



# Routed Optical Networking Solution Components

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## Hardware components

The hardware components that enable Routed Optical Networking are:

- High density routers
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## Specifications of Cisco 8000 series routers

The Cisco 8000 series routers use Silicon One ASIC to provide full routing functionality. They offer higher capacity and a lower environmental footprint than other available routing silicon.

The Silicon One architecture supports large forwarding tables, deep buffers, flexible packet operations, and enhanced programmability to help you manage complex network requirements.

The 8000 series routers are highly scalable, have deep buffering, and are optimized for 100G, 400G, and 800G. They are also available with additional on-chip High Bandwidth Memory (HBM) to support additional resource scale.

#### Cisco 8010 series router: PLE service endpoint router

The Cisco 8011-2X2XP4L PLE (Private Line Emulation) Service Endpoint Router (PLE-SER) is a fixed-port router in a one rack unit form factor. It supports 2 x 10G SFP+ PLE, 2 x 10G SFP+ Ethernet, and 4 x 10G, 25G, or 50G SFP56 ports. Private Line Emulation (PLE) enables private line services to be carried over the same IP network for non-Ethernet type services like SONET, SDH, and Fiber Channel.

The PLE client ports support these configuration options:

- 2 x 1G and 10G
- 2 x 10G
- 2 x OTU2
- 2 x OC192 or STM64
- 2 x OTU2e
- 2 x OC48
- 2 x FC-1, 2, 4, 8, or 16G
- 1 x FC-32G (only on port 0)

#### Cisco 8200 series routers

The Cisco 8200 series uses a single Silicon One ASIC to provide full routing functionality. It is designed for use cases that require high buffering and high scale. These fixed-port and high-density routers provide up to 19.2 Tbps of network bandwidth while consuming significantly less power than comparable 20 Tbps systems.

This table details the specifications of the routers.

Router	Capacity	Form factor	400G QSFP-DD ports	100G QSFP28 ports
Cisco 8201	10.8 Tbps	1 rack unit (RU)	24	12
Cisco 8202	10.8 Tbps	2 RU	12	60
Cisco 8201-32FH	12.8 Tbps	1 RU	32	—
Cisco 8202-32FH-M	12.8 Tbps	2 RU	32	—
Cisco 8201-24H8FH	5.6 Tbps	1 RU	8	24

### Cisco 8800 series routers

The Cisco 8800 series provides high density and efficiency. It provides the extensive scale, buffering, and feature capabilities found in all Cisco 8000 series routers. The 8800 series routers provide up to 260 Tbps through 648 400 GbE ports. The 8800 series includes four chassis options to meet a variety of network and facility requirements.

This table details the specifications of the routers.

Router	Capacity	Form factor	400G QSFP-DD ports
<b>Cisco 8804</b>	Up to 57.6 Tbps	4-slot, 10 RU	Up to 144
<b>Cisco 8808</b>	Up to 115.2 Tbps	8-slot, 16 RU	Up to 288
<b>Cisco 8812</b>	Up to 172.8 Tbps	12-slot, 21 RU	Up to 432
<b>Cisco 8818</b>	Up to 259.2 Tbps	18-slot, 33 RU	Up to 648

### Cisco 8800 series line cards

The Cisco 8800 series modular platform supports 400 GbE line cards for high-speed networking.

This table details the specifications of the routers.

Line cards	Bandwidth	400G QSFP-DD ports
<b>8800-LC-36FH</b>	14.4 Tbps	36
<b>88-LC0-36FH-M</b>	14.4 Tbps	36
<b>88-LC0-36FH</b>	14.4 Tbps	36

For information on ZR and ZR+ port support, see [Specifications of 400G ZR and ZR+ transceivers](#).

For more information about Cisco 8000 series routers, see the [Cisco 8000 series Routers Data Sheet](#).

## Specifications of Cisco NCS 5500 series routers

The Network Convergence System (NCS) 5500 platform offers high port density, high-performance forwarding, low jitter, and low power consumption.

### Cisco NCS-55A2 series fixed port routers

NCS-55A2-MOD-S is a fixed port, high-density, two RU form factor router. It provides 24 SFP or SFP+ ports supporting Gigabit Ethernet or 10-Gigabit Ethernet, and 16 SFP, SFP+, or SFP28 ports supporting Gigabit Ethernet, 10-Gigabit Ethernet, or 25-Gigabit Ethernet. The router supports up to two Modular Port Adapters (MPA).

This table details the specifications of the routers.

Router	Capacity	Form factor	Nx100G QSFP-DD ports on MPA-2D4H	100G QSFP28 ports on MPA-4H
NCS-55A2-MOD-S	900Gbps	2 RU	8	8

For more information about Cisco NCS-55A2 series fixed port routers, see the [Cisco Network Convergence System 5700 series: NCS-55A2 Fixed Chassis Data Sheet](#).

### Cisco NCS-57B1 series fixed port routers

NCS-57B1-6D24-SYS and NCS-57B1-5DSE-SYS routers provide 4.8 terabits (Tbps) of 400GE or 100GE optimized forwarding capacity. They include QSFP-DD optics, deep packet buffering, full line-rate MACsec, Class C 1588 Precision Time Protocol (PTP), and Synchronous Ethernet (SyncE) in a power-efficient, one RU package.

This table details the specifications of the routers.

Router	Capacity	Form factor	400G QSFP-DD ports	100G QSFP-DD ports
NCS-57B1-6D24-SYS	Up to 4.8 Tbps	1 RU	6	24
NCS-57B1-5DSE-SYS	Up to 4.4 Tbps	1 RU	5	24

For more information about Cisco NCS-57B1 series fixed port routers, see the [Cisco Network Convergence System 5700 series: NCS-57B1 Fixed Chassis Data Sheet](#).

### Cisco NCS-57C1 series fixed port routers

NCS-57C1-48Q6-S is a fixed chassis that combines low port densities of 1GE, 10GE, or 25GE with higher port densities of 50GE, 100GE, or 400GE. It also offers QSFP-DD optics, deep packet buffering, MACsec, Class C 1588 PTP, and SyncE in a power-efficient, one RU package.

This table details the specifications of the routers.

Router	Capacity	Form factor	400G QSFP-DD ports	100G QSFP28 ports
NCS-57C1-48Q6-SYS	Up to 2.4 Tbps	1 RU	6 Four 400G and two Nx100G ports	-

For more information about Cisco NCS-57C1 series fixed port routers, see the [Cisco Network Convergence System 5700 series: NCS-57C1 Fixed Chassis Data Sheet](#).

### Cisco NCS-57D2 series fixed port routers

The NCS-57D2-18DD-SYS is a two RU router designed for mass-scale core and aggregation networks. It delivers 7.2 Tbps of 400GE or 100GE optimized forwarding capacity and features high power efficiency, QSFP-DD optics, deep packet buffering, full line-rate MACsec, IPSec, Class C 1588 PTP, and SyncE. The router runs on Cisco IOS XR7. It offers advanced capabilities such as next-generation security, automation, telemetry, segment routing, EVPN, and Equal-Cost Multipathing (ECMP). The router supports 18 ports of 400G and 66 ports of 100G, all with QSFP-DD. Breakout options are available for 10G, 25G, and 100G.

This table details the specifications of the routers.

Router	Capacity	Form factor	400G QSFP-DD ports	100G QSFP28 ports
NCS-57D2-18DD-SYS	Up to 7.2 Tbps	2 RU	18	66

For more information about Cisco NCS-57C1 series fixed port routers, see the [Cisco Network Convergence System 5700 series: NCS-57C1 Fixed Chassis Data Sheet](#).

### Cisco NCS-57C3 series fixed port routers

The Cisco Network Convergence System 57C3 series routers are designed for cost-effective delivery of next-generation networking services. These routers are high-capacity and low-power consuming devices available in a three RU compact form factor. The chassis, along with the Modular Port Adapters (MPAs), provides options for using different types of interfaces ranging from 1GE to 400GE. It also supports industry-standard MACSec encryption and Class C Timing. These devices also provide Control Plane redundancy, which enables high availability and reliability.

The Cisco NCS 57C3 series routers are suited for a range of applications, including Carrier Ethernet Aggregation, Subscriber Services, Business Ethernet, Mobile Edge, Campus, Peering, and Core roles. The router runs on Cisco IOS XR. It supports a rich and comprehensive set of features like QoS, IP/MPLS, Segment Routing, SRv6, and Ethernet VPN (EVPN).

This table details the specifications of the routers.

Router	Capacity	Form factor	400G QSFP-DD ports on MPA-2D4H	100G QSFP28 ports on base unit
NCS-57C3-MOD-S	Up to 2.4 Tbps	3 RU	Slot 1 - 4 Nx100G ports, Slot 2 and 3 - two 400G ports or four Nx100G ports	8
NCS-57C3-MOD-SE	Up to 2.4 Tbps	3 RU		4

For more information about Cisco NCS-57C1 series fixed port routers, see the [Cisco Network Convergence System 5700 series: NCS-57C3 Fixed Chassis Data Sheet](#).

### Cisco NCS 5500 modular chassis

The Cisco NCS 5500 modular chassis series is available in three system sizes: NCS 5504, NCS 5508, and NCS 5516. All NCS systems are highly reliable and resilient platforms. These platforms support a wide range of line card options. NCS 5500 modular router line cards and fabric modules directly attach to each other with connecting pins. In contrast, most traditional modular platform designs require a midplane.

This table details the specifications of the routers.

Platform	Capacity	Form factor	400G QSFP-DD ports	100G QSFP28 ports
NCS 5504	Up to 14.4 Tbps	4-slot, 7 RU	Up to 96	Up to 144
NCS 5508	Up to 76.8 Tbps	8-slot, 13 RU	Up to 192	Up to 288

<b>NCS 5516</b>	Up to 153.6 Tbps	16-slot, 21 RU	Up to 384	Up to 576
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For more information about Cisco Network Convergence System 5500 series modular chassis, see the [Cisco Network Convergence System 5500 series Modular Chassis Data Sheet](#).

### NCS 5700 series line cards

NCS 5700 series line cards are 400G line cards for the NCS 5500 series modular chassis. NCS 5700 series line cards consist of two versions of 400GE optimized line cards: the base version and the scale version. The two 400GE optimized line cards in the NCS5700 series are NC57-24DD and NC57-18DD-SE.

The Cisco NCS 5700 series 100G optimized baseline card, NC57-36H6D-S is a combo line card with 4.8-Tbps throughput. NC57-36H6D-S provides a mix of 100GE, 200GE, and 400GE ports. NC57-36H6D-S line card provides flexible port configuration and can be used as 36x100GE or 24x100GE + 12x200GE(2x100GE) or 24x100GE + 6x400GE ports.

The Cisco NCS 5700 series line card, NC57-48Q2D-S, is a high-density line card with a 2.4-Tbps throughput. It provides a mix of 1GE, 10GE, 25GE, 50GE, 100GE, and 400GE ports. The NC57-48Q2D-S line card features 32 SFP28 ports capable of 1/10/25G, 16 SFP56 ports capable of 1/10/25/50G, and 2 QSFP-DD ports supporting 40/100/200/400G with breakout options.

The Cisco NCS 5700 series line card, NC57-48Q2D-SE-S, is a high-density scale edition line card with a 2.4-Tbps throughput. It provides a mix of 1GE, 10GE, 25GE, 50GE, 100GE, and 400GE ports. The NC57-48Q2D-SE-S line card features 32 SFP28 ports capable of 1, 10, or 25G, 16 SFP56 ports capable of 1, 10, 25, or 50G, and 2 QSFP-DD ports supporting 40, 100, 200, or 400G with breakout options. This "Scale Edition" variant includes an external TCAM (OP2) that enables higher prefix and service scale.

For information on ZR and ZR+ port support, see [Specifications of 400G ZR and ZR+ transceivers](#).

For more information about Cisco Network Convergence System 5700 series 400GE, see the [Cisco Network Convergence System 5700 series: 400GE and 100GE Line Cards Data Sheet](#).

### NCS 5700 series modular port adapters

The Cisco Network Convergence System 5700 series is designed to efficiently scale between data centers and large enterprises, web, and service provider WAN and aggregation networks. The chassis and line cards support many applications and services through available interfaces. The Modular Port Adapters deliver flexibility to the chassis and line cards. They provide ports with bandwidth up to 400GE and pluggable form factors like QSFP-DD.

#### NC57-MPA-2D4H-S MPA

NC57-MPA-2D4H-S is a 4-port 800GE modular port adapter (NC57-MPA-2D4H-S) that supports QSFP28 and QSFP-DD optical transceivers. All 4 ports support QSFP28-100GE transceivers. Ports 0 and 2 (even-numbered ports) support two QDD-400G transceivers at the same time. This configuration is supported in both the MPA slots of the NCS-55A2-MOD-HD-S, NC55-55A2-MOD-SE-S, NCS-55A2-MOD-S, or NCS-55A2-MOD-HX-S chassis. Port 0 supports only one QDD-400G transceiver in Nx100G modes in both the MPA slots of the NCS-55A2-MOD-HD-S, NC55-55A2-MOD-SE-S, NCS-55A2-MOD-S, or NCS-55A2-MOD-HX-S chassis.

#### NC55-OIP-02 MPA

NC55-OIP-02 is an 8-port modular port adapter that supports SFP+ optical transceivers. This MPA is supported in the NC55A2-MOD-S and NC57C3-MOD-SYS routers.

The modular port adapter supports these port modes:

- Ethernet - 1GE and 10GE
- Fiber channel (FC) - 1GFC, 2GFC, 4GFC, 8GFC, 16GFC, 32GFC
- Optical Transport Network (OTN) – OTU2, and OTU2e
- SONET/SDH - OC-48 or STM-16, OC-192 or STM-64

NC55-OIP-02 MPA is used to support PLE.

For more information about Cisco Network Convergence System 5700 series modular port adapters, see the [Cisco Network Convergence System 5700 series: Modular Port Adapters Data Sheet](#).

## Specifications of Cisco ASR 9000 series

The Cisco ASR 9000 series Aggregation Services Routers (ASR 9000 series) introduces a new paradigm in edge and core routing. These routers offer exceptional scalability, carrier-class reliability, environmentally conscious design, flexibility, and a compelling price-to-performance benchmark. The Cisco ASR 9000 series includes a wide range of products, from the Cisco ASR 9001 (two RU) to the Cisco ASR 9922 (44 RU). Each system is designed to provide true carrier-class reliability with the Cisco IOS XR operating system, comprehensive system redundancy, and full network resiliency. Finally, the Cisco ASR 9000 series is designed to enhance and simplify the operational aspects of service delivery network deployment.

The Cisco ASR 9000 series offers advanced switching capacity, optimized power consumption and cooling, high availability design, and a modular operating system to significantly lower the Total Cost of Ownership (TCO) for service providers.

This table details the specifications of the routers.

Router	Capacity	Form factor	400G QSFP-DD ports
<b>ASR 9006</b>	Up to 16 Tbps	10 RU	Up to 20
<b>ASR 9010</b>	Up to 32 Tbps	21 RU	Up to 32
<b>ASR 9904</b>	Up to 16 Tbps	6 RU	Up to 8
<b>ASR 9906</b>	Up to 32 Tbps	14 RU	Up to 16
<b>ASR 9910</b>	Up to 64 Tbps	21 RU	Up to 32
<b>ASR 9912</b>	Up to 80 Tbps	30 RU	Up to 40
<b>ASR 9922</b>	Up to 160 Tbps	44 RU	Up to 80

For more information on Cisco ASR 9000 series, see [Cisco ASR 9000 series Aggregation Services Routers Data Sheet](#).

### Cisco ASR 9902 compact router

The Cisco ASR 9902 router is a compact, high-performance device that delivers up to 800 Gbps of nonblocking, full-duplex capacity in a two RU form factor. It uses the same Cisco IOS XR software as other routers in the Cisco ASR 9000 series and provides the same features and services. Customers can standardize on the Cisco IOS XR operating system. ASR 9902 supports multiple port rates, including 100 and 40 Gigabit Ethernet, 25 Gigabit Ethernet, and 10 Gigabit Ethernet. Customers can mix and match interface types on the same chassis. Operators are equipped to support large-scale networking.

This table details the specifications of the router.

Router	Capacity	Form factor	100G QSFP-DD ports
ASR 9902	Up to 800 Gbps	2 RU	Up to 2

For more information on Cisco ASR 9902 compact high-performance router, see [Cisco ASR 9902 Compact High-Performance router Data Sheet](#).

### Cisco ASR 9903 compact router

The Cisco ASR 9903 router is a compact router that supports two redundant Route Processors (RP), two integrated switch fabrics, four AC or DC power supply modules, and four fans in redundant configuration. The router includes a fixed board, with 16 integrated QSFP28-based 100GE ports and 20 integrated SFP+-based ports. It also offers an optional Port Expansion Card (PEC), which you can insert into the dedicated slot when needed.

The ASR 9903 fixed board supports up to 1.6Tbps data bandwidth. The Cisco A9903-20HG-PEC module offers 20 physical ports and provides up to 2 Tbps data capacity. Five of these ports are 400GE, 200GE, or 100GE multirate QSFP-DD or QSFP28-based ports. You can migrate each port to 400GE with the appropriate license. The other 15 ports are 100GE QSFP28-based ports.

This table details the specifications of the router.

Router	Capacity	Form factor	400G QSFP-DD ports
ASR 9903	Up to 7.2 Tbps	3 RU	Up to 5

For more information on Cisco ASR 9903 compact high-performance router, see [Cisco ASR 9903 Compact High-Performance router Data Sheet](#).

### Cisco ASR 9000 series line cards

Cisco ASR 9000 series routers support 400G line cards.

#### ASR 9000 series 5th generation high-density multi-rate line cards

ASR 9000 series 5th generation high-density multi-rate line cards are fully compatible with these routers:

- Cisco ASR 9006
- Cisco ASR 9010
- Cisco ASR 9904

- Cisco ASR 9906
- Cisco ASR 9910
- Cisco ASR 9912
- Cisco ASR 9922

This table details the specifications of the line cards.

Line card	Bandwidth	400G QSFP-DD ports
<b>A9K-20HG-FLEX-SE</b>	2 Tbps	5
<b>A9K-20HG-FLEX-TR</b>	2 Tbps	5
<b>A9K-8HG-FLEX-SE</b>	800 Gbps	2
<b>A9K-8HG-FLEX-TR</b>	800 Gbps	2

For more information on Cisco ASR 9000 series 5th generation high-density multi-rate line cards, see [Cisco ASR 9000 series 5th Generation High-Density Multi-Rate Line Cards: 2 Terabit and 0.8 Terabit Cards Data Sheet](#).

#### ASR 9900 series 5th generation 10-port 400-Gigabit Ethernet line cards

The ASR 9900 series 5th generation 10-port 400-Gigabit Ethernet line cards are fully compatible with these routers:

- Cisco ASR 9904
- Cisco ASR 9906
- Cisco ASR 9910
- Cisco ASR 9912
- Cisco ASR 9922

This table details the specifications of the line cards.

Line card	Bandwidth	400G QSFP-DD ports
<b>A99-10X400GE-X-SE</b>	4 Tbps	10
<b>A99-10X400GE-X-TR</b>	4 Tbps	10

For information on ZR and ZR+ port support, see [Specifications of 400G ZR and ZR+ transceivers](#).

For more information on Cisco ASR 9900 series 5th generation 10-Port 400-Gigabit Ethernet line card, see [Cisco ASR 9900 series 5th Generation 10-Port 400 Gigabit Ethernet Line Card Data Sheet](#).

## Specifications of Cisco NCS 540 series routers

Cisco Network Convergence System (NCS) 540 series is a converged access platform designed to cost-effectively deliver services and applications. The NCS 540 offers temperature-hardened hardware, low power consumption, and a small form factor suitable for indoor or outdoor use.

### Cisco NCS 540 large density routers

The Cisco Network Convergence System (NCS) 540 large density router is a one RU platform that supports QSFP56-DD ports and offers you a 400G coherent optics transport solution. The NCS 540 large density platform enhances the existing NCS 540 portfolio by offering high throughput and flexible port interfaces that range from 1G to 400G.

Cisco NCS 540 large density routers are suitable for both outdoor and indoor deployments. The NCS 540 large density platform offers 1 Tbps throughput as well as best-in-class hardware and software security.

This table details the specifications of the router.

Router	Capacity	Form factor	400G QSFP-DD ports
N540-24Q8L2DD-SYS	1 Tbps	1 RU	2

For information on ZR and ZR+ port support, see [Specifications of 400G ZR and ZR+ transceivers](#).

For more information on Cisco Network Convergence System 540 large density routers, see [Cisco Network Convergence System 540 Large Density Routers Data Sheet](#).

## Specifications of 400G ZR and ZR+ transceivers

The QDD-400G-ZR-S and QDD-400G-ZRP-S optical modules offload wavelength-division multiplexing (WDM) functionality to the router. They operate as DWDM C-band (196.1 to 191.3 THz with 100-MHz spacing) tunable optical modules. These optical modules enable high-bandwidth 400G links and support the 400G Ethernet rate.

The ZR/ZR+ pluggable optical modules are based on the QSFP-DD form factor. This standard form factor ensures interoperability with other vendors.

This table provides specifications for the ZR and ZR+ pluggable modules.

**Table 1: Specifications of ZR and ZR+ pluggable modules**

Parameter	QDD-400G-ZR-S	QDD-400G-ZRP-S
<b>Client speed</b>	400G, 4x100G	400G, 4x100G, 3x100G, 2x100G, 1x100G
<b>Trunk speed</b>	400G	400G, 300G, 200G, 100G
<b>FEC</b>	cFEC	oFEC, cFEC
<b>Modulation</b>	16-QAM	16-QAM, 8QAM, QPSK
<b>Frequency</b>	C-Band, 196.1 to 191.3 THz	C-Band, 196.1 to 191.3 THz

This table provides the ports on line cards that support ZR and ZR+ pluggable modules.

Table 2: Support matrix of ZR and ZR+ pluggable modules

Platform	Line card or fixed platform	Ports supporting ZR	Ports supporting ZR+	Supported breakout modes
<b>Cisco ASR 9000 series routers</b>	A99-10X400GE-X-TR A99-10X400GE-X-SE	3, 4, 5, 7, 9	3, 4, 5, 7, 9	1x100, 2x100, 4x100, 1x400
	<b>A9K-8HG-FLEX-TR</b> <b>A9K-8HG-FLEX-SE</b>	0, 7	0, 7	1x100, 2x100, 4x100, 1x400
	<b>A9K-20HG-FLEX-TR</b> <b>A9K-20HG-FLEX-SE</b>	0, 7, 8, 12, 19	0, 7, 8, 12, 19	1x100, 2x100, 4x100, 1x400
	<b>A9903-20HG-PEC</b>	0, 4, 8, 12, 16	0, 4, 8, 12, 16	1x100, 1x400
	<b>ASR-9902</b>	-	11,37	1x100
<b>Cisco NCS 540 series routers</b>	N540-24Q8L2DD-SYS	0, 1	0, 1	1x100, 2x100, 4x100, 1x400
<b>Cisco 8000 series routers</b>	8201-SYS	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23	0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22	1x100, 2x100, 3x100, 4x100, 1x400
	<b>8202-SYS</b>	48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59	48, 50, 52, 54, 56, 58	1x100, 2x100, 3x100, 4x100, 1x400
	<b>8101-32FH</b> <b>8201-32FH</b>	All ports	All ports	1x100, 2x100, 3x100, 4x100, 1x400
	<b>88-LC0-36FH-M</b> <b>8800-LC-36FH</b>	All ports	0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34	1x100, 2x100, 3x100, 4x100, 1x400
	<b>88-LC0-36FH</b>	All ports	All ports	1x100, 2x100, 3x100, 4x100, 1x400
	<b>8201-24H8FH</b>	0,2,4,6,8,10,12,14	0,2,4,6,8,10,12,14	1x100, 2x100, 3x100, 4x100, 1x400
	<b>8101-32FH-M</b>	All ports	All ports	1x100, 2x100, 3x100, 4x100, 1x400

Platform	Line card or fixed platform	Ports supporting ZR	Ports supporting ZR+	Supported breakout modes
Cisco NCS 5500 series routers	NCS57B1-6D24H-SYS	24, 25, 26, 27, 28, 29	24, 25, 26, 27, 28, 29	1x100, 2x100, 3x100, 4x100, 1x400
	NCS57B1-5D-SE-SYS	24, 25, 26, 27, 28	24, 25, 26, 27, 28	1x100, 2x100, 3x100, 4x100, 1x400
	NC57-24DD	0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22	0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22	1x100, 2x100, 3x100, 4x100, 1x400
	NC57-18DD-SE	12, 14, 16, 18, 20, 22, 24, 26, 28	14, 16, 18, 20, 22, 24	1x100, 2x100, 3x100, 4x100, 1x400
	NC57-36H6D-S	24, 26, 28, 30, 32, 34	24, 26, 28, 30, 32, 34	1x100, 2x100, 3x100, 4x100, 1x400
	NCS-57C1-48Q6-SYS	0, 2, 4	0, 2, 4	1x100, 2x100, 3x100, 4x100, 1x400
	NC57-MOD-S (fixed ports)	8, 9	8, 9	1x100, 2x100, 3x100, 4x100, 1x400
	MPA-2D4H 400G slot	0, 1, 2, 3	0, 1, 2, 3	1x100, 2x100, 3x100, 4x100
	NC57-48Q2D-S(E)-S	48	48	1x100, 2x100, 3x100, 4x100, 1x400
	NCS-57D2-18DD-SYS	0, 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64, 65	0, 3, 4, 7, 8, 11, 12, 15, 16, 19, 20, 23, 24, 27, 28, 31, 32, 35, 36, 39, 40, 43, 44, 47, 48, 51, 52, 55, 56, 59, 60, 63, 64, 65	1x100, 2x100, 3x100, 4x100, 1x400
MPA-2D4H 800G slot	0, 1, 2, 3	0, 1, 2, 3	1x100, 2x100, 3x100, 4x100, 1x400	

This table provides the maximum number of ZR and ZR+ modules supported in each breakout mode.

**Table 3: Support matrix of ZR and ZR+ pluggable modules**

Line card	Max number of ZR supported in mode		Max number of ZR+ supported in mode				
	400G	4x100G	400G	4x100G	3x100G	2x100G	1x100G
NC57-24DD	12	12	12	12	12	12	12
NC57-18DD-SE	9	9	6	6	6	6	6
NC57-36H6D-S (400G ports)	6	6	6	6	6	6	6
NCS-57B1-6D24-SYS (400G ports)	6	6	6	6	6	6	6

Line card	Max number of ZR supported in mode		Max number of ZR+ supported in mode				
	400G	4x100G	400G	4x100G	3x100G	2x100G	1x100G
NCS-57B1-5DSE-SYS (400G ports)	5	5	5	5	5	5	5
MPA-2D4H-S (400G mode MPA)	-	1	-	1	1	2	4
NCS-55A2-MOD-S(E)-S with 2x400G MPA-2D4H	-	2	-	2	2	4	8
MPA-2D4H-S (800G mode MPA)	2	2	2	2	2	4	4
NCS-57C3-MOD(S)-SYS with 2x800G+1x400G MPA-2D4H	4	5	4	5	5	10	12
NC57-MOD-S (Fixed ports)	2	2	2	2	2	2	2
NC57-MOD-S with 2x800G MPA-2D4H	6	6	6	6	6	10	10
NCS-57C1-48Q6-SYS	3	3	3	3	3	3	3
NCS-57D2-18DD-SYS	18	18	18	18	18	34	34
NC57-48Q2D-S(E)-S	1	1	1	1	1	1	1
NC55-MOD-A(-SE)-S with 2x400G MPA-2D4H	-	2	-	2	2	4	8
N540-24Q8L2DD-SYS	2	2	2	2	2	2	2
8201	24	24	12	12	12	12	12
8202	12	12	6	6	6	6	6
8800-LC-36FH	36	36	18	18	18	18	18
88-LC0-36FH-M	36	36	18	18	18	18	18
8101-32FH	32	32	16	16	16	16	16
8201-32FH	32	32	16	16	16	16	16
8201-24H8FH	8	8	8	8	8	8	8
8202-32FH-M	32	32	32	32	32	32	32
88-LC0-36FH	36	36	18	18	18	18	18
A99-10X400GE-X-SE/TR	5	5	5	5	-	5	5
A9K-20HG-FLEX-SE/TR	5	5	5	5	-	-	5
A9K-8HG-FLEX-SE/TR	2	2	2	2	-	-	2
A9903-20HG-PEC	5	-	5	-	-	-	5
ASR-9902	-	-	-	-	-	-	2

This table provides the ports on line cards that support Bright ZR+ pluggable module.

Table 4: Support matrix of Bright ZR+ pluggable module

Line card or fixed platform	Ports supporting Bright ZR+	Supported breakout modes
<b>A9K-20HG-FLEX-TR</b> <b>A9K-20HG-FLEX-SE</b>	0, 7, 8, 12, 19	1x100, 2x100, 4x100, 1x400
<b>A9K-8HG-FLEX-TR</b> <b>A9K-8HG-FLEX-SE</b>	0, 7	1x100, 2x100, 4x100, 1x400
<b>8201-32FH</b>	0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30	1x100, 2x100, 3x100, 4x100, 1x400
<b>8201-24H8FH</b>	0,2,4,6,8,10,12,14	1x100, 2x100, 3x100, 4x100, 1x400
<b>NCS-57C3-MOD-SYS with NC57-MPA-2D4H-S</b>	Slot 1, 2, 3: Ports 0, 1, 2, 3 Only on MPA ports	1x100, 2x100, 4x100, 1x400

For more information on Cisco 400G Digital Coherent Optics QSFP-DD optical modules, see the [Cisco 400G Digital Coherent Optics QSFP-DD Optical Modules Data Sheet](#).

## Specifications of Cisco high-power QSFP-DD ZR+ module

Cisco 400G QSFP-DD high-power (Bright) optical modules are high Tx power variants (+2dBm of Tx Power) of the 400G QSFP-DD modules.

These high-power optical modules allow easier interoperability with all deployed add and drop architectures and enhance unamplified reach by about 12dB as compared to QDD-400G-ZR-S and QDD-400G-ZRP-S. The optical specifications of these Bright ZR+ pluggables are aligned with current OpenZR+.

Cisco Bright QSFP-DD ZR+ modules operate at a default TX power of +1 dBm for all platforms. In contrast to ZR and ZR+ modules, the TX power level for Bright ZR+ remains at +1 dBm at all speeds and modulations. If you configure the FEC type to cFEC, the power reduces to -10 dBm for ZR compatibility. Cisco Bright QSFP-DD ZR+ modules support the same modes as QDD-400G-ZRP-S -10 dBm optics.

Two product variants are available:

- Ethernet variant (DP04QSDD-HE0)
- Multirate OTN and ethernet variant (DP04QSDD-HK9)

### Cisco 400G QSFP-DD high-power (Bright) optical module ethernet variant

Cisco 400G QSFP-DD high-power (Bright) optical module Ethernet variant is an enhanced version of the existing QSFP-DD ZR+ optical module. It leverages the same operational modes, but the main enhancement is an increase in Tx optical power to +2 dBm.

The supported client interface for this pluggable is Ethernet-based, making this model suitable for hosting on a router or switch. The module uses GMP to map an ethernet signal from a switch or router to an intermediate 400ZR frame structure, and then adapts this frame to the appropriate FEC engine. The encoded signal is then DSP-framed and modulated for transmission as a coherent dual-polarity mQAM signal. The PID for this pluggable optical module is DP04QSDD-HE0.

In Cisco IOS XR Release 7.9.1, these routers support Cisco Bright QSFP-DD ZR+:

- NCS-57C3-MOD
- 8201-32FH
- 8201-24H8FH
- A9K-20HG-FLEX-SE/TR
- A9K-8HG-FLEX-SE/TR

From Cisco IOS XR Release 7.10.1, all NCS-5500 and NCS-5700 platforms support Cisco Bright QSFP-DD ZR+ modules.




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**Note** NCS-55A2-MOD-S(E)-S with MPA-2D4H support Bright ZR+ from Cisco IOS XR Release 7.11.1.

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### Cisco 400G QSFP-DD high-power (Bright) optical module multirate ethernet and OTN variant

The Cisco 400G QSFP-DD high-power (Bright) optical module multirate Ethernet and OTN variant shares the same hardware platform and high Tx power as the ethernet variant, but it also supports OTN clients. The module leverages intermediate ODUFlex, OTUCn, and FlexO-x frame structures, and then adapts these frame structures with OFEC.

This variant supports Layer-1 (L1) functions, including authentication, encryption, and decryption of the OPU[Cn,4] payload. The security IP enables wire-speed AES 256-bit encryption with Galois-Counter Mode (GCM). It supports authentication using the GMAC algorithm, encryption or decryption using CTR mode, or both using GCM.

For more information on Bright ZR+ optical modules, see the [Cisco 400G QSFP-DD High-Power \(Bright\) Optical Module Data Sheet](#).

### Legacy 200G modulation modes

Cisco ZR+ modules support a ZR+ legacy mode, including 200G-8QAM at 40 Gbaud and 200G-16QAM at 30 Gbaud. These modes allow a 200G rate to fit within a 50 GHz spaced optical system. In the default mode, the modules operate in 200G QPSK at 60 Gbaud.

### OpenZR+ compatibility mode

Cisco QDD-400G-ZRP-S and DP04QSDD-HE0 modules have an OpenZR+ MSA compatibility mode. This mode:

- sets modem mode to **standard**
- is set by configuring optics controller Dac-Rate to
  - **1x1** for 400G, 300G, and 200G trunkrates on ZR+
  - **1x1.5** for all trunkrates on Bright ZR+ and 100G trunk rate on ZR+
- is used to interoperate with ZR+ optics from other vendors



**Note** Setting a DAC rate of 1x1 disables TX shaping as it affects the TX power levels.

This table lists the possible transponder and muxponder configuration values for the DP04QSDD-HE0 optical module.

**Table 5: Bright ZR+ transponder and muxponder configuration values**

TXP or MXP	Client	Trunk	Modulation	FEC	DAC rate
400G-TXP	1 Client, 400G speed	1 trunk, 400G speed	16 QAM	oFEC	1x1.25
400G-TXP	1 Client, 400G speed	1 trunk, 400G speed	16 QAM	cFEC	1x1.5
400G-TXP	1 Client, 400G speed	1 trunk, 400G speed	16 QAM	oFEC	1x1.5
4x100G- MXP	4 clients, 100G speed	1 trunk, 400G speed	16 QAM	oFEC	1x1.25
4x100G- MXP	4 clients, 100G speed	1 trunk, 400G speed	16 QAM	oFEC	1x1.5
4x100G- MXP	4 clients, 100G speed	1 trunk, 400G speed	16 QAM	cFEC	1x1.5
3x100G-MXP	3 clients, 100G speed	1 trunk, 300G speed	8 QAM	oFEC	1x1.25
3x100G-MXP	3 clients, 100G speed	1 trunk, 300G speed	8 QAM	oFEC	1x1.5
2x100G-MXP	2 clients, 100G speed	1 trunk, 200G speed	QPSK	oFEC	1x1.5
2x100G-MXP	2 clients, 100G speed	1 trunk, 200G speed	8 QAM	oFEC	1x1.25
2x100G-MXP	2 clients, 100G speed	1 trunk, 200G speed	16 QAM	oFEC	1x1.25
1x100G-MXP	1 client, 100G speed	1 trunk, 100G speed	QPSK	oFEC	1x1.5

## Specifications of Cisco QSFP-DD pluggable OLS

The QSFP-DD Open Line System (OLS) is a pluggable solution that integrates with Cisco routers. This optical amplifier module, when used with channel breakout options, provides a simple and powerful open line system in a pluggable form factor.

### Cisco QSFP-DD pluggable OLS

The QSFP-DD OLS is a pluggable module that integrates two variable-gain amplifiers: a pre-amplifier and a booster amplifier. These amplifiers boost both the up and down fiber streams.

Various channel breakout options are available to combine or separate each channel from a coherent DWDM optical source. The TX-EDFA acts as a booster amplifier and compensates for the loss from the optical multiplexers, providing a power boost before the link. The RX-EDFA serves as a preamplifier that restores link loss, increasing the optical signal to a level above the receiver sensitivity after the demultiplexer.

The QSFP-DD OLS extends the reach of a 400G QSFP-DD ZR and ZR+ link from 40 to 130 km or farther, based on fiber specifications, channel count, and line rate. For Bright 400G QSFP-DD ZR and ZR+ links, the extension range is 80 to 130 km or farther, subject to the same factors.

Industry-standard CS connectors enable you to integrate ingress and egress ports on the QSFP-DD OLS faceplate. The QSFP-DD-OLS offers two bi-directional optical ports: COM-RX and TX, which connect to the Mux or DMX unit, and LINE-TX or RX, which connect to the fiber link.

The optical connectors are 2x CS-UPC. The CS connector provides the characteristics and simplicity of the duplex LC connector into a smaller footprint to allow two pairs of CS connectors to fit within the physical constraints of the QSFP-DD form factor. Since the other optical units like Coherent Interfaces modules, DWDM Add and Drop multiplexers, and fiber patch panels have normally LC connectors, a hybrid adaptation patch cord with a CS dual connector on one side and two LC connectors on the other side is available to interconnect the QSFP-DD-OLS modules with other optical equipment.

Optical safety is enabled by default to

- switch off each section independently in case Optical LOS is detected at its input, and
- set the TX-EDFA in Automatic Power Reduction (APR) at 8dBm in case a LOS is cleared at the COM-RX port, but LOS is still present at LINE-RX.

This table shows the routers and line cards that support Cisco QSFP-DD pluggable OLS (QSFP-DD OLS) and the release from which they support the module.

**Table 6: QSFP-DD OLS pluggable support**

IOS-XR release	Platform
7.10.1	<ul style="list-style-type: none"> <li>• NCS-57B1-6D24-SYS</li> <li>• NCS-57B1-5DSE-SYS</li> <li>• NCS-57C3-MOD (using NC57-MPA-2D4H-S modular port adapter)</li> <li>• NCS-55A2-MOD (using NC57-MPA-2D4H-S modular port adapter)</li> </ul>
24.1.1	<ul style="list-style-type: none"> <li>• 8201-32FH</li> <li>• 8201-24H8FH</li> <li>• 8201</li> <li>• 8202-32FH-M</li> </ul>

IOS-XR release	Platform
24.3.1	<ul style="list-style-type: none"> <li>• 88-LC0-36FH</li> <li>• 88-LC0-34H14FH</li> <li>• 8608</li> <li>• 88-LC0-36FH-M</li> </ul>
24.4.1	<ul style="list-style-type: none"> <li>• NC57-36H6D-S</li> <li>• NC57-24DD</li> <li>• NC57-18DD-SE</li> <li>• NCS-57C1-48Q6-SYS</li> <li>• NCS-57D2-18DD-SYS</li> <li>• NC57-MOD-S (using 2x800G MPA-2D4H)</li> <li>• NC55-MOD-A-S(E)-S (using 2x400G MPA-2D4H)</li> <li>• NC57-MOD-S</li> <li>• NC57-36H-SE</li> <li>• A9K-20HG-FLEX-SE/TR</li> <li>• A9K-8HG-FLEX-SE/TR</li> <li>• A9903-20HG-PEC</li> <li>• A99-10X400GE-X-SE/TR</li> <li>• N540-24Q8L2DD-SYS</li> </ul>

### Multi-channel line system using QSFP-DD OLS

The user can build a multi-channel line system using the QSFP-DD OLS and its associated components:

- **A single-channel system:** It requires no special components to add and drop. A special CS-LC cable (ONS-CAB-CS-LC-5) has been made available to interconnect LC ports of the QSFP-DD coherent source or the network with the CS ports of the QSFP-DD OLS. One pair of these cables is sufficient to make a single-channel system. All the gain of the amplifier is available for the single channel in focus.
- **A four-channel system:** To achieve a 4-channel combine and split, an FLD-4 (fixed 4 channel OADM) can be used. This is a passive optical Add/Drop unit belonging to the ONS-15216 platform that is able to multiplex or demultiplex 4 channels over the 100GHz ITU grid.
- **A eight-channel system:** To achieve an 8-channel combine and split, a 1x8 channel breakout cable can be used. This new breakout cable (ONS-BRK-CS-8LC) is a dual fanout 1x8 cable with an embedded passive splitter and coupler. The cable is grid-less, allowing any port to receive any optical frequency without constraints on frequency value or channel spacing.

- **A 16-channel system:** To achieve a 16-channel combine and split, a 1x16 channel breakout cable can be used. This new breakout cable (ONS-BRK-CS-16LC) is a dual fanout 1x16 cable with an embedded passive splitter and coupler. The cable is grid-less so any port can be fed with any optical frequency without any constraints of frequency value or spacing between the channels.
- **A 32-channel system:** To achieve a 32-channel combine and split, a 64-channel multiplexer or demultiplexer can be used (of which 32 channels are used). The NCS1K-MD-64-C is a passive optical Add/Drop unit for the NCS1K platform, capable of multiplexing or demultiplexing up to 64 channels over the 75GHz grid. Due to the limited operating bandwidth of the QSFP-DD-OLS, only a subset of the MD-64 channels can be used: from port CH-19 (194.75 THz) to port CH-50 (192.425 THz).

For more information on configuring Cisco QSFP-DD pluggable OLS, see [Configuring QDD Optical Line System](#). For more information on the Cisco QSFP-DD pluggable OLS, see the [Cisco QSFP-DD Pluggable Open Line System Data Sheet](#).

## Modules in Cisco Network Convergence System 2000 series

The Cisco Network Convergence System 2000 series delivers agility, programmability, and massive scale across ultra-long haul, metro, and enterprise optical networks. Using the Cisco NCS 2000 series, you can deploy a simple, yet intelligent dense wavelength-division multiplexing (DWDM) network that scales with operational ease. The NCS 2000 devices are managed by the Shelf Virtualization Orchestrator (SVO) available in , Release 12.3.1.

### Cisco NCS 2006 shelf

The NCS 2006 shelf has eight horizontal card slots. The chassis is six RU, with six slots for service cards and two slots for controller cards. It supports multishelf management of up to 50 shelves.

For more information on Cisco Network Convergence System 2000 series, see the [Cisco Network Convergence System 2000 Series Data Sheet](#).

### Shelf Virtualization Orchestrator

Cisco NCS 2000 Shelf Virtualization Orchestrator (SVO) introduces programmability of optical network elements and automation with NETCONF interface and YANG models. SVO enables end-to-end, software-defined automated networks that help maximize customer revenue and simplify network turn-up, operation, and maintenance.

SVO is available with a server on a blade encasing a high-speed processor with virtualized instances of multiple reconfigurable optical add/drop multiplexer (ROADM), optical line amplifier (OLA), and dynamic gain equalizer (DGE) sites of the network.

An SVO line card, together with the application software, provides licenses for alarm correlation, performance monitoring, connection verification, and optical time domain reflectometry (OTDR).

The Cisco NCS 2000 SVO helps to maintain and improve profitability with the orchestration of network elements and their functionalities. SVO allows the network elements to do only forwarding functions. SVO manages the configuration and monitoring of network elements at the node level using a centralized controller.

For more information on Cisco NCS 2000 Shelf Virtualization Orchestrator, see the [Cisco NCS 2000 Shelf Virtualization Orchestrator Data Sheet](#).

### Control cards

Cisco NCS 2000 Series Transport Node Controller 2 with Optical Time Domain Reflectometry (TNCS-2O) card performs these key operations:

- system initialization
- provisioning
- alarm reporting
- maintenance and diagnostics
- IP addressing
- Data-Communications-Channel (DCC) termination
- monitoring of system input voltage
- system fault detection
- multishelf management connections

Optical Time Domain Reflectometry (OTDR) provides information about the basic characteristics of the optical fiber among optical nodes, such as insertion loss, concentration points of reflection, fiber-to-fiber connection losses, and reflectance.

For more information on Cisco Transport Node Controller (TNC) and Transport Shelf Controller (TSC) cards, see the [Cisco Transport Node Controller and Transport Shelf Controller Cards Data Sheet](#).

### ROADM cards

The 20-SMRFS card is tunable over 96 channels in the C band, at 50-GHz spacing on the ITU-T grid. The card provides flex spectrum capability, allowing flexible allocation of channel bandwidth and improved network scalability. With flex capability, channel bandwidth is adjustable and can be defined arbitrarily, with specified granularity and within a given range. The card increases network flexibility by allowing reconfiguration of optical channels at any time.

The 20-SMRFS card is a single-slot card that integrates two cross-connect blocks (multiplexer and demultiplexer), a variable-gain EDFA preamplifier, and a variable-gain EDFA booster amplifier. The card supports up to 20 directions for each ROADM node. The EDFA preamplifier in this card has gain ranges of 0 to 17 dB and 12 to 24 dB with controlled tilt and extended gain ranges of 20 dB and 35 dB with uncontrolled tilt.

For more information on Cisco NCS 2000 SMRFS line card, see the [Cisco NCS 2000 Flex Spectrum Single Module ROADM Line Cards Data Sheet](#).

### Amplifier cards

The Cisco NCS 2000 offers enhanced optical amplifier cards operating in the C band region of the optical spectrum to extend the reach and capacity of a metro, regional, or long-haul network. The optical amplifier cards are part of the Cisco NCS 2000 intelligent DWDM architecture that is engineered to reduce DWDM complexity and speed the deployment of next-generation networking solutions.

### EDFA cards

The OPT-EDFA-17 and OPT-EDFA-35 cards are C band DWDM EDFA amplifiers and preamplifiers. The cards are true variable gain amplifiers, offering an optimal equalization of the transmitted optical channels

over a wide gain range. They support 96 channels at 50-GHz channel spacing in the C band (that is, 1528.77 to 1566.72 nm wavelength range). The OPT-EDFA-17 card delivers 20 dBm output power. The OPT-EDFA-35 card delivers +23 dBm output power. These cards do not contain midstage access loss for a Dispersion Compensation Unit (DCU). The cards provide a noise-figure optimized version of the EDFA amplifiers to cope with new modulation formats like PM-DQPSK, which do not need dispersion compensation.

For more information on Enhanced C band 96-channel EDFA amplifiers for the Cisco ONS 15454 Multiservice Transport Platform (MSTP), see the [Enhanced C-Band 96-Channel EDFA Amplifiers for the Cisco ONS 15454 MSTP Data Sheet](#).

### EDRA cards

The double-slot EDRA-2-26 card combines standard erbium-doped fiber amplifiers and a Raman amplifier to enable amplification on long unregenerated spans. These plug-in modules support an ultra-low noise figure that is critical for long-distance, high-bit-rate transmission. They support 96 channels in the C band (wavelengths from 1528.77 to 1566.72 nm), providing the reach and optical performance required to meet the most demanding distance requirements of service provider and enterprise DWDM networks. EDRA-2-26 includes an erbium-doped preamplifier, EDFA1, with a nominal gain of 14 dB and an erbium-doped booster amplifier, EDFA2. It supports a maximum span of 26 dB on standard single-mode fiber.

For more information on Cisco Network Convergence System 2000 series Erbium Doped Raman amplifiers, see the [Cisco Network Convergence System 2000 Series Erbium-Doped Raman Amplifiers Data Sheet](#).

### Raman amplifier cards

The Cisco ONS 15454 MSTP high-power counter-propagating Raman amplifiers operate in the C band region of the optical spectrum to extend the reach and capacity of regional, long-haul, and ultra-long-haul optical.

Raman amplifiers use the intrinsic properties of silica fiber in such a way that the transmission fibers themselves become a medium for amplification. This approach allows the attenuation of data signals transmitted over the fiber to be mitigated within the fiber itself. An amplifier using this principle is commonly known as a distributed Raman amplifier or simply, a Raman amplifier. The high-power counterpropagating unit injects counterpropagating optical power to generate a Raman effect in the span fiber and thus amplifies the signals propagating in the same fiber.

The single-slot RAMAN-CTP card supports counter Raman amplification on long unregenerated spans. The cards manage up to 96 ITU-T 50 GHz spaced channels over the C band of the optical spectrum (wavelengths from 1528.77 to 1566.72 nm).

For more information on high-power counter-propagating and co-propagating Raman units for the Cisco ONS 15454 MSTP, see [High Power Counter-Propagating and Co-Propagating Raman units for the Cisco ONS 15454 Multiservice Transport Platform \(MSTP\)](#).

### Passive multiplexer and demultiplexer module

NCS1K-MD-64-C is a passive optical multiplexer and demultiplexer module. The new optical module is based on athermal waveguide (AWG), providing 64 channels at 75 GHz spacing across the extended C band of the optical spectrum. The passive module allows you to transmit 400G ZR and 400G ZR+ wavelengths.

NCS1K-MD-64-C is a bidirectional unit that has the multiplexing and demultiplexing functions implemented as two different sections. The NCS1K-MD-64-C module supports bidirectional connection toward the Router or DCI that is equipped with QDD-400G-ZR-S and QDD-400G-ZRP-S.

For more information on Cisco NCS 1000 multiplexer and demultiplexer 64-channel patch panel module, see [Cisco NCS 1000 Mux/Demux 64-Channel Patch Panel Data Sheet](#)

## Passive patch panel modules in Cisco Network Convergence System 2000 series

The passive optical modules are used to design the optical network system.

### MPO-16 to 16-LC fan-out module

The MPO-16 to 16-LC fan-out module is a double slot module with one MPO-16 connector (COM) and eight LC duplex connectors (Port-i-TX/RX). It contains 16 photodiodes to monitor the power of the channel input ports. The MPO-16 to 16-LC fan-out module provides fan-out of the MPO-16 connector to or from the LC connections and interconnects the optical modules having LC connectors (TXP) with modules having MPO-16 connectors (SMR20 FS).

### Cisco 1 x 6 colorless flex spectrum add and drop module

The Cisco 1 x 6 colorless flex spectrum add and drop module (6AD-CFS) is a passive unit including one 1 x 6 splitter and one 6 x 1 combiner, and 7 photodiodes. This module is single-slot height in the mechanical frame chassis. Its primary function is to provide optical multiplexing and demultiplexing for up to six optical signals. Because it is based on optical splitter and combiner technology, only transceivers employing coherent detection can be directly connected to the six client ports of the unit. Integrated photodiodes provide connectivity check and monitoring functions. Virtual PDs are implemented by the unit on the output ports (AD-i-TX, COM-TX) by subtracting the insertion losses from the real photodiode (PD) reading. Power values and the manufacturing data stored in the flash memory are provided to a Cisco Transport Controller (CTC) through the USB connection.

### Cisco five-degree modular patch panel module

The Cisco five-degree patch panel module (MF-DEG-5) provides interconnections between five 8-port MPO connectors; it is used to connect any combination of up to five ROADM line degrees (express connections) and add or drop components (add or drop connections). The 40 optical paths are interconnected. Five photodiodes provide power monitoring of fiber 1 of each MPO connector. Power values and the manufacturing data stored in the flash memory are provided to CTC through the USB connection. This module is single-slot height in the mechanical frame chassis.

### Cisco four-degree upgrade modular patch panel module

The Cisco four-degree upgrade modular patch panel module (MF-UPG-4) provides interconnections among eight 8-fiber MPO connectors; it is used to expand the number of degrees and the number of add or drop ports that are supported by the node. The 64 optical paths are interconnected. A total of eight photodiodes provides power monitoring of fiber 1 of each MPO connector. Power values, and the manufacturing data stored in the flash memory are provided to a CTC through the USB connection. This module is single-slot height in the mechanical frame chassis.

For more information on Cisco Network Convergence System 2000 series passive patch panel modules, see the [Cisco Network Convergence System 2000 Series Passive Patch Panel Modules Data Sheet](#).

## Modules in Cisco Network Convergence System 1010

Cisco NCS 1010 is a next-generation optical line system optimized for ZR and ZR+ WDM interfaces in routers. The system provides point-to-point connectivity between routers with WDM interfaces and multiplexes WDM signals from multiple routers over a single fiber. In addition, the system supports ROADM express of

up to eight degrees. It supports both C band transmission and C+L combined WDM transmission, maximizing capacity.

### Modules in Cisco NCS 1010

Cisco NCS 1010 is a three RU chassis that has an in-built External Interface Timing Unit (EITU) and these field-replaceable modules:

- Controller
- Two power supply units
- Two fan trays
- Fan filter
- Line card

### Line cards in Cisco NCS 1010

There are five different variants of the line card:

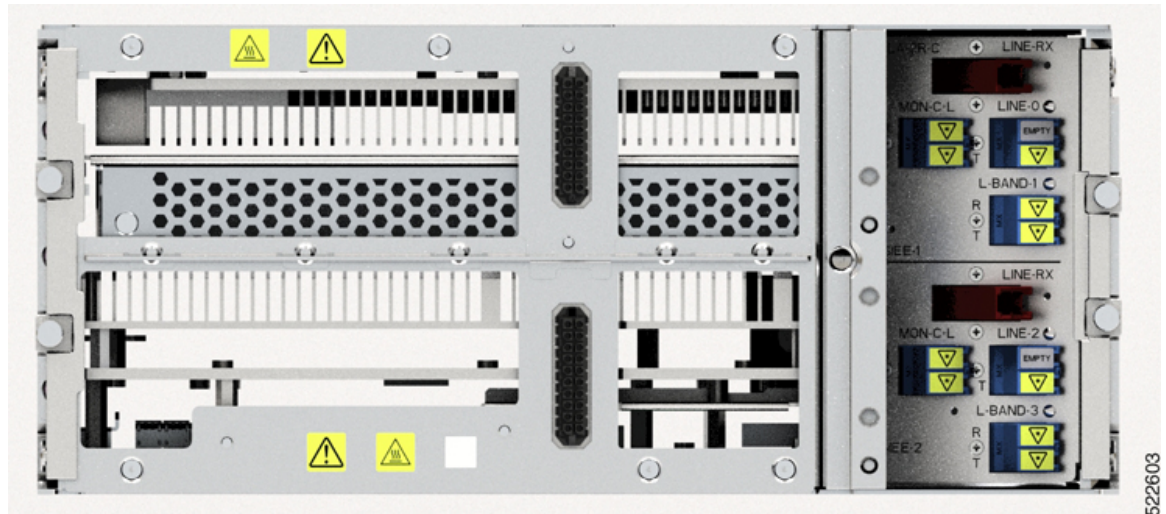
- OLT-C line card: C band Optical Line Terminal (OLT) without Raman
- OLT-R-C line card: C band OLT with Raman
- ILA-C line card: C band In-Line Amplifier (ILA) without Raman
- ILA-R-C line card: C band ILA with one side Raman
- ILA-2R-C line card: C band ILA with both sides Raman

*Figure 1: Perspective view of OLT-R-C line card*



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Figure 2: Front view of ILA-2R-C line card



### NCS 1010 for Routed Optical Networking

These features of the NCS 1010 Optical Line Systems (OLS) make it ideal for Routed Optical Networking:

- Support for low-power coherent sources
  - Ingress EDFA amplifier on OLTs to support 400ZR and OpenZR+ DCOs.
  - Low loss couplers to support 95 and 140 GBaud rates that need higher Rx power.
- Capacity scaling built-in by design
  - Hitless upgrade from C band to C+L band
  - Embedded channelized ASE for consistency in performance from day-1 to full capacity growth
  - 33-port Twin-WSS architecture to use as express or add and drop
- Simplicity of the OLS
  - Simpler integrated module
  - Independent degree operation
  - Automated turn-up
  - Full spectrum loading from the beginning
  - DGE on ILAs for equalization and better control of Raman Gain ripple
- Automation of entire life cycle
  - Device automation using ZTP, OpenConfig YANG configuration and telemetry
  - Automated E2E turn-up with embedded control loops
  - Automated connection verification for patch loss checks at each site

- Enhanced visibility using OTDR, OSC, and OCM

### **Cisco NCS 1000 32-channel multiplexer and demultiplexer patch panel**

The Cisco NCS 1000 32-channel multiplexer and demultiplexer patch panels are a pair of passive Athermal Arrayed Waveguide Grating (AAWG) base modules (PIDs NCS1K-MD-32O-C and NCS1K-MD32E-C). Each multiplexer and demultiplexer panel has 32 channels. It serves as an add and drop unit for the OLT-C and OLT-R-C line cards. Each multiplexer and demultiplexer panel allows the multiplexing and demultiplexing of 32 channels with 150-GHz spacing. 75 GHz frequency shift exists between the ODD and EVEN panels. When both the panels are used on the same OLT (OLT-C and OLT-R-C) line cards, their combined capacity is 64 channels with 75 GHz spacing. Each multiplexer and demultiplexer panel provides wide optical pass-band support. When used standalone, each panel acts as an add and drop unit for 32 channels operating at 140 gigabaud.

The NCS1K-MD32O/E-C panel operates in C band. The Cisco NCS 1000 multiplexer and demultiplexer patch panels are fully passive. The units are powered by a USB 3.0 connection in the NCS 1010 chassis. The panels monitor signals, verify connections, and retrieve the inventory data.

### **Cisco NCS 1000 breakout patch panel and modules**

#### **Cisco NCS 1000 breakout patch panel**

Cisco NCS 1000 breakout patch panel is a colorless breakout-modular patch panel. It is powered by the NCS 1010 chassis using a single USB 3.0 cable. The breakout panel contains four USB 2.0 connections that power the passive optical modules. It allows connections between the OLT-C and OLT-R-C line cards installed in the NCS 1010 chassis and the optical passive modules using MPO cables. The breakout panel is four RU high and has adjustable fiber guides for fiber routing. The empty slots are covered with dummy covers.

The NCS1K-BRK-SA breakout panel is a four RU breakout patch panel. It interfaces four passive optical modules with the NCS 1010 chassis. The breakout panel supports up to 72 colorless multiplexer and demultiplexer channels. The breakout panel supports 8-directional interconnections.

The panel is shipped with USB 2.0 connectors connected to the corresponding dummy covers. The plastic transparent cover can be installed in front of the panel for fiber protection. The panel is designed to fit a 19-inch rack. The panel can also be installed on ETSI and 23-inch rack using adapter brackets.

#### **Cisco NCS 1000 breakout modules**

The Cisco NCS 1000 breakout Modules are a set of three optical breakout units. The modules can be connected to the A/D 4 to 11, A/D 12 to 19, A/D 20 to 27 and A/D 28 to 33 MPO connector ports of the OLT-C and OLT-R-C line cards to provide ROADM node internal connections and for local channels add and drop.

The breakout panel supports these passive optical modules:

#### **NCS1K-BRK-8**

The NCS1K-BRK-8 module provides the breakout of 16 fibers from an MPO-24 connector to eight duplex line card connectors. It essentially performs an optical connection adaptation of MPO-to-LC connectors for the ADD and mDROPi signals of the MPO ports on OLT line cards. For each port—MPO and LC—, power monitors with tone detection capability are available. A filtered optical loopback (191.175 THz) from one MPO input port (fiber-1) to all MPO output ports is available for connection verification.

#### **NCS1K-BRK-24**

The NCS1K-BRK-24 module provides the breakout of 16 fibers from an MPO-24 connector to 24 duplex LC connectors. The signals on each fiber from the MPO input ports are split over three LC output ports by a 1x3

optical splitter. The signals from the three adjacent input LC ports are combined into a single MPO fiber output port through a 1x3 optical coupler. For each port (MPO and LC), power monitors with tone detection capability are available. A filtered optical loopback (191.175 THz) from one MPO input port (fiber-1) to all MPO output ports is available for connection verification.

For more information about the Cisco Network Convergence System 1010, see the [Cisco Network Convergence System 1010 Data Sheet](#).

## Components of network planning

Use these components to plan the network:

- Routed Optical Networking planning service
- Cisco WAN Automation Engine
- Cisco Optical Network Planner

### Routed Optical Networking planning service

Cisco CX provides a unified planning service to help customers simplify and plan the transition to a converged IP-Optical Routed Optical Network. By modeling current and future architectures, Unified Networking Planning accelerates progress toward Routed Optical Networking and creates opportunities for customers to reduce operating expenses.

Cisco CX uses questionnaires, workshops, interviews, and documentation reviews to capture unified planning requirements.

To execute network planning and assessment, Cisco CX

- collects information on sites, traffic demand, modeling requirements, interface types
- visualizes network layout with forecasted capacity and performs network modeling
- estimates traffic behaviors in failure scenarios, assesses failure impact, and
- compares network architectures in terms of number of interfaces, hardware, sites, rack space, and power requirements.

Cisco CX provides ongoing technical advice and guidance, enabling customer planning teams to share interim and final planning service results and reports

### Cisco WAN Automation Engine

The Cisco WAN Automation Engine (WAE) platform is an open, programmable framework that interconnects software modules, communicates with the network, and provides APIs to interface with external applications.

Cisco WAE provides the tools to create and maintain a model of the current network through continual monitoring and analysis of the network and its traffic demands. At any time, this model contains all relevant network information, including topology, configuration, and traffic details. This information forms the basis for analyzing the impact of changes in traffic demands, paths, node and link failures, network optimizations, or other adjustments.

Cisco WAE is used for IP and optical network planning of multivendor networks.

For more information, see [Cisco WAN Automation Engine Data Sheet](#)

### Cisco Optical Network Planner

Cisco Optical Network Planner (Cisco ONP) is a tool that models and tests Optical Transport Networks and DWDM optical networks using a graphical environment. The primary purpose of Cisco ONP is to design and validate networks of the NCS 2000 series and NCS 1010. Using the Cisco ONP tool, you create multiple instances of a network, modify different parameters at each instance, and compare the instances.

Cisco ONP

- generates a rack view of all the sites in the network
- shows the differences between the instances, and
- provides a complete Bill of Materials (BOM) for the network.

Cisco ONP models the optical network, generates the BOM, and provides detailed information about the network. This information includes connection reports, optical reports, and traffic matrix.



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**Note** Cisco ONP must be used to perform the final optical network feasibility analysis and generate production network designs.

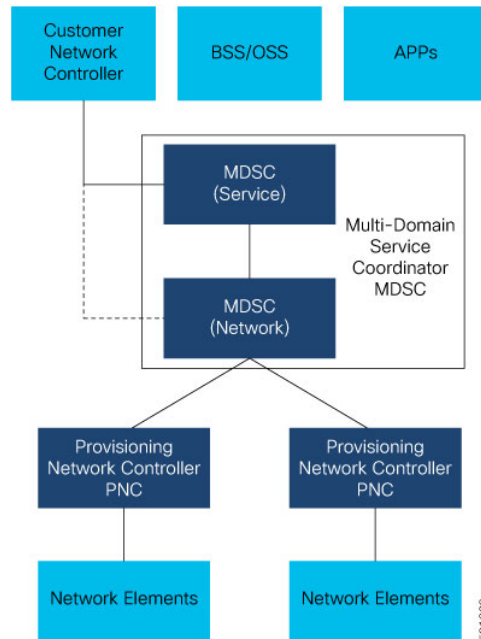
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For more information, see [Cisco Optical Network Planner \(CONP\) Data Sheet](#)

## Components of automation

Automation of the Routed Optical Networking solution follows the IETF ACTN SDN controller framework. Cisco Optical Network Controller is the Cisco optical domain PNC and Crosswork Network Controller is the multivendor IP-domain PNC. Crosswork Hierarchical Controller unifies IP and optical information from Cisco Optical Network Controller and Crosswork Network Controller. It provides multilayer and multidomain visualization, Routed Optical Networking service assurance, and Routed Optical Networking service management in the MDSC role.

**Figure 3: IETF ACTN – open automation reference framework**



### Components of automation

The automation stack consists of these components:

- Crosswork Hierarchical Controller: manages Routed Optical Networking deployments by leveraging advanced multilayer and multivendor capabilities to provision and assure both IP and optical networks.
- Cisco Optical Network Controller: (CONC) configures Cisco optical network elements, monitors the topology (physical or virtual) of networks, performs optical path computation, and collects topology information.
- Crosswork Network Controller: simplifies and automates intent-based network service provisioning, monitoring, and path optimization in an IP multi-vendor network environment with a common GUI and API.
- Evolved Programmable Network Manager (EPNM): performs deep inventory and is an element management system that manages device lifecycles for converged IP and optical networks. EPNM also collects fault and alarm information, and performs node-level performance measurement statistics collection.

### Routed Optical Networking automation solution architecture

This diagram provides a high-level illustration of how the components of the solution work together.

Figure 4: Routed Optical Networking automation architecture

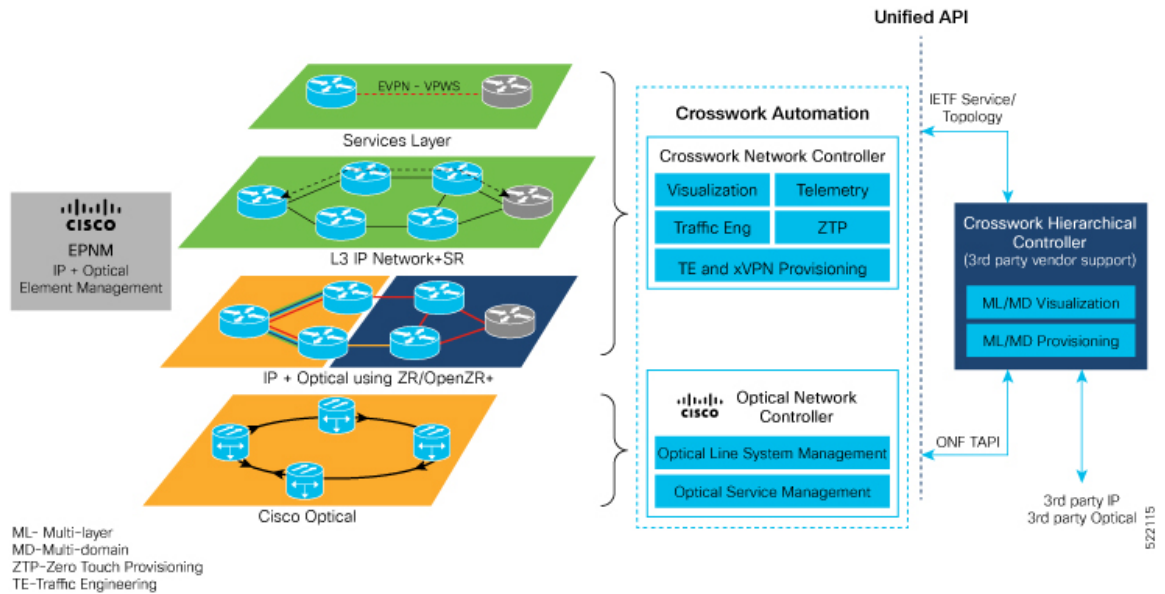


Table 7: Automation software roles

Automation software	Roles
SR-PCE	<ul style="list-style-type: none"> <li>• Packet layer PCE</li> <li>• Required to advertise IGP topology to Cisco Crosswork Network Controller</li> <li>• Uses BGP-LS to the network for IGP topology</li> <li>• Can run as virtual router or on a hardware router</li> </ul>
Cisco Crosswork Infrastructure	<ul style="list-style-type: none"> <li>• IP domain controller</li> <li>• Crosswork Network Controller Essentials package is required for Routed Optical Networking</li> <li>• RESTConf API covering provisioning, data collection, and topology</li> <li>• EMS app is recommended to collect device-level inventory and alarms</li> </ul>
Cisco Crosswork Data Gateway	<ul style="list-style-type: none"> <li>• Router data collection</li> <li>• Required by Cisco Crosswork Network Controller for all data collection</li> <li>• Required by the Hierarchical Controller for DCO-PM collection</li> </ul>

Automation software	Roles
<b>Network Services Orchestrator</b>	<ul style="list-style-type: none"> <li>• RON service management</li> <li>• RON core function pack is required to be installed for RON service management</li> <li>• Also used for connectivity verification</li> <li>• Communicates to routers using CLI NED</li> </ul>
<b>Cisco Optical Network Controller</b>	<ul style="list-style-type: none"> <li>• Optical domain EMS and controller for NCS 101x</li> <li>• Exposes the TAPI NBI interface for OLS topology, provisioning, and inventory</li> <li>• Communicates with Cisco Optical Site Manager for optical node management and provisioning</li> <li>• Power level data available for NCS 1010 as part of connection verification</li> </ul>
<b>Cisco Optical Site Manager</b>	<ul style="list-style-type: none"> <li>• Optical site manager for NCS 1010</li> <li>• Embedded in 1010 XR, a cluster is treated as a multishelf node and can run in active or standby mode.</li> <li>• Required component for Cisco Optical Network Controller 3.1 and later releases to communicate to nodes through NETCONF</li> </ul>
<b>Cisco Crosswork Hierarchical Controller</b>	<ul style="list-style-type: none"> <li>• Multivendor or legacy IP plus optical</li> <li>• Communicates to Cisco Crosswork Network Controller through RESTCONF, telemetry through CDG through gRPC</li> <li>• Communicates to Cisco Optical Network Controller through RESTCONF TAPI, 1010 through RESTCONF and gRPC</li> <li>• Router inventory through XR CLI adapter</li> </ul>

Automation software	Roles
Cisco Evolved Programmable Network Manager	<ul style="list-style-type: none"> <li>• Router and OLS element management</li> <li>• Not used for RON service management in this solution</li> <li>• Collects inventory, alarm, and PM data from routers directly using NETCONF over CLI, syslog</li> <li>• Collects inventory, alarm, and PM data from NCS 2000 and NCS 1010</li> </ul>

## Features of Cisco Crosswork Hierarchical Controller

Cisco Crosswork Hierarchical Controller provides an API and single-pane-of-glass user interface for Routed Optical Networking infrastructure and services. It manages your existing optical and packet domains with the same unified approach. Routed Optical Networking with Crosswork Hierarchical Controller dramatically simplifies the operation of multilayer networks. These networks were previously managed independently using NMS and EMS products.

Crosswork Hierarchical Controller serves as a multidomain, multilayer, multivendor network controller. Crosswork Hierarchical Controller maps between IP and optical layer ports. This capability provides a comprehensive view of the network. The system interfaces with SDN Domain Controllers for the packet layers (IP, MPLS) and transport layers (WDM, OTN, and Packet-Optical) to create a coherent view of the entire transport network. Crosswork Hierarchical Controller enables automation of its functions. It also supports simplified, abstracted interactions with service orchestrators and OSS tools.

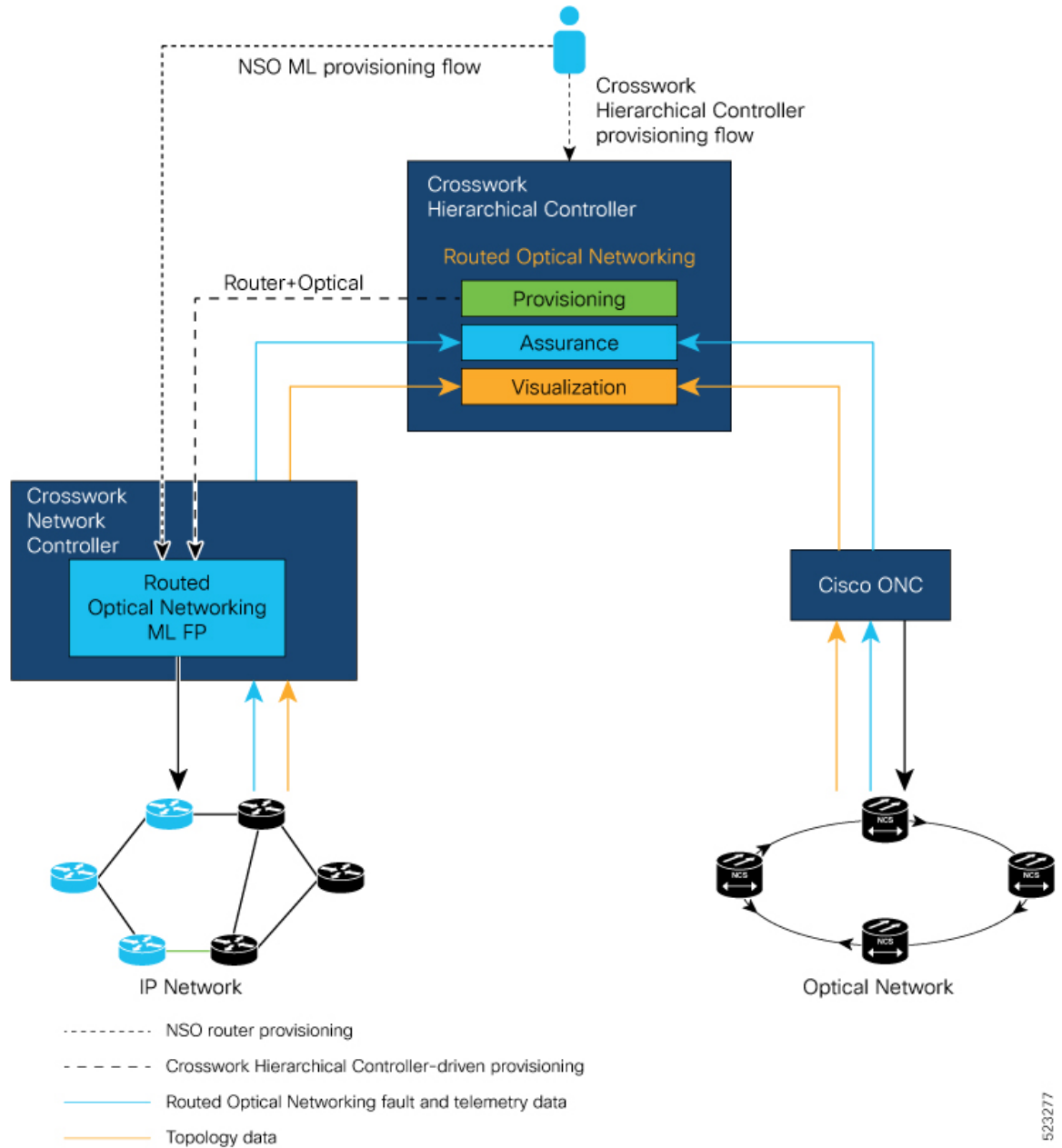
### Key capabilities

The key capabilities of Crosswork Hierarchical Controller used by Routed Optical Networking are:

- Multilayer discovery and visualization of Routed Optical Networking links allows you to create a trustworthy digital twin of your network. This digital twin can assist with operations and provide data to OSS tools.
- Multilayer provisioning of 400G Routed Optical Networking links with a multi-layer provisioning interface through domain controllers.
- End-to-end assurance of service across all domains enables you to meet strict service requirements.

This figure shows the workflow of Crosswork Hierarchical Controller.

Figure 5: Crosswork Hierarchical Controller workflow



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### Crosswork Hierarchical Controller adapters

Crosswork Hierarchical Controller uses adapters to connect to a device or management system and to collect information for the network model and configure the device.

The adapters installed as part of the Crosswork Hierarchical Controller installation are:

- **cisco-cnc-adpt**: collects IP network topology, link state information, and router hardware inventory including discovery for DCO.
- **cisco-onc-adpt**: adapter for Cisco optical network controller.

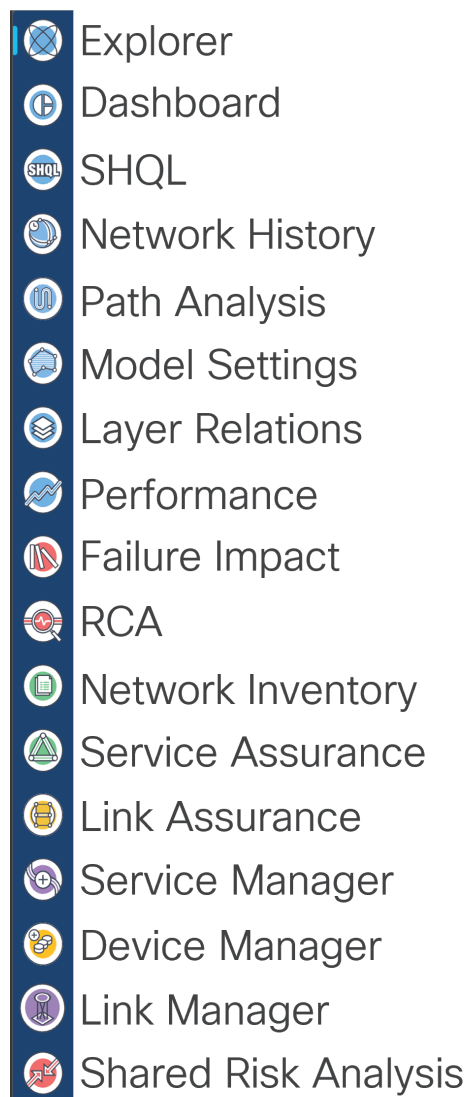
- **cisco-ios-xr-adpt**: collects inventory data and statistics.
- **cisco-cdg-adpt**: collects performance measurement data using streaming telemetry.

You can have multiple adapters of the same type. Each domain uses a separate Cisco Optical Network Controller adapter when several optical domains have different Cisco Optical Network Controller instances.

### Crosswork Hierarchical Controller applications

The Crosswork Hierarchical Controller is a customized bundle of applications and adapters. This can be installed using an executable installer. The Crosswork Hierarchical Controller Web interface can be accessed using a custom URL.

This figure shows the applications included in Crosswork Hierarchical Controller.



For more information about Cisco Crosswork Hierarchical Controller, see [Cisco Crosswork Hierarchical Controller](#)

## Features and components of Cisco Crosswork Network Controller

Cisco Crosswork Network Controller (Crosswork Network Controller) is a network automation solution for deploying and operating IP and Routed Optical Networking converged transport networks. Crosswork Network Controller delivers increased service agility, cost efficiency, and optimization for faster time-to-customer value and lower operating costs.

The solution combines intent-based network automation to deliver critical capabilities for service orchestration and fulfillment, network optimization, service path computation, device deployment and management, and anomaly detection and automatic remediation. Using telemetry gathering and automated responses, Cisco Crosswork Network Controller provides network optimization capabilities that are difficult to replicate manually.

The integrated solution uses core capabilities from several products: Cisco Network Services Orchestrator (NSO), Cisco Segment Routing Path Computation Element (SR-PCE), and the Cisco Crosswork suite of applications. Its unified user interface allows real-time visualization of the network topology and transport provisioning.

### Features of Cisco Crosswork Network Controller

The features of Crosswork Network Controller include:

- **Active Topology:** The logical and geographical maps in Active Topology provide real-time visibility into the physical and logical network topology, service inventory, SR-TE policies, and RSVP-TE tunnels. Operators can quickly view the health and status of devices, services, and policies.
- **Common UI and API:** All Crosswork Network Controller functionality is provided within a single, common GUI. This common UI brings together the features of all components of Crosswork Network Controller, including common inventory, network topology and service visualization, service and transport provisioning, and system administration and management functions.
- **Platform Infrastructure and Shared Services:** The Platform Infrastructure provides a resilient and scalable platform on which all Cisco Crosswork applications can be deployed. It is a microservices-based platform that uses streaming telemetry and model-driven APIs to improve network operations of the service provider. The platform retrieves real-time network information, analyzes the data, and applies changes using APIs. The platform uses a cluster architecture for extensibility, scalability, and high availability.

### Components of Cisco Crosswork Network Controller

The essential components of Crosswork Network Controller are:

- **Cisco Crosswork Optimization Engine:** Cisco Crosswork Optimization Engine provides real-time network optimization allowing operators to effectively maximize network capacity utilization and increase service velocity. Crosswork Optimization Engine provides closed loop tracking of the network state and responds quickly to changes in network conditions, supporting automated network recovery. For more information, see [Cisco Crosswork Optimization Engine Data Sheet](#).
- **Cisco Crosswork Data Gateway:** Cisco Crosswork Data Gateway (Crosswork Data Gateway) is a secure, common collection platform for gathering network data from multivendor devices. It is an on-premise application that is deployed close to network devices. Crosswork Data Gateway supports multiple data collection protocols including MDT, SNMP, CLI, standards-based gNMI (dial-in), and syslog. Crosswork Data Gateway can collect any type of data as long as the data can be delivered over one of the supported protocols. See [Cisco Crosswork Data Gateway Data Sheet](#).

- **Cisco Segment Routing Path Computation Element:** Cisco Segment Routing Path Computation Element (SR-PCE) is an IOS-XR multidomain stateful Path Computation Engine (PCE) supporting both segment routing (SR) and Resource Reservation Protocol (RSVP). Cisco SR-PCE builds on the native PCE abilities within IOS-XR devices, and provides the ability to collect topology and segment routing IDs through BGP-LS, calculates paths that adhere to service SLAs, and programs them into the source router as an ordered list of segments. A Path Computation Client (PCC) reports and delegates control of headend tunnels that are sourced from the PCC to a PCE peer. The PCC and PCE establish a Path Computation Element Communication Protocol (PCEP) connection that the SR-PCE uses to push updates to the network and reoptimize paths where necessary.
- **Cisco Network Services Orchestrator (NSO) Function Packs:** Cisco Crosswork Network Controller is packaged with these Cisco NSO function packs:
  - SR-TE core function pack (CFP)
  - Sample function packs for provisioning IETF-compliant L2VPN and L3VPN
  - Sample RSVP-TE function pack that is IETF-compliant

The optional components of Crosswork Network Controller are:

- **Cisco Crosswork Health Insights:** Cisco Crosswork Health Insights is a network health application that performs real-time Key Performance Indicator (KPI) monitoring, alerting, and troubleshooting. Cisco Crosswork Health Insights enables programmable monitoring and analytics. It provides a platform for dynamically addressing changes to the network infrastructure. See [Cisco Crosswork Change Automation and Health Insights Data Sheet](#).
- **Cisco Crosswork Zero-Touch Provisioning:** The Cisco Crosswork Zero-Touch Provisioning (ZTP) application is an integrated solution for onboarding and provisioning new IOS XR devices automatically. ZTP results in faster deployment of new hardware at lower operating costs. Operators can provision devices using a Cisco-certified software image and a day-zero software configuration. Once provisioned in this way, the new device is onboarded to the Crosswork device inventory where it can be monitored and managed like other devices. See [Cisco Crosswork Zero-Touch Provisioning Data Sheet](#).
- **Cisco Service Health:** Service Health substantially reduces the time required to detect and troubleshoot service quality issues. It monitors the health status of provisioned Layer 2 and Layer 3 VPN services and enables operators to pinpoint why and where a service is degraded. It provides service-specific monitoring, troubleshooting, assurance, and proactive root cause identification using a heuristic model that visualizes these elements:
  - Health status of subservices to a map when a single service is selected.
  - Service logical dependency tree and help the operator in troubleshooting in case of degradation by locating where the problem resides, an indication of possible symptoms, and impacting metrics in case of degradation.
  - Historical view of service health status up to 60 days.
- **Crosswork EMS Services:** Element Management System (EMS) services are bundled with the Crosswork Network Controller Advantage pack. The EMS functions include inventory, fault, and Software Image Management (SWIM).
  - Inventory service integrates deep inventory collection with the Device Lifecycle Management (DLM) feature of Cisco Crosswork. It enriches the existing device onboarding workflow to gather more insights about the device. Built-in device packages enable deep inventory collection when the

user manually attaches a device to the Crosswork Data Gateway. The system stores the collected information in the database and monitors it using the Inventory APIs.

- Fault service is associated with alarm management. It provides API support for subscription, request, retrieval, and auto-clearing of alarms for Topology Visualization services. Monitored using the Fault APIs, the fault service improves the existing topology views by showing the alarm status for devices and links.
- SWIM is integrated with Crosswork Change Automation and managed with SWIM APIs. It enables operators to view, import, delete, and push software images to devices in the network. SWIM accelerates upgrades, improves compliance, and enhances the network engineer experience.

Cisco Crosswork Network Controller is multivendor capable for

- network service orchestration,
- telemetry data collection,
- topology and transport discovery,
- transport path computation, and

For more information about Cisco Crosswork Network Controller, see the [Cisco Crosswork Network Controller Data Sheet](#).

## Features of Cisco Optical Network Controller

Cisco Optical Network Controller (Optical Network Controller) is a domain controller for optical networks and provides data to Hierarchical Controllers. Optical Network Controller provides centralized network management and control for optical environments.

### Features

The features of Optical Network Controller include:

- **SDN domain controller functionality:** collects and abstracts optical network data for higher-layer controllers.
- **Standardized TAPI model support:** abstracts device-level details, enabling hierarchical control and orchestration.
- **Provisioning and monitoring:** configures network elements, monitors physical and virtual topologies, and collects topology information.
- **Application extensibility:** supports addition of optical applications to improve hardware capability.
- **Centralized control loop functions:** maintains and programs optical hardware components efficiently.

For more information about Cisco Optical Network Controller, see the [Cisco Optical Network Controller Data Sheet](#).

## Features of Cisco Optical Site Manager

Cisco Optical Site Manager is a software application deployed on NCS 1010 or NCS 1014 controller cards. The software application can be enabled on one or two controllers to provide high availability. Cisco Optical Site Manager software instances use open Netconf or YANG Northbound Interfaces to aggregate current and future NCS 1000 devices at a site. The application provides an abstracted site or node view to the Cisco Optical Network Controller or a third-party controller. Cisco Optical Site Manager also provides a Web user interface for site-level operation and maintenance.

### Features

Cisco Optical Site Manager provides these features:

- Seamless integration with Cisco Optical Network Controller for SDN automation
- OLS (Open Line System) site, OT (Open Terminal) site, or OLS+OT site abstraction
- Site aggregation, topology, and nodal functional view
- Site-level database information including inventory, site topology, correlated alarms, and performance monitoring
- Retention of current performance monitoring data up to the last 32 bins
- Connection verification, loopbacks, PRBS, OTDR, and TCA
- Web user interface with site-level management
- Mechanical layout for chassis, cards, and passive devices
- Card and module configurations

Cisco Optical Site Manager works with Cisco Optical Network Controller. It can also function as a standalone tool for Local Craft, which is useful for deployments or local management.

For information about installing and setting up Cisco Optical Site Manager, see [System Setup and Software Installation Guide for Cisco Optical Site Manager, IOS XR](#).

For more information about Cisco Optical Site Manager, see the [Cisco Optical Site Manager Data Sheet](#).

## Features of Cisco Network Services Orchestrator

Cisco Network Services Orchestrator (NSO) provides comprehensive orchestration and lifecycle management across physical and virtual network functions.

### Features

The features of Cisco NSO include

- pluggable function packs to translate network wide service intent into device-specific configuration
- flexible service orchestration and lifecycle management across physical and cloud based virtual network functions (VNFs)
- multivendor support and compatibility with multiple technology stacks
- rich set of APIs that enable developers to implement service applications and extend automation

- support for YANG data models to define and execute customer service configurations
- consistent operational model for physical and virtual network elements, and
- seamless orchestration in multivendor environments and across different device types.

For more information about Cisco Network Services Orchestrator, see [Cisco Network Services Orchestrator Data Sheet](#).

## Functions of Cisco NSO Routed Optical Networking function pack

The NSO Routed Optical Networking CFP uses NSO to automate device management in a Routed Optical Networking network. It also performs end-to-end service provisioning across the IP and optical layers. The NSO Routed Optical Networking CFP uses the same NSO instance as Crosswork Network Controller.

### Routed Optical Networking ML service

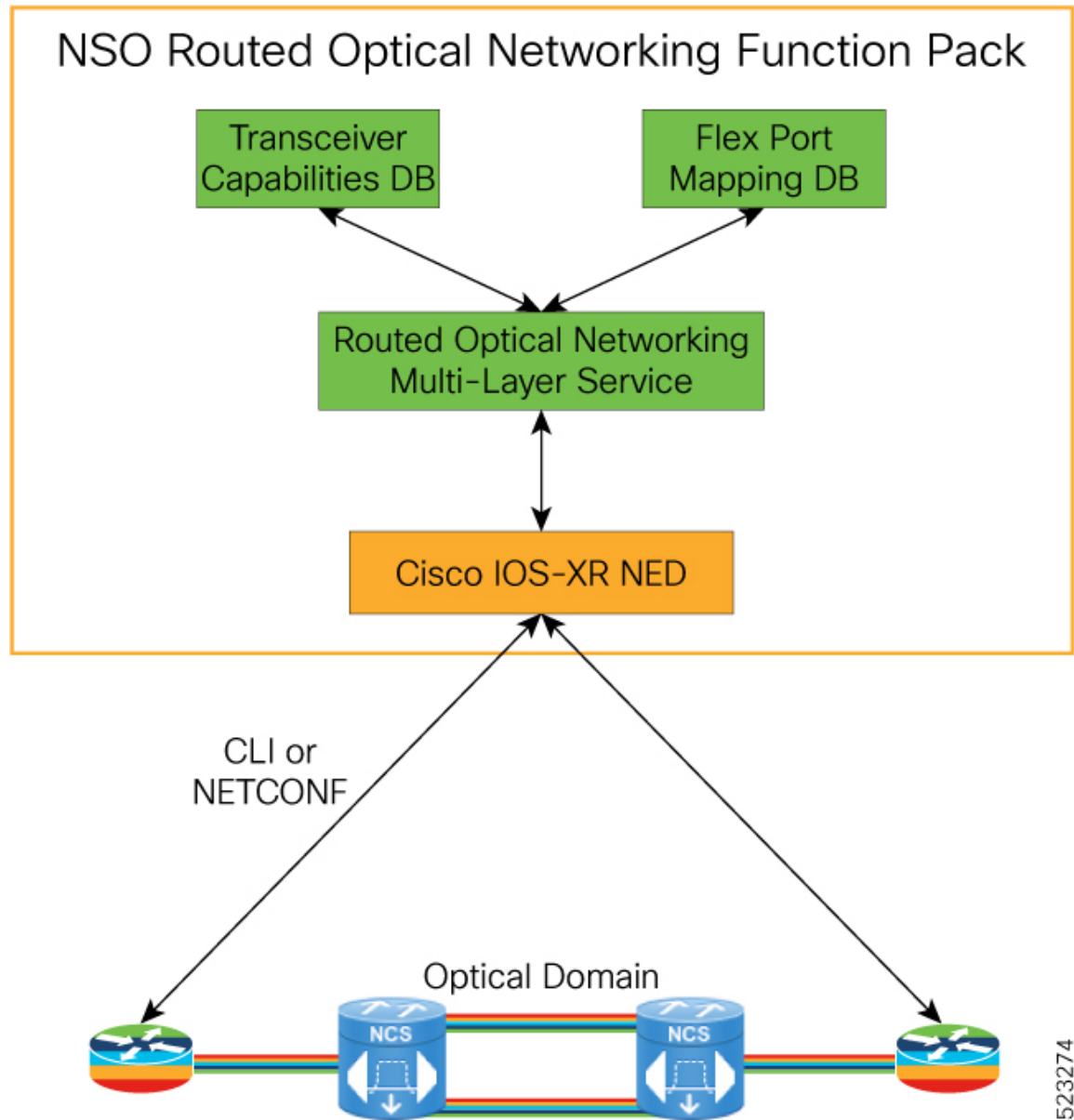
The Routed Optical Networking ML service connects two DWDM optical ports with a fixed bandwidth of either 100G, 200G, 300G, or 400G between the routers. This service is characterized by a single DWDM wavelength.

The Routed Optical Networking ML service helps to

- provision line card modes to support 100G and 400G digital coherent optics
- configure the optical parameters on the digital coherent optics
- assign IP address to Ethernet interfaces or bundle interfaces, and
- bundle discrete Ethernet interfaces.

Functions of Routed Optical Networking ML function pack

Figure 6: Routed Optical Networking ML function pack



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This table describes the functions of various components of the Routed Optical Networking ML function pack.

Component	Function
Flex-port mapping DB	Maintains chassis and line card PID database for ports that must be pre-provisioned before the ZR configuration. NCS57-18DD-SE and ASR 9000 multi-rate line cards must be pre-provisioned.

Component	Function
Transceiver capabilities DB	Maps ZR and ZR+ optics PIDs to capabilities. For example, ZR supports 400G, 4x100G; ZR+ supports 100G, 2x100G, 3x100G, 4x100G, or 400G.
Routed Optical Networking ML service	Performs ZR and ZR+ optical layer configuration. The function pack can also optionally configure IP layer LAG membership and IP addressing.
Cisco IOS-XR NED	Provisions router elements. NSO network equipment driver used for southbound communication with routers.



**Note** The inter-layer link services are user-defined. Flex-port mapping and transceiver capabilities are installed as part of the function pack, but can be modified by the user.

## Features of Cisco Evolved Programmable Network Manager

The Cisco Evolved Programmable Network Manager (EPNM) is an all-in-one management solution for today's converging packet and optical networks. Cisco EPNM supports the Cisco Routed Optical Network architecture. It provides Cisco Optical and IP full device management, as well as Cisco optical circuit network assurance. Cisco EPNM discovers the physical and logical configuration of managed devices and represents them. Cisco EPNM provides full software image management and configuration management for Cisco optical and IP devices.

Network operators see a live view of the device through a graphical chassis with status indications. EPNM stands out from other network management systems by discovering optical circuits from the network and maintaining an up-to-date representation of both the optical circuit and infrastructure dependencies.

EPNM reduces the time required to identify conditions that affect the network or optical circuits. It correlates raw events and associates alarm conditions with affected managed network elements, network connectivity, and circuits. Contextual dashboards and 360-degree device and port-level views present relevant information that helps network operators identify and resolve problems quickly and efficiently.

EPNM reduces restoration and repair time by guiding troubleshooting. It uses alarm correlation, identifies affected components or optical circuits, and analyzes connectivity. EPNM collects fault and alarm information. It performs node-level performance statistics measurement.

For more information about Cisco Evolved Programmable Network Manager, see the [Cisco Evolved Programmable Network Manager Data Sheet](#).

## Software versions of Routed Optical Networking components

This table lists the software versions of the Routed Optical Networking solution components.

Component	Software version
SR PCE	IOS-XR 7.11.1

Cisco Crosswork Infrastructure	6.0
Crosswork Network Controller cApps	6.0
Crosswork Data Gateway	6.0
Network Services Orchestrator	6.1.9
Cisco Optical Network Controller (CONC)	3.1
Cisco Optical Site Manager (COSM)	7.11.2
Crosswork Hierarchical Controller	8.0
Cisco Evolved Programmable Network Manager	7.1.2
Cisco Optical Network Planner	5.2

## IOS-XR software components

Cisco IOS XR is a modern and flexible network operating system. IOS XR improves operational efficiency by integrating management APIs. This integration enables automated configuration and delivers actionable telemetry data in near real time.

The features utilized to help ensure modern standards-based management of Routed Optical Networking are:

- **YANG-modeled management layer APIs:** Automate device provisioning and management using both native IOS XR and OpenConfig models.
- **Streaming telemetry capabilities:** Provide cadence-based or event-driven monitoring of network data derived from YANG-modeled paths in the manageability layer over gRPC, TCP, or UDP.
- **Configuration of Digital Coherent Optics using CMIS Application Selection Code:** Enables configuration of Digital Coherent Optics using CMIS Application Selection Code.

## Features of NETCONF protocol

Network Configuration (NETCONF) is a standards-based and XML-encoded protocol. NETCONF provides a transport mechanism to send YANG-formatted configuration or operational data requests from an application running on a centralized management platform to a Cisco device. You can use NETCONF to send requests for configuration or operational data retrieval.

NETCONF provides transaction-based services. For example, if part of a configuration request fails, the entire request is aborted.

NETCONF uses a simple Remote Procedure Call based mechanism to enable communication between clients, such as centralized management platform scripts or applications, and servers, such as Cisco switches or routers. NETCONF uses SSH as the transport layer for communication between network devices.

## Types and functions of YANG data models in Routed Optical Networking

Data models provide an alternate centralized way to configure devices instead of using the CLI or SNMP and to collect operational data from Cisco devices. Because the data models are standards-based, you can use the same procedures to configure or collect data from non-Cisco devices. This ability makes them ideal for

customers that support multiple vendors. You can use a centralized management platform to configure or collect data from multiple Cisco devices. The data model architecture allows for automating these procedures.

Yet Another Next Generation (YANG) is a standards-based data modeling language. You can use YANG to create requests for device configuration or operational data. It has a structured, human-readable format similar to a computer program. To create configuration and operational data requests, several applications are available that can run on a centralized management platform.

### Types of YANG models

There are two types of YANG models:

- **Standard (common):** YANG data model that applies to all vendors. For example, a request to disable or shut down an Ethernet interface is identical for Cisco and non-Cisco devices.
- **Device (native, vendor-specific):** YANG data model that facilitates configuration or that collects of operational data related to proprietary vendor features.

### Functions of YANG models in Routed Optical Networking

This table lists Cisco native models, their Open Config equivalents used in the Routed Optical Networking solution, and their functions.

Unified model	Open Config	Function
Cisco-IOS-XR-platform-oper	openconfig-platform	Retrieve line card information for flex-port mapping
Cisco-IOS-XR-optics-port-mode-cfg	No equivalent	Configure flex port modes
Cisco-IOS-XR-controller-optics-oper	openconfig-platform openconfig-platform-transceiver	Retrieve optics PID information
Cisco-IOS-XR-um-cont-optics-cfg	openconfig-terminal-device openconfig-platform-transceiver	Configure ZR optical parameters
Cisco-IOS-XR-um-if-bundle-cfg	openconfig-if-aggregate	Bundle configuration
Cisco-IOS-XR-um-interface-cfg	openconfig-interfaces	IPv4 and IPv6 interface configuration
Controller-otu-oper	No equivalent	Coherent DSP operation data
Cisco-IOS-XR-um-dac-rate-cfg	No equivalent	DAC rate configuration
Cisco-IOS-XR-um-cont-breakout-cfg	No equivalent	Breakout configuration

**Note**

- The openconfig-terminal-device model configures the logical hierarchy of connections from ingress to egress. For Cisco optical devices, you can use OpenConfig to configure nx100G muxponder or transponder modes, and trunk rate.
- Use the openconfig-platform model to configure the physical layer parameters:
  - Frequency
  - TX power
  - Operational-mode (Modulation, FEC, and TX shaping)
- See [Managing OpenZR+ and OIF ZR transceivers on Cisco routers using OpenConfig](#) for information about managing pluggable digital coherent optics using OpenConfig.

## Features of model-driven telemetry

Telemetry is an automated communications process used to collect measurements and other data at remote or inaccessible points and transmit them to receiving equipment for monitoring. Model-Driven Telemetry (MDT) streams YANG-modeled data to a data collector. Model-Driven telemetry enables network devices to continuously stream real-time configuration and operating state information to subscribers.

Applications can subscribe to specific data items using standards-based YANG data models over Network Configuration Protocol (NETCONF), RESTCONF, or gRPC Network Management Interface (gNMI) protocol. You can also create configured subscriptions using CLIs. Devices publish structured data at a defined cadence or when changes occur, based on the subscription criteria and data type. For information about telemetry sensor paths and corresponding data fields, see [Troubleshoot provisioning issues on ZR or ZR+ optics](#).

MDT uses structured data models supported by the networking device. MDT provides critical data that is defined in those data models. Telemetry helps you manage your multivendor network by using a common network management system, standardized processes, and applications. The data collected from the network is standards-based and uniform across vendor implementations.