
Scale made simple
Agility and flexibility through OTN
NOKIA

Meeting the multi-service, multi-tenant challenge

Modern networks need to do more than ever. Network operators need to deliver connectivity services for wide-ranging applications such as data center interconnect (DCI), 5G mobile networks, enterprise or government private networks and many others.

The wholesale services market enables communications service providers (CSPs) to capitalize on their typically large and far-reaching networks to serve a broad range of end users and access customers and markets that would otherwise be difficult or impossible to access.

Large CSPs operate national and international backbone networks that provide end-to-end connectivity for a wide range of internal business units and external customers. For example, a CSP may operate a wholesale backbone network that provides connectivity to its mobile service subsidiaries, its enterprise and business services unit, and to its subsidiaries that operate distinct national networks.

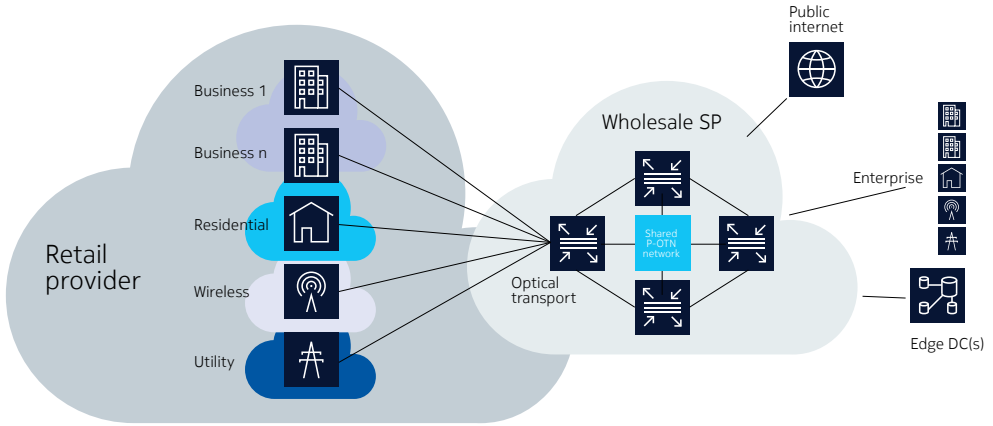
In other cases, a large incumbent may have a difficult time reaching sectors of the retail market due to contractual or regulatory issues in certain geographies. Selling capacity through a separate retail provider allows the CSP to enjoy otherwise unreachable revenue, for example from small to medium enterprises, residential municipal broadband, wireless or power utility customers.

The CSP gains market share while also amortizing the cost of its entire network. This enables third-party service providers to provide a broader range of connectivity options to their end customers than they otherwise could, based on their limited network scope. At the same time, the wholesale CSP benefits from a broader range of new wholesale revenue opportunities.

This wholesale service provider model is a prime example of a multi-service, multi-tenant network offering services across its national or global infrastructure to customers with a range of capacity, protocol, latency, availability and other performance requirements. End users include webscale companies connecting to data centers or peering sites, other CSPs needing connectivity outside their network and large enterprises operating international private networks.

Some customers and applications need to accommodate large traffic flows and scaling of service bandwidths. Other customers require tight latency or security requirements, while yet others have less stringent, elastic traffic demands. For the wholesale provider, the challenge is efficiently scaling to meet these growth needs, adding new protocols or services, guaranteeing SLAs and pricing them competitively, all over a common infrastructure. The challenge is for the CSP to meet the needs of all through a shared network (see Figure 1).

Figure 1. Wholesale service provider challenge: Multiple services, multiple tenants



Traffic grooming at the best network layer

There are many aspects of the network to be considered in delivery of wholesale services. At the foundation is layer 0: optical wavelengths that carry large pieces of capacity. At layer 1 we can make better use of a wavelength's capacity through OTN encapsulation and switching, providing an efficient means to aggregate various service types and speeds, and efficiently containerize them for transport across the network.

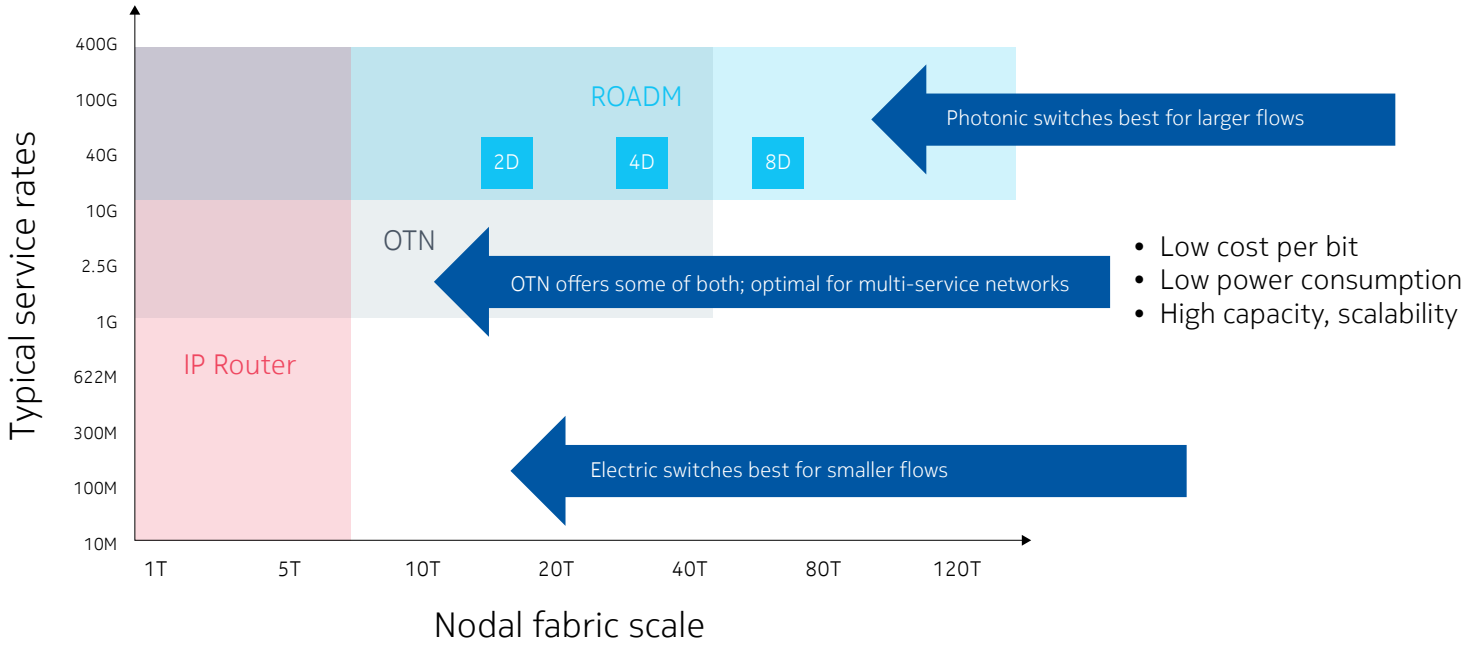
OTN plays a role nicely between layer 0 wavelength routing with ROADMs and layer 2 packet or layer 3 IP routing. As shown in Figure 2, each layer plays a role in network optimization and SLA assurance, and there is a special role for OTN.

Remember the old adage, "switch where you can; route where you must"? This saying still is pertinent today as routers, along with various forms of switching, have evolved. We like to think of routers as switches of switches; operating at the electrical level, intending to route traffic closest to its fundamental end-user service rate towards the subscriber. End-user rates continue to increase, and we now have 400G router interfaces.

Between the two options of electrical switches and photonic switches lies OTN, which provides a clear set of benefits for CSPs and will continue to do so for a long time. OTN switching provides an excellent compromise between the capacity and scalability of photonic switching and the granularity, grooming and bandwidth efficiency of IP routing.

There are also operations, administration, maintenance and provisioning (OAM&P) benefits from OTN that many CSPs have built their brands upon. Retaining these capabilities helps the CSP gain market share and ensure operational continuity.

Figure 2. OTN optimal for service provider networks



OTN basics

OTN was established as a standard by the ITU-T Recommendation G.709 in 2001. This standard defines OTN as a transparent method for transport of data services over optical wavelengths. While initially developed as a digital wrapper for WDM wavelengths, OTN has evolved to a role as a generic, protocol-agnostic container for transport and switching of virtually any service.

OTN utilizes a containerization method that allows for efficient packaging of traffic into payload containers which then can be aggregated, switched and transported across the network both efficiently and with a high degree of determinism. The standard hierarchy can be thought of as boxes loaded onto a truck (see Figure 3).

The OTN standard provides for simple scaling implicitly to 100 Gbps and has been updated to meet changing industry demands. With the more recent B100G initiative, scaling continues upwards in 100 Gbps increments. This scaling increase gives operators a long timeline for the useful life of OTN network equipment as they scale capacity to 400 Gbps and beyond.

OTN's structure provides many inherent benefits for operators as they evolve their networks to meet the needs of different customers. As client services (signals) are mapped into the OTN container, overhead is added to allow for monitoring of the traffic type, its status as it traverses the network, and the health of the network over time (see Figure 4).

Figure 3. Universal OTN payloads

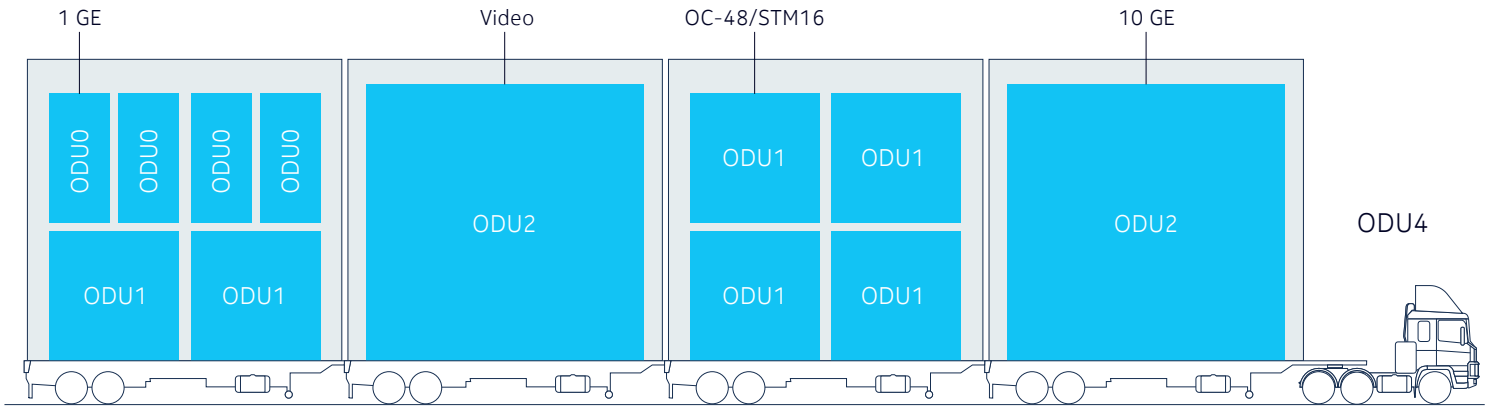
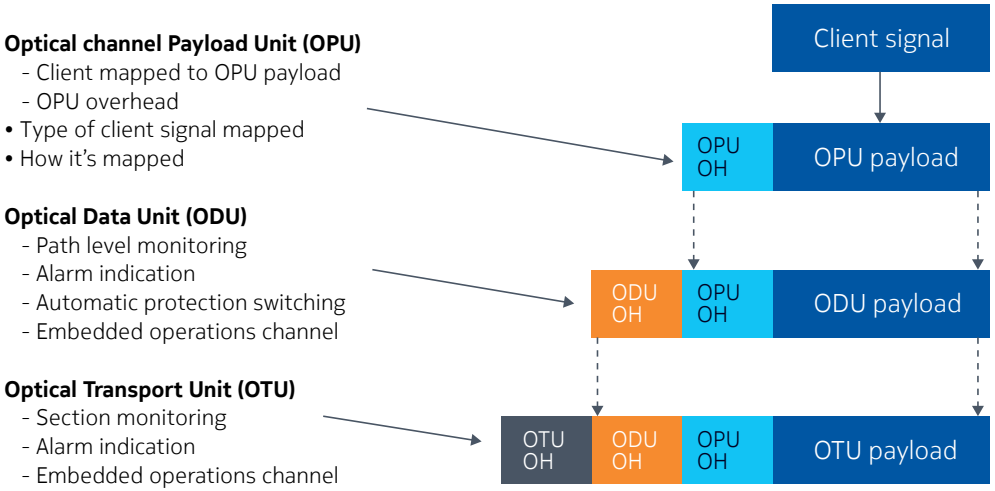


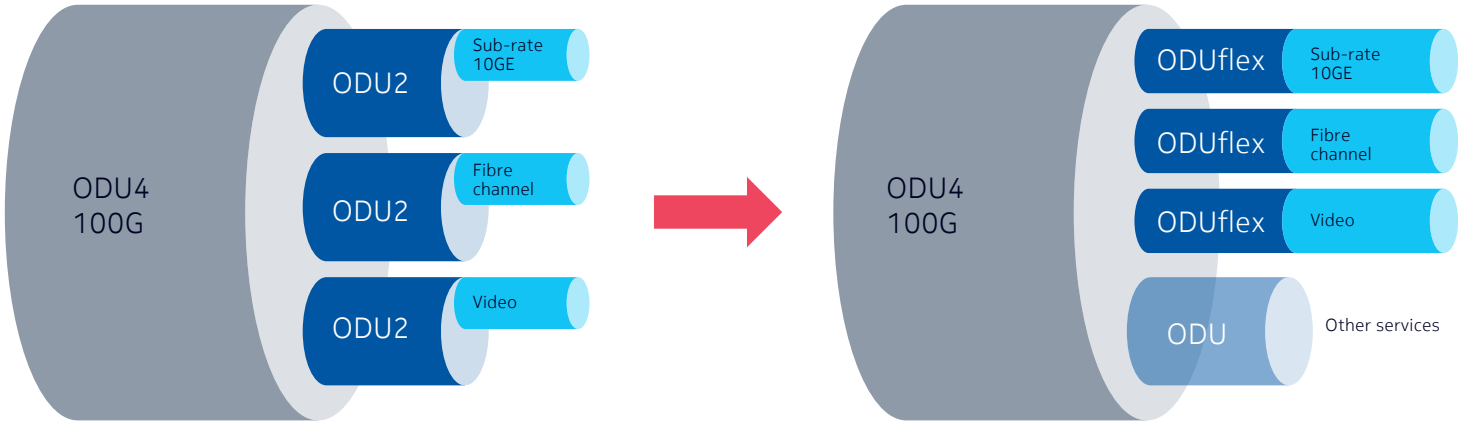
Figure 4. OTN container structure



This structure yields numerous benefits for network operators, including:

- Improved network efficiency and utilization
- An industry-standard multiplexing method for 100G, 400G and higher payloads
- Protocol flexibility: The container carries any traffic type, including sub-rate services (SONET/SDH, packet, video, etc.)
- Common, standardized, well-defined OAM&P
- Optical-layer performance monitoring, forward error correction and protection switching
- Traffic segregation and hard isolation
- Service differentiation and SLA assurance.

Figure 5. ODUflex



ODUFlex

- Flexible mapping structure for non-standard rate services
  - Sub-rate 10GE, fibre channel, infiniband, etc
- Any service can be mapped into "n x TS" (~1.25G tributary slots), improved bandwidth efficiency
- Traditional OTN payloads closely linked to client service types, but not very efficient for non-standard rates
  - 1 GE ODU0
  - 10GE / OC-192 / SM-64 ODU2
  - 100GE ODU4

Over time, the OTN standard has evolved to add powerful service flexibility. For example, ODUflex is a mechanism for including sub-rate services of any speed in an ODU container. By using 1.25 Gbps tributaries, ODUflex allows for very efficient transport of services within the network (see Figure 5).

Another attractive OTN capability is its ability to provide robust protection and failure resilience. Much as in TDM networks, the overhead structure provides a strong means to monitor network section and path health, and take corrective actions in the event of a failure.

OTN supports various protection mechanisms, including 1+1, 1:n and ODUk shared protection rings. These protection topologies give operators assurance that service can be quickly restored when fiber cuts or other failures occur, further aiding in meeting the demands of customer SLAs.

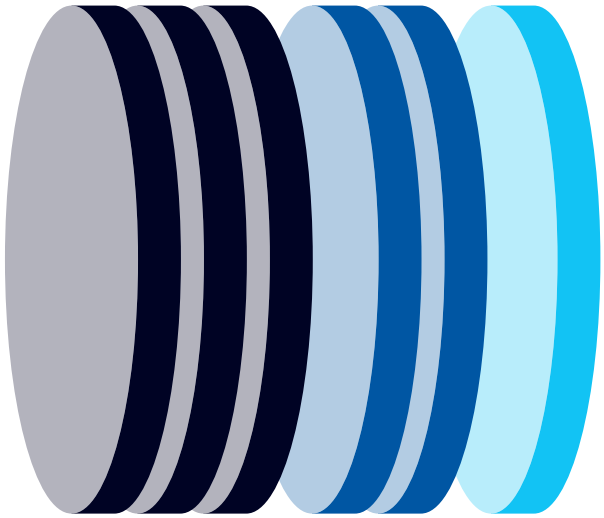
Slice off the right piece

To support multiple network users and related services, each with their own unique requirements, resources need to be allocated for each, often in groups or slices of capacity. Splitting the network by creating multiple, logical networks for each user from a common physical infrastructure is referred to as network slicing (see Figure 6).

In the Nokia white paper Traffic isolation in transport networks, we define three broad network slices: multi-service, CSP multi-tenant and mobile network operators (MNOs). A wholesale service provider could make a slice for any or all of these types. This creates multiple, logical networks for each user from a common physical infrastructure.

Figure 6. Network slicing: Slices of the network for different users

Supporting multiple network users, each with unique requirements, demands creation of multiple, logical networks within a common physical infrastructure: **Network slicing**



Multi-service	**CSP multi-tenant**	**MNO for 5G**
Enterprise PL	Residential	eMBB
Res. BB	Wireless	URLCC
Wireless	Business/Enterprise	mMTC

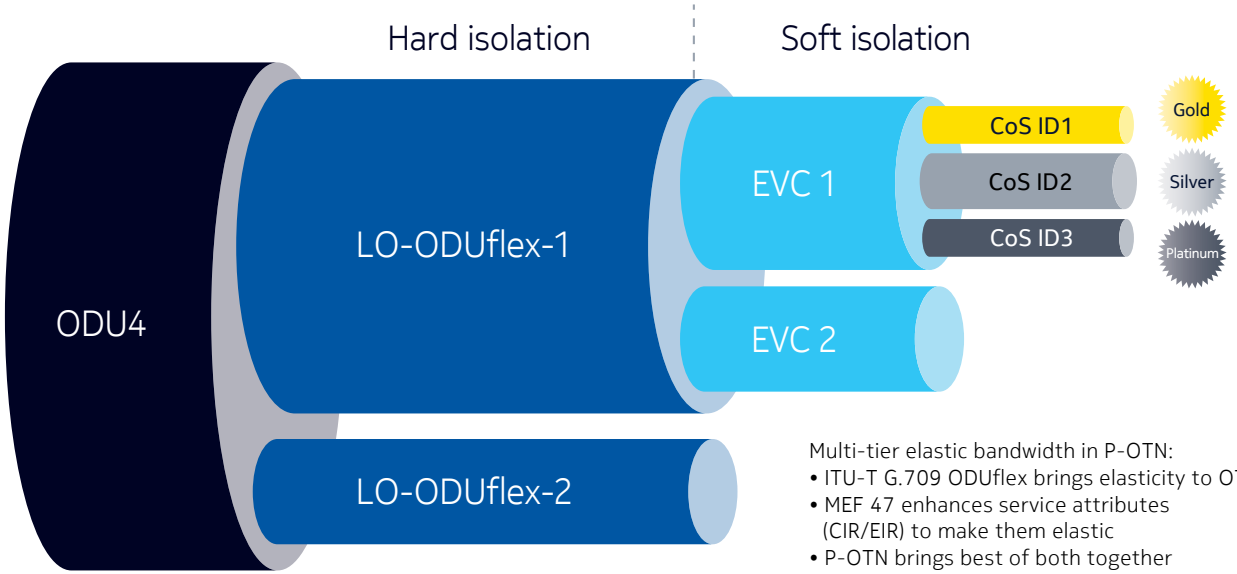
Hard or soft isolation?

Traffic isolation goes together with network slicing because a method is needed to separate the traffic in one slice from the traffic in another slice within the same transport network. This process comprises several classes of network isolation, including hard isolation and soft isolation.

Hard isolation is a method for isolating traffic on an interface or link using a circuit-switched connection. The traffic load of one virtual network (VN) has no impact on the traffic in any other VN, including QoS effects.

Hard isolation is implemented by providing independent, circuit-switched connections for the exclusive use of one VN. These connections can be provided by, for example, a dedicated wavelength or a dedicated TDM timeslot, such as an ODUk/ODUflex in OTN or a mobile transport network section (FlexE) timeslot. With hard isolation, there is no sharing of resources (see Figure 7).

Figure 7. OTN providing a hard isolation network slice



Soft isolation is a method for isolating traffic on an interface or link at the packet level using any layer 2 or layer 3 virtual private network (VPN) technique. The traffic load of one VN can have an impact on the QoS provided to the traffic in other VNs. Soft isolation is implemented by statistically multiplexing the traffic from two or more VNs using a packet technology. Traffic engineering can constrain the QoS impact of traffic on other VNs.

Multiprotocol Label Switching (MPLS) tunnels, Segment Routing MPLS tunnels or segments, and hierarchical QoS queues are packet technologies and provide soft isolation only.

In a converged, multi-service metro network, the challenge for the transport network operator is to apply the type of isolation necessary to meet the QoS requirements of its service mix and provide the tools to monitor and protect each service appropriately while optimizing bandwidth efficiency.

A network view for the 2020s

Nokia's view of the optimized multi-layer, multi-service network includes at least four areas:

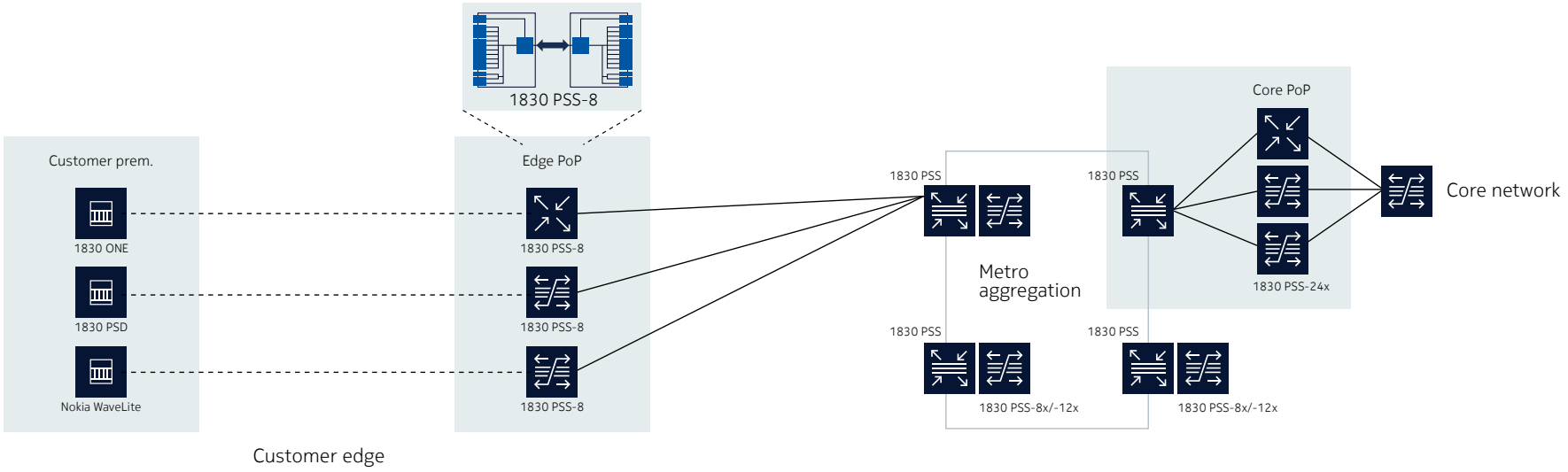
Customer premises aggregation devices, to collect and hand off traffic to edge service provider points. These devices might also need to perform multiplexing or emulation functions. For all of these tasks, the Nokia 1830 Optical Network Extender (ONE), Nokia 1830 Photonic Service Demarcation (PSD) and the Nokia WaveLite optical networking products bring end-to-end OTN service benefits to the network edge. Compact and application-optimized, these products meet the specific traffic needs of various types of end customers.

Distributed OTN edge switching, delivered through the S13X100 card used in WDM transport platforms such as the Nokia Photonic Service Switch platforms (PSS-8 or PSS-16), can increase efficiency at the edges of the network, where large OTN switching is not deployed. This distributed OTN edge switching allows an operator to increase end capacity at an attractive price point.

Centralized OTN metro switching and transport using the PSS-8x or PSS-12x at the metro aggregation or metro core in conjunction with PSS line systems provides scaling efficiency for wavelength utilization and also offers wholesale customers service separation, security and hard isolation. With the PSS-8x or PSS-12x, operators can scale to non-blocking switching capacities of 4 Tbps or 12 Tbps.

Core network, centralized OTN switching provided by the PSS-24x delivers yet more scaling efficiency and traffic segregation capabilities as well as network resiliency and protection. Using the PSS-24x, operators can support nonblocking switching matrices of 24 Tbps per shelf or 48 Tbps per shelf pair. The Nokia solution for an optimized multi-layer, multi-service network that includes all of the preceding elements is OTN switching (see Figure 8).

Figure 8. Nokia solution: OTN switching in multi-layer, multi-service networks



Nokia OTN solutions: a powerful tool for your network

OTN is a well-proven, mature technology that is ready today to help network operators meet the needs of a changing and diverse communications market. Though TDM applications are declining, there is a continuing need to deliver these services while gracefully modernizing to a packet-based landscape. OTN can meet this need and will continue to deliver value to operators well into the next decade.

A Packet-OTN (P-OTN) network can deliver numerous benefits to operators, including:

- **Scalability**
  Scales to 400 Gbps and beyond through standardized initiatives such as B100G and OTUCn. OTN is ready to scale into the foreseeable future.
- **Service transparency**
  Easily transports any service with a high degree of reliability and assurance.
- **Deterministic performance**
  OTN adds the ability to ensure deterministic transport to packet services, aiding in the ability to guarantee SLAs.
- **Transport efficiency**
  Ability to make the most use of each wavelength on a network fiber through efficient multiplexing and switching of high-growth services.
- **End-to-end monitoring**
  Much like SDH/SONET networks, OTN offers the ability to accurately monitor network health from the customer premise to destination and perform automated protection as needed. OTN's OAM&P capabilities also permit the end user to monitor the health of their own virtual circuit, providing an automated monitoring capability.
- **Resilience and assurance**
  OTN offers protection mechanisms that allow the operator to be assured of network availability in the face of fiber cuts.

Nokia offers network operators a full range of OTN solutions, designed for use at the enterprise/customer edge, metro and core network. At the edge, Nokia's 1830 ONE, 1830 PSD, and WaveLite products provide the ability to aggregate and transport OTN services onto the network with great economy and ease. In the network core, our PSS-x family of platforms provide OTN switching and transport though a range of service interfaces and switching fabrics that can be matched to the unique needs of each network design.

Learn more

To learn more about Nokia OTN solutions for network operators, visit **https://www.nokia.com/networks/products/1830-pss-x-otn-switching-platforms/**

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Document code: CID212302 (February)

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Adhering to the highest standards of integrity and security, we help build the capabilities needed for a more productive, sustainable and inclusive world.