Routed Optical Networking

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

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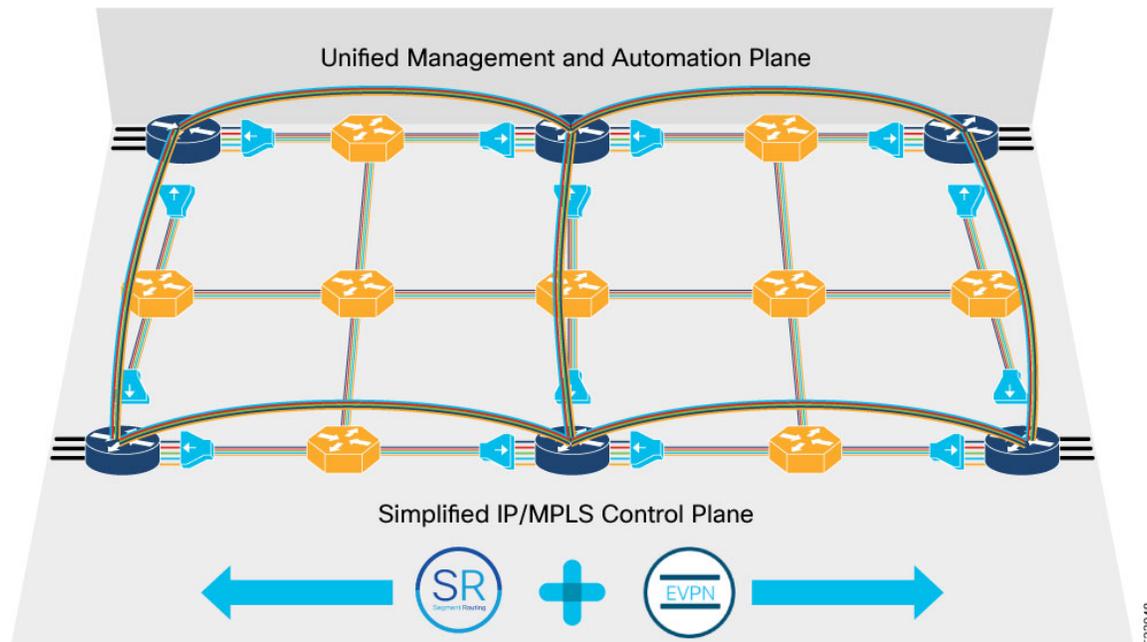
A Converged SDN Transport architecture simplifies the network by converging services on a unified, automated infrastructure for maximum scalability and agility to support emerging services for the 5G era and beyond. See Converged SDN Trasnport.

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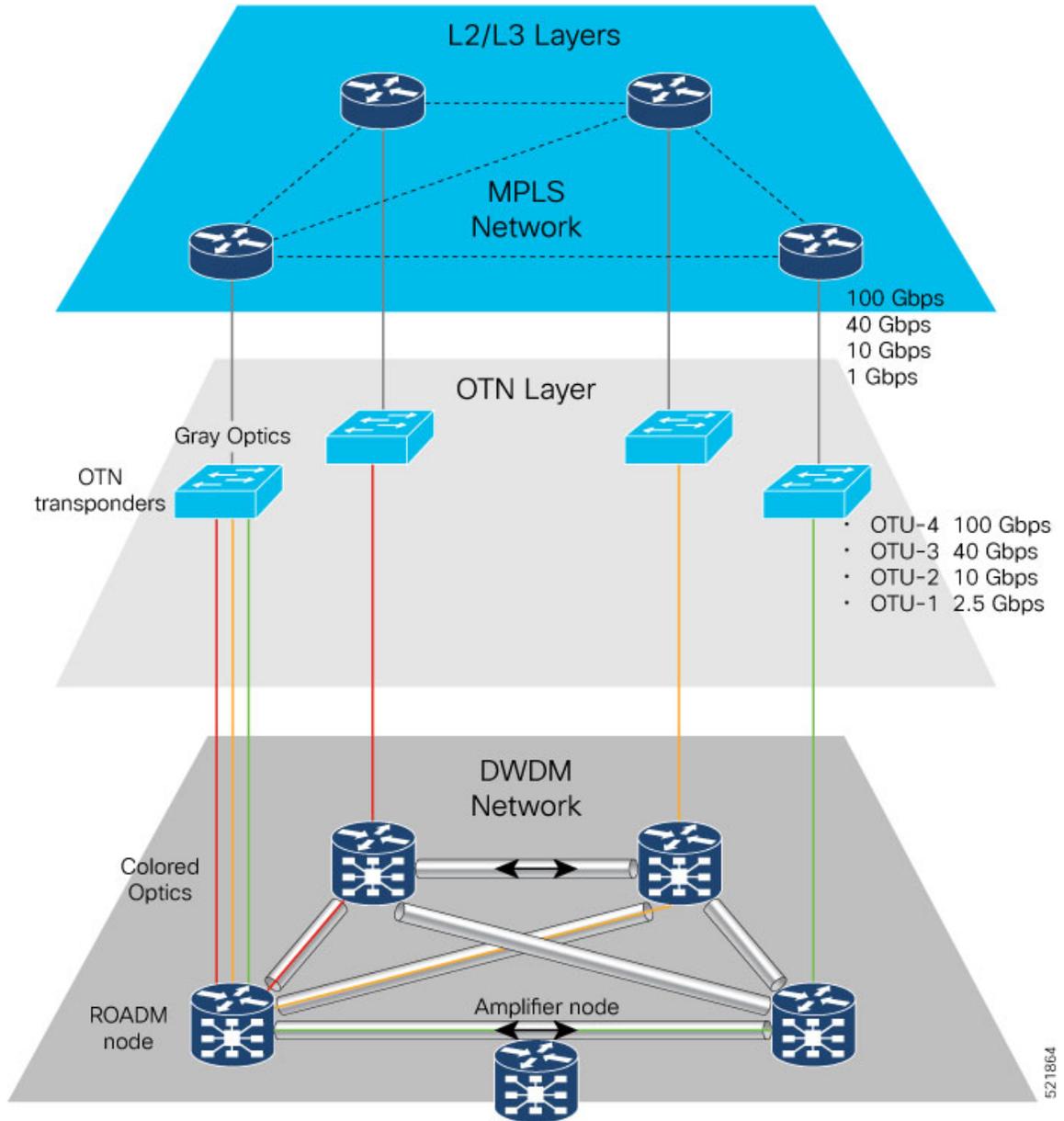
Routed Optical Networking is a transformative architecture that disrupts the existing multilayer network architecture. It converges all network services into a single layer.

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.

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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
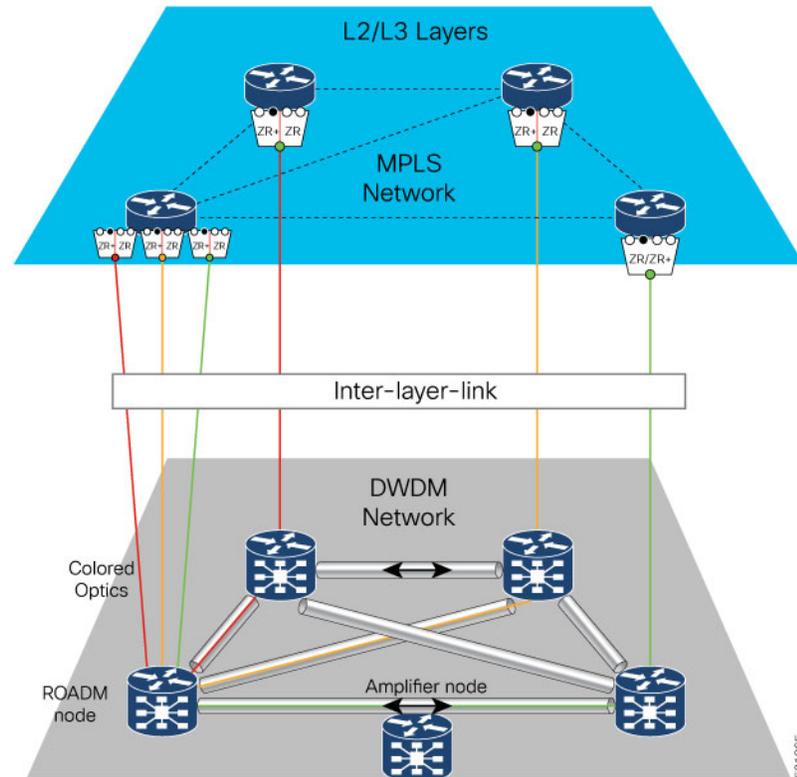
Benefits of Routed Optical Networking

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 3.0

Feature	Release	Description
Automation Starter Solution	Crosswork Hierarchical Controller 8.0	Automation Starter Solution accelerates adoption of Routed Optical Networking by simplifying the installation and deployment of the overall Routed Optical Networking solution. It is a simplified automation stack that is used to manage ZR/ZR+ optics in Cisco routers. The primary difference between the starter and full solution is the absence of Crosswork Network Controller in the Starter solution.

Feature	Release	Description
Support for QDD-based Optical Line System	Cisco IOS XR Release 7.11.1	The following routers support Cisco QSFP-DD Pluggable Open Line System Modules (QSFP-DD OLS): • NCS-57B1-6D24-SYS and NCS-57B1-5DSE-SYS routers. • NCS-57C3-MOD and NCS-55A2-MOD routers (only through NC57-MPA-2D4H-S modular port adapter)

Support for 100G-ZR coherent transceivers	Cisco IOS XR Release 7.11.1	The following routers support DP01QSDD-ZF1:
		• N540-24Q8L2DD-SYS
		• NCS-57B1-6D24H-S
		• NCS-57B1-5D24-SE
		• NCS-57D2-18DD-S
		• NC57-48Q2D-S
		• NC57-48Q2D-SE-S
		• NC57-MOD-S and NC57-MPA-2D4H-S on:
		  • NCS-55A2
		  • NC55-MOD
		  • NC57-MOD
		  • NCS-57C3

Support for 400G-ER coherent transceivers	Cisco IOS XR Release 7.11.1	The following routers support DP04QSDD-ER1: • NC57-18DD-SE
Cisco Optical Site Manager	Cisco IOS XR Release 7.11.2	Cisco Optical Site Manager runs as an extra application on IOS-XR on the NCS 1010 and is packaged with NCS 1010 IOS-XR releases. Cisco Optical Site Manager provides site-level management for an NCS 1010 network built using multiple disaggregated NCS 1010 devices. It offers a single communication point for controllers such as Cisco Optical Network Controller. The web UI allows users to perform management and assurance tasks related to the site nodes such as viewing alarms, performance statistics, and performing OAM functions like OTDR and connectivity verification.

Feature	Release	Description
Cross Launch between Automation software suite applications	Cisco Optical Site Manager 7.11.2 Crosswork Hierarchical Controller 8.0 Cisco Crosswork Network Controller 6.0 Cisco Optical Network Controller 3.1	You can now setup SSO login for Cisco Optical Site Manager, Crosswork Hierarchical Controller, Cisco Crosswork Network Controller, and Cisco Optical Network Controller. After setting up SSO, you can cross-launch among these applications. For example, you can launch the node functional view in Cisco Optical Site Manager from the Link Assurance application in Crosswork Hierarchical Controller.