcatel-Lucent advantage
12	Abbreviations

Introduction

The growing demand for crude oil and gas is driving investments in new exploration activities. At the same time, the supply of crude oil and gas is subject to uncertainty, including geo-political influences, causing oil and gas companies to invest considerably more in project management, safety and protection of their assets. This in turn forces the oil and gas companies to achieve improved operational efficiencies. Consequently, IT spending is focused on having access to real-time data from all phases in the process, from exploration to production, and within production, from upstream, downstream and midstream operations. Ensuring this data is accessible at any time from anywhere in the network is vital.

Oil and gas companies often have multiple communications networks, utilizing TDM, ATM and/or Frame Relay technologies, for the various applications and operations required for their businesses. Typically, voice and data traffic is carried over TDM-based circuits on a SONET/SDH infrastructure providing high reliability and scalability. It is not uncommon to find a mix of optical, microwave and electrical network elements, based on factors such as availability of fiber, terrain and required bandwidth. Increasingly, applications are IP-based and many of these applications require significantly high bandwidth, availability and responsiveness. Rather than adding another overlay packet-based network for these IP applications, companies can improve the efficiency of their operations by adopting an IP/MPLS converged network for all their communications needs. This approach provides oil and gas companies with an effective solution to manage all IP video, voice and data applications while continuing to support their existing applications.

Alcatel-Lucent has a proven solution that will enable any oil and gas company to maximize the cost-effectiveness and efficiency of its network. This application note illustrates the advantage of using IP/MPLS at the core of the network while leveraging microwave and fiber optics where appropriate, all within an integrated and end-to-end communications infrastructure. The network solution helps oil & gas companies meet their current requirements, enables the development of new exploration and production methods, reduces costs, and protects the investment in existing applications.

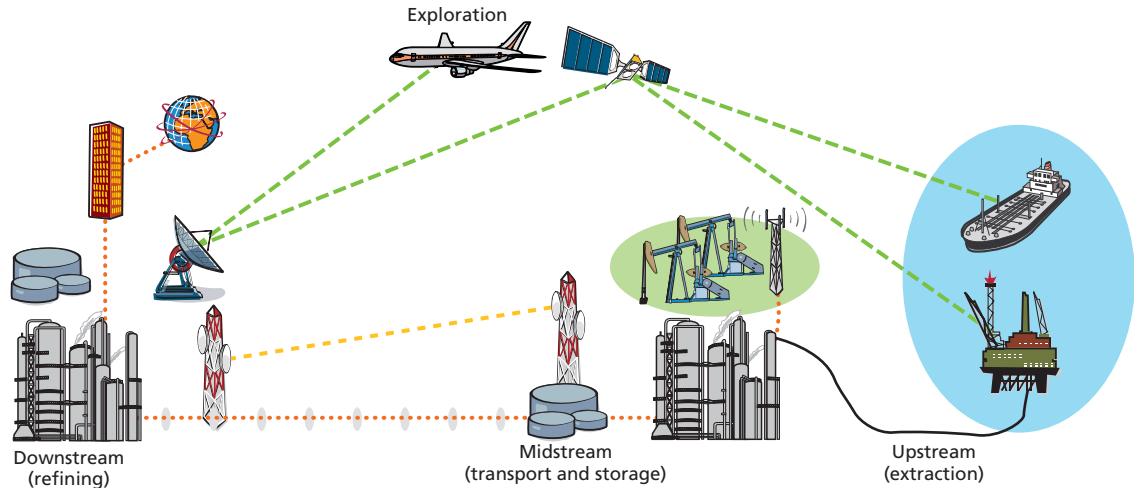
The traditional oil and gas networking infrastructure

Critical communications solutions:

- Ensure flawless operational control of wells, off-shore platforms, pipelines and reservoir systems
- Maintain a safe environment for employees and the general public
- Offer voice, video and data applications to improve efficiency and productivity
- Secure operation of all parts of the oil and gas company infrastructure
- Better align the extraction, storage and refining of oil and gas with the demand

These networks are traditionally built to carry information between the company's headquarters and all remote sites — information that is used to manage capacity, monitor and control the system, bill customers, provide mobile radio communication, and more. Traffic is typically carried over TDM-based circuits (RS232, V.35 and E&M). Traditional oil and gas company applications are shown in Figure 1.

Figure 1. Traditional oil and gas operations



Bandwidth and quality of service

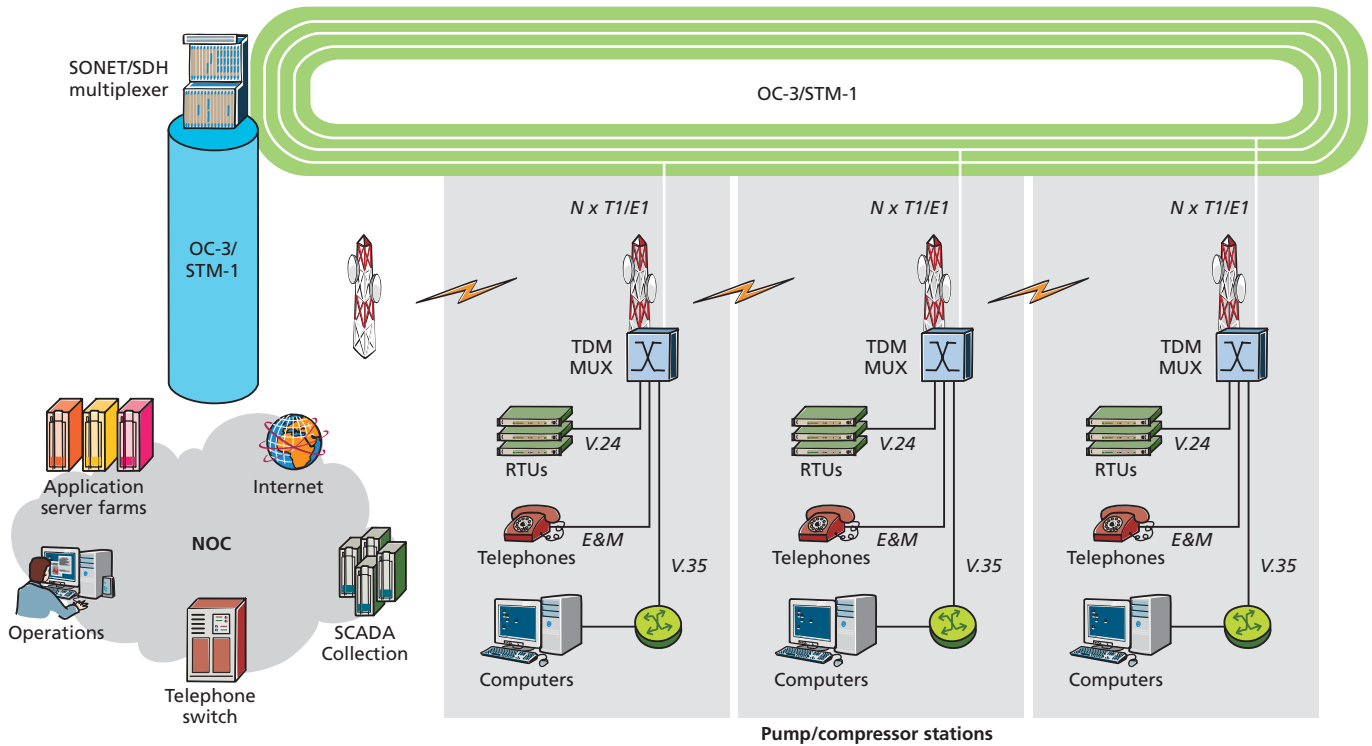
TDM systems support high reliability levels through a unidirectional path-switched ring (UPSR) when using SONET or SDH, which allows an oil and gas company to recover from a network (a node or link) failure in less than 50 milliseconds.

To provide the required network protection, SONET/SDH has been used in a ring environment in which traffic is replicated and sent in both directions, effectively doubling the required bandwidth consumption. With SONET/SDH, the circuits are established in a static configuration, usually in increments of VT1.5 (1.5 Mb/s) or TU-12 (2 Mb/s). This approach works well and is deployed in many oil and gas company networks today, but it means that the bandwidth is reserved for a particular circuit whether it is used or not. Consequently, one application may have insufficient bandwidth while bandwidth that is reserved for an inactive application is inaccessible. These networks are also not designed to transport bursty and variable bandwidth data- and video-based applications.

Because each circuit in a traditional TDM implementation is set with predefined bandwidth, quality of service (QoS) is inherent in the system; once the circuit is set, an application can only utilize the bandwidth assigned to it. When new packet-based services (primarily IP applications) are being integrated over a common infrastructure with TDM, the network must be able to discriminate between high priority critical traffic and lower priority traffic, while enforcing upper bounds on delay and jitter across the network.

Figure 2 shows a traditional oil and gas company SONET/SDH network. Typically, management and control functions are centralized and linked via the ring to all pump/compressor stations. The network operations center (NOC) is connected to the ring at up to an OC-3/STM-1 rate, and the pump/compressor stations may be connected by fiber or through a wireless connection at NxT1/E1 rates.

Figure 2. Traditional SONET/SDH/TDM implementation



CAPEX/OPEX and scalability

In a SONET/SDH setting, the granularity of the bandwidth tends to be in the order of VT1.5 (1.5 Mb/s) or TU-12 (2 Mb/s). As packet-based applications converge over SONET/SDH networks, bandwidth can quickly be exhausted. Operational complexity also grows when running packet applications on top of a TDM infrastructure. Utilities must consider budget constraints when evaluating any new network or service. The oil and gas company must be able to add users and services without negatively impacting operating costs associated with equipment and maintenance, network carrier charges, and network administration.

Next-generation oil and gas company network requirements

Today, oil and gas companies are aggressively pursuing communications options that will result in improved operational efficiency and increased productivity, which means that many important parameters must be kept in balance. First, the solution must be highly reliable: in a mission-critical environment, no compromise is acceptable. Second, capital expenditures (CAPEX) and operating expenditures (OPEX) must be minimized. Finally, the network should offer the opportunity to implement new services in a rapid and cost-effective manner. The ideal solution is one that offers the same level of reliability, QoS and security as that of the traditional oil and gas company network while supporting any existing TDM and packet services that are needed for core oil and gas operations and administration.

New networking technologies provide oil and gas companies with the opportunity to migrate traditional legacy applications to more efficient IP and Ethernet technologies and to implement new IP-centric applications, such as:

- IP-based mobile radio
- Ethernet Supervisory Control And Data Acquisition (SCADA)
- IP-based video surveillance

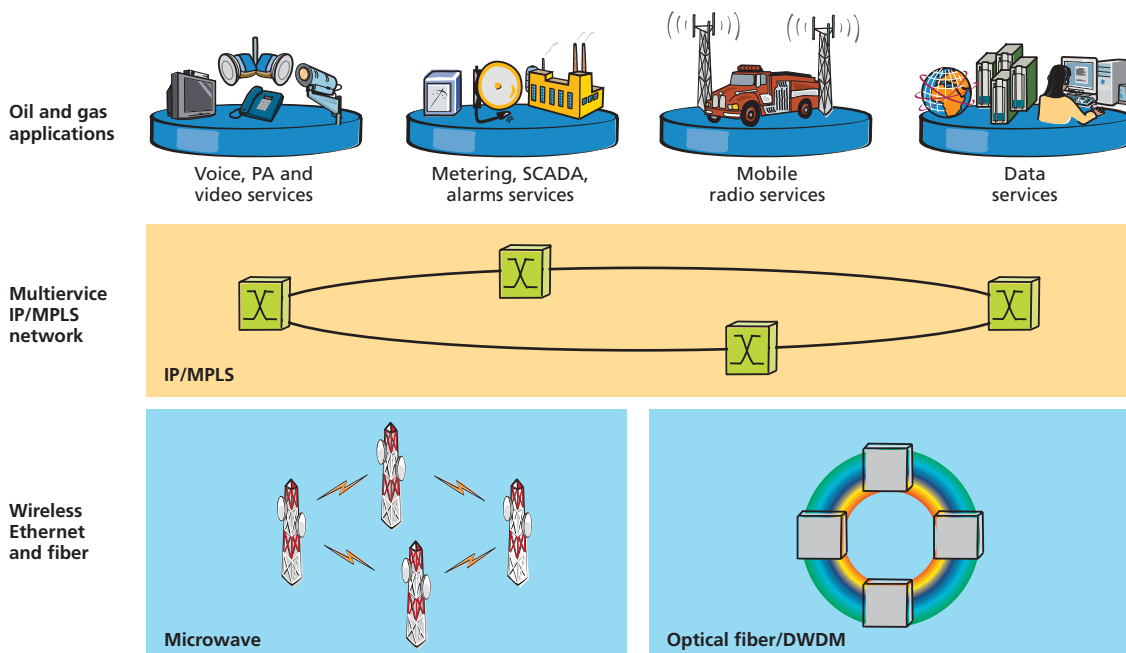
- Collaboration tools
- Voice over IP (VoIP)
- IP Mobility/WiFi Alliance WiFi™

IP technology can increase operational efficiency and provide support for existing critical applications while providing access to the benefits of new applications. There are several main drivers behind this migration to IP:

- Traditional mobile radio systems tend to lack interoperability, which can place the oil and gas company in a propriety implementation situation and create isolated mobile radio islands. An IP-based mobile radio platform allows users to communicate across multiple mobile radio vendor systems and provides better interoperability between different systems. The migration of existing data networks and voice networks to new IP-based systems is enabling more flexible connectivity and improving worker productivity. New collaboration software leverages the combination of voice, data and video on a common IP network; improves productivity; and helps the company to respond efficiently to emergencies irrespective of workers' locations.
- Legacy SCADA systems tend to be expensive, complex and difficult to commission and deploy. Many are also facing end-of-life issues. Ethernet-based SCADA enables a simplified architecture and efficient bandwidth utilization. Ethernet-based SCADA and intelligent devices provide remote management capabilities leading to maintenance-free compressor/pump stations.
- Oil and gas companies use video surveillance to ensure the physical security of their critical assets. A modern video surveillance system is IP-based and it is becoming integrated with the information technology infrastructure of the organization. Adding closed-circuit television (CCTV) traffic into a network unprepared for video traffic can adversely impact all services on the network.

Figure 3 shows a high-level view of a typical oil and gas company's IP/MPLS implementation. The physical layer can be either wireless or fiber. The multiservice IP/MPLS network supports a flexible array of oil and gas company applications.

Figure 3. IP/MPLS-based network



Bandwidth

The growth in IP applications drives the need for bandwidth and, more importantly, the need for bandwidth flexibility and efficiency. The new IP-centric applications tend to exhibit “bursty” traffic behavior: the application grabs a high level of bandwidth to send a large amount of traffic then, when the transmission ends, releases the bandwidth for other applications. With a traditional TDM core implementation, running multiple services becomes a challenge, as TDM is not designed to handle the burstiness of IP-based traffic. The oil and gas company needs a service-aware network that can support IP and Ethernet applications without jeopardizing system availability.

Security

Existing and new applications require a communication network to support a large variety of traffic profiles and interconnection topologies. The network needs to securely transport this broad range of applications over one physical infrastructure. Therefore, the network needs to support and maintain traffic separation and bandwidth traffic engineering, and to restrict access to the authorized traffic on configured ports. As with an optical SONET/SDH-based network, these networks need to be reliable and resistant to security attacks.

The oil and gas company needs a service-aware network that can support legacy, IP and Ethernet applications without jeopardizing system availability and security.

Reliability

The network must offer the necessary level of reliability to maintain uninterrupted operation for voice, data and video traffic. A single failure in the network should not be service-affecting. Service interruptions in oil and gas company environments can lead to consumers losing services, overload conditions, loss of communication over mobile radio, and the development of other potentially unsafe conditions. TDM systems traditionally support high levels of reliability when using SONET/SDH, allowing an oil and gas company to recover from a failure in less than 50 milliseconds. That level of service must be matched in a new IP/MPLS-based network.

Mobility

Oil and gas company employees can be more productive if they can be mobile. Mobile access to data and voice services allow users to respond to events more quickly, expediting oil and gas company operations and improving customer satisfaction. Data mobility encompasses the ability to send and receive files such as work orders, schedules, manuals and procedures, and to monitor reports. Voice mobility allows users to roam across the oil and gas company network footprint, including WiFi access points, rather than being tethered to a physical location. For most efficient and reliable operations, IP-based mobility applications require an IP/MPLS-based network.

Manageability

The management of an oil and gas company network has a direct impact on the operational cost of maintaining and scaling the network. OPEX should not escalate exponentially as new services are added or as the number of network elements increases. Service-aware management software can simplify network operations while streamlining operational processes such as maintenance, troubleshooting, scaling and commissioning.

The Alcatel-Lucent next-generation oil and gas company network solution

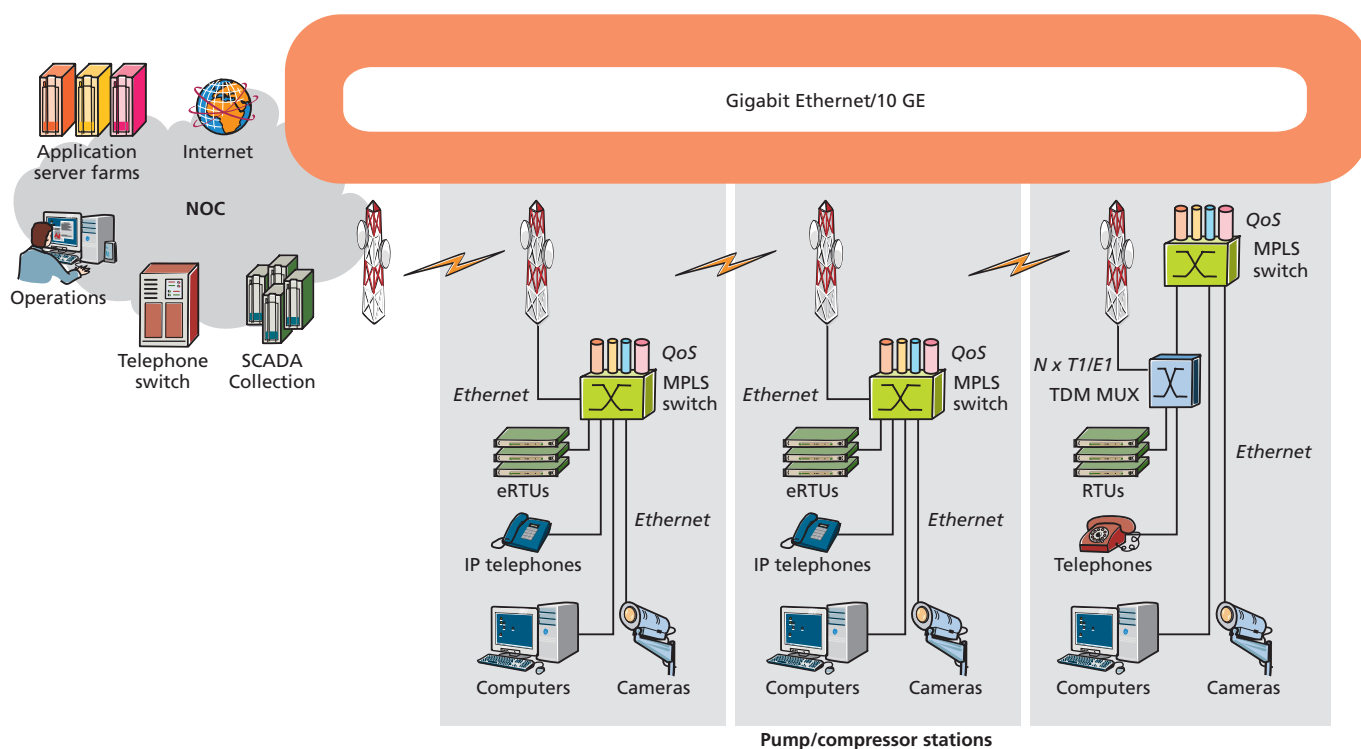
The oil and gas company communications network must:

- Support critical existing oil and gas company TDM services
- Support existing and new IP-based applications and services
- Minimize costs without compromising features, functionality and reliability
- Scale, allowing the oil and gas company to increase services and grow the number of users, applications and capacity
- Ensure network and operational system security
- Be highly available and resilient, with no single point of failure
- Enable scalable QoS to prioritize mission-critical applications over other traffic
- Provide reliable transmission over wireless microwave and fiber optic systems

Each oil and gas company may have a different approach or preference when implementing a communications network. The core of the operational network can be based on SONET/SDH, ATM, IP/MPLS and/or Ethernet. The Alcatel-Lucent solution portfolio includes a broad range of products to support the implementation of these different approaches. However, there is a clear movement towards implementing an IP-based network infrastructure for oil and gas companies for all of their communications needs. IP-based networks are more flexible, support higher capacities and are better designed to handle the new range of voice, video and data traffic. Not all IP-based solutions are appropriate for oil and gas companies. To support the mission-critical traffic of oil and gas companies, an IP/MPLS-based solution is needed. IP/MPLS networks can support all traffic types and leverage the benefits of microwave and fiber optics where appropriate.

Figure 4 shows an overview of the Alcatel-Lucent solution for a next-generation oil and gas company IP/MPLS network. The network leverages MPLS to bring the advantages of a circuit-based network to an IP network, and to enable network convergence, virtualization and resiliency.

Figure 4. Alcatel-Lucent next-generation oil and gas company IP/MPLS network



Alcatel-Lucent IP/MPLS solution building blocks

The Alcatel-Lucent IP/MPLS solution leverages multiple state-of-the-art technologies to enable an oil and gas company network to continue supporting existing TDM-based applications while providing a smooth migration path to IP-based services. The service-aware infrastructure efficiently supports the full range of IP-based applications, ensuring that each application can be allocated the resources it needs in terms bandwidth, QoS level, security, availability, and so on. Furthermore, hierarchical QoS (H-QoS) guarantees that no bandwidth is “wasted” when an application is idle, that is when it is not transmitting information onto the network.

The components of the IP/MPLS-based solution are based on and can include:

- Alcatel-Lucent 7750 and 7710 Service Router (SR) product family
- Alcatel-Lucent 7450 Ethernet Service Switch (ESS)
- Alcatel-Lucent 7705 Service Aggregation Router (SAR)
- Alcatel-Lucent 7210 Service Access Switch (SAS)
- Alcatel-Lucent 5620 Service Aware Manager (SAM)
- Alcatel-Lucent 5650 Control Plane Assurance Manager (CPAM)
- Alcatel-Lucent OmniSwitch 6850 and/or 6855 (OS6850/OS6855 (not MPLS))

These Alcatel-Lucent products support routing, switching and multiservice capabilities¹ enabling the oil and gas network operator to support real-time applications across the full extent of the network. The Alcatel-Lucent IP/MPLS implementation includes non-stop routing and non-stop service capabilities that provide unparalleled reliability.

The network and element administration of the Alcatel-Lucent IP/MPLS-based solution is handled by the industry-leading Alcatel-Lucent 5620 SAM, an integrated application that covers all aspects of element, network and service management on one platform. It simplifies the programming and management of the network including automating routine tasks, correlating alarms to problems, managing the assignment of end-to-end connections, and facilitating the introduction and administration of new services, all through a user-friendly point-and-click interface. The Alcatel-Lucent 5620 SAM can also manage many of the other Alcatel-Lucent and third-party elements within the network.

For IP routing management control, the Alcatel-Lucent 5650 CPAM offers real-time control plane visualization, proactive control plane surveillance, configuration, validation and diagnosis. It enables oil and gas operators to overlay Layer 2 and Layer 3 services, MPLS tunnels and various operations, administration and maintenance (OAM) traces on the control plane map. This simplifies problem resolution, reduces control plane configuration errors, and reduces troubleshooting time.

The services enabled by the next-generation IP/MPLS infrastructure include, but are not limited to:

- Critical traditional and Ethernet SCADA traffic
- Wellhead automation
- Pipeline inspection gauge (PIG) & valve control
- Reservoir control
- Access control
- Mobile radio for internal operations
- IP telephony, collaboration and operations

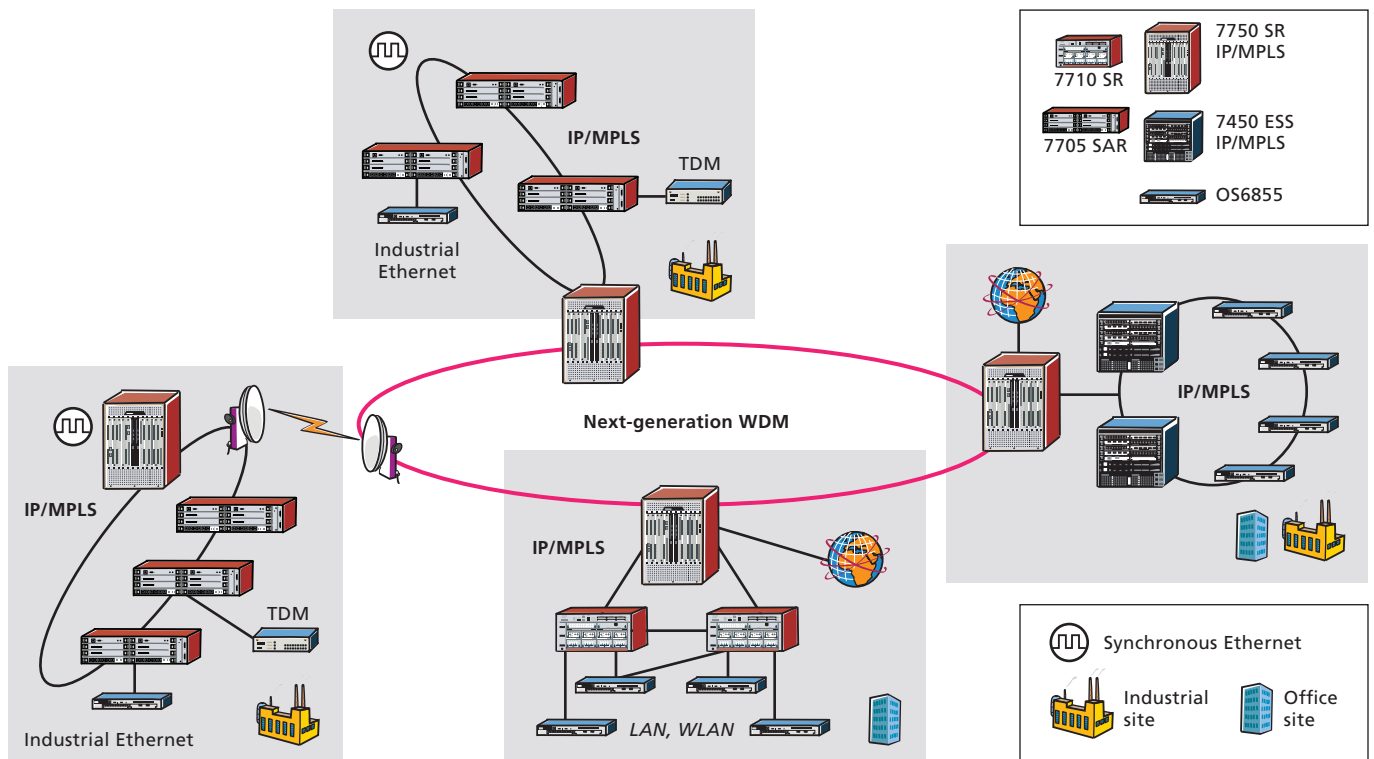
¹ For a complete set of supported features, functions and standards (including RFCs) please contact your sales representative.

- Wireless IP data access points for workforce mobility
- Alarm circuits for all remote sites
- Virtual private networks (VPNs)
- Customer relationship management
- IP-based video surveillance
- Interactive entertainment systems
- Video conferencing
- Corporate LAN/intranet
- Extranet services to suppliers, service companies and contractors

The network topology

A network topology is determined by the graphical mapping of the physical and logical interconnections. The IP/MPLS network is deployed on a ring-based architecture or on partially meshed architectures.

Figure 5. Typical ring and meshed architecture



A ring architecture provides an efficient, reliable environment as traffic can be rerouted in the opposite direction of the ring, should a failure occur. In a SONET/SDH application, every node is typically transmitting on both sides to provide end-to-end protection, effectively duplicating all traffic on the ring. In the Alcatel-Lucent IP/MPLS solution, the network relies on the IP/MPLS fast reroute (FRR) feature for resiliency, which eliminates the requirement to duplicate the traffic on the ring. All the bandwidth can be fully utilized and FRR ensures traffic is rerouted in sub-50 milliseconds in the event of a node or link failure in the ring, preserving all traffic on the ring. Traffic engineering is used to efficiently carry the traffic in a reliable and secured way over the ring. This topology is often used in the aggregation part of the network and offers a very efficient way to aggregate and backhaul traffic over a relatively low number of links.

Traffic engineering is used to carry the traffic over the different meshed links across the core of the network. A partially meshed architecture uses more links and therefore provides more rerouting alternatives. Partially meshed network are able to recover from double faults and are often deployed in the core of the network.

CAPEX/OPEX and scalability

To meet the oil and gas company's growing requirements in terms of service deployment and bandwidth, the Alcatel-Lucent IP/MPLS-based architecture is extremely scalable, with the bandwidth in each ring able to scale up or down independently, according to changing requirements.

The IP/MPLS network can accommodate a growing number of users and services. The Alcatel-Lucent IP/MPLS network has expanded media access control (MAC) entry support for up to hundred of thousands of MAC addresses and up to several thousand services per uplink port. The granularity in MPLS bandwidth, scaling options and statistical multiplexing result in minimal CAPEX requirements to deploy and scale this solution. The converged architecture and the ease of Ethernet technology allow for optimized OPEX.

Multiservice support

The Alcatel-Lucent next-generation IP/MPLS-based oil and gas company architecture offers a flexible network and service environment that enables the continued support of existing services while incorporating new IP-based applications. The IP-based applications are typically more efficient in terms of bandwidth usage when deployed over an IP/MPLS packet-based solution. All services converge at the IP/MPLS layer at the access of the network, where the required packet handling, such as encapsulation, packet metering, and QoS capabilities are executed. Different applications are transported between the users via dedicated VPNs in a point-to-point, point-to-multipoint or multipoint-to-multipoint manner. The network also supports the migration of the TDM-based services on to the IP/MPLS-based infrastructure. The solution supports both structured and unstructured T1/E1 services while providing a secure environment where different user groups can participate in different VPNs.

Reliability

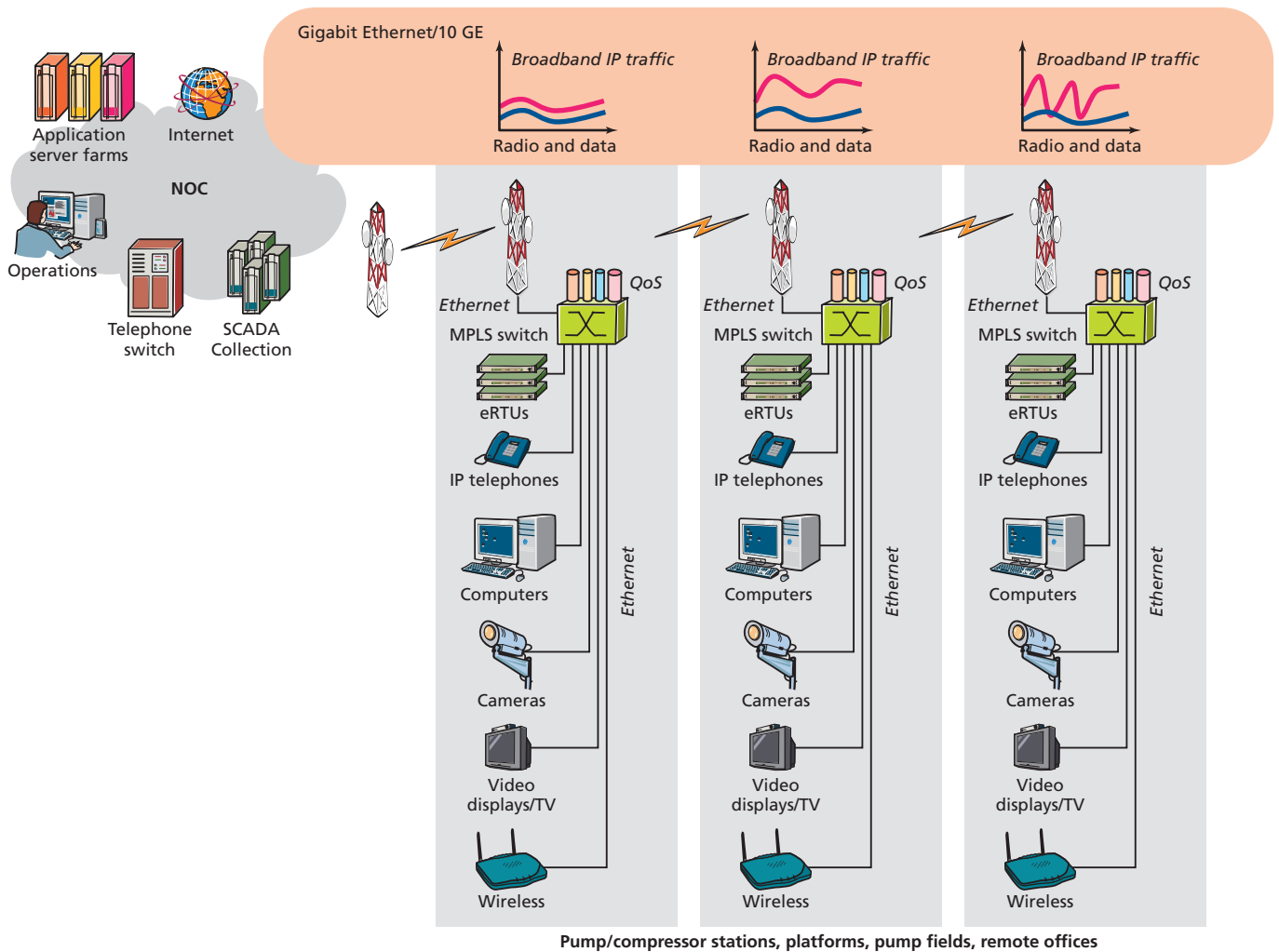
With the Alcatel-Lucent IP/MPLS solution, the oil and gas company has the necessary reliability level to maintain uninterrupted operations for voice, video and data traffic. The network must be able to find an alternative route around a failure. The MPLS FRR feature enables the network to reroute connections around a failure in less than 50 milliseconds. Because the network is service-aware, FRR can distinguish and prioritize traffic redirection according to priority. Furthermore, non-stop routing and non-stop service features ensure reliability levels equal to those of TDM-based networks.

Bandwidth efficiency

The Alcatel-Lucent IP/MPLS architecture provides a SONET/SDH-like reliability of sub-50 milliseconds recovery without duplicating the traffic. IP/MPLS can deploy explicit route label-switched path (LSP) capabilities to traffic engineer the network and optimize bandwidth utilization. IP/MPLS is based on statistical multiplexing, so the oil and gas company operator can still configure circuits with a very low bandwidth granularity; moreover, when the assigned bandwidth is not in used by the application or application group, the unused bandwidth can be temporarily allocated for use by other applications or application groups to ensure best use of the available bandwidth.

This concept is illustrated in Figure 6.

Figure 6. Efficient bandwidth management with an IP/MPLS architecture



Quality of service

In an oil and gas company environment where multiple services converge over a common infrastructure, QoS is essential. The service-aware Alcatel-Lucent IP/MPLS solution enables the network to discriminate among various types of traffic, based on a rich set of classification attributes (including MAC address, IEEE802.1p, and IP addresses) and prioritizes transmission of higher priority traffic over lower priority. The Alcatel-Lucent product portfolio's superior H-QoS implementation also allows lower priority traffic to burst to fill available bandwidth when higher priority applications go idle. H-QoS uses an advanced scheduling mechanism to implement service hierarchies. These hierarchies provide maximum isolation and fairness across different traffic while optimizing uplink utilization. With multiple levels and instances of shaping, queuing and priority scheduling, the Alcatel-Lucent IP/MPLS solution can manage traffic flows to ensure performance parameters (such as bandwidth, delay and jitter) for each application are met.

Virtualization

The Alcatel-Lucent IP/MPLS solution provides for the virtual isolation of various traffic types on a single infrastructure. This allows the full separation of traffic from different departments or operations within a company, allowing for a secure environment and bandwidth allocation designation. The IP/MPLS architecture supports this by enabling scalable Ethernet-based virtual private LAN service (VPLS) and IP-based virtual private routed networks (VPRN), which can be used to provide different applications, user groups or even customers (in a bandwidth leasing situation) an environment that is unseen and unaffected by other traffic.

Mobility

The Alcatel-Lucent IP/MPLS solution offers an oil and gas company's mobile field workforce ubiquitous access to critical applications that improve productivity and efficiency. In the Alcatel-Lucent IP/MPLS network, mobility can be achieved by supporting WiFi access points to allow the secure transmission and reception of data wirelessly. When within the coverage range of a wireless access point, users can send and receive vital data files regardless of location. The network also permits the partitioning of different application portfolios and access rights for different groups with defined privileges. All WiFi sites are networked over the IP/MPLS backbone. Since the WiFi network can enable both data applications and wireless VoIP services, the IP/MPLS network infrastructure prioritizes traffic types to enforce the necessary QoS policies.

Synchronous Ethernet

Oil and gas companies are looking to migrate their synchronization infrastructures to a familiar and manageable model. Synchronous Ethernet may be the easiest and quickest way to achieve (frequency) synchronization and to allow the benefits of an Ethernet network infrastructure to be realized without any change to the existing TDM network applications. The concept behind synchronous Ethernet is similar to SONET/SDH system timing capabilities.

With Synchronous Ethernet, the network elements derive the physical layer transmitter clock from a high quality frequency reference via the physical Ethernet interfaces. This does not affect the operation of any of the Ethernet layers and is transparent to them. The receiver at the far end of the link locks onto the physical layer clock of the received signal, and thus itself gains access to a highly accurate and stable frequency reference. Then, in a way similar to conventional hierarchical master-slave network synchronization, this receiver locks the transmission clock of its other ports to the frequency reference and a fully time-synchronous network is established.

The implementation of Synchronous Ethernet will allow an oil and gas company to gracefully integrate its existing systems and future deployments into a conventional industry-standard synchronization hierarchy.

Manageability

Effective network management allows the oil and gas company to maintain, manage and add new network services while minimizing operational risk and impact. The service-aware Alcatel-Lucent IP/MPLS network management system extends all features to all sites. A powerful set of OAM tools is available to assist the oil and gas company operator with the management of every aspect of the 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. OAM tools measuring the end-to-end jitter and delay are great tools to support the transport of jitter- and delay-sensitive applications. The measurements are collected by the network management systems and are compared with the agreed service level agreement. The oil and gas company operator can also oversee the entire network from a single, centralized, network management station.

Summary

Oil and gas companies are experienced at building and operating reliable and effective networks to ensure the delivery of essential information and maintain flawless service delivery. The Alcatel-Lucent IP/MPLS solution can enable the oil and gas company to extend and enhance its network with newer technologies like IP, Ethernet and MPLS. These new technologies will enable the oil and gas company to optimize its network to reduce both CAPEX and OPEX without jeopardizing reliability. Advanced technologies also allow the introduction of new applications that can improve operational and workflow efficiency within the oil and gas company. Alcatel-Lucent leverages cutting edge technologies along with the Company's broad and deep experience in the energy industry to help oil and gas companies build better, next-generation networks.

The Alcatel-Lucent advantage

Alcatel-Lucent has years of experience in the development of IP, MPLS and Ethernet technologies. The Alcatel-Lucent IP/MPLS solution offers oil and gas companies the flexibility, scale and feature sets required for mission-critical operation. 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 fixed, mobile and converged broadband networking, IP technologies, applications, and services. The Company's Professional Services Portfolio includes Service and Solution Consulting, Network Build Out, and Operations Support. Within the oil and gas company industry, Alcatel-Lucent has proven to be a reliable partner with an excellent record for cooperation and communications throughout a project's life cycle, high technical competence, consistently high-quality implementations, and solution-oriented project execution.

Abbreviations

ATM	Asynchronous Transfer Mode	PIG	Pipeline Inspection Gauge
CAPEX	Capital expenditure	QoS	Quality of service
CCTV	Closed-circuit television	RTU	Remote termination unit
E&M	Ear and mouth	SCADA	Supervisory control and data acquisition
FRR	Fast reroute	SDH	Synchronous Digital Hierarchy
H-QoS	Hierarchical quality of service	SONET	Synchronous Optical Network
IP	Internet Protocol	TDM	Time Division Multiplexing
IP/MPLS	IP/Multiprotocol Label Switching	UPSR	Unidirectional path switched ring
LSP	Label switched path	VoIP	Voice over IP
MAC	Media access control	VPLS	Virtual Private LAN Service
MPLS	Multiprotocol Label Switching	VPN	Virtual private network
NOC	Network operations center	VPRN	Virtual private routed network
OAM	Operations, administration and maintenance	VT1.5	SONET/SDH equivalent of T1-1.5 Mb/s
OPEX	Operating expenditure	WiFi	Wireless fidelity
PA	Public announcement		

www.alcatel-lucent.com Alcatel, Lucent, Alcatel-Lucent and the Alcatel-Lucent logo are trademarks of Alcatel-Lucent. All other trademarks are the property of their respective owners. The information presented is subject to change without notice. Alcatel-Lucent assumes no responsibility for inaccuracies contained herein. Copyright © 2009 Alcatel-Lucent. All rights reserved.
CPG4688090105 (02)

