



## Legacy connectivity migration in transportation networks

Application note series: Network modernization  
with the Nokia 1830 Photonic Service Switch (PSS)

Application note

## Abstract

Transportation systems link people to their daily lives and business to its daily operations, providing the basis for a functioning society. Road, railway, air and maritime transportation systems all can benefit from adoption of Intelligent Transportation Systems (ITS) that monitor and control traffic flow through connected devices in a transportation Internet of Things (IoT). ITS yields public benefit through improved safety, reduced energy consumption, increased economic output and better quality of life.

Communications networks must support the continuing evolution of smarter transportation initiatives, including ITS, video surveillance, data center interconnect (DCI) and other functions. These factors and the pressure to ensure effective transportation operation while controlling costs are driving investments in network modernization that allow for staged, careful packet service upgrade while supporting legacy applications.

This application note is the second in a series of three papers outlining the requirements, technology options and Nokia solutions needed to construct a modern packet optical network. The series includes:

- “Photonic networks for transportation”: Outlines photonic layer requirements and highlights the Nokia 1830 Photonic Service Switch (PSS) as a foundation for ITS initiatives
- “Legacy service migration in transportation networks”: Discusses solutions for migration of legacy TDM services and applications toward a modern packet-optical network
- “Packet-optical networks for transportation”: Defines packet-optical transport and compares common technologies and solutions.

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## The transportation communications landscape

For decades, networks have relied on Synchronous Digital Hierarchy/ Synchronous Optical Network (SDH/SONET) and wavelength division multiplexing (WDM) technologies to build resilient and secure photonic communications networks. SDH/SONET offers reliable, circuit-based connectivity for TDM-based user equipment for a wide variety of mission-critical applications. Application-specific networks are still common, with applications such as video, voice and telemetry data multiplexed and transported through TDM systems.

While effective, this approach is fast reaching obsolescence as packet-based technologies have become the preferred way to connect virtually any traffic type. With the availability of TDM solutions declining and the aging of embedded equipment, transportation networks need to migrate toward a packet optical architecture. Yet, it is not reasonable to expect one-step replacement of TDM systems; a migration path is needed to allow simultaneously support of TDM and packet-based traffic.

The communications network needed for modern transportation systems differs from that of a few years ago. For example, transportation authorities now operate systems that control roadway sensors, cameras, toll collection and electronic signs in addition to traditional applications such as record keeping, voice and other data communications. A backbone optical network based on an optical transport network (OTN) and coarse or dense WDM (CWDM or DWDM) can provide the flexibility, scalability, reliability and security needed to ensure the continuous, efficient operation of a modern transportation system. This network has the inherent capability of connecting any traffic type: circuit TDM, IP packet, Ethernet, High Definition - Serial Data Interface (HD-SDI) video and others.

## Legacy connectivity migration

Most communications networks must be able to support legacy traffic while newer technologies are phased in. Wholesale rip and replace of systems is quite rare because most systems upgrade their infrastructure on a carefully planned basis, favoring long-lived assets. Connectivity to older voice and ATM systems may be required for years while newer systems are adopted. The ability to support legacy TDM applications and packet-based applications across the same network is key to aiding modernization of the communications network. This implies a high degree of flexibility to add or remove services as end applications are upgraded or decommissioned. At the same time, all connectivity must be highly reliable, deterministic and secure.

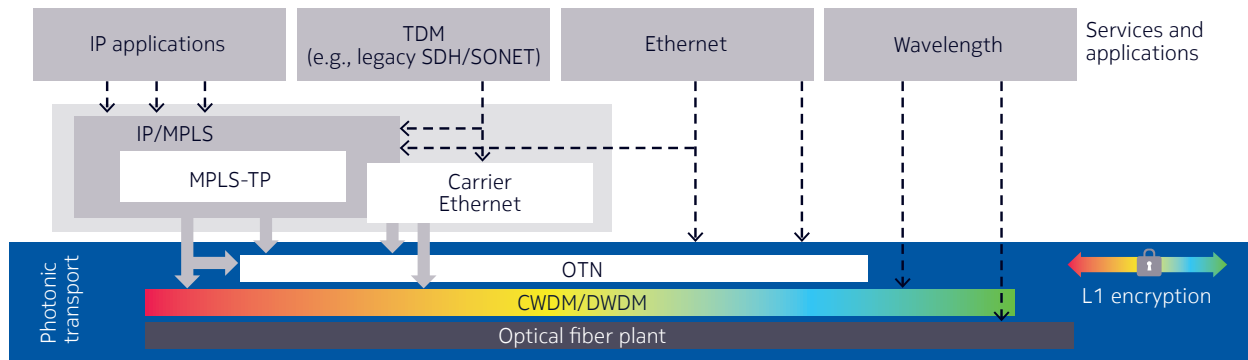


To deliver on the promise of modernization, a transportation communications network must meet several requirements.

- **Flexibility and scalability:** Application-specific networks are no longer viable in an environment where needs rapidly change and resources are limited. For example, a railway may need to simultaneously support surveillance video of a secure facility as well as rail telemetry, positive train control and voice traffic. As ITS becomes more common across transportation infrastructure, networks need to scale in capacity while being flexible enough to support any type of data protocol, including Ethernet, IP, TDM, video, Fibre Channel and others.
- **Reliability:** For any application, the network must be highly resilient to ensure continuity of operations. Networks must be built using equipment designed for high availability, utilizing redundant systems and automatic protection mechanisms. The network also should utilize diverse connectivity paths and a rich set of diagnostics to predict and prevent outages before they occur.
- **Security:** As essential infrastructure to a region's stability, road, rail, air and maritime systems must be protected from intrusion that could lead to disruption of service or threaten public safety.
- **Traffic segregation:** Using a shared infrastructure also means that measures must be taken to segregate different traffic streams. Many transportation systems share their backbone networks with government agencies and also offer broadband access service, open to the public. This implies a need for logical network segregation.
- **Deterministic performance:** The network should assign priority to critical applications to ensure availability during peak traffic periods. For example, highway telemetry and surveillance video traffic should be assigned a higher priority than data center backup traffic, such that if total demand exceeds available bandwidth, only the lower priority data center backup traffic is temporarily impacted.
- **Ease of use:** The network must be easy to provision, operate and maintain. Software control should extend across network elements, reducing the need for physical hardware changes and allowing remote provisioning.
- **Long asset life:** Budgeting cycles typically require that capital assets be depreciated over long time periods. A modernized network must support technologies from at least 15 years ago and for 10 years into the future. This implies use of a modular and extensible architecture, allowing older technologies to be easily maintained or phased out while new technologies are gradually introduced.
- **Economically attractive:** All the previous requirements must be met with a high degree of economy, balancing initial capital expense with ongoing operational expense. Use of common platforms for multiple applications and a high degree of software control are desirable, as are modular equipment architectures and common software control.

These requirements are met through use of a photonic network capable of supporting the services and applications shown in Figure 1. This ecosystem is described in the Nokia application note, “Photonic networks for transportation.”

Figure 1. Packet optical network



## Nokia solution

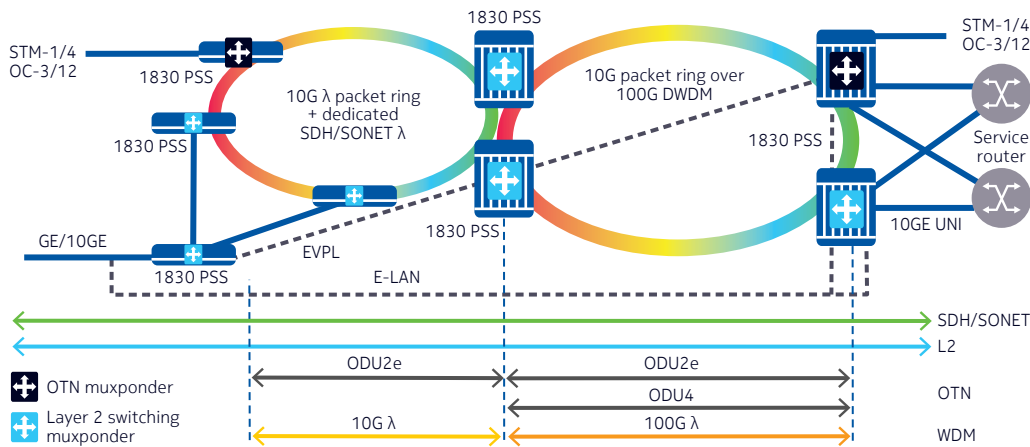
### TDM migration with Nokia 1830 PSS

The Nokia 1830 PSS can provide the flexibility needed to simultaneously connect TDM and packet-based traffic, with the ability to scale up packet capacity while reducing TDM capacity as needed. The modular system architecture and available interface cards open virtually endless possibilities of SDH/SONET, Ethernet, Fibre Channel and other traffic protocol combinations.

As a network operator migrates toward a packet-based infrastructure, they will still need to support some TDM traffic. Using the 1830 PSS, the network operator can migrate toward packet connectivity through a combination of solutions that can be selected to match their specific needs. The 1830 PSS offers several options for supporting TDM services over a packet core.

- **OTN Layer 1 muxponders:** The 1830 PSS product family includes “multiplexing transponders” that multiplex and map SDH and SONET signals into an OTN signal. Existing SDH/SONET traffic, for example, can be taken from an existing add-drop multiplexer, encapsulated as an OTN wavelength and then multiplexed with other OTN and packet traffic. This hybrid scenario is shown in Figure 2.

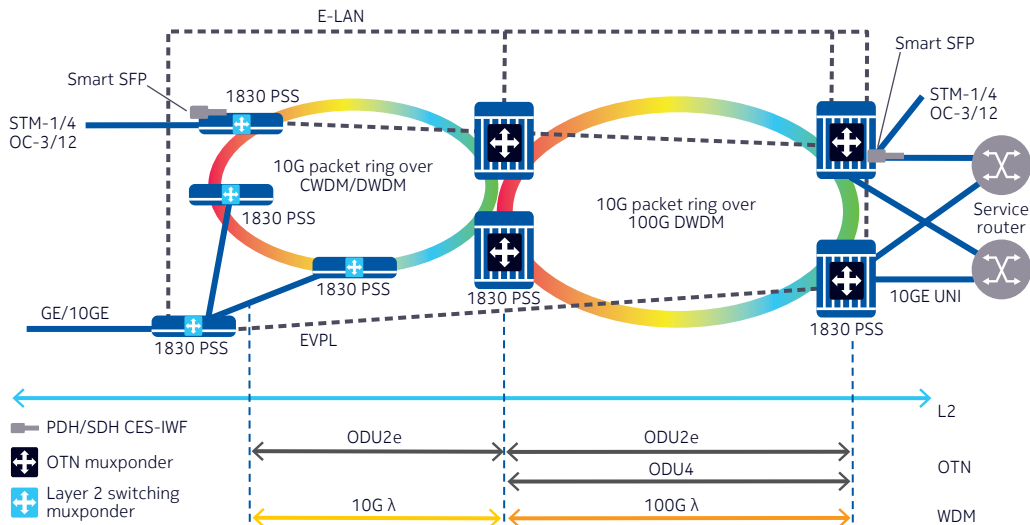
Figure 2. TDM-to-packet transport migration: Hybrid scenario



- Layer 2 switching cards:** The 1830 PSS product family includes a set of interface cards that provide Ethernet aggregation and switching capabilities for a set of 10M/100M/1G/10G client ports switched to high-speed line ports configured as OTUk, 10GBASE-R or 100GBASE-R Ethernet ports. These cards support pluggable optics, enabling a wide set of configuration possibilities.

For TDM-to-packet migration applications, these cards can work with Transparent SONET over Packet (TSoP), Channelized SDH/SONET over Packet (CSoP) or Transparent PDH over Packet (TPoP) smart SFP modules. These modules allow an operator to deploy an 1830 PSS Layer 2 switching card (such as 11QPE24, 11QCE12X or 11OPE8) on a node that may simultaneously be supporting other packet or TDM services. As operations allow, the operator can migrate their TDM core to a converged packet scenario, as shown in Figure 3.

Figure 3. TDM-to-packet transport migration: Converged packet scenario



The TSoP provides a TDM interface with legacy access equipment operating at either OC-3/STM-1 or OC-12/STM-4 rates and presents an Ethernet interface to the 1830 PSS Layer 2 cards. Similarly, the TPoP SFP provides an E1/DS1 interface to the legacy TDM access point and presents an Ethernet interface to the 1830 PSS. Together with the CSoP, these smart SFP modules comply with industry standards and support all the functionality of their respective TDM clients. The operator can add a desired number of modules and supporting Ethernet ports based on the number of legacy TDM interfaces present at a particular node.

As needs change and these legacy services are upgraded to Ethernet devices, the smart SFP module is simply removed and the Ethernet port is then utilized for the upgraded service. This method provides an economical, reliable and easily manageable upgrade solution.

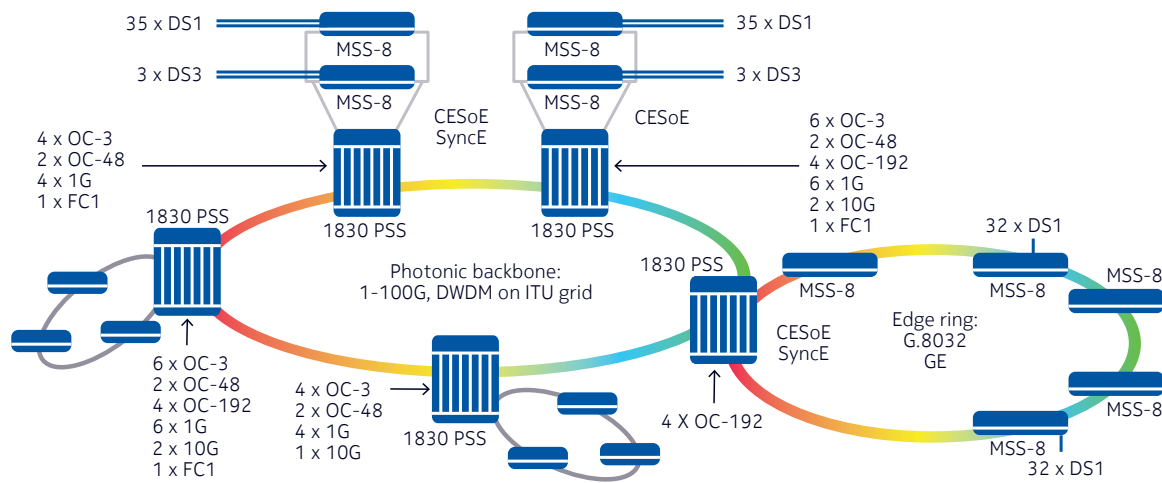
- **1830 PSS with the Nokia 9500 MSS adjunct shelf:** Many legacy TDM applications require aggregation of a large number of low-data rate interfaces. Some networks support telemetry equipment for road monitoring and roadway signs. These networks tend to use 64 kb/s channels. In most cases, these signals are multiplexed into higher rate signals before hand-off to the optical network.

Some of the legacy TDM applications have requirements for timing and synchronization that must be maintained when migrating onto a packet-based optical network. The Circuit Emulation Service over Ethernet (CESoE) standard provides this capability by ensuring suitable packet delay variation (PDV), latency, traffic prioritization and TDM circuit performance. This is easily accomplished through use of the Nokia 1830 PSS supported by a Nokia 9500 Microwave Service Switch (MSS) service shelf. The 9500 MSS shelf provides a service aggregation point for the low-speed interfaces and provides circuit emulation compliant with CESoE standards.

Figure 4 shows an example of such a deployment. The 1830 PSS forms a central photonic backbone using 100G wavelengths on the ITU-T grid. The 1830 PSS photonic transport backbone is fed by various lower rate services, including Plesiochronous Digital Hierarchy (PDH) services aggregated by 9500 MSS shelves. The 9500 MSS shelves provide CESoE hand-offs to local 1830 PSS shelves equipped with a Layer 2 interface card.



Figure 4. Low-rate TDM aggregation: Nokia 1830 PSS with Layer 2 interface and Nokia 9500 MSS shelf



- **Nokia 1830 TDM Extender (TDMX/TDMXC):** Many legacy TDM applications require aggregation of a relatively large number of low-data rate interfaces. For example, some networks use SCADA equipment to collect telemetry data from traffic control systems. These networks may use 64 kb/s channels, multiplexed into higher rate signals, such as E1 (2.048Mb/s) or E3 (32.368Mb/s), before hand-off to the optical network.

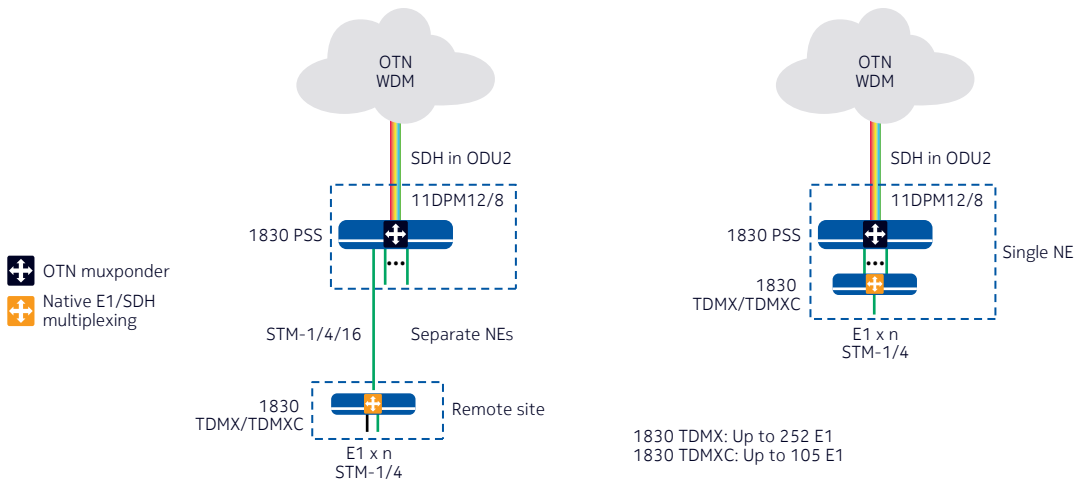
Often, the systems require high densities of E1 interfaces at one location and also need service protection, resiliency and operations, administration and maintenance (OAM) features. This is easily accomplished through use of the Nokia 1830 PSS extended by the Nokia 1830 TDMX/ TDMXC extension shelf. The 1830 TDMX and 1830 TDMXC provide high density, high port count service aggregation and full interoperability with the 1830 PSS.

Depending on application needs, the TDMX/TDMXC can be configured to operate either as a single, col-located network element with the 1830 PSS or operated separately, with the TDMX/TDMXC located remotely.

The 1830 TDMXC is a 1RU compact shelf supporting two service cards and up to 105 E1 ports. The 1830 TDMX is a 2RU chassis supporting six service slots and up to 252 E1 ports.

Figure 5 shows an example of a deployment where the 1830 PSS forms the photonic WDM backbone, fed by various lower rate services, multiplexed by the 1830 TDMX/TDMXC.

Figure 5. High-density, low-rate TDM aggregation with Nokia 1830 TDMX/TDMC



## Conclusion

As transportation systems become more intelligent and connected, they need to be mindful of existing communications networking assets. Supporting a wide range of monitoring, control and reporting can be accomplished with a communications network that is highly agile, scalable and secure. This implies use of networking technologies that allow for the addition of packet-based applications while simultaneously providing connectivity for older, embedded systems. A high degree of flexibility allows the network operator to add new capabilities and phase out older systems as needed.

Nokia offers a full suite of networking solutions to accomplish the migration of legacy systems to a modern packet optical communications network. Using the features of the Nokia 1830 PSS and Nokia 9500 MSS or Nokia 1830 TDMX/TDMC, the network can easily scale newer packet-based applications while continuing to provide TDM application connectivity. This is accomplished through Layer 2 switching cards and smart SFP modules, providing flexibility to design solutions that match needs for a mix of connectivity, including DS1, DS3 and SDH/SONET interfaces alongside Ethernet and storage networking interfaces such as Fibre Channel.

In the long term, as the need for PDH and SDH/SONET interfaces is reduced, network capacity and equipment ports can simply be reconfigured for packet traffic.

The Nokia product portfolio offers a complete set of options to meet modern communications requirements. The Nokia 1830 PSS offers the most powerful photonic network solution to meet these needs. To learn more, visit [our optical networking web site on nokia.com](https://www.nokia.com/optical-networking).

## Acronyms

ATM	asynchronous transfer mode	NE	network equipment
CES-IWF	Circuit Emulation Service - Interworking Function	OC-n	optical channel n
CESoE	Circuit Emulation Service over Ethernet	ODU	optical data unit
CSoP	Channelized SONET over Packet	ODUK	optical data unit k
CWDM	coarse wavelength division multiplexing	OSI	Open Systems Interconnection
DWDM	dense wavelength division multiplexing	OTN	optical transport network
E-LAN	Ethernet virtual private LAN	PDH	Plesiochronous Digital Hierarchy
EVPL	Ethernet virtual private line	PSS	Photonic Service Switch
GE	Gigabit Ethernet	SCADA	Supervisory Control and Data Acquisition
HD-SDI	High Definition - Serial Data Interface	SDH	Synchronous Digital Hierarchy
ITS	Intelligent Transportation System(s)	SFP	small form-factor pluggable
IP	Internet Protocol	SONET	Synchronous Optical Network
ITU-T	International Telecommunications Union – Telecommunication Standardization sector	SyncE	Synchronous Ethernet
L1	Layer 1 - OSI reference model	STM-n	Synchronous Transport Module n
L2	Layer 2 - OSI reference model	TDM	time division multiplexing
LAN	local area network	TPoP	Transparent PDH over Packet
MPLS	multiprotocol label switching	TSoP	Transparent SDH/SONET over Packet
MPLS-TP	MPLS - Transport Profile	UNI	user-to-network interface
MSS	Microwave Service Switch	WDM	wavelength division multiplexing

## References on Nokia.com

[1830 PSS Product Information](#)

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