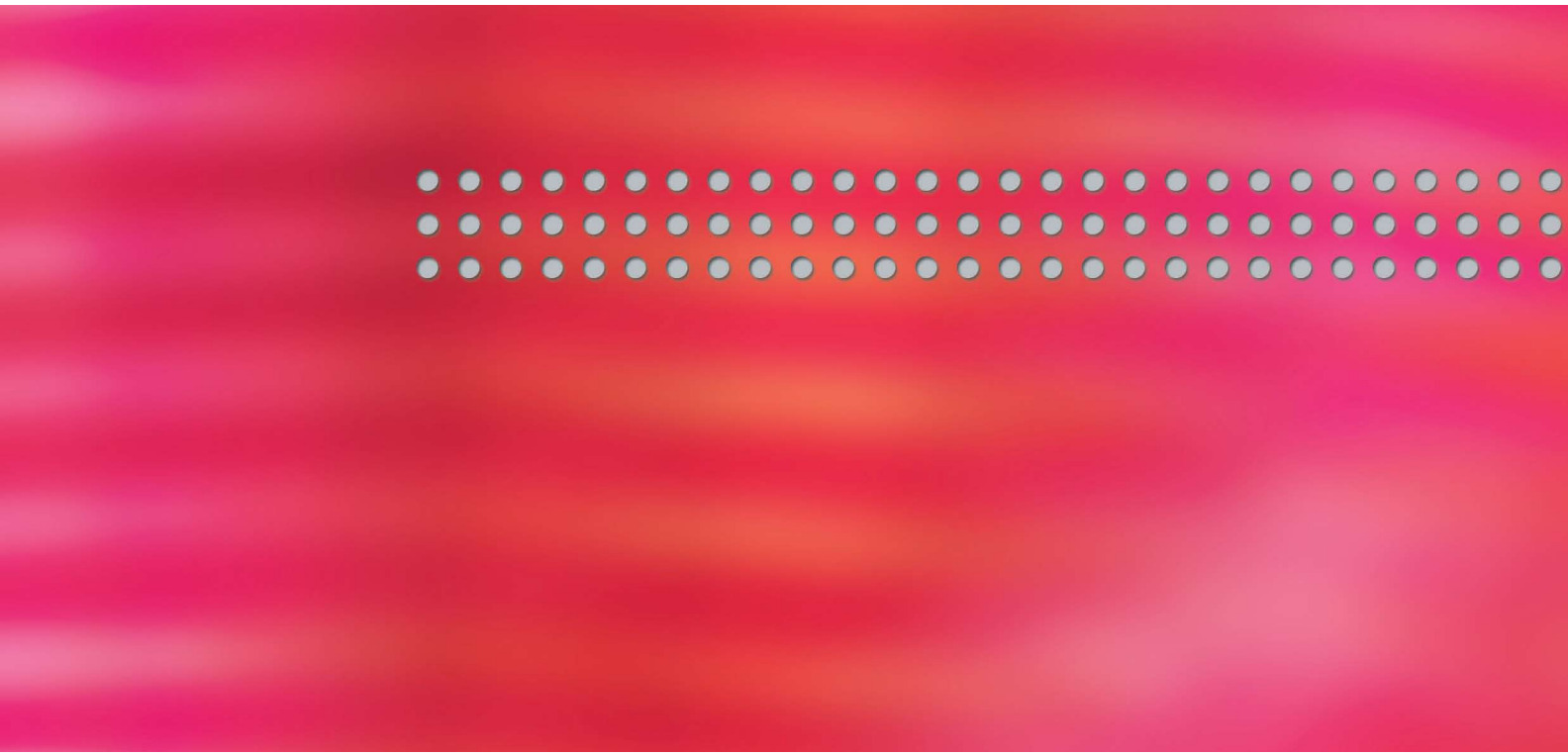
Alcatel·Lucent

APPLICATION NOTE

Network Transformation: TDM Services on a Packet Network



Abstract

Operators must decide how to transform their existing networks from SDH/SONET to MPLS and how to effectively serve their end customers. Operators are faced with changing network technologies in conjunction with a move toward service based applications. They have pressure to reduce the operating cost and capital expenditures of their overall infrastructure. At the same time their existing TDM networks are reaching the end of their life cycle and will need to be replaced. Under these pressures, operators must consider how to leverage the new IP/MPLS network technology when migrating legacy systems and services. High growth areas such as L2VPN and L3VPN business services over an IP/MPLS network are pushing the demand for services closer to the edge of the network. With this technology shift, operators can take advantage of the IP/MPLS functionality and transition their customer's legacy applications.

Private Line Business Services is a market operators must address. These services are typically point to point TDM circuits which deliver secure, predictable and fixed bandwidth applications from small offices or remote locations to office headquarters for voice and data services. As IP/MPLS network technologies mature, they deliver the same quality of experience as the existing TDM network infrastructure with the same level of predictability but at a reduced cost of ownership.

This document includes a business case for how Alcatel-Lucent's 7705 Service Aggregation Router (SAR) reduces CAPEX and reduces cost of ownership. In this business case, the 7705 SAR delivers private line business services via T1/E1 circuits, with comprehensive synchronization and OAM functionality directly over a converged IP/MPLS network. Using Alcatel-Lucent's 7705 SAR, the service provider transitions to a packet network while saving 30% CAPEX costs over the service provider's native TDM network; all this while delivering the same TDM services and additionally enabling the ability to provide new service offerings.

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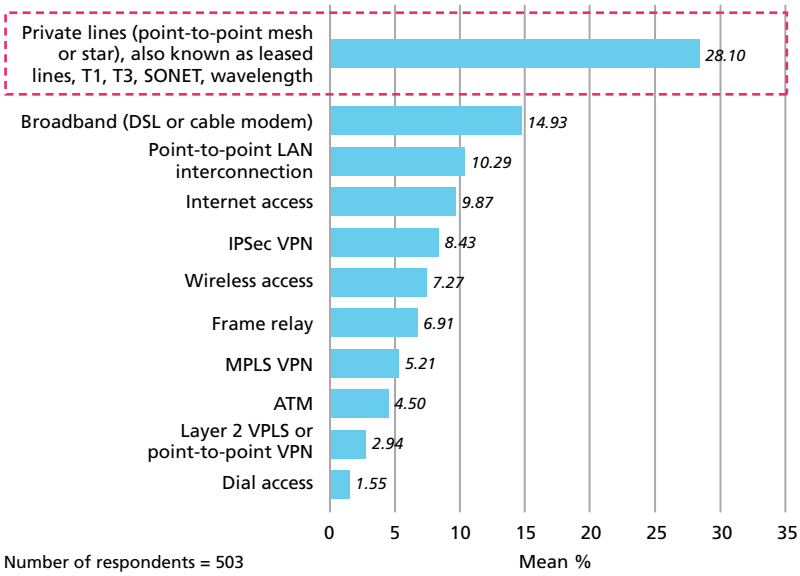
Challenges and opportunities

There is tremendous pressure on operators to reduce their cost base, eliminate parallel networks and reduce the operational complexity of delivered services. To address these issues, networks are shifting toward IP/MPLS based infrastructures using Ethernet as the principal transport mechanism. Operators must determine what applications to distribute over the new infrastructure. They must also weigh their ability to maximize profits while analyzing the OPEX and CAPEX requirements of shifting to an IP/MPLS based solution.

Obvious candidates for distribution over the new infrastructure are high growth and high demand services such as L2VPN and L3VPN. These services require the underlying technologies of IP/MPLS in order to deliver carrier grade services.

How can operators leverage the same packet network to deliver TDM private line services?

Figure 1. Current WAN Access Port Share by Technology Platform (source: IDC)



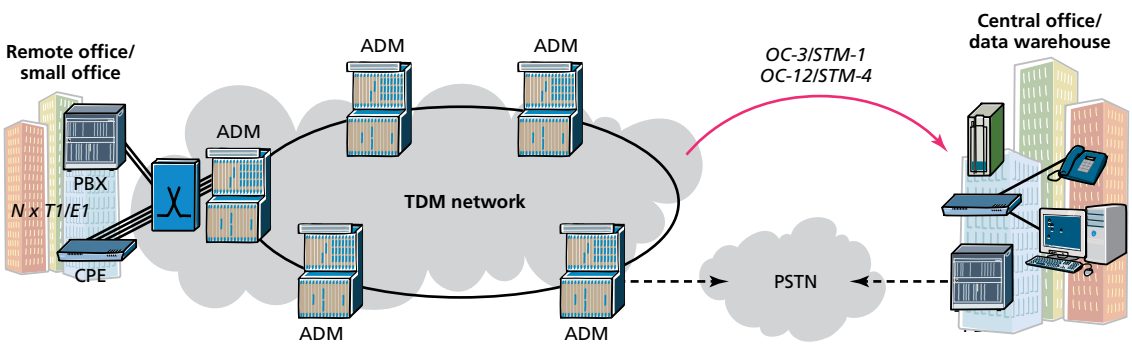
Operators wishing to support next generation services and TDM services over a converged packet network must consider the following:

- The cost to maintain parallel TDM and packet network is high.
- A converged approach can provide flexible service access for TDM and packet networks.
- Private line services still represent over 28% of all business services within the network[1].
- Enterprises are increasingly demanding higher bandwidth services with application-level Service Level Agreements (SLAs).

A TDM to packet transformation solution

The present mode of operation (PMO) uses SDH/SONET and ATM technology to aggregate and deliver private line services. These services are secure, predictable and have fixed bandwidth from end to end, allowing remote offices to connect to a central location or the PSTN.

Figure 2. SONET/SDH PMO



1 IDC – Business Network Services: A Demand-Side View from the 2007 U.S. WAN Manager Survey

The networking industry is shifting toward a service-based mode of operation which can deliver new high growth services such as L2VPN and L3VPN to business customers. A common transport mechanism for these services is IP/MPLS. With IP/MPLS in place, the operator can begin to look at how Private Line services can be migrated to make use of the common infrastructure. These include service delivery such as:

- Private Line service to a Central Office
- Private Line services for PSTN access
- IP Connectivity for VPRN access
- IP connectivity for High Speed Internet (HSI) access

Figure 3. Flexible access including VPN and Private Line services over T1/E1 interfaces

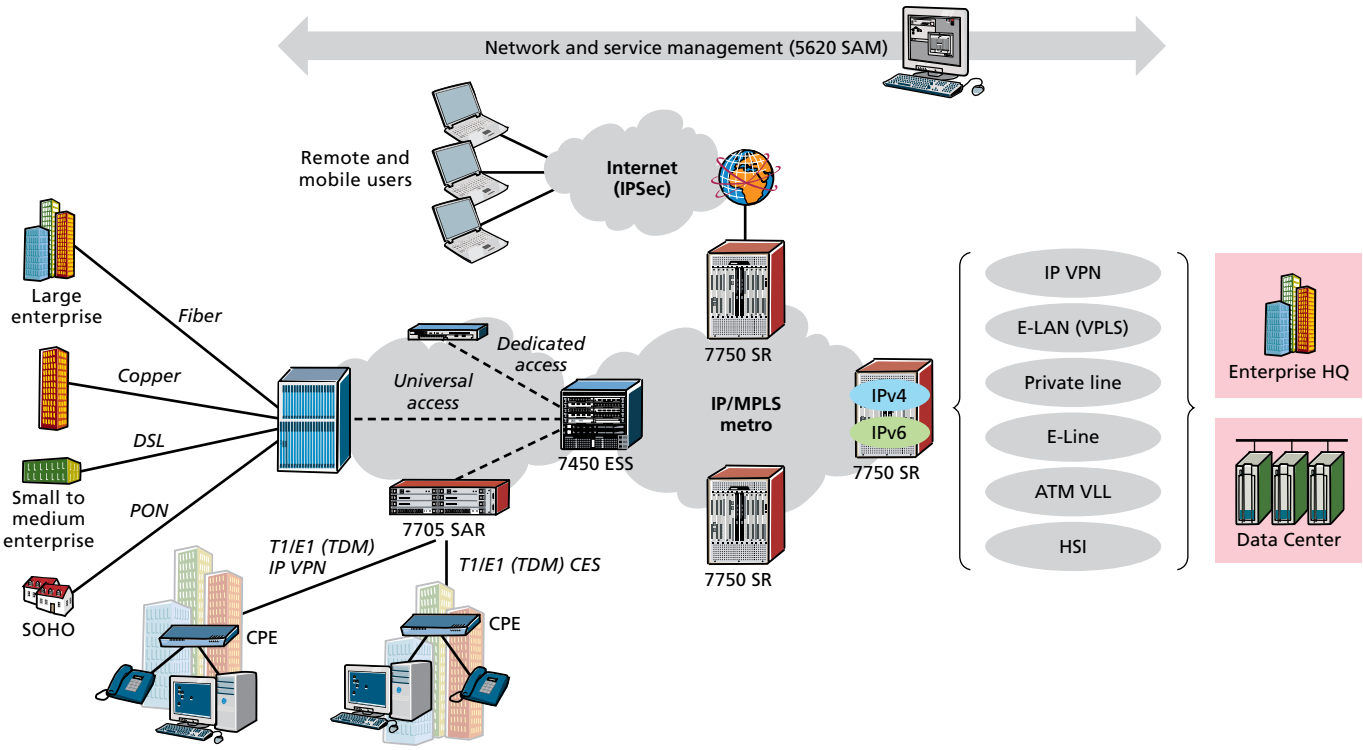


Figure 3 illustrates that by extending the reach of business VPNs and Private Line services over an IP/MPLS enabled network, it is possible to:

- Protect existing TDM revenue while investing in packet network technologies.
- Simplify the operational model for multiple business services.
- Provide comprehensive synchronization solutions.
- Optimize cost with a converged IP/MPLS enabled Carrier Ethernet architecture including embedded OAM and Network Management.
- Provide Metro Ethernet Forum (MEF) standards based support for T-Line and TDM Access Line Service (TALS).
- Provide a full transition to a packet network over time while providing service continuity.

Application features and benefits

In order to accomplish this transformation to a packet network, operators require a flexible platform capable of addressing the service demand. With Alcatel-Lucent's 7705 SAR, 5620 Service Aware Manager (SAM) and the SR family of products working together, operators can easily migrate to a simplified network infrastructure with end to end continuity and a common platform for network management.

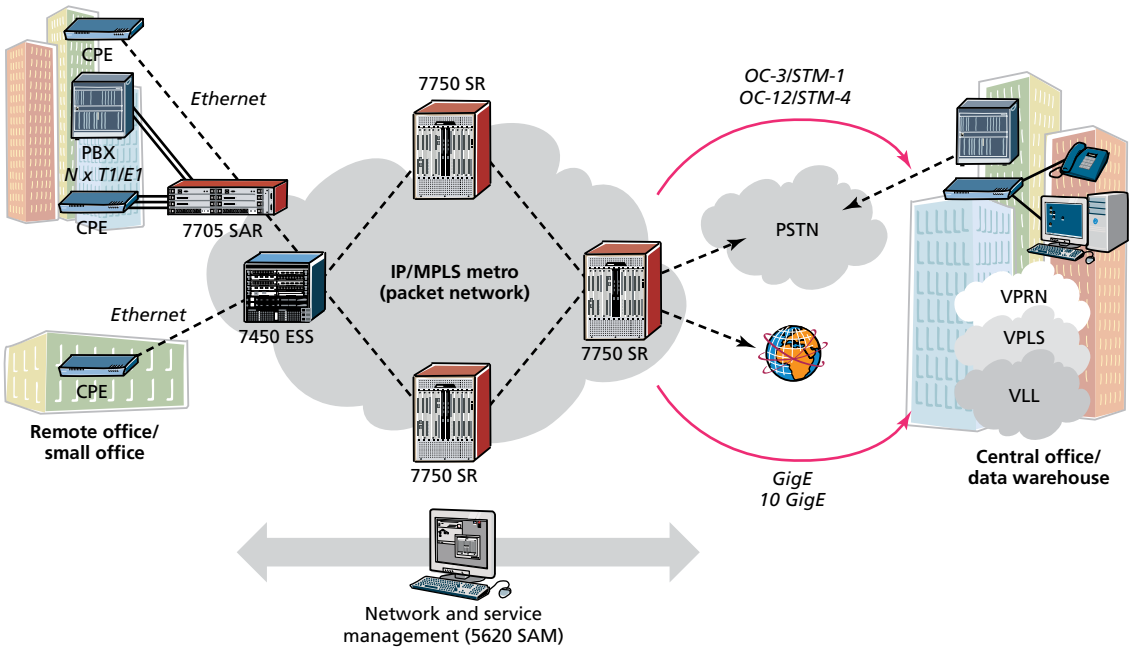
Table 1. Features and benefits of the 7705 SAR based solution

FEATURE	FUNCTION	BENEFIT
Circuit Emulation Services	Ability to transport TDM voice and data services over a packet architecture	Consolidation of services over a common technology and infrastructure
Quality of Service	Maintain differentiation and control of service priority within the network	Deliver the quality of experience for constant bit rate services across the network
Network Timing and Synchronization	Distribute network timing information from a central primary reference clock	Provide timing information to access devices for synchronization or as a service to the end customer
Network protection	Provide reliable and resilient network protection for end-to-end service delivery	Maintain the customer SLA for delivered services
Network Security	Protect the network from malicious intrusions	Secure network resources and protect customer services
Network Management	Provide the ability to effectively manage the network resources	Increase network visibility while reducing OPEX

Application architecture

Operators implementing IP/MPLS enabled metro networks can transition their existing private line services to the IP/MPLS based packet network. This transition reduces OPEX through better network visibility and reduces CAPEX by eliminating the need to maintain a parallel network and replace the existing SONET/SDH and ATM networks.

Figure 4. Private Line services using the future mode of operation (FMO)



Introduction of a 7705 SAR into the network at the service edge allows an operator to migrate T1/E1 private line services to an IP/MPLS enabled metro network—at the same time maintaining the existing customer premise equipment (CPE) and existing T1/E1 facilities. The 7705 SAR is a redundant system that provides all the technical capabilities needed within a high density shelf and up to 96 T1/E1 physical interfaces.

The 7705 SAR builds on the widely deployed Alcatel-Lucent Service Router (SR) family making use of the same operating system and service architecture. Additionally, the 5620 SAM provides fault, configuration, accounting, performance and security management (FCAPS) for the full suite of SR products. The following quote from PT Telkom illustrates how Alcatel-Lucent's 7705 SAR, in combination with the SR family, enables PT Telkom to transform their network capabilities.

"As the country's largest carrier Ethernet infrastructure, it will support PT Telkom in our next-generation network transformation while enabling us to introduce new advanced services to enterprises throughout the country," **said Ermadi Dahlan, PT Telkom's Network Director**. "This reliable, high-speed network will make it possible for us to offer IP-based virtual private networks (VPN) and Ethernet VPNs as well as broadband Internet access to enterprises."

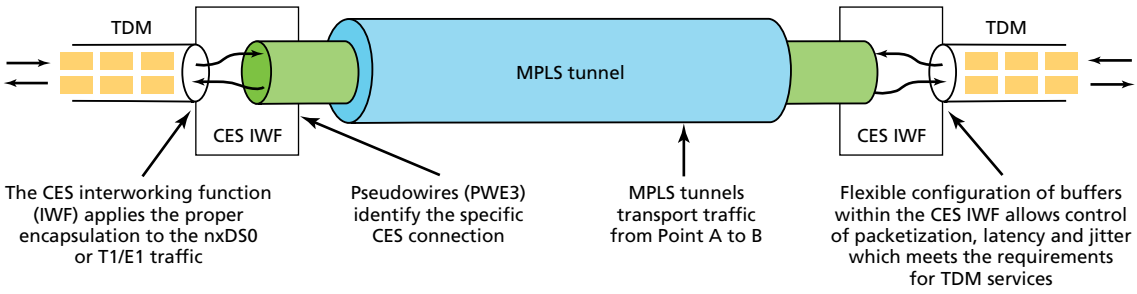
Circuit Emulation Service (CES)

Circuit emulation capabilities are required for TDM Services over a packet network. Two principal types of circuit emulation can be used: Circuit Emulation Service over Packet (CESoPSN[2]) and Structured Agnostic TDM over Packet (SAToP[3]). CESoPSN allows NxDS0 service including full T1/E1 capability. SAToP provides the ability to carry unstructured T1/E1 circuits across the IP/MPLS network.

In an IP/MPLS network the MPLS tunnel is used as the transport layer between the provider edge (PE) devices. A Pseudowire (PWE3[4])is created to identify the specific TDM circuit within the MPLS tunnel.

A circuit emulation interworking function on the 7705 SAR ensures that all information required by the T1/E1 circuit is maintained across the packet network. This provides a transparent service to the end user.

Figure 5. Circuit Emulation Service functionality overview



2 [RFC5086] A. Vainshtein, Ed., I. Sasson, E. Metz, T. Frost, P. Pate, « Structure-Aware Time Division Multiplexed (TDM) Circuit Emulation Service over Packet Switched Network (CESoPSN) », RFC 5086, December 2007.
3 [RFC 4553] Vainshtein, A., Ed., and YJ. Stein, Ed., "Structure-Agnostic Time Division Multiplexing (TDM) over Packet(SAToP)", RFC 4553, June 2006.
4 [RFC3985] Bryant, S. and P. Pate, "Pseudo Wire Emulation Edge-to-Edge (PWE3) Architecture", RFC 3985, March 2005.

Quality of Service (QoS)

The 7705 SAR provides comprehensive QoS functionality for controlling the network access traffic. At the network access point there are many customers and services configured. However, these services do not require the same treatment within the network. With mixed services, operators must be able to classify the traffic priority of Constant Bit Rate (CBR) services, high priority data services and best effort services. Once the traffic is classified, appropriate buffering and scheduling is provided for the given service. For example, voice traffic has very stringent latency and jitter requirements which translate to a high priority service with minimal queuing. High priority data may also require prioritized scheduling but may be less sensitive to delay and more sensitive to data loss - this requires a high priority classification with deep queuing capabilities. In the event of congestion, the system must police traffic flows to guarantee that lower traffic priorities are discarded before higher priorities.

In addition to controlling the QoS within the access node, the system must allow for appropriate handling within the packet network. This is achieved by shaping the traffic as it leaves the node and marking the traffic such that other elements within the packet network can make the appropriate decisions about the priority of this traffic.

Network timing and synchronization

In most TDM networks, synchronization is distributed within the network using the SONET/SDH mechanisms built into the physical layer definition. To deliver the TDM service via a packet network the same synchronization must be achieved through other means. Some TDM applications require Stratum level clocking and distribution of information with very stringent accuracy. Other applications, such as SLA management, only require timing for reporting purposes and have a much less stringent accuracy requirement. Alcatel-Lucent's announcement to expand the 7705 SAR product offering prompted the following statement.

> "The announcement reinforces the breadth and depth of the Alcatel-Lucent portfolio for mobile backhaul," said Stephane Teral, Infonetics. "Solving the Synchronous Ethernet is critical for the successful evolution to Ethernet in mobile backhaul. As HSPA data volumes continue to ramp, the networking solutions for networking offload should prove attractive as well."

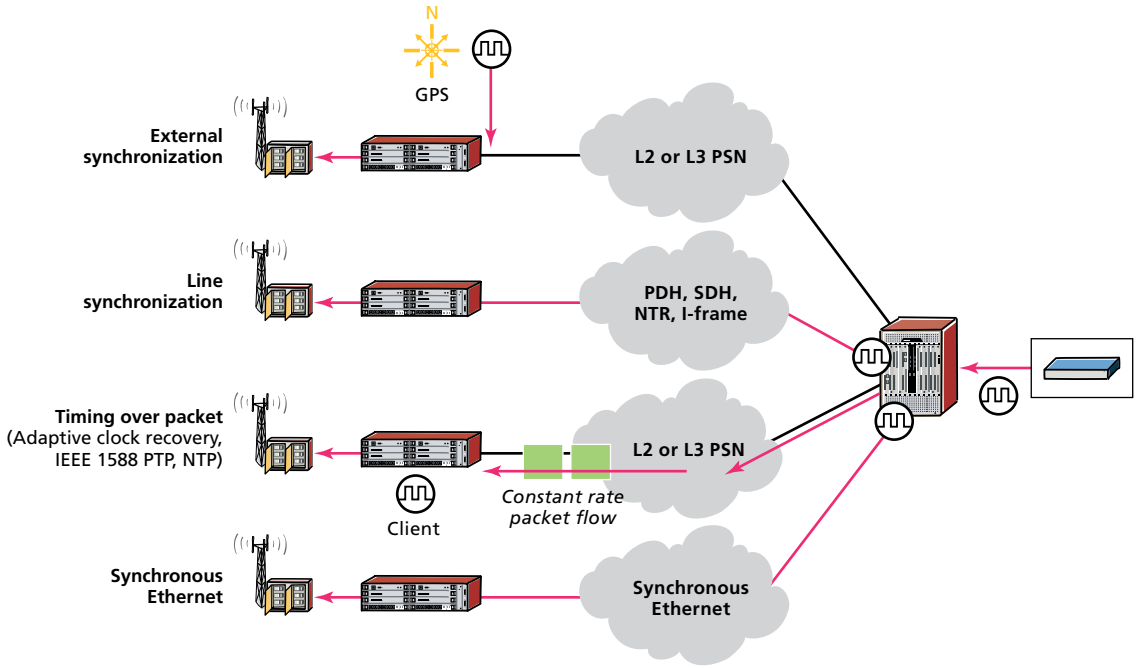
For OAM functions, it may be sufficient to use the Network Time Protocol (NTP) to synchronize the time of day of the various nodes in the monitored path.

Packetized data such as ATM or Ethernet do not have as stringent requirements for timing as TDM services. Buffering and idle data can be used to compensate for short term differences and data arrival rates.

For TDM services the operator can synchronize their network elements using one of the available methods:

- Synchronous Ethernet, if it is available on all elements within the packet network
- External timing using BITS or GPS input if the elements are within a central office
- Line timing, if there are available E1 links coming from the SONET/SDH network
- Adaptive Clock Recovery (ACR) for a remotely located network element.

Figure 6. Timing and synchronization delivery mechanisms on the 7705 SAR



In all cases the CPE device on the customer site can use the T1/E1 line timing to drive port synchronization. Across the packet network the T1/E1 buffers at both ends of the TDM PW can be sized to account for some level of packet delay variation (PDV). Depending on the type of information transported (voice or data) there may be a limitation to buffer size before there is an impact on the data quality.

An enterprise can distribute its own primary clock reference (PRC) to the remote offices. This is achieved by creating a TDM Pseudowire (PW) which derives the port clocking from the CPE connected to the customers Primary Reference Clock (PRC). The timing service is then transported across the packet network to the remote PE device where ACR is configured to capture the clocking information from the TDM PW. The timing is then delivered to the T1/E1 connected CPE on the remote customer site.

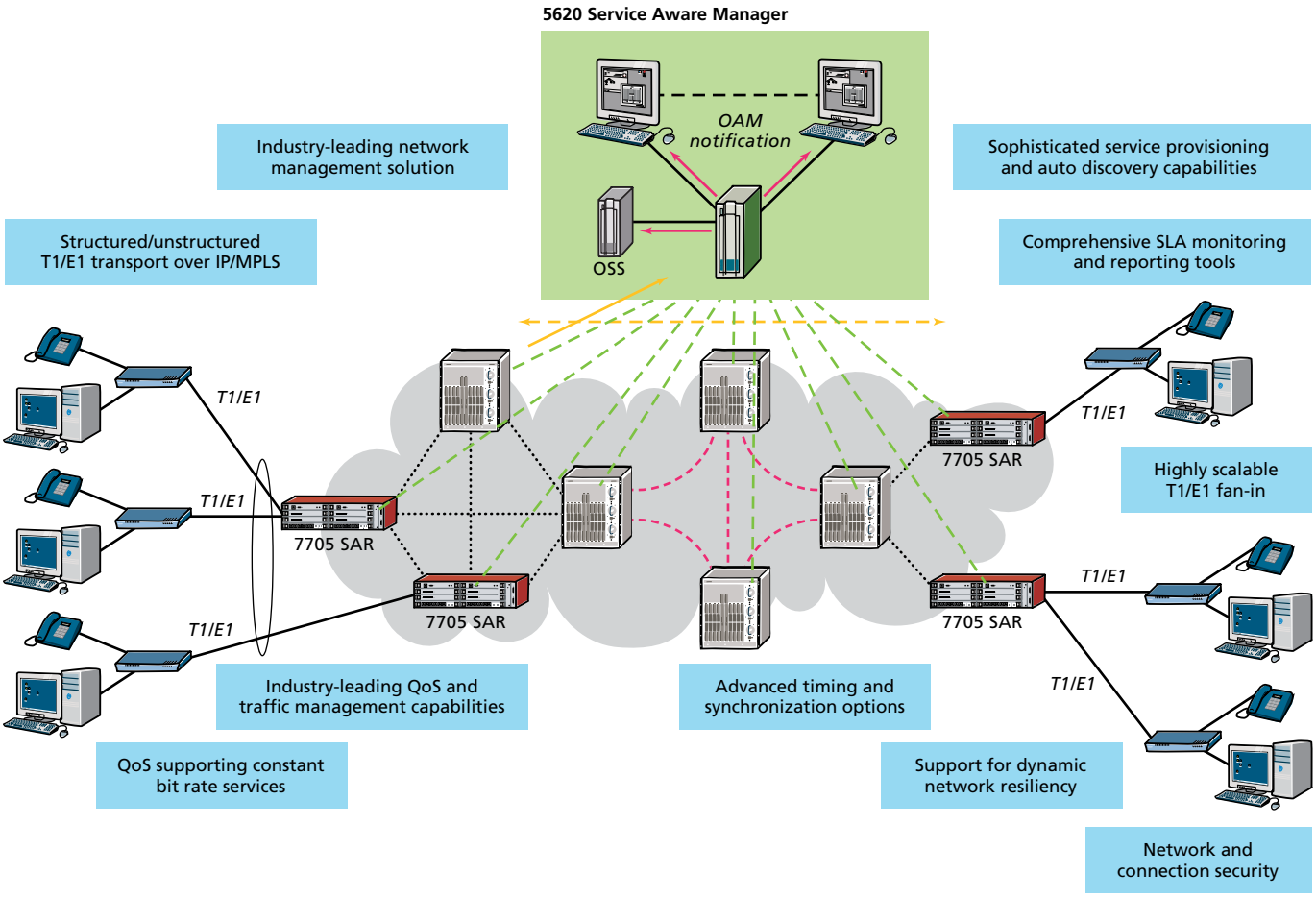
The choice for a synchronization deployment depends on the network architecture and services being delivered. However, a system must have the flexibility for configuration in a variety of clock distribution models that address the operator's requirements.

Network Resilience and Reliability

With IP/MPLS as the transport mechanism on the 7705 SAR, the network can take advantage of Fast Reroute (FRR) to direct traffic around network failures. The 7705 SAR can also create backup paths and standby pseudowires through the network. Additionally, Bidirectional Forward Detection (BFD) detects outages and initiates the 7705 SAR to move traffic to a standby path to avoid the network outage at the source of the MPLS path in the network.

The above functions work together to help minimize network outages and maintain the end-to-end SLA to the customer.

Figure 7. Network management for the end-to-end solution



Network Management and OAM

Operators have a powerful advantage when using one Network Management system such as the 5620 SAM to configure the network infrastructure and services from end to end. Problem detection and isolation is simplified with unmatched visibility of alarms, their information and their effect on network services. Collection of network statistics and inventory information is simplified. Operators receive feedback on the performance of the network and can pro-actively monitor the health of their services using standards based OAM tools such as VCCV, IP Ping, 802.1ag and 802.3ah. Further reporting or data processing is provided through open interfaces towards third party OSS tools or web portals.

One Network Management system simplifies the overall operational model.

Network and service security

Security is a serious mater within the network. A network element must protect against local intrusion to management and configuration, against nodal attacks and against malicious intrusion to the network.

The 7705 SAR uses secure open interfaces such as SSHv2, secure FTP, and SNMPv3 for remote access. The 7705 SAR also uses multiple methods of authentication and authorization such as local password protection, RADIUS or TACACS. System logging can be enabled to capture specific performed activities and to securely send the data to a remote server. Alarms may be raised upon suspicious sequences of operations such as multiple failed login attempts.

Additionally, basic firewall functions such as Access Control Lists (ACL) can be used to prevent malicious users from entering the system from the network. The control infrastructure is protected from denial of service attacks by rate-limiting the flow of traffic to the control and switching module.

Solution business case

Alcatel-Lucent performed a solution business case based on Tier 1 North American operator data and industry information. The business case focus is to study the value proposition of providing T1 services over a packet network.

The business case examines the following:

- The present mode of operation (PMO) which includes the cost of investing in legacy Plesiochronous Digital Hierarchy (PDH) access equipment to provide the T1 access
- The future mode of operation (FMO) which includes the cost of moving all T1 services to an IP/MPLS infrastructure using Alcatel-Lucent's 7705 SAR

The services considered in the analysis were Private Line and IP VPN services. The business case analyzes both a dense and sparse metro area for the total cost of ownership (TCO). This includes both the capital investment and operations expenses incurred over a five year period (2009-2013).

The assumptions made for the capital investment analysis are:

- Existing TDM equipment will be replaced due to life cycle reasons.
- Metro Ethernet core has been deployed for other services and is not heavily utilized (30% utilization).
- Network Management and Engineering, and Installation and Integration are included at normal industry cost for both PMO and FMO.

The assumptions made for operating expense analysis are:

- Network operations savings due to faster provisioning of services and improved efficiency in responding to alarms[5] as well as the reduction in Network Operations Center (NOC) costs.
- Maintenance charges including both network elements and network management.
- T1 facility leasing charges are included.

The assumptions on network operations are based on Metro Ethernet Forum data (2005).

Metro traffic is projected to grow at 5% annually over the planning horizon for both dense and sparse metro scenarios.

Figure 8 and Figure 9 compare the TCO for replacing the existing SONET network in the PMO with the TCO of introducing the 7705 SAR into the FMO to provide Private Line services. Two types of metropolitan areas are considered in this example: A dense metro area such as Washington, DC and a sparse metro area such as Buffalo, New York. Figure 8 illustrates the TCO comparison while Figure 9 illustrates the details of the CAPEX component.

5 Forrester report on 5620 SAM, December 2007

Figure 8. Total Cost of Ownership (TCO) comparison of PMO to FMO for dense and sparse metro areas

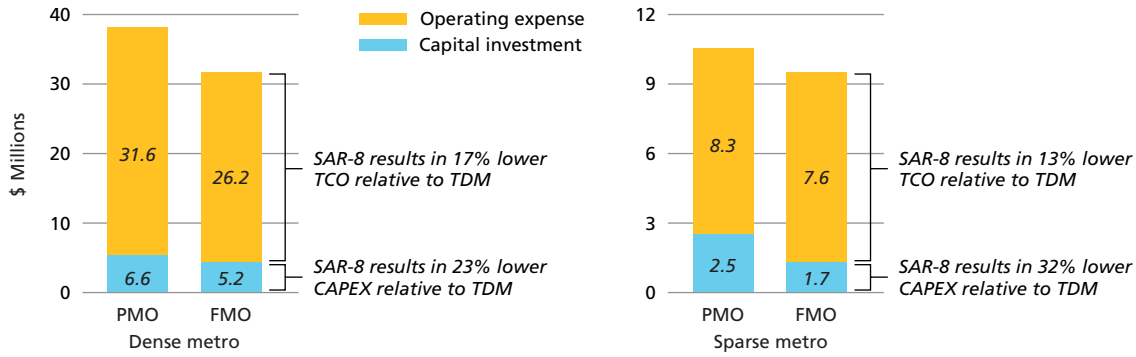
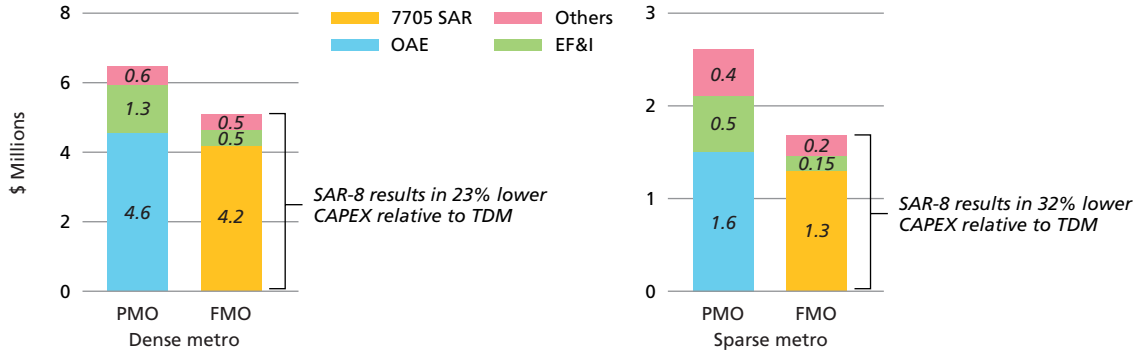


Figure 9. CAPEX breakdown comparison of PMO to FMO for dense and sparse metro areas



Business case summary

The business case shows that Alcatel-Lucent's 7705 SAR, when used to transition the T1 Private Line services to an IP/MPLS network, reduces the CAPEX; a 23% reduction over the PMO in the dense metro and as much as a 32% reduction in the sparse metro. The TCO results show that the 7705 SAR reduces total cost of ownership by 17% over the PMO in the dense metro and 9% in the sparse metro.

There is a significant OPEX savings in the FMO due to the increased capabilities provided through the common network management tool, 5620 SAM. The dense metro shows more dramatic improvements over the sparse metro due to the overall number of network operations such as customer adds or changes. Increased visibility of the network and effective tools to manage the network also provide a dramatic difference to the overall solution.

CAPEX savings are quite dramatic. Installation and commissioning costs represent a major area of savings. A simple-to-deploy and centrally configurable system reduces the expertise required for on-site installation and allows for centralized expertise centre. Effective remote trouble shooting tools will also reduce the on-site hours and isolate issues in the network more accurately and quickly.

In summary, the FMO shows greater OPEX and CAPEX savings than those seen through replacement of the existing SONET network. Additionally, the operator can provide new services such as L2VPN and L3VPN connectivity to their customer. This solution is very compelling; it transitions existing services and provides the ability for new service delivery while saving expenditures.

Summary

Operators must protect their existing TDM revenues while providing the same quality of experience. At the same time, operators are under pressure to reduce spending and offer new services. To address these objectives operators must leverage a common infrastructure with flexible access options that address a number of technical requirements: Delivery of circuit emulation, quality of service, network synchronization, network resiliency, network security and a network management platform which brings the solution together.

The introduction of IP/MPLS within the metro network allows operators to capture revenues from high growth services such as L2VPN and L3VPN Business Services. It also creates an opportunity for operators to leverage IP/MPLS to carry other existing services such as Private Line services. Operators must decide how to transform their network from SDH/SONET to MPLS and how to effectively serve their end customers. Maximizing the return on the IP/MPLS network by migrating services provides both CAPEX and OPEX returns for total cost of ownership.

Alcatel-Lucent products facilitate the transition of Private Line services using the 7705 SAR and the 5620 SAM in conjunction with the SR family of products. This product suite allows an operator to provide circuit emulation services in a predictable and secure way through a common infrastructure—providing the quality of experience business customers require. Simultaneously, the provider's operations are streamlined through efficient end to end service provisioning and network management.

With Alcatel-Lucent, operators have a solution that provides the technical requirements to meet their needs; a solution that allows them to successfully meet their customer expectations and compete in the marketplace.

Abbreviations

ACR	Adaptive Clock Recovery
ACL	Access Control List
BFD	Bidirectional Forward Detection
CBR	Constant Bit Rate
CES	Circuit Emulation Service
CPE	Customer Premise Equipment
FCAPS	Fault, Configuration, Accounting, Performance and Security Management
FMO	Future Mode of Operation
FRR	Fast Reroute
HIS	High Speed Internet
L2VPN	Layer 2 Virtual Private Network
L3VPN	Layer 3 Virtual Private Network
MEF	Metro Ethernet Forum
NOC	Network Operations Center
NTP	Network Time Protocol
OAE	Optical Aggregation Equipment
PDH	Plesiochronous Digital Hierarchy
PDV	Packet Delay Variation
PE	Provider Edge
PMO	Present Mode of Operation
PRC	Primary Clock Reference
PSTN	Public Switched Telephone Network
PW	Pseudowire
RADIUS	Remote Access Dial-In Service
SLA	Service Level Agreement
SNMP	Simple Network Management Protocol
SSH	Secure Shell
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical Networking
TACACS	Terminal Access Controller Access-Control System
TALS	TDM Access Line Service
TCO	Total Cost of Ownership
TDM	Time-Division Multiplexing
VPRN	Virtual Private Routed Network

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