Meeting pervasive Ethernet-based service demands with Integrated Packet Transport

The value of packet-optimized optical networks

Application note

NOKIA

Abstract

The rising demand for Ethernet-based cloud, mobile and video services continues to apply enormous pressure on networks. Consider that 40% of all new premises-based compute and storage will soon be cloud-based, approximately 65% of all Internet traffic is video (up from 51% in 2016), and by the end of the decade, mobile data traffic will triple to reach over 400 exabytes (EB) per month. 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 Nokia Service Router Operating System (SR OS). This operating system has been augmented to the scalable, multiservice Nokia 1830 Photonic Service Switch (PSS) transport platform which is proven in over 1,100 customer networks worldwide. 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 wavelength division multiplexing (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).

Contents

Carrier Ethernet transport market drivers

Carrier Ethernet (CE) has become well accepted in various enterprise, wholesale, and vertical market applications, owing to its superior performance, cost-effectiveness, and adherence to global standardization. CE efficiently handles packet-based traffic in alignment with the Metro Ethernet Forum (MEF) specifications, revolving around scalability, reliability, service management, quality of service (QoS), and standardized services. With the proliferation of on-demand Ethernet-based cloud, video, and mobile broadband services, the demand for new service connectivity models with exceptional Quality of Experience (QoE) underscores the imperative for network capacity to scale effectively, ensuring enhanced performance at lower costs.

The Carrier Ethernet transport market is being propelled by a convergence of key factors, each contributing to its rapid expansion and evolution. These include:

- **Rising demand for subscription-based services**: Subscription-based models such as network-as-a-service are fueling the growth of metro Ethernet, with a projected increase in premises-based compute and storage consumed as a service by 2025. This transition towards a broadband utility model necessitates low-latency Ethernet services capable of handling various applications with SLA guarantees.
- **Mission-critical applications**: While standard Ethernet offers limited quality of service across multiple domains, Carrier Ethernet provides end-to-end connections with determinism, resiliency, and robust service management features crucial for supporting mission-critical applications. This enables service providers to scope, scale, and differentiate services to maximize profit margins.
- **Rising video content**: High-definition video applications like video conferencing and streaming are driving up data traffic needs, necessitating metro networks designed to handle increased bandwidth demands. The surge in video content consumption, estimated to account for 65% of total Internet traffic in 2022, underscores the need for enhanced metro Ethernet services globally.
- **Cloud computing**: The escalating demand for cloud-based applications, coupled with the proliferation of metro networks from 1 GE to 100 GE ports and connections, is driving the adoption of metro Ethernet. Businesses are increasingly migrating mission-critical applications to the cloud to enhance agility and efficiency, requiring carrier Ethernet solutions that address transport capacity, reliability, and data security requirements.
- **Cost-effective enterprise connectivity**: As enterprises embrace digital transformation, there's a growing need for high-quality, scalable, and dependable connectivity, particularly in the retail sector. Enterprises seek to converge multiple services onto a single Ethernet connection to improve total cost of ownership (TCO), enhance performance monitoring, and simplify operations.
- **Mobile data traffic**: The migration of mobile transport protocols towards Ethernet-based transport for backhaul and fronthaul (eCPRI) has led to increased Ethernet connectivity demands, with fronthaul links requiring 25GE per radio link and nx100GE line rates. Total global mobile data traffic is expected to triple by 2029 reaching over 400 EB per month.

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

More than
40%
of all new premises-based compute and storage will be consumed as a service by 2025*

Approximately
65%
of all Internet traffic was video in 2022**

More than
300%
increase in global mobile data traffic by 2029.***

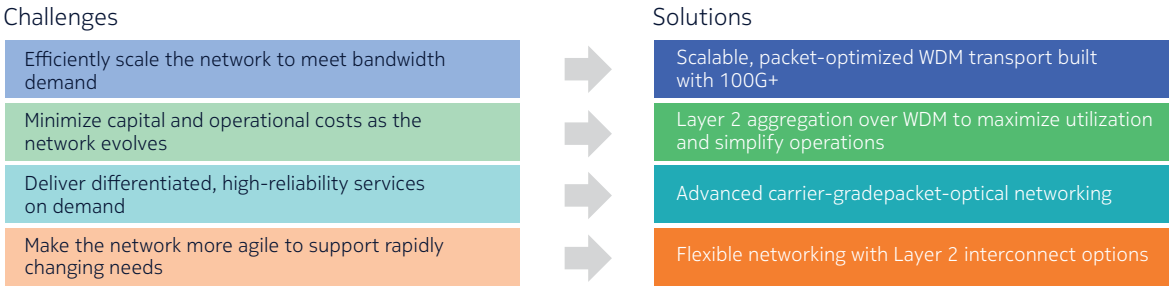
* Gartner, March 2023
** Sandvine Global Internet Phenomena Report, 2022
*** GSMA, The Mobile Economy, 2023

These megatrends serve as a catalyst for service providers to embrace packet-optical network solutions. By efficiently meeting escalating bandwidth requirements and facilitating Carrier Ethernet-based services, these solutions unlock revenue potential while minimizing both capital and operational expenses. Efficient, versatile, and reliable packet-optical transport network designs are paramount to capitalizing on this opportunity and ensuring sustainable growth in an increasingly competitive market landscape.

Strategy for packet-optical transport network transformation

Pervasive Ethernet-based cloud, mobile and video services dictate evolution to a packet-optimized 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

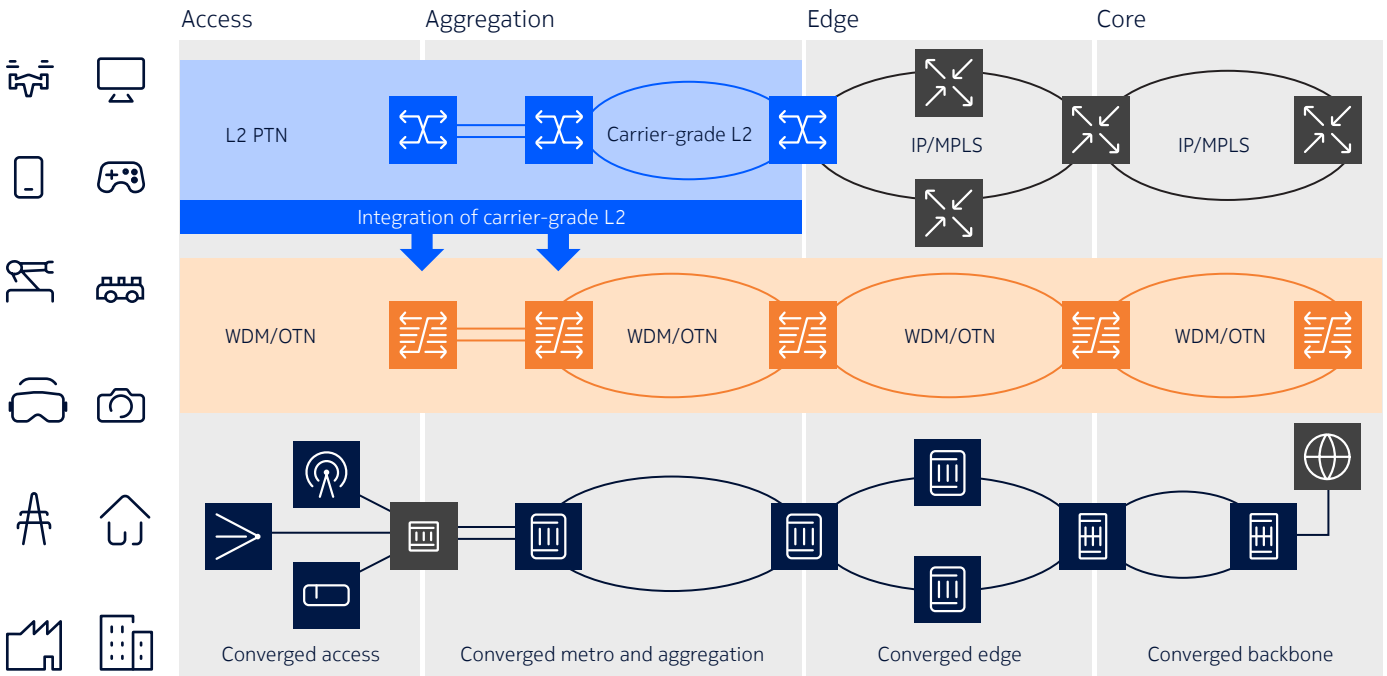


Packet-optimized WDM – A streamlined solution for pervasive Ethernet services

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), video, storage area network (SAN), wavelength, 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

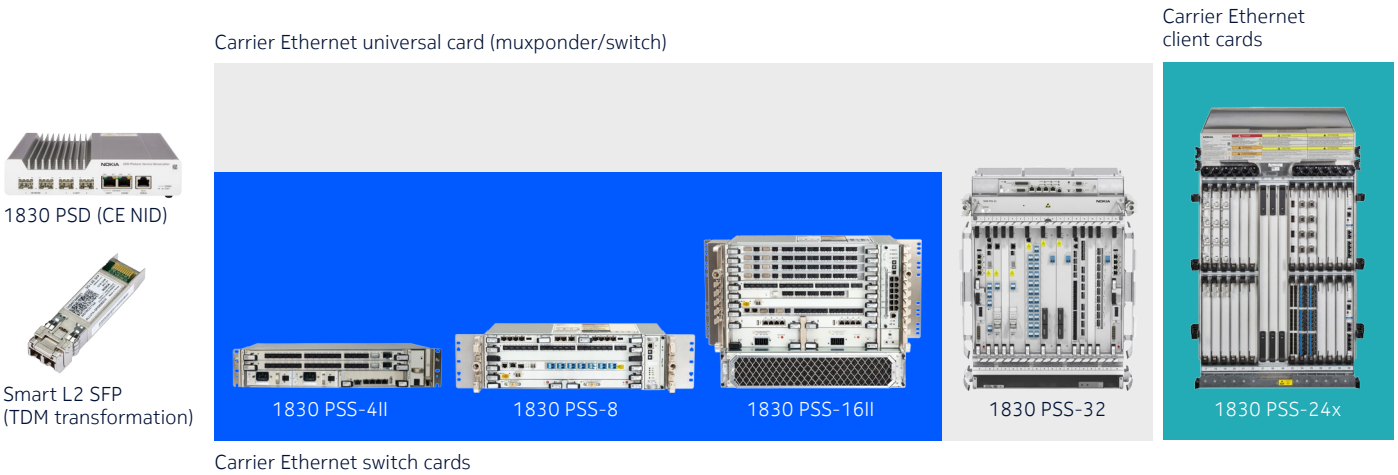


Integrated Packet Transport – Leveraging Nokia Service Router Operating System

Integrated Packet Transport provides carrier-grade L2 transport, switching, and networking plus OTN aggregation and on-ramp converged in the Nokia 1830 Photonic Service Switch (PSS). This single-box WDM/OTN 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 Nokia Service Router Operating System (SR OS) to enable a fully managed packet solution with a common service, operations, and management model across the Nokia 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 the Carrier Ethernet universal card, Carrier Ethernet muxponders and switches, Carrier Ethernet client cards, network interface demarcation devices, 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 Nokia Network Services Platform (NSP) aligned with Nokia IP and Optical products.

Figure 4. Integrated Packet Transport – key elements



The 1830 PSS Carrier Ethernet universal card is a highly flexible card that can be deployed in multiple configurations, including as a stand-alone muxponder or client card for uplink, while providing higher interface rates and higher L2 switching capacities.

The Carrier Ethernet universal card is complementary to the 1830 PSS Carrier Ethernet muxponders and switch cards, delivering a full set of Carrier Ethernet services in point-to-point and multipoint configurations. Carrier Ethernet client cards connect to the OTN fabric of the 1830 PSS-24x shelf and provide packet-optimized transport over an OTN transport layer as a further degree of optimization on top of OTN multiplexing/aggregation. These cards support switching among any client Ethernet interface and any “WAN” interfaces or ODUk terminated on the OTN fabric interface.

The Integrated Packet Transport cards extend the reliability, flexibility and scalability for L2 switching in the 1830 PSS product families, and support a fully managed, end-to-end packet solution based on SR OS.

Key features:

- Full interworking with the Nokia 7750 Service Router (SR), the Nokia 7450 Ethernet Service Switch (ESS), and the Nokia 7210 Service Access Switch (SAS) under common network management
- MEF 2.0 certified: E-Line, E-LAN, E-Tree, Access E-Line, and Transit E-Line services
- Quality of Service – multiple classes of service using SR OS service model
- Carrier Ethernet OAM (IEEE 802.1ag, ITU-T Y.1731, MEF17/30/35, 802.3ah EFM) and MPLS-TP IETF OAM
- Performance monitoring for SLAs, proactive/predictive maintenance
- High availability options including ITU-T G.8032 ERP, MPLS-TP Linear Protection, PW redundancy, Link Aggregation with Multi-Chassis LAG (IEEE 802.1ax)
- Flexible classification, rate controls, queuing, congestion management, and scheduling options
- Synchronous Ethernet and IEEE 1588v2 PTP
- IEEE 802.1Q PB and MPLS-TP packet switching technologies

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
- L2 Smart SFP™: Enabling TDM network transformation
  - Supporting PDH or SDH/SONET circuit emulation services with TSoP, CSoP, TPoP Smart SFPs
- Remote management from the Nokia 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 Nokia SR OS to provide comprehensive Ethernet switching capability
- Consistent operations model for Ethernet services between Nokia 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

Delivering Ethernet over packet optical enables increased operational efficiency, scalability, network optimization and bandwidth utilization, compared with point-to-point interconnection of routers. Extending SR OS to the packet-optical systems 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 (Nokia NSP). 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, wavelength, and OTN.

Get more reliability

The Integrated Packet Transport solution 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.

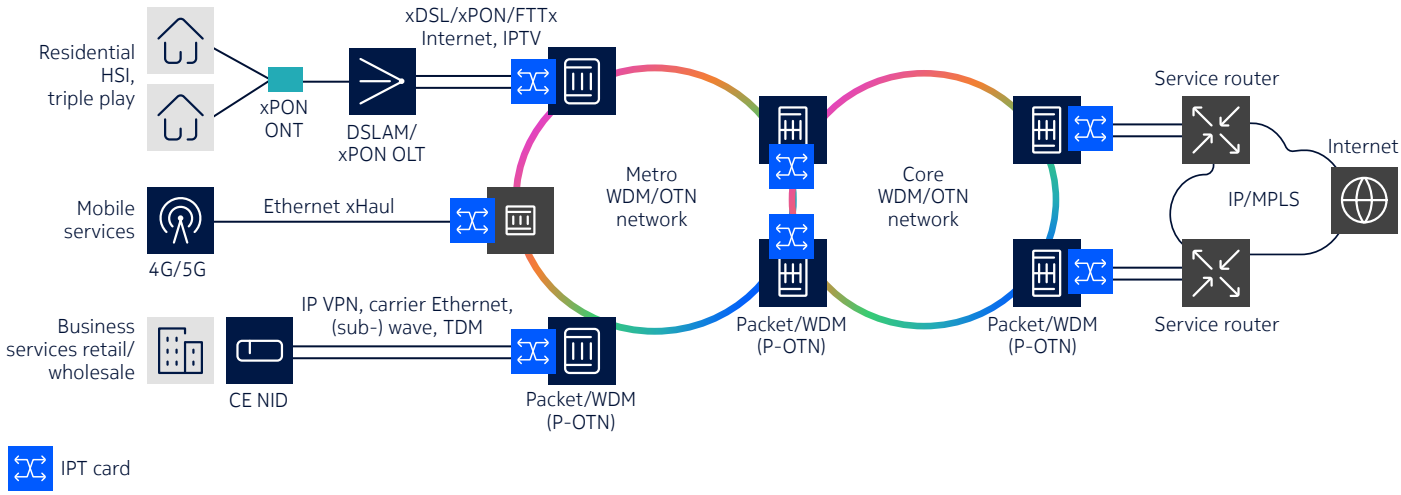
Table 1. Integrated Packet Transport features and benefits

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 • Nokia packet SR OS augmented for transport – with 7x50 interworking, common service model, feature implementation and CLI/MIBs • End-to-end 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/GE, N x 1GE, N x 10GE • 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™

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 TDM, video, SAN, wavelength, and OTN.

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



Features:

- Bandwidth scalability including FE, GE, 10GE, 25GE, 100GE 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™)

Broadband backhaul and IPTV/video distribution

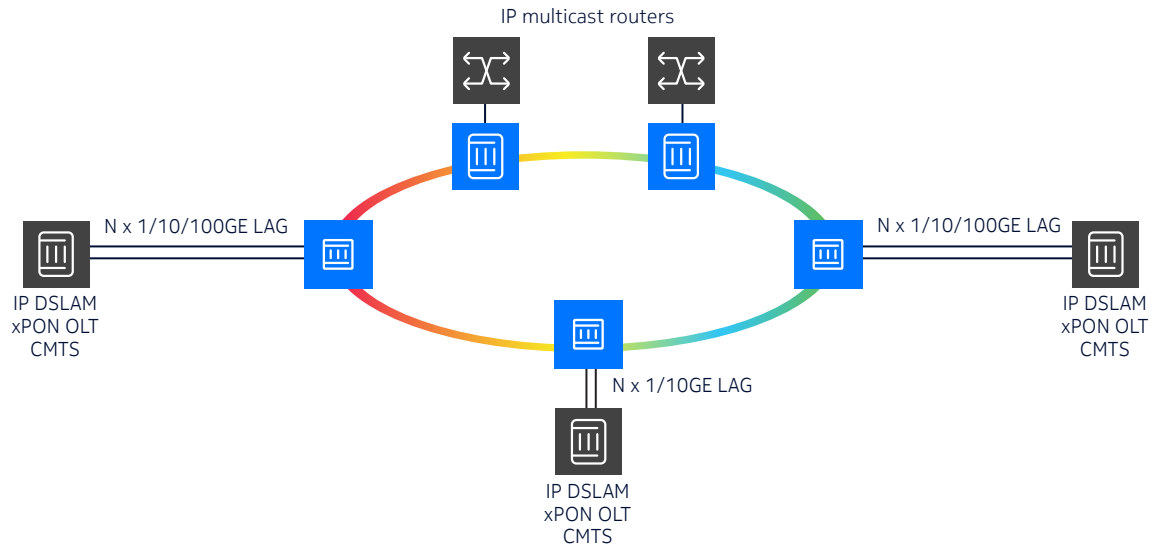
Service providers must evolve their network to handle the bandwidth demands from burgeoning FTTx deployments. The bandwidth growth resulting from the transition from digital subscriber line (DSL) to multi-gigabit capable Passive Optical Network (xPON) calls for WDM aggregation rings. Converging packet 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 much fewer wavelengths. L2 multicasting features including Internet Group Management Protocol (IGMP) snooping, and fast leave and proxy, make this the most efficient bandwidth approach.

Features:

- 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

Figure 6. Integrated Packet Transport for broadband backhaul and IPTV/video distribution



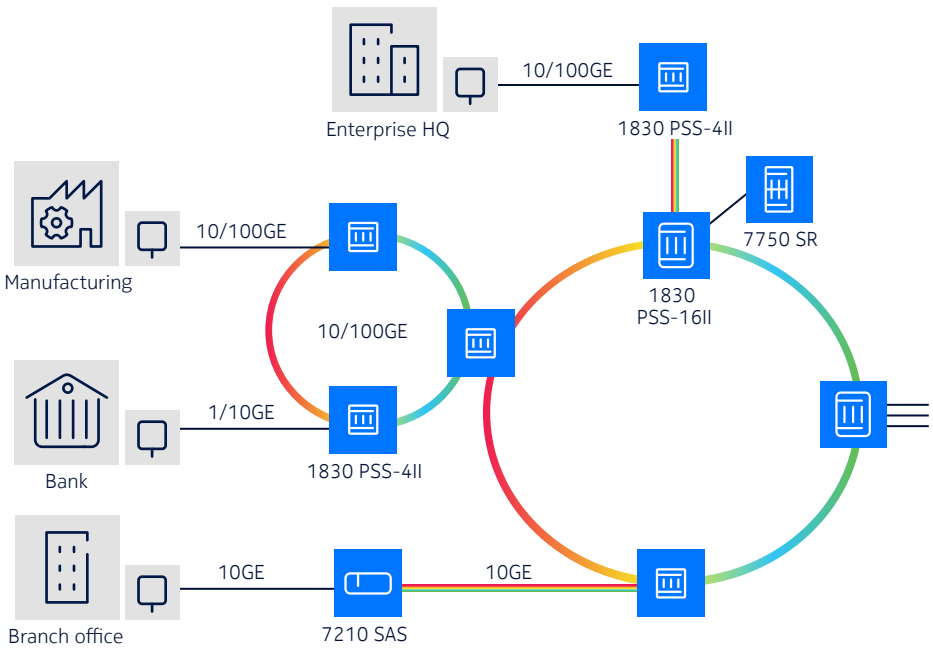
Business Ethernet access services

New, on-demand point-to-point and multipoint services require scalable, versatile and reliable packet transport architectures. The ability to provide a 10/100GE 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.

Features:

- Part of a comprehensive Ethernet business access services solution along with the Nokia 7210 SAS, Nokia 7450 ESS, and the Nokia 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), GE, N x 1GE, 10GE, 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

Figure 7. Integrated Packet Transport for business Ethernet access services



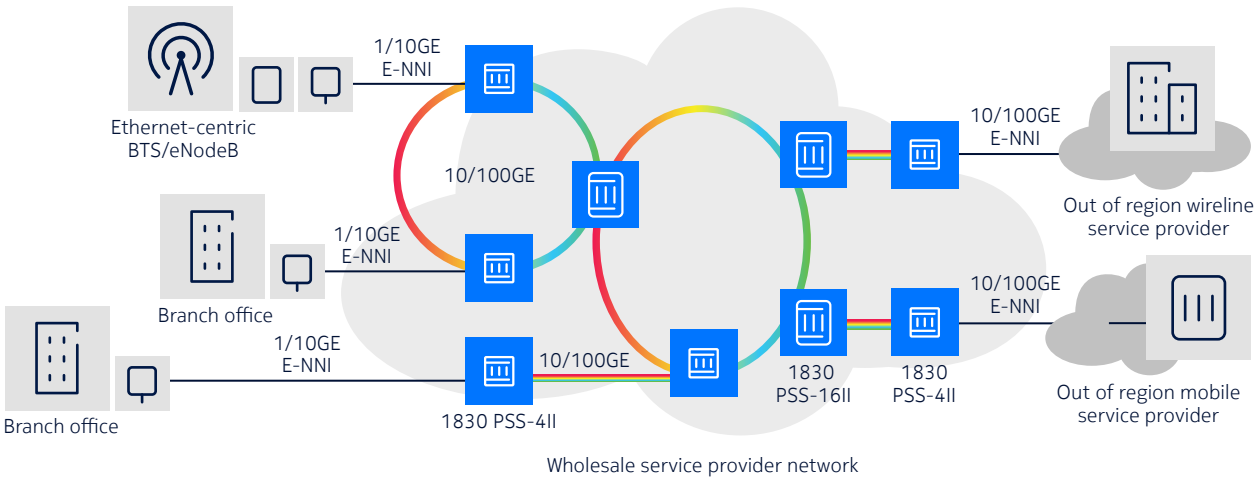
Wholesale Ethernet access services

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.

Features:

- 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

Figure 8. Integrated Packet Transport for wholesale Ethernet access services



Mobile backhaul and fronthaul for 3G, 4G, and 5G

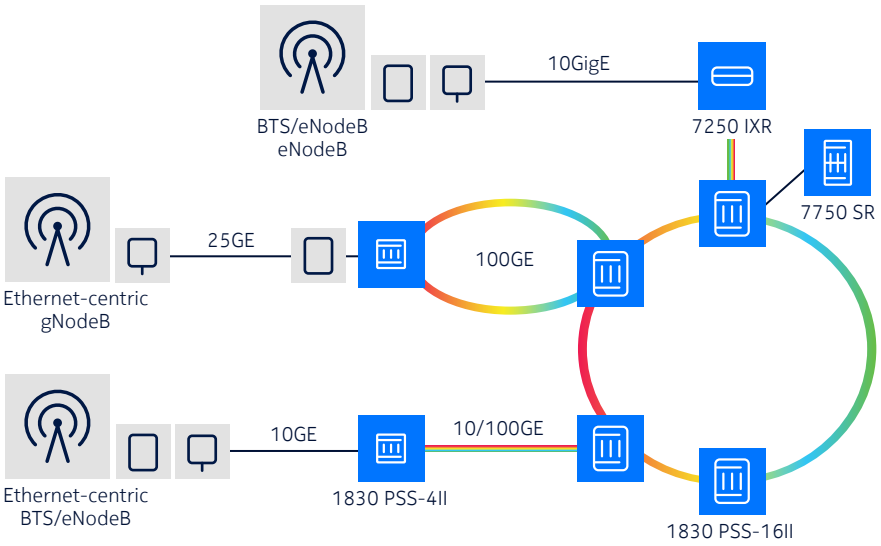
Today's mobile backhaul transport solutions must support a wide range of standard interconnection options from the cell site to the aggregation layer. The 1830 PSS supports multiple aggregation applications with a full range of Ethernet packet modules and interconnection options.

While 2G and 3G backhaul were primarily E-Line, 4G/Long Term Evolution (LTE) backhaul introduced a paradigm shift in the service connectivity models between eNodeBs and gateways, for which E-LAN and E-Tree services are very well suited. Furthermore, 5G introduced several possible functional splits between the radio units, distributed units, and centralized units giving rise for the need to support a mix of fronthaul, midhaul, and backhaul. Offering exceptional CE backhaul feature richness, the 1830 PSS supports these different architectures and enables service providers with differentiated granular services including high speed fronthaul links that can reach to 25GigE per radio link. 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 10GE port density.

Features:

- Enhanced SyncE (eEEC) for frequency synchronization and Phase/Time synchronization (Class C/D T-BC)
- 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



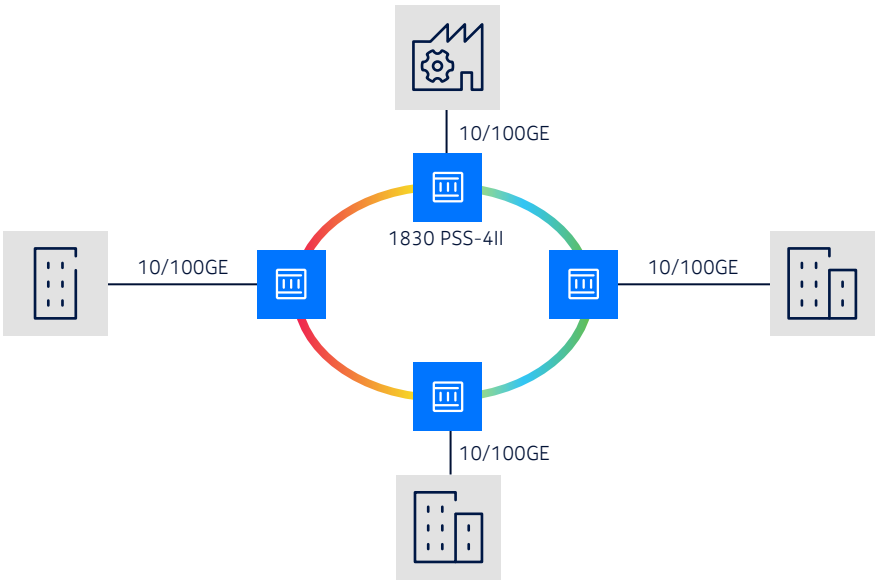
Enterprise verticals

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

Features:

- 10/100GE 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.

Features:

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

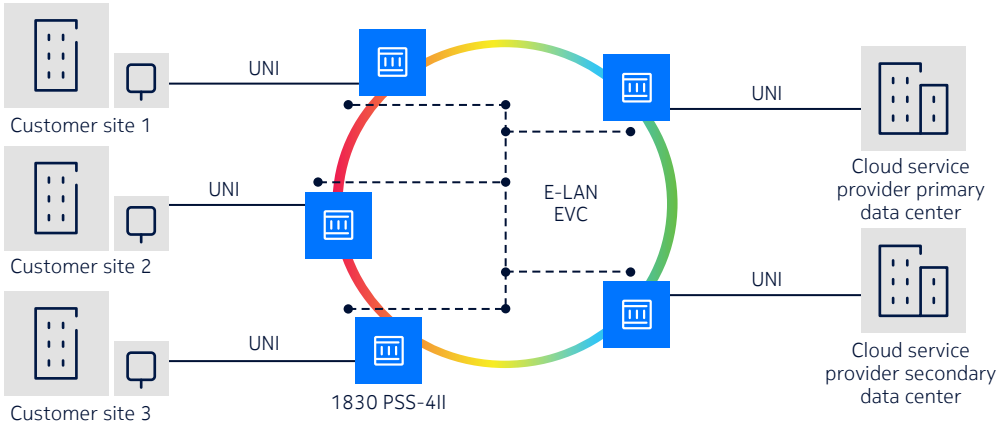
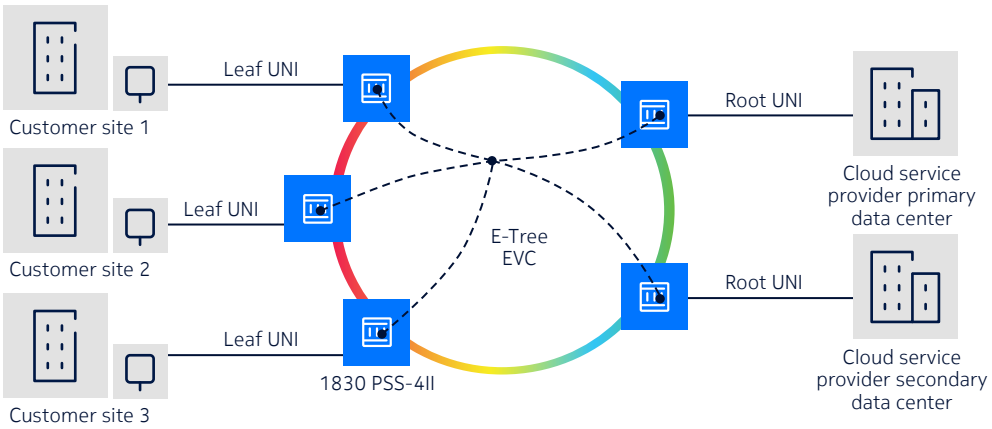


Figure 12. Integrated Packet Transport for cloud services: E-Line or E-Tree for private cloud, community cloud or hybrid cloud WAN solution



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 Nokia 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.

Abbreviations

BTS	base transceiver station
CAPEX	capital expenditures
CCAP	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
EB	Exabyte
eEEC	Enhanced Ethernet Equipment Clock
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
GE	Gigabit Ethernet
xPON	multi-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
NSP	Network Services Platform
OAM	operations, administration, and maintenance
ODU	optical data unit
OLT	optical line terminal
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
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
T-BC	Telecom Boundary Clock
TCO	total cost of ownership
TDM	time division multiplexing
TPMR	two-port MAC relay
UNI	user network interface
VLAN	virtual LAN
VPLS	virtual private LAN service
WAN	wide area network
WDM	wavelength division multiplexing

About Nokia

At Nokia, we create technology that helps the world act together.

As a B2B technology innovation leader, we are pioneering networks that sense, think and act by leveraging our work across mobile, fixed and cloud networks. In addition, we create value with intellectual property and long-term research, led by the award-winning Nokia Bell Labs.

Service providers, enterprises and partners worldwide trust Nokia to deliver secure, reliable and sustainable networks today – and work with us to create the digital services and applications of the future.

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