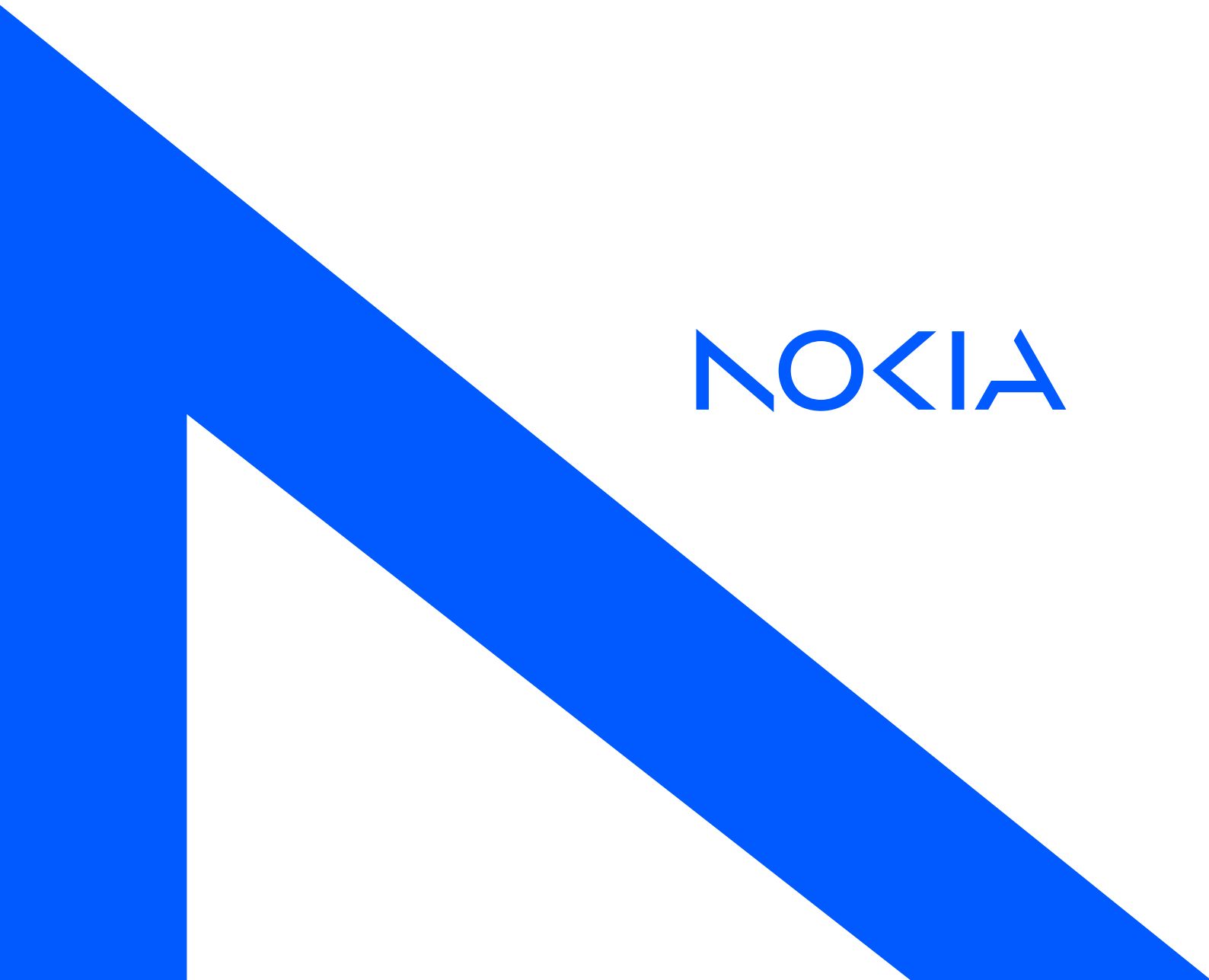
Universal network demarcation

Enabling Ethernet and wave services with the Nokia 1830 PSD

Application note



Contents

Introduction

Carriers, cloud service providers and internet content providers are under tremendous pressure to scale their networks to meet the continuously increasing bandwidth demands of business-critical enterprise applications, wholesale services, data center interconnect (DCI), storage extension and high-performance computing (HPC), as well as the growing shift to cloud services. Enterprise customers, who until now have only had modest WAN requirements, perhaps even relying on public internet connectivity or low-bandwidth IP services, now need low-latency, guaranteed private line services. This requires new solutions that can deliver increased bandwidth to many more end nodes and customer locations that have size and power constraints, as well as the need for service-level agreement (SLA) assurance with proper network demarcation and operational simplicity.

Photonic Service Demarcation (PSD) addresses these challenges by providing a compact, high-capacity, low-delay and easy-to-deploy solution. It delivers important features needed in the access nodes, enabling operators and service providers to benefit by providing MEF-compliant Carrier Ethernet and wavelength services (otherwise known as wave services or MEF63 layer 1 subscriber services) in one platform. The carrier-class device supports high-availability and security features including quantum-safe layer 1 encryption, optical path protection, dual power supplies, and OAM functions and tools.

Market drivers

Over the past decade, both Carrier Ethernet and private line wave services have been deployed in support of business-critical applications. The following section contrasts these two types of services, showing their service characterstics and the applications they support.

Wave services

Wave services today are characterized by highly available point-to-point, private line offerings where end customers have dedicated full-rate bandwidth over layer 1 WDM or OTN networks. The services are often protocol independent and offer extremely low-latency connectivity in support of applications that are latency sensitive. Today more than 100 service providers offer wave services, with more expected now that subscribers can benefit from standardized MEF63 layer 1 subscriber services that create a consistent set of service attributes.

Layer 1 subscriber services are defined in a similar fashion to existing E-Line service constructs as defined within the MEF. Multiprotocol layer 1 subscriber services provide cost-effective connectivity from the customer edge across single or multiple provider networks for bandwidth-intensive applications. Multiprotocol layer 1 subscriber services offer the familiarity and simplicity of private lines to support low-latency, multiprotocol solutions such as storage area network (SAN) extension, DCI and HPC. To support these applications, network operators demand layer 1 subscriber solutions that provide the following attributes on products for the network edge:

- Higher full-rate services (e.g., 1 Gb/s to 100 Gb/s)
- Service transparency (Ethernet, FC, FICON, InfiniBand, SDH/SONET, OTN)
- High availability (99.999%)
- Extremely low latency (from 1 ms to 20 ms)
- Sync transparency (IEEE 1588v2/SyncE)
- Layer 1 encryption for secure applications

Carrier Ethernet services

Ethernet has been used to provide WAN services for over a decade, delivering better bandwidth scalability at a lower cost per bit than the legacy private line services it was replacing. The definition of standardized OAM functions and broad availability of equipment have accelerated deployment of Carrier Ethernet-based networks and services. With the shift to higher-speed services driven by the move to cloud-based services, larger data centers and network functions virtualization (NFV), among others, the MEF has standardized Carrier Ethernet 2.0 (CE 2.0), which has been adopted globally offering speeds up to 100G. The key pillars of CE 2.0 are standardized interfaces and operational procedures for interconnect and access, which enable network operators to interconnect with one another with assurance of performance and adherence to global standards of interconnection. Thus, in addition to the point-to-point and multipoint services previously defined by the MEF, CE 2.0 also brings new point-to-multipoint services as well as new access services, enabling operators and service providers to offer those services at business locations served by Ethernet-based premises equipment. Because of the sheer number of access locations that need to be connected, the premises equipment must be optimized for cost, power consumption and size, all of which are critically important.

Applications served by CE 2.0 can include a mix of private line services, VPNs, wholesale access and cloud services. To support these applications, network operators demand carrier-grade Ethernet solutions that provide the following key attributes on products operating at the network edge:

- Full-rate Ethernet services (100 Mb/s to 10 Gigabit Ethernet (10GE))
- Carrier-class OAM tools to monitor optical fiber, the link layer and service layers
- Very low latency (<20 ms)
- Low power, compact size
- Compatibility with Synchronous Ethernet (SyncE) and IEEE 1588 (PTP)

Table 1 contrasts the Carrier Ethernet and Wave service characteristics.

Table 1. Carrier Ethernet and wave services: applications and service characteristics

	MEF Services (CE 2.0) E-Line, E-LAN, E-Tree, E-Access	Wave Services W-Line, Ethernet W-Line, Multiprotocol W-Line, Encrypted W-Line
Transport network	Carrier Ethernet Network	WDM/OTN network
Availability	99.99%	99.999%
Rates	100 Mb/s to 10 Gb/s	1 Gb/s to 100 Gb/s
L1 encryption	No	Available
Latency	<20 ms	<1 to 20 ms

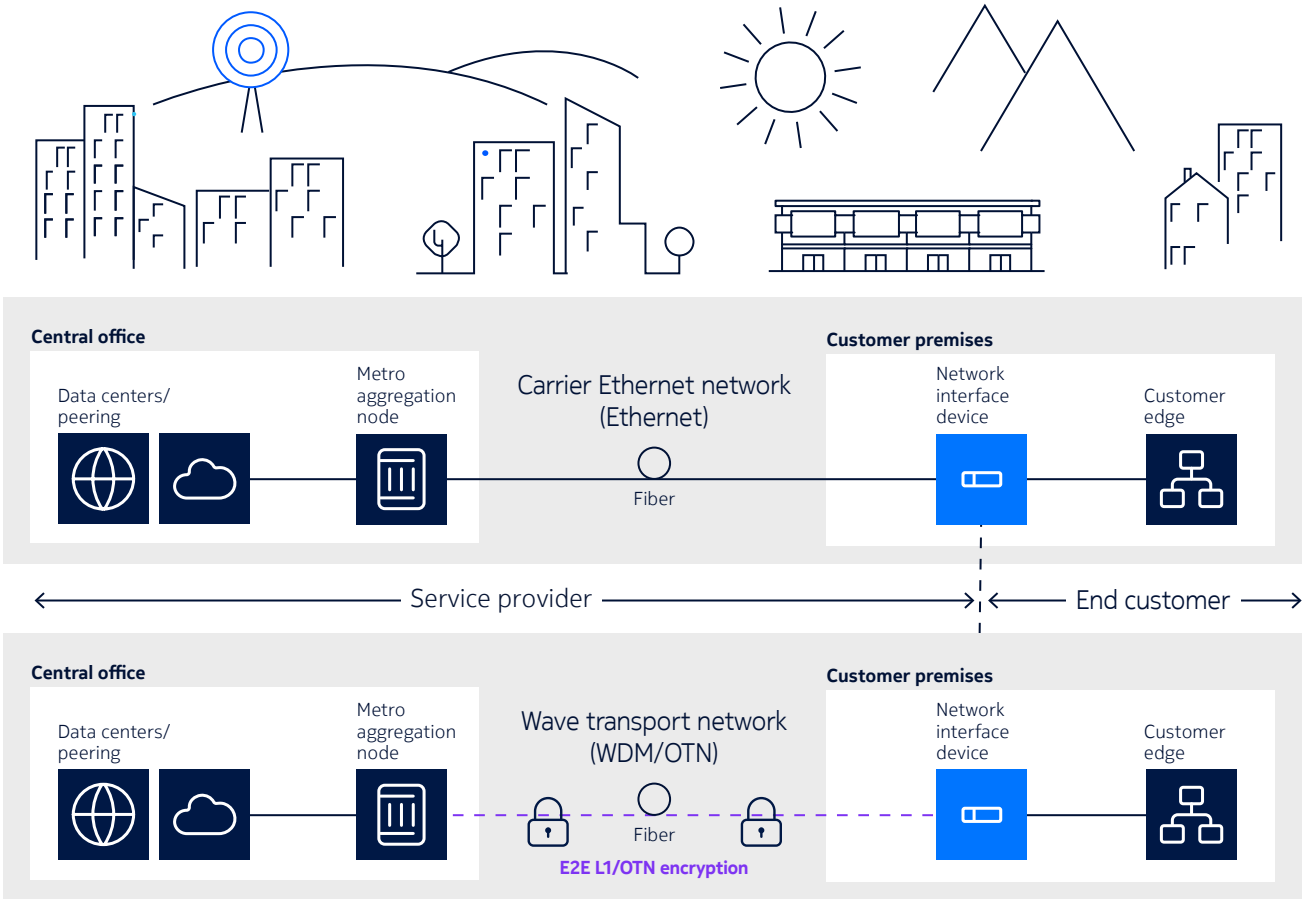
The need for network demarcation

When delivering services, whether they are Ethernet or wave services, carriers must be able to maintain SLAs between themselves and their end customers that define service parameters on an end-to-end basis. This entails separating their network domain from that of their end customer through a network demarcation device, usually termed a network interface device (NID). This separation allows the carrier to test and monitor its network all the way up to the customer's premises, allowing it to manage the network service and to ensure that SLA performance requirements are met.

In many networks the demarcation point is implemented as a small Ethernet switch that supports a network interface and one or more customer-facing ports. A NID often implements OAM functions to assist the operator in monitoring, troubleshooting and localizing faults. A NID allows operators to effectively isolate the customer's network when testing and monitoring the end-to-end link, thereby eliminating diagnostic errors due to end-customer activities. In some cases, NIDs require active cooling through the use of fans to enable operation over a wide temperature range. And in most cases, these traditional NIDs only support layer 2 Carrier Ethernet services, precluding their ability to leverage existing layer 1 optical networks and limiting service offerings to the service attributes associated with MEF-defined Carrier Ethernet services as outlined in the previous section.

Figure 1 shows the placement of the NID at the network edge where the access network could either be a Carrier Ethernet network or a wave transport network. Since the demarcation device is always in the data path, it is important that it be able to support wire-speed rates without introducing significant delay or jitter to avoid adversely impacting network performance. It also needs to provide robust OAM capabilities—supporting intelligent loopbacks and traffic monitoring and allowing tracking of the data stream. It should also support options for protection and secure transmission when needed for business-critical applications.

Figure 1. Access networks with NID demarcation



1830 Photonic Service Demarcation

The Nokia 1830 Photonic Service Demarcation (PSD) NID provides network demarcation and optical transport for Ethernet and wave services. The 1830 PSD NID can be configured in either OTN or Ethernet mode, providing universal support for both layer 1 subscriber and E-Line services demarcation for wholesale, business services, DCI and cloud services. It supports accelerated service activation with automated installation and commissioning capabilities afforded through a simple-to-use commissioning application.

The Nokia 1830 PSD is a low-latency, compact and versatile NID designed for customer premises. It effectively extends the reach of the optical network in support of Ethernet or wave services. It enables operators to deliver SLA-assured services where space and power consumption are constraints measuring less than 20 cm in width and 1RU high. It supports optical uplinks for Ethernet (1G/10G), TDM (sub-2.5G, 2.5G), and OTN (OTU1 and OTU2/2e) client services. The product simplifies the service provider solution to provide a demarcation point for a fully managed, protected single-port or dual-port service. It reduces carrier costs by eliminating the need to engineer, order, stock and spare different card types for each service type or optical rate.

The client and line ports feature pluggable optics, so the different services can be easily provisioned. It leverages the Nokia portfolio of small form-factor pluggables (SFPs) used in other 1830 products, and Smart SFPs for TDM network migration. And it is fully SNMP-managed by the Nokia WaveSuite Network Operations Center (WS-NOC), enabling seamless interworking with the Nokia 1830 Photonic Service Switch (PSS) portfolio to deliver the ultimate in performance, operational simplicity and space/power savings.

Two variants of the Nokia NID are available: 1830 PSD and 1830 PSD-2. The 1830 PSD-2 supports the same physical footprint and features as the 1830 PSD. In addition, it offers enhanced hardware performance and extends the feature set to include dual AC or dual DC power supplies, layer 1 encryption, extended temperature range (ETR), add-drop multiplexer (ADM) mode and dual client support.

Applications and key parameters

The 1830 PSD integrates key functions of an Ethernet and OTN NID with carrier-class OAM within a single platform. This enables operators to simplify their edge networks by adding flexibility into the services supported using a common platform. Due to its compact size and low power requirements, the 1830 PSD can be deployed in various network scenarios. Table 2 shows its main applications.

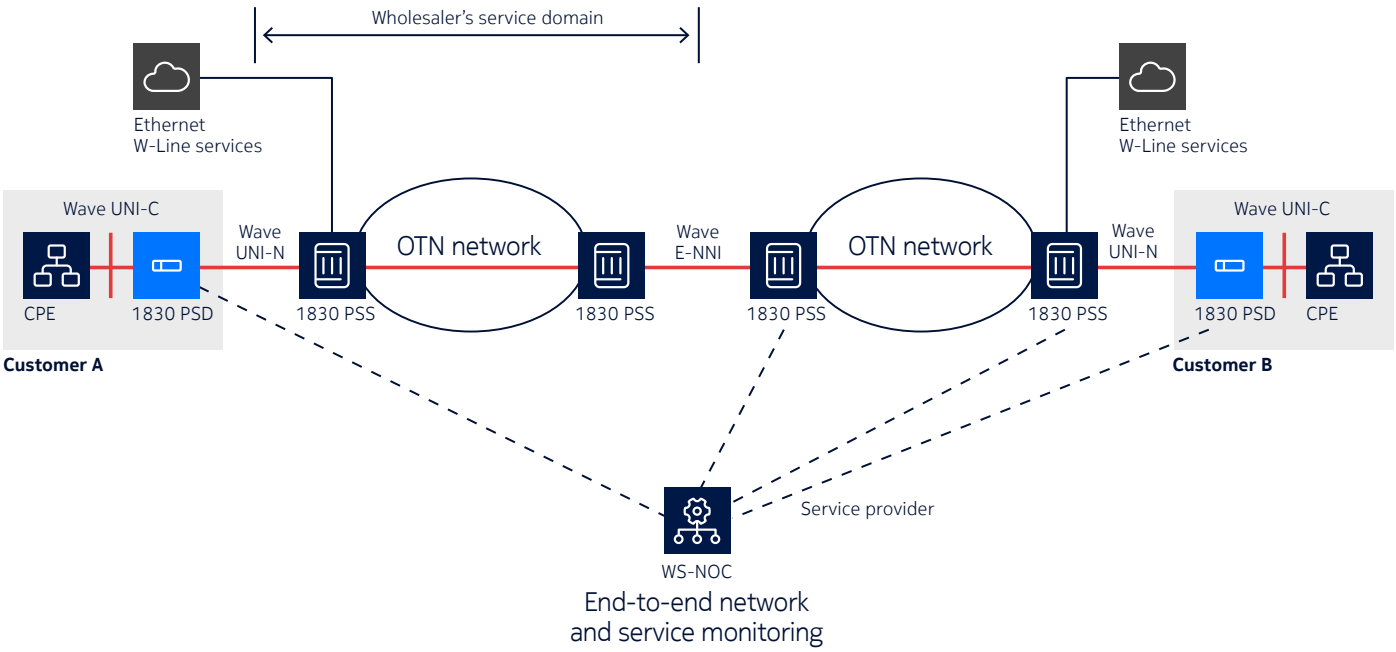
Table 2. Key applications of the 1830 PSD

Application	Key parameters
Network extension	Provides E2E link/service OAM and CFM tools enable service activation testing and service monitoring to uphold SLAs
Network interconnection/access	Enables Ethernet and wave service connectivity while assuring SLAs in support of access to infrastructure resources
Service interworking	Integrated E-Line and layer 1 subscriber services provide seamless services spanning technologies

The 1830 PSD is very versatile in being able to address either Ethernet or wave services within the same platform. This section describes some of the deployment scenarios where the demarcation device can be used.

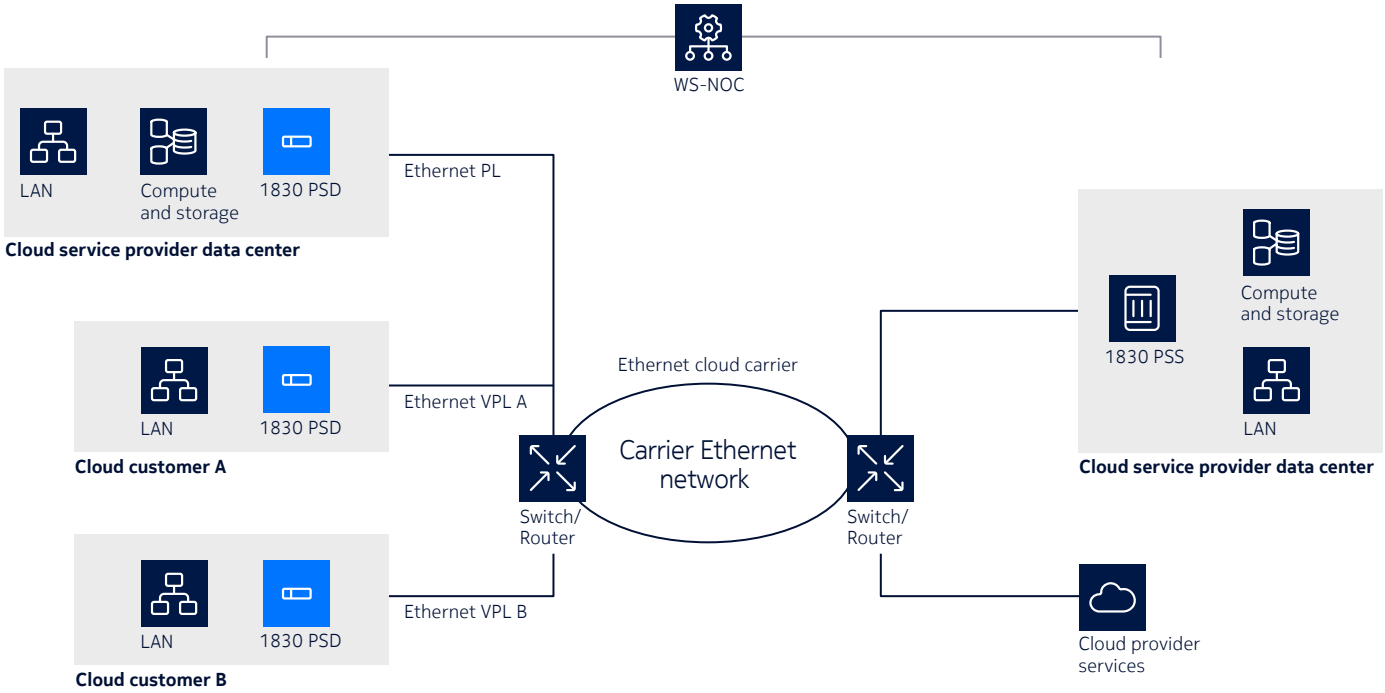
- **Network extension** in support of wholesale or retail services by service provider
  - Cost-effective access (Ethernet or OTN) at customer premises, extending optical network with a “remote port”
  - Service extension to out-of-footprint locations

Figure 2. Service extension to out-of-footprint locations



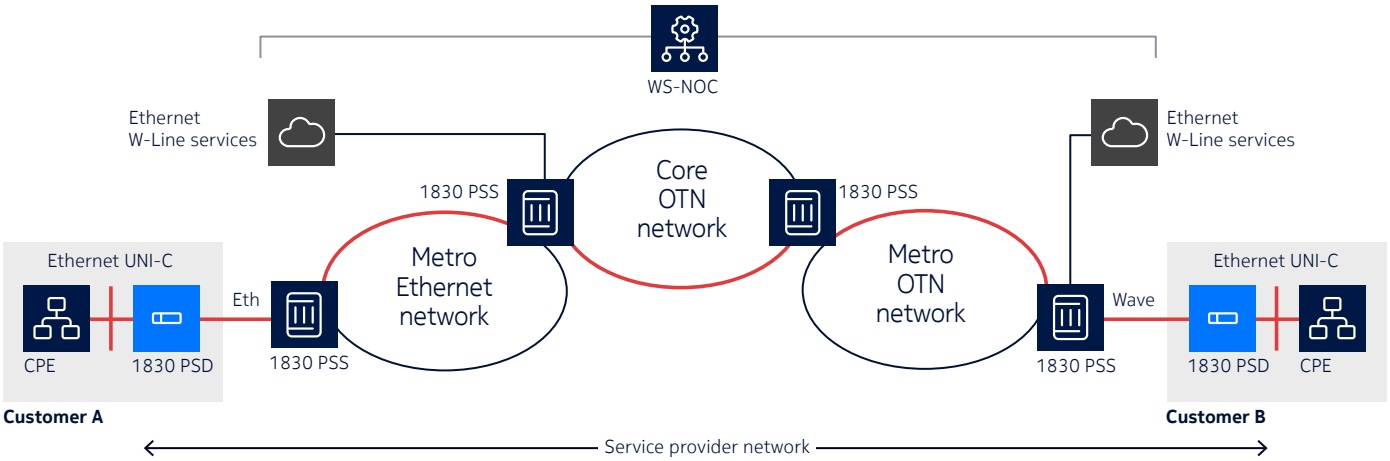
- **Network interconnection/access** (service provider or private build)
  - Cloud services—access to HPC, storage or other infrastructure through Ethernet or OTN network
  - DCI/data center access (DCA)
  - Direct connect—via fiber infrastructure (NID to NID)

Figure 3. Carrier Ethernet cloud services



- **Service interworking**
  - Integrated E-Line and layer 1 subscriber services—end-to-end service offering connecting customer endpoints served by different network technologies
  - Media conversion/legacy interworking—connecting dissimilar networks (Ethernet to OTN) or legacy networks (SONET to OTN) without having to revamp the existing network

Figure 4. Integrated E-Line and wave services



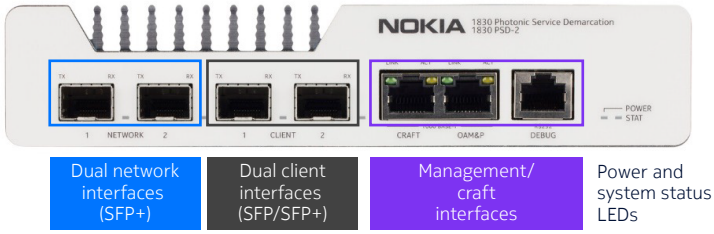
Optical interfaces

The 1830 PSD supports a flexible range of interfaces in support of Ethernet and wave services as well as OAM-related ports as indicated below.

- Client interfaces
  - Ethernet: FE, 1GE, 10GE
  - SDH/SONET: STM1/OC-3, STM-4/OC12, STM16/OC-48
  - OTN: OTU1, OTU2, OTU2e
  - PDH: E1/T1
- Network interfaces
  - 10GE (Ethernet mode)
  - OTU1, OTU2, OTU2e (OTN mode)
- Black & White (grey optics), bi-directional, CWDM, DWDM, Smart SFP
- Management and debug ports

A second interface is available on both the network and client sides, which can be optionally utilized for path protection. The 1830 PSD-2 supports dual network and client ports for both protection and dual services.

Figure 5. 1830 PSD-2 interfaces



Link and service OAM

The 1830 PSD supports link and service OAM. Link OAM is used for installation and service activation of new access links. The 1830 PSD is installed at the customer edge of the network. Service personnel can use standard measurement equipment at the network center to perform extensive link monitoring and performance testing using the 1830 PSD as an active remote loopback device during service activation. After service turn-up, the access link is continuously monitored and link level alarms and performance monitoring reports are collected and reported to the network operations center.

The IEEE 802.1ag standard and ITU-T Y.1731 recommendation provide network monitoring tools that function at the service layer, allowing for end-to-end monitoring of Ethernet virtual connections. Service OAM can be used at multiple levels to support monitoring of the access portion of the network. The 1830 PSD can be configured to support specific maintenance levels and maintenance domains, and can support multiple levels simultaneously. A typical application is to deploy the 1830 PSD at the customer premises. The customer can then use service OAM to monitor their own connection to verify that they obtain the services agreed in the SLA with their service provider. Additionally, the WaveSuite service enablement application can be used to improve service monitoring and SLA assurance for optical connectivity services. The 1830 PSD allows access network providers to continuously monitor the throughput, availability and frame loss parameters that are critically important for their operator customers. It also supports path delay measurement on Ethernet and OTN networks for performance monitoring.

1830 PSD-2 Nokia quantum-safe layer 1 connectivity

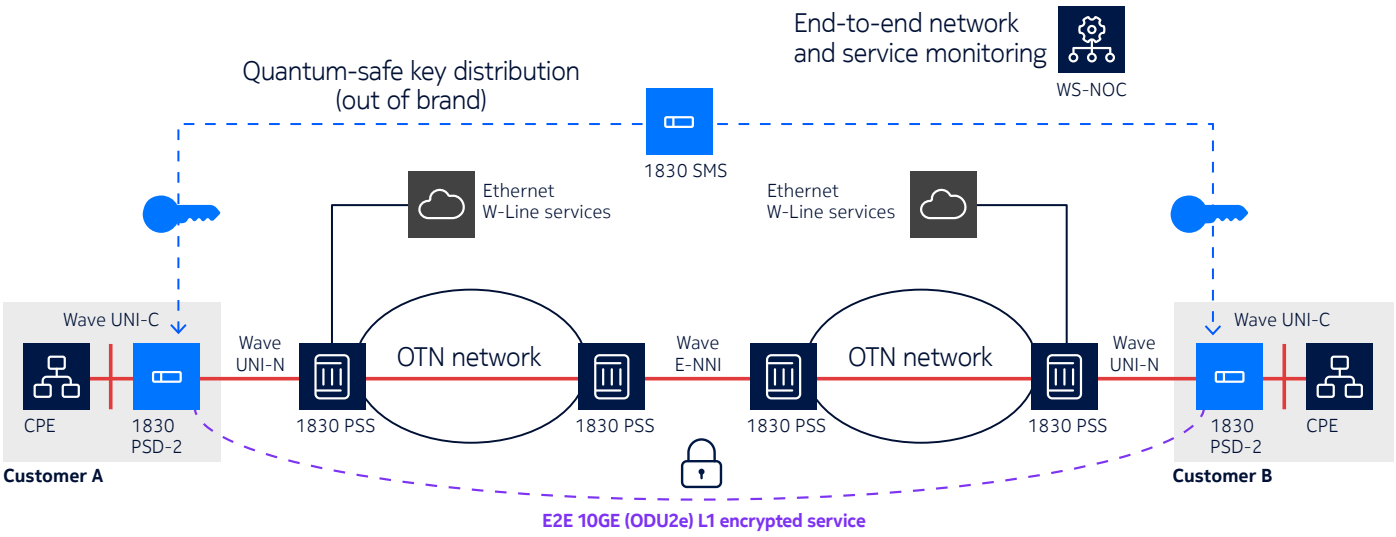
Data confidentiality and security are key requirements for industry verticals such as finance, transportation, utilities, healthcare, public safety, defense and government. In preparation for a world comprised of quantum computers and advanced AI, organizations must begin transitioning to resilient quantum-safe cryptographic infrastructure now to ensure secure operations and maintain trust with stakeholders in an evolving digital landscape. The 1830 PSD-2 adds physical (layer 1) encryption to optical data links, providing end-to-end protection against loss of confidentiality along the fiber.

1830 PSD-2 enables quantum-safe connectivity by transparently mapping 10GE over ODU2e using AES-256 Galois Counter Mode (GCM) encryption at the OTN level. This provides a cost-effective solution that protects data from theft and security threats. When paired with the Nokia 1830 Security Management Server (SMS), quantum-safe encryption through symmetric key management is simplified and automated, helping to reduce OPEX while maintaining the best-in-class protection. This ensures that all transmitted data is encrypted and becomes unusable by unauthorized entities.

To implement quantum-safe layer 1 connectivity, 1830 PSD-2 works with the Nokia 1830 SMS to provide:

- High-quality keys from physical spawned entropy
- Proper key length: a key of 256 bits is considered quantum safe (2^256 possibilities)
- Safe and automated symmetric key distribution using keys that are pre-shared to encryption engines across the network, out of band (OOB)
- Strong data encryption algorithm using AES-256 GCM
- Automated key rotation, refreshing the key periodically creates an ephemeral connection that is more difficult to tap
- Separation of duty between network operations (NOC) used for service creation and deletion, and the security operations (SOC) used for service security policy (including encryption and policy management)

Figure 6. 1830 PSD-2 Nokia quantum-safe connectivity solution



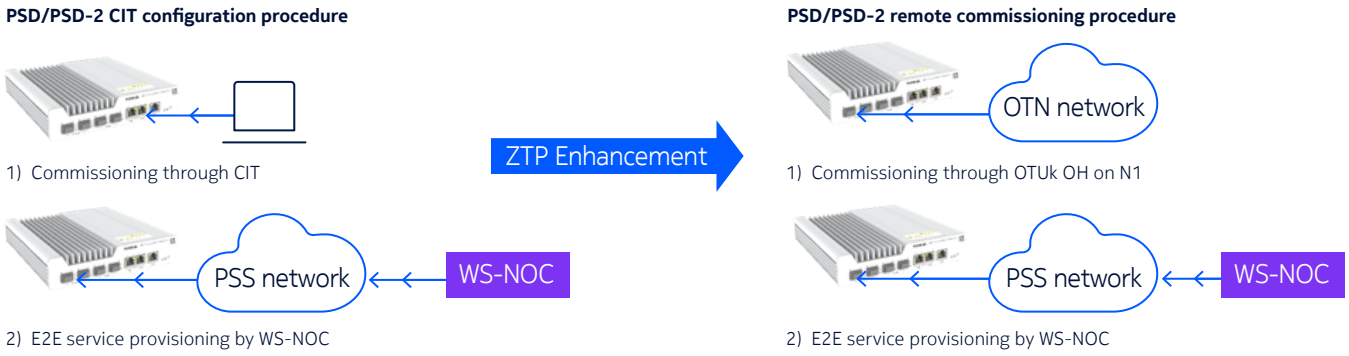
Automatic discovery and configuration

Given the sheer number of demarcation devices located at customer premises across the network, there is a requirement that the devices support plug-and-play deployment capabilities such as automatic discovery and configuration, fast service activation, and report creation and troubleshooting to simplify the maintenance of the network.

The 1830 PSD is managed by the Nokia WS-NOC and tightly integrated with the 1830 Photonic Service Switch (PSS) solution. The WS-NOC simplifies and enhances optical network management. It encompasses network operations, administration and maintenance (OAM), as well as assurance, optimization and service protection. The 1830 PSD supports the zero-touch provisioning (ZTP) enabling automated, high-volume and straightforward remote commissioning. The ZTP helps network owners to install and configure the 1830 PSD demarcation devices across the network in a very convenient way avoiding infield configurations.

When a new 1830 PSD is installed and powered on, it automatically configures the line rate, DCN parameters (including IP loopback address), and transmit frequency (for T-DWDM line plugs) based on the OTN overhead settings, removing the need for manual configuration by a technician.

Figure 7. 1830 PSD remote commissioning procedure



Conclusion

The 1830 PSD is a revolutionary NID that addresses layer 1 and layer 2 network demarcation at customer premises in support of Ethernet and wave services. Its support for standardized layer 1 subscriber services enables highly available, low-latency services needed for today's demanding business-critical applications. It greatly reduces network complexity at the network edge, providing operators and service providers with robust OAM capabilities as well as smart commissioning tools that enable fast turn-up. And its compact size and low power draw enable a cost-effective solution at the network edge.

The Nokia 1830 PSD-2 adds to the advanced feature set with enhanced hardware, redundant AC or DC power, ETR and dual client support while integrating physical layer encryption to optical data links for end-to-end protection, including SNCP OTN path protection when required.

For additional information about the 1830 PSD, please visit https://www.nokia.com/networks/optical-networks/1830-photonic-service-demarcation/

Abbreviations

AES	Advanced Encryption Standard
CE 2.0	Carrier Ethernet 2.0
CFM	connectivity fault management
CO	central office
CPE	customer premises equipment
CWDM	coarse wavelength division multiplexing
DCA	data center access
DCI	data center interconnect
DWDM	dense wavelength division multiplexing
eCE	evolved Commissioning Expert
ETH	Ethernet
ETR	extended temperature range
FC	Fibre Channel
FICON	Fibre Connection
GE	Gigabit Ethernet
GCM	Galois Counter Mode
HPC	high-performance computing
IEEE	Institute of Electrical and Electronics Engineers
ITU-T	International Telecommunication Union – Standardization Sector
MEF	Metro Ethernet Forum
NID	network interface device
NFV	network functions virtualization
NMS	network management system
NNI	network-to-network interface
OAM	operations, administration and maintenance
ODU	Optical Data Unit (ITU-T G.709)
OMS	Optical Management System
OTN	Optical Transport Network (ITU-T G.870, G.709)
OTU	Optical Transport Unit (ITU-T G.709)
PSD	Photonic Service Demarcation
PSS	Photonic Service Switch
PTP	Precision Time Protocol

QKD	quantum key distribution
QSN	quantum-safe networks
SAN	storage area network
SDH	Synchronous Digital Hierarchy
SFP	small form-factor pluggable
SLA	service level agreement
SMS	Security Management Server
SNMP	Simple Network Management Protocol
SONET	Synchronous Optical Network
SyncE	Synchronous Ethernet
TDM	time division multiplexing
TPoP	Transparent PDH over Packet
UNI	user-to-network interface
VLAN	virtual LAN (IEEE 802.1Q)
VPL	virtual private line
VPN	virtual private network
WDM	wavelength division multiplexing
WS-NOC	WaveSuite Network Operations Center
ZTP	zero-touch provisioning

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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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