

MEETING PERVASIVE ETHERNET-BASED SERVICE DEMANDS WITH INTEGRATED PACKET TRANSPORT

THE VALUE OF PACKET-OPTIMIZED WDM APPLICATION NOTE



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ABSTRACT

The rising demand for Ethernet-based cloud, mobile and video services continues to apply enormous pressure on networks. Soon 80 percent of all new software will be available through the cloud, approximately 58 percent of all web traffic will be video based and, by the end of the decade, there will be 20 billion smart devices¹ connected to the network. These megatrends represent an inflection point for service providers to consider adopting a packet-optical network solution that cost effectively meets bandwidth demands and enables differentiated, Carrier Ethernet-based services. Integrated Packet Transport (IPT) leverages the power and value of the Alcatel-Lucent Service Router Operating System (SR OS). Proven in over 500 customer networks worldwide, this system has been augmented to the scalable, multiservice Alcatel-Lucent 1830 Photonic Service Switch (PSS) wavelength division multiplexing (WDM) transport platform. IPT is easily integrated into a fully managed end-to-end Layer 2 transport architecture using a common service, operation, and management model from core to aggregation to the customer edge. Integrated Packet Transport, based on scalable packet-optimized WDM, enables the transformation to a converged metro aggregation network that cost effectively delivers multiple services. This is a key step in the evolution to Agile Optical Networking. Our comprehensive and optimized Integrated Packet Transport feature drives lower total cost of ownership (TCO), differentiated services, and maximum return on investment (ROI).

TABLE OF CONTENTS

Carrier Ethernet Transport Market Drivers / 1 Strategy for Packet-Optical Transport Network Transformation / 1 Packet-Optimized WDM - a Streamlined Solution for Pervasive Ethernet Services / 2 Integrated Packet Transport - Leveraging Alcatel-Lucent Service Router Operating System / 3 Efficient, versatile, and reliable Layer 2 transport / 4 Get more efficiency / 5 Get more versatility / 5 Get more reliability / 5 Integrated Packet Transport Applications / 6 Broadband backhaul and IPTV/video distribution / 7 Business Ethernet access services / 8 Wholesale Ethernet access services / 9 Mobile backhaul for 3G, 4G, and LTE / 10 Enterprise verticals / 11 Cloud services / 11 Summary / 12 Acronyms / 13

CARRIER ETHERNET TRANSPORT MARKET DRIVERS

Carrier Ethernet (CE) is well accepted in a range of enterprise, wholesale, and vertical market applications due to its performance, economics, and global standardization. It has successfully overtaken legacy time division multiplexing (TDM) services to handle predominantly packet-based data, video and mobile traffic. The Metro Ethernet Forum (MEF) specifications are built around the five key attributes of CE: scalability, reliability, service management, quality of service (QoS), and standardized services.

This has led to the wide adoption of MEF-certified equipment and services in the last 10 years. However, the influx and expected growth of on-demand Ethernet-based cloud, video and mobile broadband services (see Figure 1), the new service connectivity models along with the same or better quality of experience (QoE), will further stress network capacity, performance and costs.

Figure 1. Megatrends in the industry: Cloud, video and mobile



Approximately **58%** of all Internet traffic will be video by 2015**



* Bell Labs study, Value of Cloud for a Virtual Service Provider, 2011.

** Informa Telecoms and Media, 2011

*** Strategy Analytics

These megatrends represent a trigger for service providers to consider adopting a packet-optical network solution that cost effectively meets bandwidth demands and enables differentiated, Carrier Ethernet-based services. Efficient, versatile, and reliable packet-optical transport network designs are needed to maximize revenue opportunities while minimizing capital expenditures (CAPEX) and operating expenses (OPEX).

STRATEGY FOR PACKET-OPTICAL TRANSPORT NETWORK TRANSFORMATION

Pervasive Ethernet-based cloud, mobile and video services dictate evolution to a packetoptimized metro core with traffic aggregation efficiency and versatility to ensure optimal user experience. Figure 2 illustrates a packet-optical transport network transformation strategy for service providers.

Figure 2. Strategy for packet-optical network transformation



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CARRIER ETHERNET DELIVERS VALUE -THE FOUR TRUTHS

- Ethernet is carrier-class and costs less
- SONET/SDH like determinism, resiliency, and end-to-end connections
- Enterprises and service providers want Ethernet
- Service providers deploy
 Ethernet to satisfy growing
 demand and to simplify their
 networks to carry growing data
 traffic as well as TDM traffic
- Ethernet is integral to network transitions
 - Goal IP/MPLS/Ethernet data service layer over a fused
 Ethernet/WDM transport layer
- Enterprises converge multiple services onto a single Ethernet connection
 - Improved TCO , performance monitoring/management, ease of use
- Infonetics "Carrier Ethernet Equipment" April, 2012

CARRIER ETHERNET ADDRESSES HIGH-PERFORMANCE, LOW-COST CHALLENGES

A report by Heavy Reading highlights the high-performance, low-cost conundrum facing service providers: "...the industry is generally moving in the direction of a broadband utility model in which utility computing and storage capabilities (located in data centers) are connected by low-latency Ethernet and wavelength services and are delivered to a customer – with an on-demand option – through a single Ethernet user network interface that can handle many applications with SLA guarantees."

- Heavy Reading Ethernet Executive Council State-of-the-Industry Report, April 2012

The implications of these trends for service providers offering advanced Ethernet services include:

- Perception that Ethernet, Cloud and transport are cheap
- Service providers must scope, scale and differentiate services to maximize profit margins
- Multipoint services become more prevalent
- Standards-based interoperable Ethernet OAM is critical

PACKET-OPTIMIZED WDM - A STREAMLINED SOLUTION FOR PERVASIVE ETHERNET SERVICES

The trends and requirements for packet transport suggest a need for a packet-optimized WDM solution for its scalability, reliability, and versatility. Until recently, most deployments of packet over WDM have used point-to-point wavelengths with basic grooming through virtual LAN (VLAN) or Optical Transport Network (OTN) multiplexing. Delivery of such Ethernet Private Line (EPL) or Ethernet Virtual Private Line (EVPL) services with different levels of transparency has been sufficient to meet most needs. However, support for more sophisticated point-to-point and multipoint services dictate a need to integrate Layer 2 (L2) aggregation into WDM while providing L2 networking. An integrated L2 over a WDM solution leverages statistical multiplexing of services from multiple sites, allows better bandwidth/wavelength utilization, supports delivery of E-LAN and E-Tree multipoint services, and provides QoS, Ethernet service operations, administration, and maintenance (OAM), and service-level agreement (SLA) monitoring. These advanced capabilities are critical to service differentiation in a competitive market.

A packet-optimized WDM solution enables the transformation to a converged metro aggregation network that cost effectively delivers multiple services including legacy and packet services such as, Synchronous Digital Hierarchy/Synchronous Optical Network (SDH/SONET), Asynchronous Transfer Mode (ATM), video, storage area network (SAN), lambda, and OTN. Using a scalable, multiservice platform, this convergence not only allows network element consolidation, but also improves bandwidth utilization and operational efficiencies. A packet-optimized WDM solution enables a more efficient, versatile, and reliable network resulting in lower TCO, accelerated time to revenue and ROI.



Figure 3. Packet-optimized WDM for more efficient, versatile, and reliable L2 transport

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INTEGRATED PACKET TRANSPORT -LEVERAGING ALCATEL-LUCENT SERVICE ROUTER OPERATING SYSTEM

Integrated Packet Transport provides carrier-grade L2 transport, switching, and networking plus OTN aggregation and on-ramp converged in the Alcatel-Lucent 1830 Photonic Service Switch (PSS). This single-box OTN/WDM platform introduces a new generation of streamlined packet-optical transport solutions spanning access through the core network. More so, it leverages the power and value of the Alcatel-Lucent Service Router Operating System (SR OS) to enable a fully managed packet solution with a common service, operations, and management model across the Alcatel-Lucent optical and IP/ MPLS/Ethernet portfolio. This results in a more comprehensive and efficient solution — from IP/MPLS core to aggregation to customer edge — versus multibox or partnered solutions using disjointed operating and management systems. IPT enables a more efficient, versatile and reliable L2 transport solution.

Key elements include point-to-point Ethernet service muxponders, Ethernet switching muxponders, Ethernet switching OTN client cards, network interface demarcation devices, miniaturized to smart Small Form Factor Pluggables[™] (SFPs) and a common IP/optical packet operational model. These all exist on a single platform for business/wholesale, mobile/broadband backhaul, public/private cloud, and vertical service delivery. End-to-end management is provided by the Alcatel-Lucent 5620 Service Aware Manager (SAM) aligned with Alcatel-Lucent IP/MPLS/Ethernet products. These key elements can also be managed by the Alcatel-Lucent 1350 Optical Management System (OMS) and the Alcatel-Lucent 1354 Photonic Manager (PhM).



Figure 4. Integrated Packet Transport – key elements

Point-to-point (P2P) muxponders feature L2 statistical multiplexing capability to aggregate Gigabit Ethernet (GigE) traffic in the access domain. Enhanced P2P muxponders offer higher service scalability and additional OAM, protection and Synchronous Ethernet (SyncE) features.

- EPL, EVPL services
- Flexible classification
- MEF ingress bandwidth profile
- CE OAM (IEEE 802.1ag and ITU-T Y.1731)
- Performance monitoring (PM)
- Link Aggregation (LAG)
- SyncE frequency synchronization
- 1588v2 P2P phase timing

Ethernet switching muxponders and Ethernet switching OTN client cards leverage SR OS. They feature L2 switching capability to aggregate traffic in the access and optional higher capacity to provide optimal scalability in the aggregation network as well as optional client/line switching to optimize OTN applications; for example, between routers and 100G WDM lines.

Features (in addition to those listed for P2P muxponders):

- Full interworking with the Alcatel-Lucent 7750 Service Router (SR), the Alcatel-Lucent 7450 Ethernet Service Switch (ESS), and the Alcatel-Lucent 7210 Service Access Switch (SAS) under common network management
- E-Line, E-LAN, E-Tree services
- SR OS service model (service access point [SAP], virtual private LAN services [VPLS])
- MEF CE 2.0 certified
- Ingress service QoS classification, metering/policing per class of service (CoS) (8 QoS classes)
- 8 queues per port with scheduling and congestion management

Ethernet demarcation options for network interface devices (NID) connected to the 1830 PSS include:

- Multichassis Link Aggregation (MC-LAG)
- ITU-T G.8032 Ethernet Ring Protection (ERP) (including multiring interconnection)
- CE NID: Fully featured and managed NID
- Smart cEDD: Simpler demarcation NID, remotely managed
 - ¬ Simpler functionality: IEEE 802.1aj two-port MAC relay (TPMR), link-level CFM, LPT
 - ¬ User network interface (UNI) service classification/QoS functionality centralized on 1830 PSS UNI and remote management from 1830 PSS
- L2 OAM Smart SFP™: Ultimate miniaturization, lowest cost and best reliability
 - ¬ Simplification and miniaturization of Smart cEDD and integration into the customer premises equipment (CPE)
- Remote management from the Alcatel-Lucent 1830 PSS
- Passive (powered by CE device)

EFFICIENT, VERSATILE, AND RELIABLE LAYER 2 TRANSPORT

Integrated Packet Transport is a comprehensive and optimal packet transport solution that combines L2 transport with the scalable, multireach, multiservice 1830 PSS WDM platform. From access to the core, the solution delivers efficiency, versatility, and reliability through advanced features such as:

- Carrier-grade L2 transport, switching and networking plus OTN aggregation
- Operational efficiency by leveraging the proven Alcatel-Lucent SR OS to provide comprehensive Ethernet switching capability
- Consistent operations model for Ethernet services between Alcatel-Lucent optical transport and IP/MPLS/Ethernet solutions
- Network optimization with a converged and scalable platform
- WDM resilience with advanced Carrier-grade Ethernet transport and networking features
- One platform for business/wholesale, mobile/broadband backhaul, private/public cloud and vertical services

Get more efficiency

Integrated Packet Transport enables increased operational efficiency, scalability, network optimization and bandwidth utilization, compared with point-to-point interconnection of routers. Extending SR OS to the IPT affords lower TCO due to fault, configuration, account, performance, security/fulfillment, assurance, billing (FCAPS/ FAB) commonality, and the common management practices derived from a unified network management platform (Alcatel-Lucent 5620 SAM). The right-size and bandwidth-efficient solution also helps service providers meet QoE requirements.

Get more versatility

Integrated Packet Transport provides optimal CE transport from the local area network (LAN) to the metropolitan area network (MAN) to the wide area network (WAN), all on one platform that addresses business/wholesale, mobile/broadband backhaul, private/ public cloud, and vertical applications. This packet-optimized WDM solution also cost effectively delivers multiple services including legacy and packet services such as SDH/SONET, ATM, video, SAN, lambda, and OTN.

Get more reliability

Integrated Packet Transport leverages the proven and reliable SR OS and advanced networking features to deliver high-availability packet services. MEF certification assures the solution meets stringent industry-adopted criteria for standardized service types, scalability, reliability, QoS, and service management.

VALUE	BENEFIT	ENABLING FEATURE
Efficiency	 Streamlines operations Scales to meet demand Consolidates and optimizes the network Makes better use of available bandwidth 	 NE and port consolidation WDM and L2 scalability Alcatel-Lucent packet SR OS augmented for transport - with 7x50 interworking, common service model, feature implementation and CLI/MIBs End-to-end 5620 SAM management Bandwidth efficiency - IGMP snooping
Versatility	 Multiple packet interconnect, service and application options on a multireach photonic platform Optimal CE transport from LAN to MAN to WAN 	 Service granularity - FE/1GigE, N x 1GigE, N x 10GigE Supports multiple aggregation applications, demarcation options Statistical multiplexing aggregation of multiple services/sites Packet system architecture evolution
Reliability	 Proven, reliable SR OS Carrier-grade Ethernet transport with advanced networking features 	 MEF CE 2.0 certified SR OS augmented to 1830 PSS platform Advanced carrier-grade networking: Multi- QoS, Ethernet OAM, PM and protection MC-LAG Multipoint service protection with load balancing Resilient ring interconnection with G.8032 ERP NID replacement with Smart SFP[™]

Table 1. Integrated Packet Transport features and benefits

INTEGRATED PACKET TRANSPORT APPLICATIONS

Integrated Packet Transport comprises features and capabilities for CE networking at L2 consistent with criteria set by the MEF. As shown in Figure 5, these features are related to scalability, service support, QoS, OAM and PM, protection, synchronization, and network interface demarcation. Such features support a range of applications. In addition, a packet-optimized WDM solution enables the transformation to a converged metro aggregation network that cost effectively delivers multiple services including legacy and packet services such as TDM, video, SAN, lambda, and OTN.



Figure 5. Integrated Packet Transport – built on the scalable, multiservice, multireach Alcatel-Lucent 1830 PSS WDM platform

- Bandwidth scalability 1GigE, N x 1GigE, 10GigE clients
- Support for E-Line, E-LAN, and E-Tree
- Ethernet Virtual Connection (EVC) segregation by VLAN
- MEF basic QoS
- Carrier-grade Ethernet Ring Protection (ERP) combined with 1 + 1 ODUk subnetwork connection protection (SNCP)
- Ethernet service OAM and PM

- LAG and MC-LAG for UNI protection in access and UNI/External network-network interface (E-NNI) protection at hub node-router handoff
- SyncE with E-SSM for frequency reference distribution
- IEEE 1588v2 PTP transparency
- Demarcation solutions (NIDs to Smart SFP[™])

Additional critical and differentiated features are also provided to support the following specific applications. In each case, IPT is part of a comprehensive Ethernet services solution along with applicable Alcatel-Lucent IP/MPLS/Ethernet elements leveraging a common operations and management model.

Broadband backhaul and IPTV/video distribution

Service providers must evolve their network to handle the bandwidth demands from burgeoning FTTx deployments. The bandwidth growth resulting from the transition from digital subscriber line (DSL) to gigabit-capable Passive Optical Network (GPON) calls for WDM aggregation rings. Converging packet and WDM into one platform not only improves the economics from an equipment CAPEX perspective — based on pure port and network element consolidation — but also from an increased fiber utilization perspective. Operational efficiencies are also achieved as the converged infrastructure is extended to transport multiple services.

The switched Ethernet transport capability on the 1830 PSS is essential for this application due to the capacities that are required. And, it is more efficient at higher scales than CE switches with multiple 10Gs of capacity with external filters, colored optics, and multiple stacked 10G WDM rings. E-LAN and E-Tree are key enablers here as well. The present mode of operation is to let the multicast router replicate at the head end and consume (n) router ports for each replication. Because most of the traffic is the same between the digital subscriber line access multiplexer/optical line terminal (DSLAM/ OLT), it is much more efficient to achieve the same result by implementing L2 multicasting, and as such, consume many fewer wavelengths. Finally, L2 multicasting will be the most efficient bandwidth approach due to Internet Group Management Protocol (IGMP) snooping, fast leave and proxy, among other reasons.

- IP DSLAM, GPON OLT, Cable Modem Termination System/Converged Cable Access Platform (CMTS/CCAP) backhaul
- E-LAN or E-Tree perfectly suited for multicast and dual router homing
- Wide range of interconnection protection options
- IPTV (streamed and on-demand video distribution) combined with Internet access for residential, and LAN interconnect for small office, home office and small to medium enterprise (SOHO/SME)
- Better wavelength and bandwidth utilization with L2 multicast and IGMP snooping
 ¬ IGMP proxy and fast leave for complete optimization and QoE



Business Ethernet access services

New, on-demand point-to-point and multipoint services require scalable, versatile and reliable packet transport architectures. The ability to provide a 10GigE UNI on a switched Ethernet card is critical to deliver enhanced Ethernet services with QoS, OAM, and multi-cast capability. Support of sub-50 ms protection is provided by hardware-based OAM. Different aspects of protection are supported, such as protection of an individual node or card, as well as end-to-end protection of an Ethernet Virtual Circuit (EVC) by ERP, and protection of a UNI and E-NNI as supported by LAG and MC-LAG. This L2/WDM solution for business services supports the ability to create service bundles. For example, Ethernet services can be combined with legacy TDM and SAN interfaces, all of which can be transported over WDM. Otherwise, a separate NID and separate transport network element would be required for each technology or service. Combined, these features enable increased bandwidth, improved reliability, greater service differentiation, and network element consolidation. The net result is reduced OPEX and CAPEX as well as improved ROI.

- Part of a comprehensive Ethernet business access services solution along with the Alcatel-Lucent 7210 SAS, Alcatel-Lucent 7450 ESS, and the Alcatel-Lucent 7750 SR
- Consistent end-to-end service operational model
- Support for E-Line, E-LAN, and E-Tree
- MEF-compliant QoS for service differentiation
- Scalable UNI: Fast Ethernet (FE), GigE, N x GigE, 10GigE,, compliant to MEF UNI Type 2 (MEF 20)
- Ethernet Service OAM for service assurance and SLA monitoring
- Carrier-grade protection with ERP and LAG/MC-LAG
- Bundling with TDM and SAN services



Wholesale Ethernet access services

IPT comprises features required in the business Ethernet access solution. However, in this case, industry-standard (MEF) E-NNI capability is provided for interconnection to external domains and networks.

- E-Access service support
- SLA-based wholesale access services
- SLA monitoring, performance measurement and reporting
- Global Interconnect with E-NNI (MEF 26)
- Resilient service delivery





Mobile backhaul for 3G, 4G, and LTE

Today's mobile backhaul transport solutions must support a wide range of standard interconnection options from the cell site to the aggregation layer. The 1830 PSS supports multiple aggregation applications with a full range of Ethernet packet modules and interconnection options.

While 2G and 3G backhaul were primarily E-Line, 4G/Long Term Evolution (LTE)/ WiMAX® backhaul introduce a paradigm shift in the service connectivity models between eNodeBs and gateways, for which E-LAN and E-Tree services are very well suited. Offering exceptional CE backhaul feature richness, the 1830 PSS enables service providers to offer differentiated granular services including FE/GigE, N x 1GigE, and 10GigE. The platform supports E-Line, E-LAN and E-Tree services. Synchronization support includes SyncE (frequency) and IEEE 1588v2 (phase/time). The 1830 PSS offers 10GigE port density.

Features:

- SyncE for frequency synchronization
- Multiple Radio Access Network (RAN) resiliency options
- Multipoint switching for S1 and X2 interfaces (LTE)
- Service OAM including delay and loss measurement per CoS
- Compliance to MEF 22.1 Mobile Backhaul Implementation Agreement
- Smart SFP[™] for remote demarcation at outdoor cell site (for example: small cells)

Figure 9. Integrated Packet Transport for mobile backhaul



Enterprise verticals

Enterprises require scalable, secure, flexible and predictable service performance for mission-critical applications as well as high-capacity data center connectivity.

Features:

- 10GigE over WDM backbone for municipalities, railway/subway companies, power utilities, National Research and Education Networks (NREN), and very large enterprises
- Transparent LAN interconnection for video surveillance, and more
- Strong Ethernet OAM for monitoring of mission-critical applications
- Carrier-grade, sub-50 ms protection

Figure 10. Integrated Packet Transport for enterprise verticals



Cloud services

Packet-optimized WDM is used to interconnect cloud consumers to service providers through CE. MEF-defined CE services supported on the 1830 PSS provide E-LAN and E-Tree to offer more scalable cloud services with disaster recovery and flexible service reconfiguration. These features and capabilities support the on-demand, bursty dynamic nature of cloud-based services in terms of service provisioning/configuration flexibility, class of service differentiation, security and reliability — all enabling new revenue-generating service potential.

- Ethernet over optical cloud carrier services: Secure, predictable performance and control of data governance
- E-LAN for private cloud WAN solution
- E-Line or E-Tree for private cloud, community cloud or hybrid cloud WAN solution
- E-LAN and E-Tree facilitate data replication, disaster recovery, and cloud bursting, making it simpler to add additional cloud customers as opposed to using E-Lines

Figure 11a. Integrated Packet Transport for cloud services: E-LAN for private cloud WAN solution



Figure 11b. Integrated Packet Transport for cloud services: E-Line or E-Tree for private cloud, community cloud or hybrid cloud WAN solution



SUMMARY

Our Integrated Packet Transport capability provides a comprehensive and optimized L2 packet transport solution for service providers who need to evolve their network to meet pervasive Ethernet-based cloud, mobile and video services. Unlike inefficient multibox or partnered CE transport solutions using disjointed operating and management systems, Integrated Packet Transport leverages the power of Alcatel-Lucent SR OS augmented to the scalable, multiservice, multireach 1830 PSS WDM transport platform. The offer is easily integrated into an optimal, fully managed packet solution — with a common service, operations and management model — from core to aggregation to customer edge. In sum, Integrated Packet Transport drives lower TCO, differentiated services and maximum ROI.

ACRONYMS

ATM	asynchronous transfer mode	
BTS	base transceiver station	
CAPEX	capital expenditures	
ССАР	Converged Cable Access Platform	
CE	Carrier Ethernet	
cEDD	compact Ethernet Demarcation Device	
CFM	Connectivity Fault Management	
CLI	command-line interface	
CMTS	Cable Modem Termination System	
CoS	class of service	
CPE	customer premises equipment	
DSL	digital subscriber line	
DSLAM	digital subscriber line access multiplexer	
DWDM	dense wavelength division multiplexing	
E-LAN	Ethernet local area network	
ELP	Ethernet link protection	
E-NNI	External network-network interface	
EPL	Ethernet private line	
ERP	Ethernet Ring Protection	
ESS	Ethernet Service Switch	
E-SSM	Ethernet synchronization status messages	
EVC	Ethernet virtual circuit	
EVPL	Ethernet virtual private line	
FAB	fulfillment, assurance, billing	
FCAPS	fault, configuration, account, performance, security	
FE	Fast Ethernet	
GigE	Gigabit Ethernet	
GPON	gigabit-capable Passive Optical Network	
IEEE	Institute of Electrical and Electronics Engineers	
IGMP	Internet Group Management Protocol	
IP	Internet Protocol	
IPTV	Internet Protocol television	
ITU	International Telecommunication Union - Telecommunication	
L2	Layer 2	
LAG	Link Aggregation	
LAN	local area network	
LPT	lower-order path termination	
LTE	Long Term Evolution	
MAC	media access control	
MAN	metropolitan area network	
MC-LAG	Multichassis Link Aggregation	
MEF	Metro Ethernet Forum	
MIB	management information base	
ML-PPP	multilink point-to-point protocol	
MPLS	Multiprotocol Label Switching	

MPLS-TP	Multiprotocol Label Switching Transport Profile	
NE	network element	
NID	network interface device	
NREN	National Research and Education Networks	
OAM	operations, administration, and maintenance	
ODU	optical data unit	
OLT	optical line terminal	
OMS	Optical Management System	
OPEX	operating expense	
OS	operating system	
OTH	Optical Transport Hierarchy	
OTN	Optical Transport Network	
P2P	point-to-point	
PhM	Photonic Manager	
PM	performance monitoring	
PSS	Photonic Service Switch	
PTN	Packet Transport Network	
PTP	Precision Time Protocol	
QoE	quality of experience	
QoS	quality of service	
RAN	Radio Access Network	
ROI	return on investment	
SAM	Service Aware Manager	
SAN	storage area network	
SAP	service access point	
SAR	Service Aggregation Router	
SAS	Service Access Switch	
SDH	Synchronous Digital Hierarchy	
SFP	Small Form Factor Pluggable™	
SLA	service-level agreement	
SME	small to medium enterprise	
SNCP	subnetwork connection protection	
SOHO	small office, home office	
SONET	Synchronous Optical Network	
SR	service router	
SyncE	Synchronous Ethernet	
TCO	total cost of ownership	
TDM	time division multiplexing	
TPMR	two-port MAC relay	
TSS	Transport Service Switch	
UNI	user network interface	
VLAN	virtual LAN	
VPLS	virtual private LAN service	
WAN	wide area network	
WDM	wavelength division multiplexing	

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