



Routed Optical Networking

This chapter provides an overview of Routed Optical Networking, its benefits, and supported deployment models.

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Routed Optical Networking Overview

Routed Optical Networking simplifies complex multilayer networks by collapsing network layers and minimizing the functional overlap. Routed Optical Networking also improves the overall network efficiency by optimizing each layer of the network. The architecture also integrates open data models and standard APIs, enriching powerful automation making Routed Optical Networking easier to operate than legacy networks.

Routed Optical Networking is able to provide improvements and simplification because it:

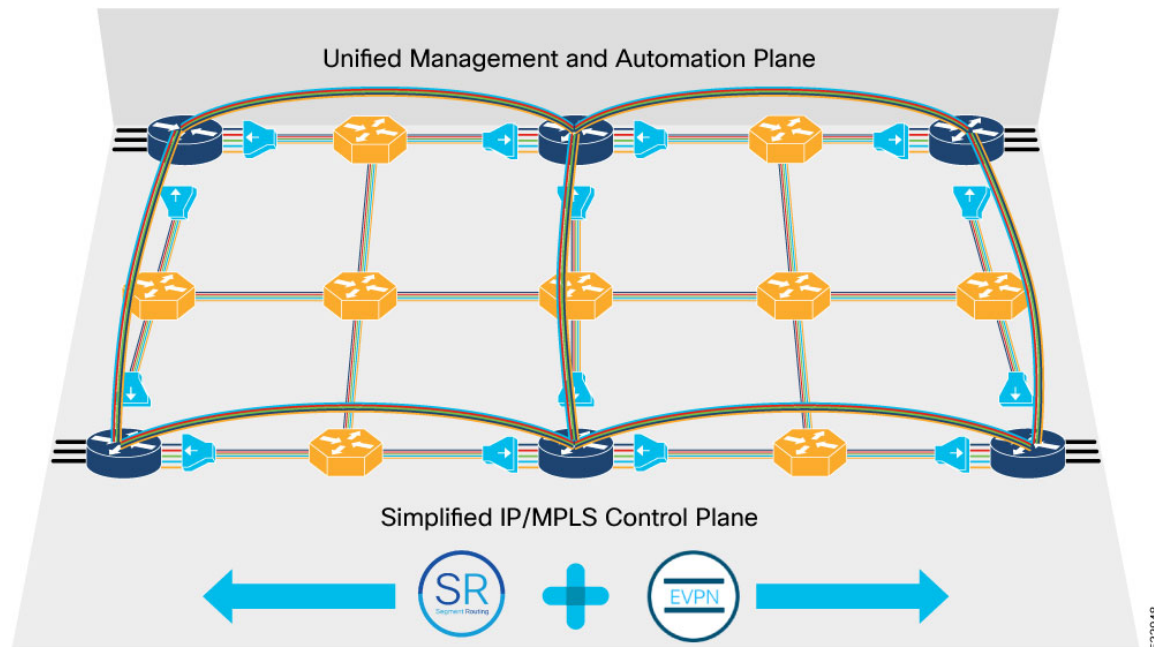
- Leverages state of the art optical and routing technologies to converge services over an IP infrastructure connected by a simplified DWDM layer
- Merges IP and private line services onto a single unified IP layer
- Simplifies end-to-end network architecture
- Utilizes a modern software stack that spans across network management and control planes
- Improves the capacity and cost efficiency of networks
- Has a smaller carbon footprint
- Offers unified capacity planning, unified EMS, unified path optimization, orchestration, and assurance
- Provides an automation ecosystem with open, programmable, and modular components
- Total Cost of Ownership savings across CapEx and OpEx

Routed Optical Networking utilizes high-density routers, high-capacity ZR or ZR+ pluggable digital coherent optics, simplified DWDM line systems, and end-to-end multi-layer automation to create next generation networks.

Routed Optical Networking Strategy

Routed Optical Networking architecture unifies the WDM, OTN, and packet transport layers into a single, easy-to-control layer.

Figure 1: Routed Optical Networking Strategy



A Converged SDN Transport architecture simplifies the network by converging services on a unified, automated infrastructure for maximum scalability and agility to support emerging services for the 5G era and beyond. See [Converged SDN Transport](#).

Routed Optical Networking as part of Cisco's Converged SDN Transport architecture brings network simplification to the physical network infrastructure, just as EVPN and Segment Routing simplify the service and traffic engineering network layers. Routed Optical Networking collapses complex technologies and network layers into a more cost efficient and easy to manage network infrastructure.

Routed Optical Networking achieves this architecture by leveraging high-density routers, high-capacity digital coherent pluggable optical modules, simplified optical elements, and advanced automation capabilities. Components of Routed Optical Network are also fully compliant ROADM-based networks and can interoperate seamlessly with a mix of traditional transponders and Routed Optical Networking DCO pluggables.

The converged architecture enables:

- Unified planning and design
- Seamless multi-layer provisioning
- Unified multi-layer management

- End-to-end multi-layer and multi-domain network visibility
- End-to-end network optimization for IP and private line services
- Convergence of IP and private line services on a single converged packet network infrastructure with guaranteed SLAs

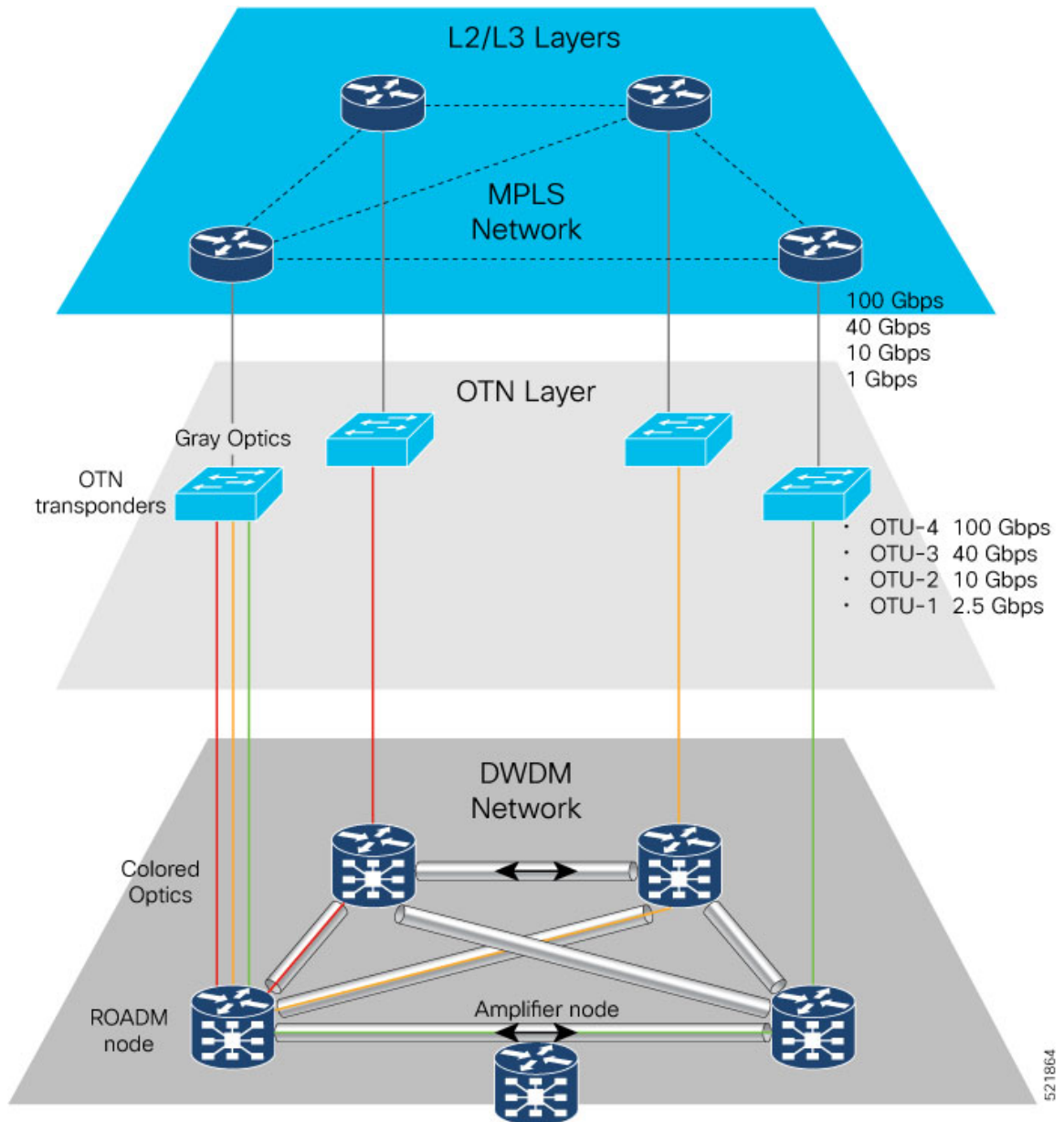
The following table compares the legacy multilayered architecture and the Routed Optical Networking architecture.

Layered Architecture	Routed Optical Networking Architecture
Trades off port density and capacity on router line cards for coherent optical transmission	Higher port density and capacity on the router line cards using digital coherent pluggable optical modules
Proprietary components; noninteroperable	Standards-based approach; interoperable across vendors
Siloed approach; separate control and management planes	Common control and management planes for converged optical and IP layer
Manual service stitching necessary across network domains	Enables end-to-end closed-loop automation and manageability
Independent capacity planning on IP and optical layers, where additional capacity is dimensioned on each layer separately leading to CapEx inefficiencies.	Unified capacity planning on a converged network optimizing CapEx investments

Technology Overview

The following diagram displays the current multilayer architecture.

Figure 2: Multilayer Architecture



Routed Optical Networking is a transformative architecture that disrupts the existing multilayer network architecture. It converges all network services into a single layer.

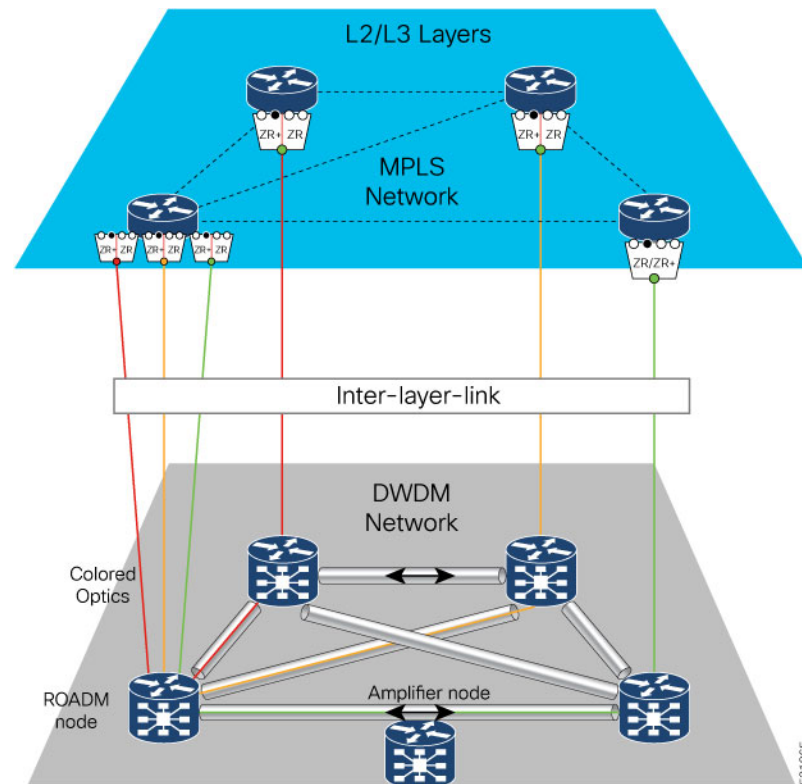
The routers are connected over either dark fiber or a DWDM network with standardized pluggable digital coherent optics, such as ZR and ZR+ transceivers. These transceivers reduce cabling, power consumption, and physical footprint requirements versus using traditional external transponders.

The routers are connected with standardized pluggable coherent optics, such as ZR/ZR+ transceivers. These transceivers reduce cabling, power consumption, and footprint requirements.

With a single service layer based on IP, flexible management tools can leverage telemetry and model-driven programmability to streamline lifecycle operations. This simplified architecture integrates open data models and standard APIs, enabling a provider to focus on automation initiatives for a simpler topology.

The following diagram displays the Routed Optical Networking architecture.

Figure 3: Routed Optical Networking Architecture



Benefits of Routed Optical Networking

The benefits of Routed Optical Networking are:

- Cost Savings:** Routed Optical Networking provides a decreased network total cost of ownership. Routed Optical networks make the most efficient use of high capacity routers and DWDM optical infrastructure. Utilizing the routers high capacity switching allows denser interconnection and the ability to move all traffic protection to the IP layer of the network. Routed Optical Networking saves costs by converging service layers, moving to a simplified DWDM optical system, and using industry standard ZR/ZR+ pluggable digital coherent optics. Elimination of multiple layers reduces power usage and hardware footprint. End-to-end multi-layer automation enables better utilization of network capacity.
- Simplification:** Using Converged SDN Transport technologies such as Segment Routing and EVPN along with the Routed Optical Networking simplifies networks from the base infrastructure layer to the services layer. Using Circuit-Style Segment Routing and Private Line Emulation, Routed Optical Networking allows providers to converge services while maintaining or exceeding current private line service SLAs. This convergence leads to simplified planning, design, activation, management, and troubleshooting.

- **Automation:** Automation improves resiliency, failure detection, and ease of repair. Enhanced multi-layer visibility and root cause analysis allows network operators to quickly discover and remediate faults. Troubleshooting is enhanced with rich network telemetry at each layer.
- **Optimize Capacity:** Routed Optical Networking takes advantage of the IP layer's ability to statistical multiplex network traffic at the packet level. Statistical multiplexing is the most efficient way to carry network traffic with the ability to adapt to instantaneous traffic demands and avoid idle link capacity. Routed Optical Networking networks utilize fiber capacity to its fullest by intelligently utilizing capacity at the IP layer instead of wasting DWDM resources with unnecessary bypass circuits.

Routed Optical Networking Deployment Models

There is no one-size-fits-all solution for deploying a new architecture. The approach depends on the structure of the network and the goals of its owner. Thus, it is critical to have a flexible control platform that supports a phased deployment and a smooth evolution. The models are:

- **Routed Optical Networking Deployment:** When a new IP and optical network is deployed, the hardware, together with its control architecture – including Crosswork Hierarchical Controller, Crosswork Network Controller, and Cisco Optical Network Controller, is installed from scratch. In fact, it may be useful to install Crosswork Hierarchical Controller ahead of time, in preparation for the Routed Optical Networking deployment, over existing parts of the network, to help plan out the Routed Optical Networking network based on accurate data about the existing services, network, and fiber assets. See [Automation Components](#). Cisco Networks managed using Cisco EPNM can utilize EPNM to manage Routed Optical Networking
- **Third-party Optical Network Routed Optical Networking Deployment:** When routers with ZR/ZR+ optics are deployed over networks that use third-party optical devices, Crosswork Hierarchical Controller is integrated with Crosswork Network Controller and the existing DWDM optical controllers. Crosswork Hierarchical Controller creates IP links between the routers by configuring the optical path through the optical controllers and terminates those paths on the DWDM transceivers in the routers.

What's New in Routed Optical Networking 2.0

Feature	Release	Description
Simple Optical Line Systems	IOS-XR: 7.7.1	<p>NCS 1010 OLS platform is an integral component of Routed Optical Networking solution. It provides point-to-point connectivity between routers with ZR/ZR+ optics and multiplexes signals from multiple routers over a single fiber. The OLS platform supports ROADM nodes of up to eight degrees.</p> <p>The NCS 1010 OLS platform provides:</p> <ul style="list-style-type: none"> • Versatility by supporting multiple coherent sources • Simplicity by using integrated Optical line cards that minimize fiber patching and cabling errors in the field. • Automation through IOS XR operating system that provides a rich suite of automation features including Zero Touch Provisioning (ZTP), open config YANG model support with NETCONF, and streaming telemetry. • Network Monitoring through a combination of probes based on OTDR, OSC, OCM, and telemetry data.
OpenConfig support for ZR/ZR+	IOS-XR: 7.7.1	You can manage the pluggable digital coherent optics using open models from the OpenConfig consortium.
Private Line Emulation	IOS-XR: 7.7.1	<p>Private line emulation (PLE) enables service providers to carry SONET/SDH, OTN, Ethernet, and Fiber Channel over a circuit-style segment routed packet network while maintaining existing service SLAs.</p> <p>Private Line Emulation (PLE) utilizes Circuit Emulation (CEM) to transparently transfer PLE client frames over MPLS or Segment Routing networks without changing the characteristics of the original signal.</p>

What's New in Routed Optical Networking 2.1

Feature	Release	Description
Cisco 400G QSFP-DD High-Power (Bright) Optical module Support	Cisco IOS XR 7.9.1	<p>The following routers support Cisco 400G QSFP-DD High-Power (Bright) Optical Module (DP04QSDD-HE0)</p> <ul style="list-style-type: none"> • NCS-57C3-MOD • 8201-32FH • 8201-24H8FH • A9K-20HG-FLEX-SE/TR • A9K-8HG-FLEX-SE/TR <p>This high-power optical module allows easier interoperability with all deployed add/drop architectures and enhances unamplified reach by about 12dB as compared to QDD-400G-ZR-S and QDD-400G-ZRP-S.</p>
PLE Improvements	Cisco IOS XR 7.9.1	Private line emulation (PLE) enables service providers to carry SONET/SDH, OTN, Ethernet, and Fiber Channel over a circuit-style segment routed packet network while maintaining existing service SLAs. In this release, the user can configure dynamic circuit-style SR-TE policies with or without bandwidth Call Admission Control (CAC).
Connection Verification Improvements	Cisco Crosswork Hierarchical Controller 7.0	You can now perform connection validation from a ZR/ZR+ pluggable on a router to the Optical Line System (OLS) add-drop port. In this release Cross-Link Connectivity Verification is supported on all router platforms and NCS 1010 OLT systems.