Network Implementation of Cisco NCS 1010 Optical Line Systems

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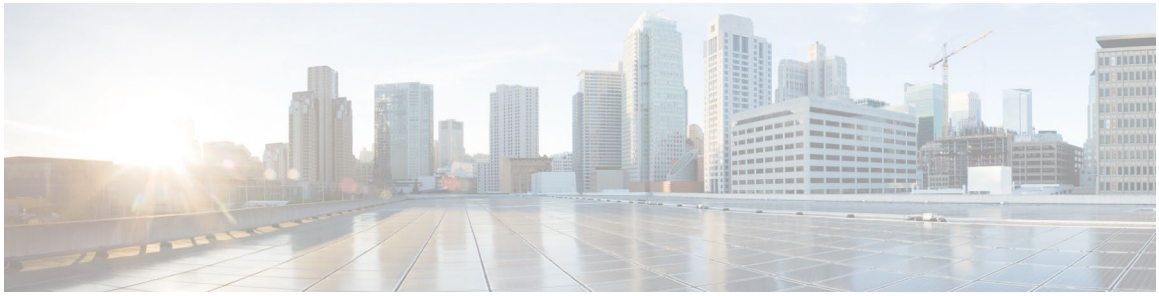

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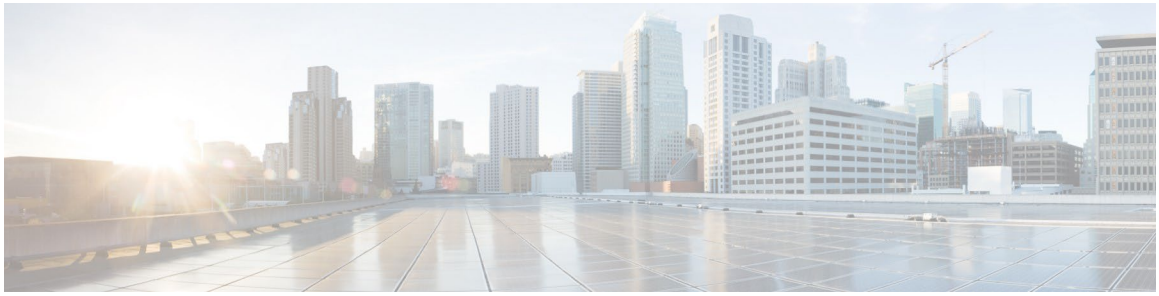


CHAPTER 1

Introduction to Cisco NCS 1010 Line System

This chapter provides an introduction to the Cisco NCS 1010 Line System product.

Routed Optical Networking

Cisco's Routed Optical Networking Solution brings architectural convergence to the traditional multilayer networking. One key component of the solution is a simplified optical line system, NCS 1010. The purpose of this document is to provide detailed implementation practices for Cisco NCS 1010 systems.

A Simplified Optical Line System

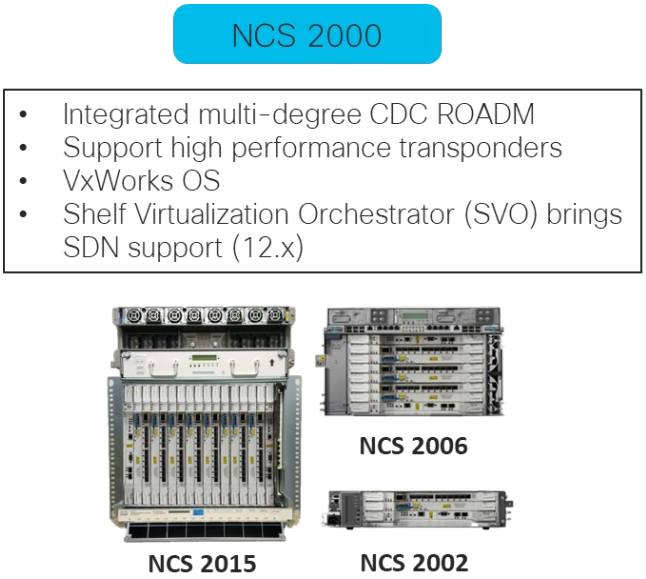
NCS 1010 is a disaggregated open optical line system that can provide optical add/drop and ROADM (Reconfigurable Optical Add/Drop Multiplexer) functionality. It can directly support lower launch power QSFP-DD Digital Coherent Optics (DCO) pluggable modules with some of its designated ports.

Key Optical Features of NCS 1010

C+L-Band Support	ASE Loading	Gain Equalization	Visibility & Manageability	Support for ZR/ZR+
Support for both C and L bands; hitless upgrade from C to C+L	Embedded channelized ASE (Amplified spontaneous emission) for consistency in performance from day 1 to full capacity growth	DGE (dynamic gain equalizer) for equalization and better control of Raman Gain ripple	Optical Channel Monitor (OCM), Optical Time Domain Reflectometry (OTDR), Optical Supervisory Channel (OSC), Connectivity Verification (CV)	Ingress amplifier supports coherent sources with low launch powers (400G ZR and ZR+ at -10 dBm)

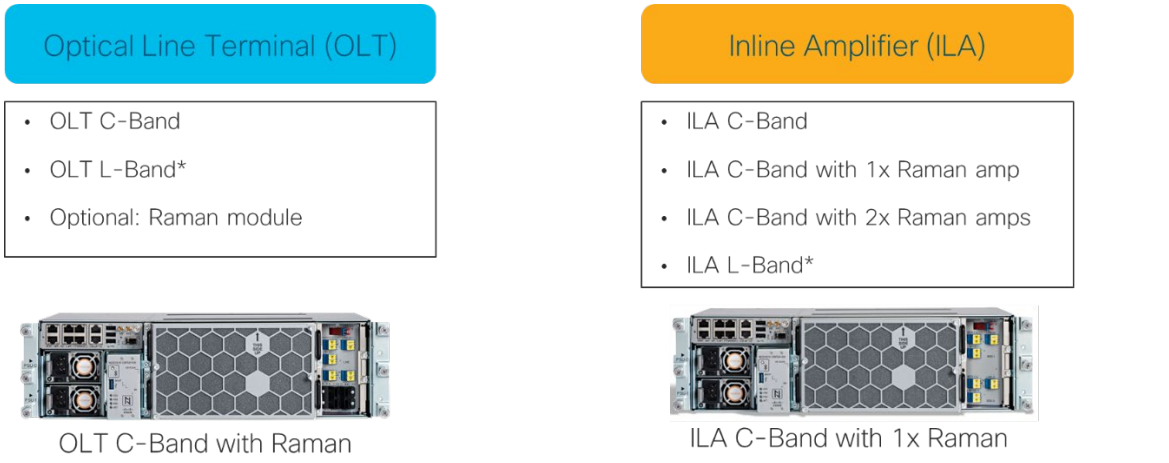
Comparison with Cisco NCS 2000

Cisco NCS 2000 is a fully integrated DWDM system that supports high performance transponders and CDC (Colorless Directionless and Contentionless) ROADM functionality. In comparison, NCS 1010 is a type of an Open Line System (OLS) with disaggregated functionality.



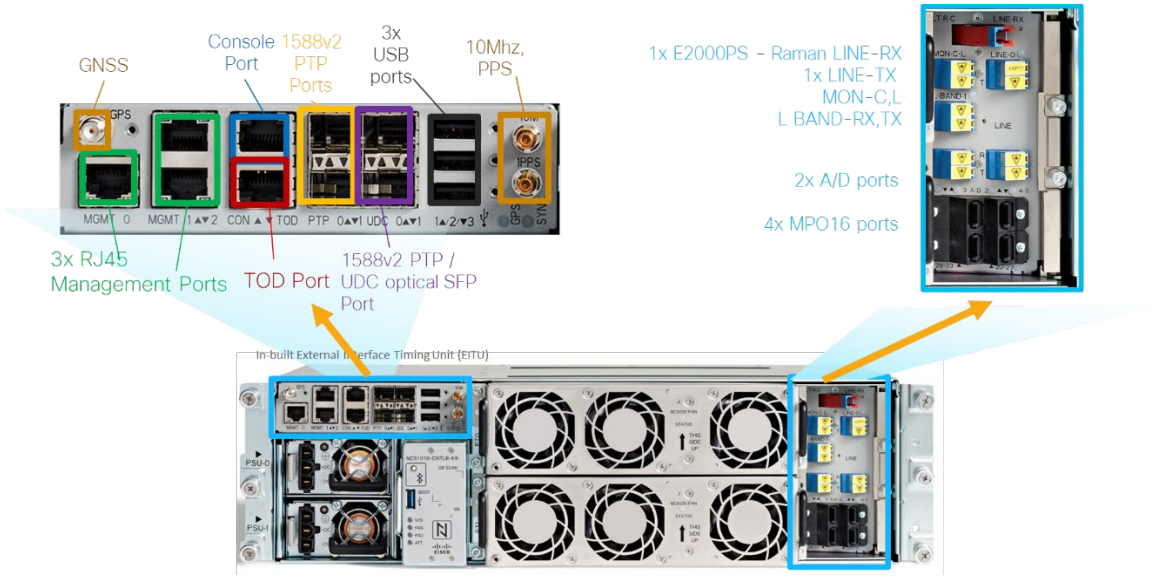
NCS 1010 Line Card Modules and Configurations

There are two chassis functions depending on the modules installed:



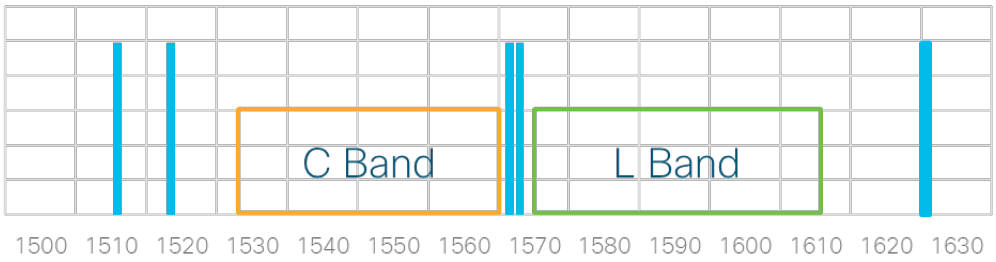
* Committed for XR 7.9.1

The following figure shows the chassis faceplate. In particular there are three USB ports that can be used to manage the passive panels. Management Ethernet ports can be used for DCN connectivity. Each chassis provides a number of fiber ports with LC and MPO connectors. Detailed port mapping is discussed in later chapters.



Some of the control wavelengths used by NCS 1010 and mapping are provided in the following table and figure.

Wavelength (nm)	Frequency (THz)	Use
1510.29	198.50	OSC C band probe
1518.32	197.45	OTDR
1528.77-1566.52	196.100-191.375	C band
1568.15	191.175	OLT C-band OOB signal
1568.77	191.100	OLT L-band OOB signal
1568.77	191.100	DFB Raman probe
1570.83-1610.70	190.850-186.125	L band
1625.33	184.450	OSC L band probe



Summary of NCS 1010 Product IDs

This table shows the PIDs for the first release with Cisco IOS-XR 7.7.1. The L-band modules are to be available with the 7.9.1 release.

Description	PID	SW Release
NCS 1010 Shelf Assembly	NCS1010-SA	7.7.1
NCS 1010 Optical Line Terminal - C-band	NCS1K-OLT-C	7.7.1
NCS 1010 Optical Line Terminal with Raman - C-band	NCS1K-OLT-R-C	7.7.1
NCS 1010 In-Line Amplifier - C-band	NCS1K-ILA-C	7.7.1
NCS 1010 In-Line Amplifier with 1x Raman - C-band	NCS1K-ILA-R-C	7.7.1
NCS 1010 In-Line Amplifier with 2x Raman - C-band	NCS1K-ILA-2R-C	7.7.1
NCS1010 Add/drop Filter Odd	NCS1K-MD-32O-C	7.7.1
NCS1010 Add/drop Filter Even	NCS1K-MD-32E-C	7.7.1
NCS 1010 Breakout Shelf	NCS1K-BRK-SA	7.7.1
NCS1010 Breakout Module	NCS1K-BRK-24	7.7.1
NCS1010 Breakout Module	NCS1K-BRK-16	7.7.1
NCS1010 Breakout Module	NCS1K-BRK-8	7.7.1

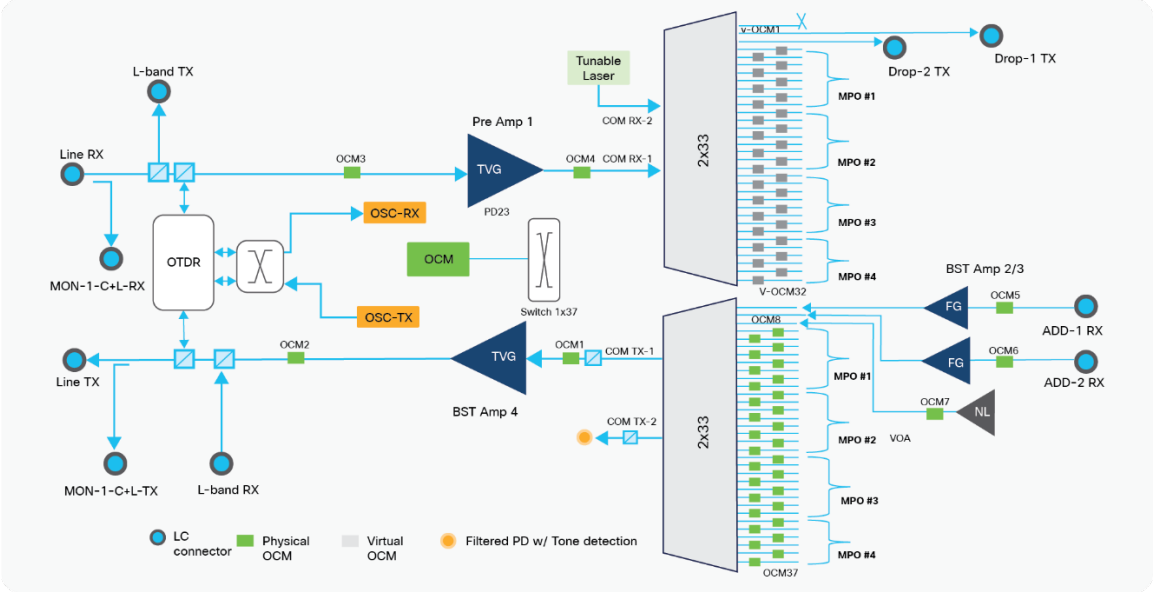
Cisco NCS 1010 Chassis Configuration

Terminal and line amplifier functionality is provided through two different chassis configurations.

OLT

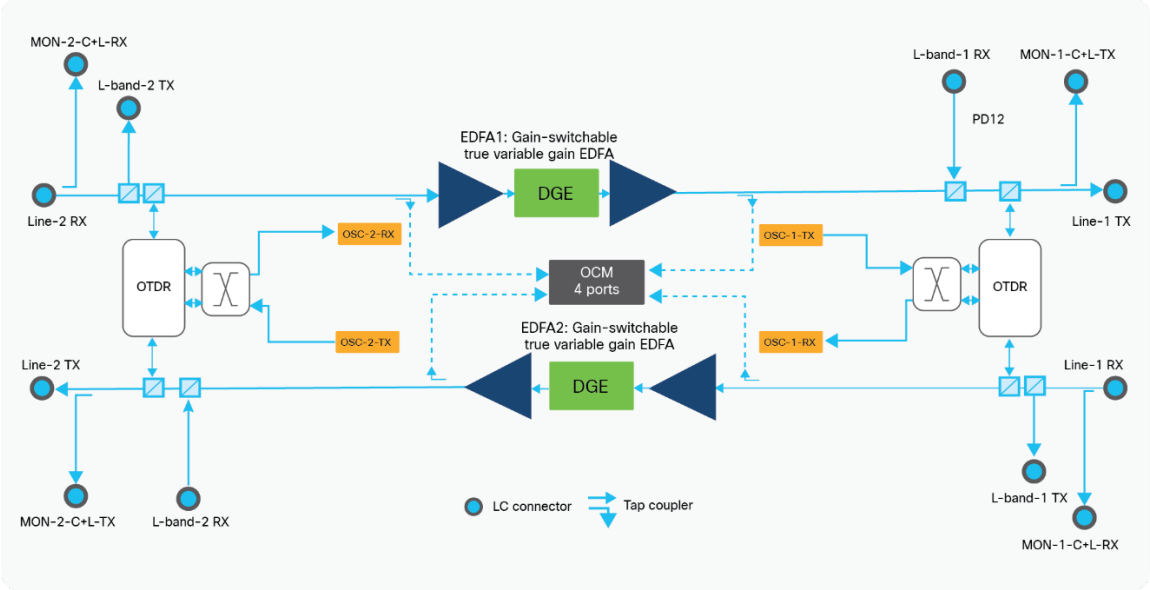
The following figure shows the internal schematics of an OLT-C. Key components are:

- Optical channel monitor
- L-band add and drop
- Bidirectional OTDR
- OSC
- 25 dBm variable-gain preamplifier (Pre Amp 1) and 23 dBm variable-gain booster amplifier (BST Amp 4)
- 2x33 port twin flex-grid Wavelength Selective Switch (WSS),
    - 2 ports supporting fixed-gain EDFAs at WSS Add for low-powered digital coherent optics
    - 30 ports for Add/Drop, in 4 MPO cabling ports
- Connection verification on fiber patches from ROADM to passive breakout or add-drop modules and on ROADM-to-ROADM express connections
- Built-in ASE loading allows for easier turn-up of the network and consistency in performance from day-1 through the life of the network



ILA

The ILA optical signal flow is shown in the following figure. A key feature of the ILA is the 2 independent variable-gain EDFA blocks.



Auxiliary Panels

Two types of passive panels are provided for channel add/dop or interconnection: fixed 32 channel filters for colored add/drops and breakout panels for colorless add/drops or inter-chassis connection. All panels can be connected to the USB ports on the NCS 1010 chassis for inventory management.

Fixed Mux-Demux Panels

There are two 32-channel versions, Even and Odd. Each panel is 1 RU height with a USB 2.0 port. With 75 GHz spacing, each panel can support 32 channel DCO ZR or ZR+ signals. The Odd version is shown below.

The following charts show the channel mapping for each LC port of the MD-32 panels. The first row is port number (0-31), the second row is channel frequency, and the 3rd row is the channel wavelength.

NCS1K-MD-32O-C Channel Plan

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
196.1	195.95	195.8	195.65	195.5	195.35	195.2	195.05	194.9	194.75	194.6	194.45	194.3	194.15	194	193.85
1528.77	1529.94	1531.12	1532.29	1533.47	1534.64	1535.82	1537	1538.19	1539.37	1540.56	1541.75	1542.94	1544.13	1545.32	1546.52

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
193.7	193.55	193.4	193.25	193.1	192.95	192.8	192.65	192.5	192.35	192.2	192.05	191.9	191.75	191.6	191.45
1547.72	1548.91	1550.12	1551.32	1552.52	1553.73	1554.94	1556.15	1557.36	1558.58	1559.79	1561.01	1562.23	1563.45	1564.68	1565.9

NCS1K-MD-32E-C Channel Plan

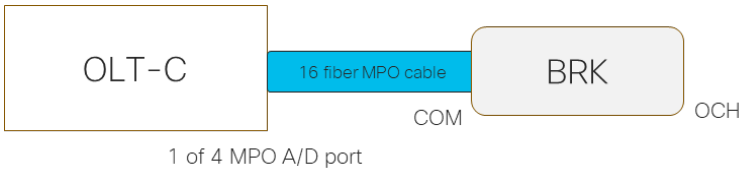
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
196.025	195.875	195.725	195.575	195.425	195.275	195.125	194.975	194.825	194.675	194.525	194.375	194.225	194.075	193.925	193.775
1529.36	1530.53	1531.7	1532.88	1534.05	1535.23	1536.41	1537.59	1538.78	1539.96	1541.15	1542.34	1543.53	1544.72	1545.92	1547.12

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
193.625	193.475	193.325	193.175	193.025	192.875	192.725	192.575	192.425	192.275	192.125	191.975	191.825	191.675	191.525	191.375
1548.31	1549.52	1550.72	1551.92	1553.13	1554.34	1555.55	1556.76	1557.97	1559.19	1560.4	1561.62	1562.84	1564.07	1565.29	1566.52

Breakout Panels

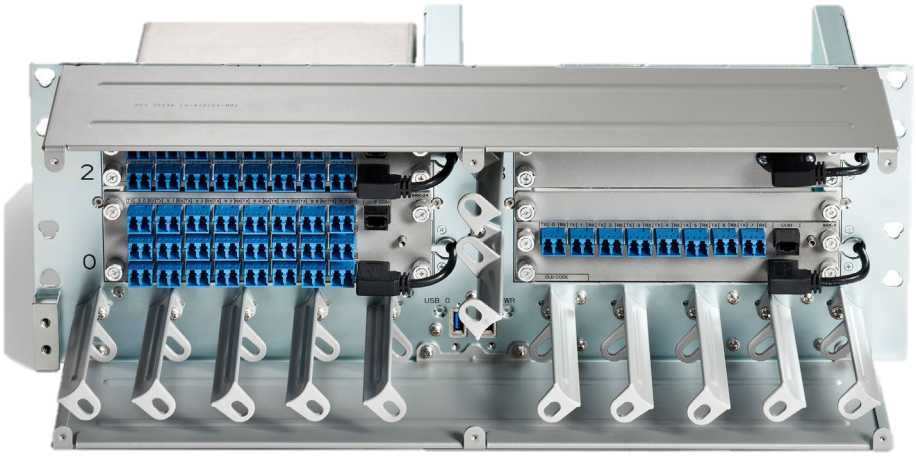
There are 3 breakout versions: 24, 16, 8 channels. Each panel is connected to one of the four MPO add/drop ports on the NCS 1010 chassis. The 16 port version, BRK-16, is not officially supported with the IOS-XR release 7.7.1 but will be supported in a future release. It is included in this document for completeness.

Each panel can be connected to an MPO Add/Drop port on the OLT chassis with a 16-fiber MPO cable. The breakout panel takes in the composite signal (COM) and breaks out into LC type optical channels (OCH).



Splitters are used internally in 24 channel and 16 channel versions, where 1:3 and 1:2 splitters are used respectively. A 1:3 splitter for example means that 1 COM port maps to 3 OCH ports. See later chapters for more details on port mapping.

Multiple breakout panels can be mounted on a shelf. The following figure shows 3 breakout panels mounted on NCS1k-BRK-SA.



The breakout panels can also be mounted on NCS2K-MF-1RU for BRK-8 and BRK-16 modules.

Cisco NCS 1010 Management and Automation

NCS 1010 devices can be managed through many different methods. Some of the common options are:

- IOS-XR CLI: CLI is available to manage all aspects of the device, including turnup, provisioning, performance monitoring, software upgrade.
- EPN Manager (EPNM 6.1): EPNM provides device lifecycle management.
- Cisco Optical Network Controller (CONC 2.0): CONC is a domain controller that supports NCS 1010. It provides a minimalist UI for direct device onboarding. Its main purpose is to provide an SDN controller function to a hierarchical controller
- Crosswork Hierarchical Controller (HCO 5.3): HCO provides device discovery. multi-layer service provisioning over an NCS 1010 network
- Cisco Optical Network Planner (CONP 5.0): CONP provides design and analysis for an NCS 1010 network and an installation file can be exported from CONP and imported into CONC for bulk device onboarding

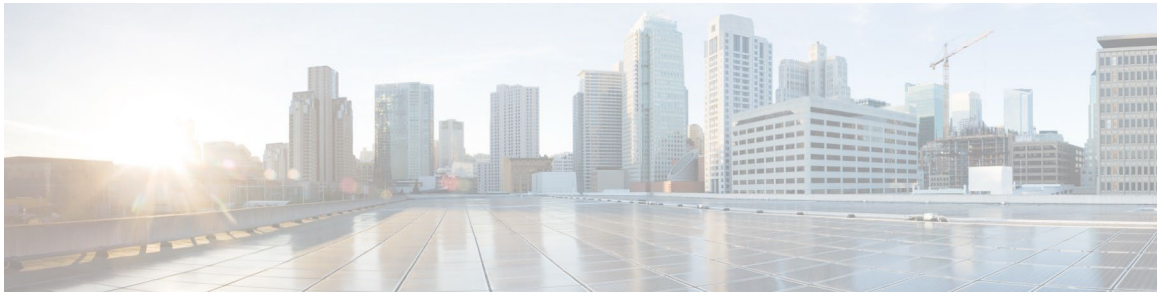
Some of these components will be covered later in this document as applicable for deployment.

Cisco Product Documentation

NCS 1010 product documentation page provides additional details. Links are provided below for reference:

Document	Link
Data Sheet	https://www.cisco.com/c/en/us/products/collateral/optical-networking/network-convergence-system-1000-series/network-conver-system-1010-ds.html
Hardware Installation Guide	https://www.cisco.com/c/en/us/td/docs/optical/ncs1010/hardware/guide/b-ncs1010-hardware-guide/m-install-ncs-1010.html?dtid=osscdc000283

Configuration Guide	https://www.cisco.com/c/en/us/td/docs/optical/ncs1010/77x/configuration/guide/b-ncs1010-system-setup-guide/m-ncs-1010-overview.html



CHAPTER 2

NCS 1010 Deployment Options

This chapter provides a number of deployment options for NCS 1010. This is not intended to be an exhaustive list but rather to provide some of the common deployment options or use cases available. The types of add/drops, the number of ROADM degrees, the number of channels and others that are include in each option are just examples to demonstrate a use case. To simplify presentation, some of the drawings only show partial diagram or one site. Some of the interconnection ports are indicated in the drawing with detailed ports and interconnections provided in later chapters.

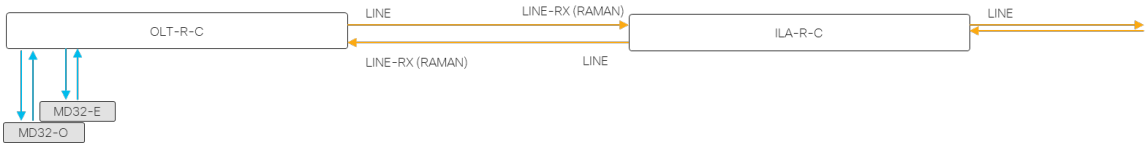
Point to Point Terminal or Line Amplifier

NCS 1010 OLT can be deployed as colored or colorless terminals depending on the type of add/drop structures are used.

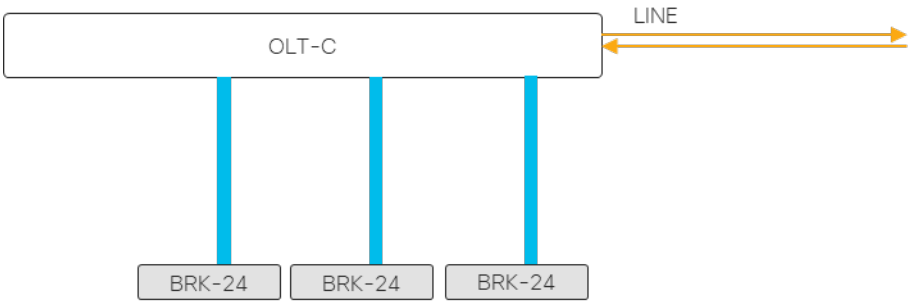
- Colored add/drop terminal: NCS 1010 Add/drop Filter Odd (NCS1K-MD-32O-C) and NCS 1010 Add/drop Filter Even (NCS1K-MD-32E-C) provide fixed filters for C band
- Colorless add/drop terminal: NCS 1010 Breakout Modules (NCS1K-BRK-24, NCS1K-BRK-16, NCS1K-BRK-8) provide multiple options to add or drop colorless signals or to interconnect OLTs into a multi-degree ROADM.

C-band 64 channel colored terminal example:

C-band 64 channel colored terminal with one RAMAN amplified span:



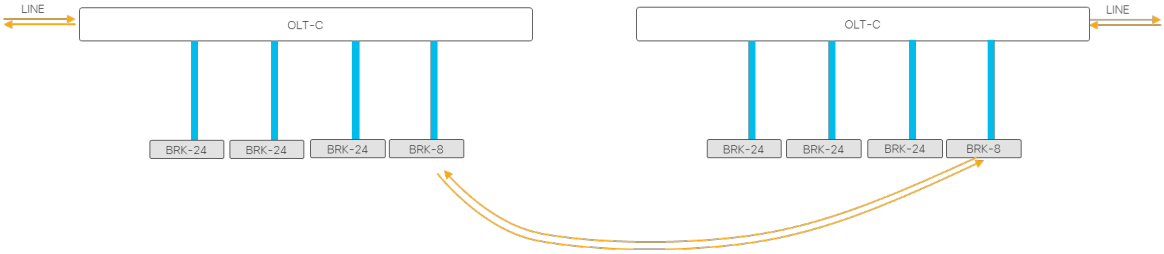
C-band 72 channel colorless terminal example:



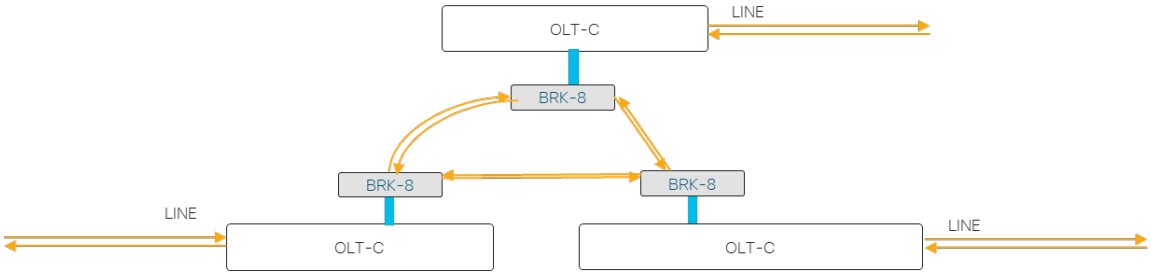
Reconfigurable Optical Add/Drop Multiplexer (ROADM)

NCS 1010 nodes can be constructed into ROADM nodes as needed by interconnecting breakout ports. Here are some of the examples.

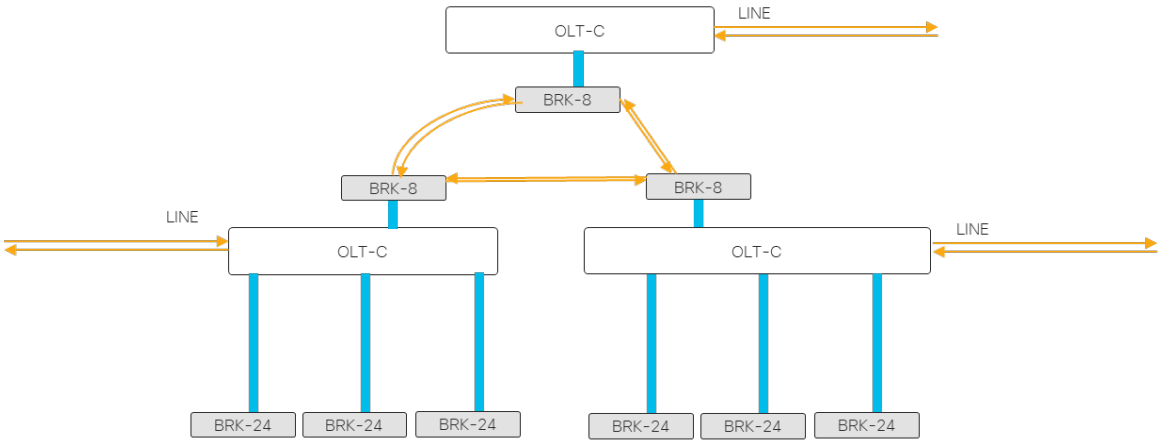
A 2-degree ROADM example with 2x72 channel colorless add/drops: BRK-8 is used to interconnect the two degrees together:



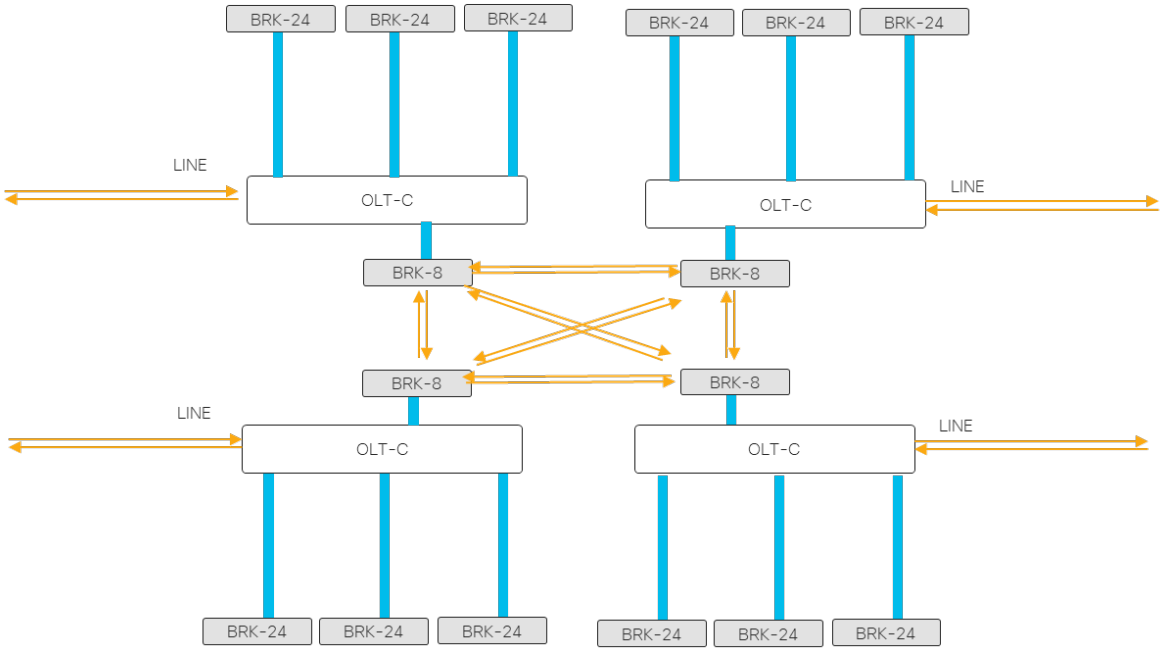
A 3-degree ROADM example with no add/drops:



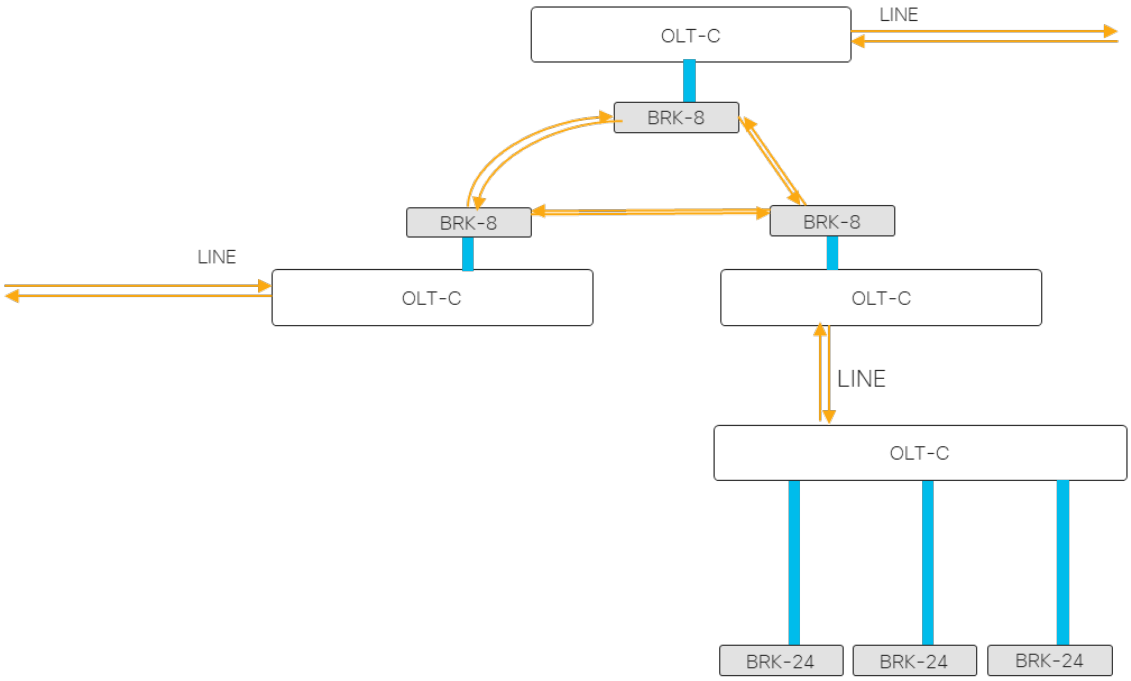
A 3-degree ROADM example with 144 channel colorless add/drops:



A 4-degree ROADM example with 4x72 channel colorless add/drops:

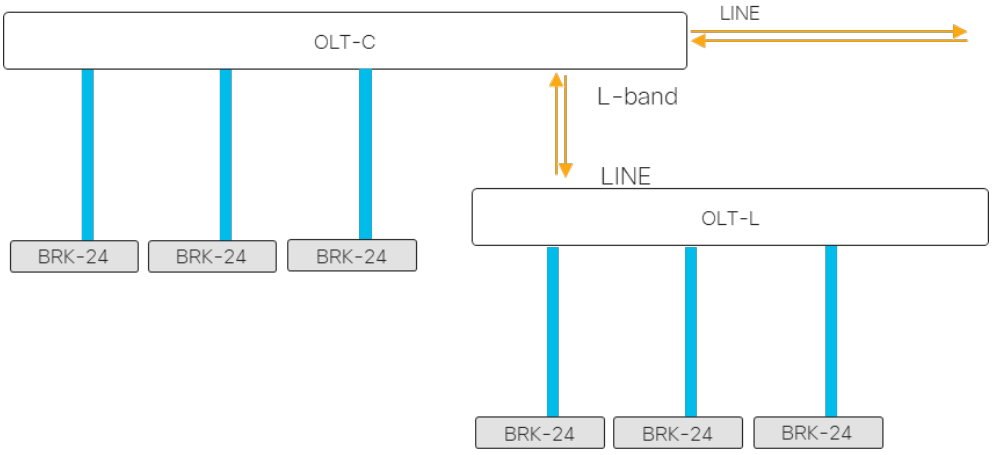


A 2-degree directionless ROADM example with 72 channel colorless add/drops. Note that this configuration option is not fully tested at the time of this documentation. The OSC must be enabled between the connectionless (omnidirectional) OLT and the OLT as part of the 2-degree ROADM. Also note that CONC does not support this configuration as a single aggregated ROADM node, instead it will be a two-node setup: one 2-degree ROADM with an externally connected terminal node.

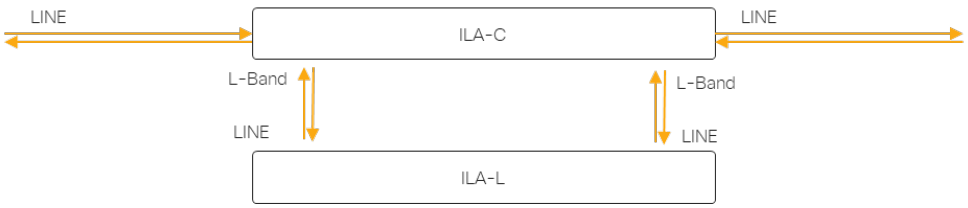


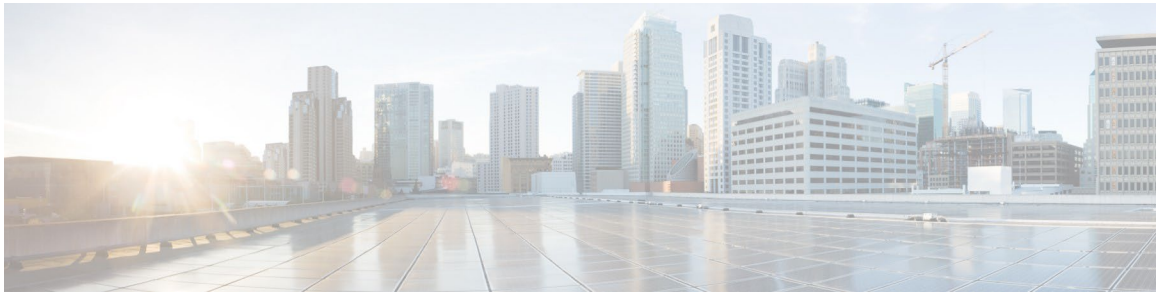
C+L Band

A C+L band terminal example for 72 channel colorless C band signals and 72 channel colorless L band signals:



A C+L band line example with a C-band ILA and an L-band ILA:





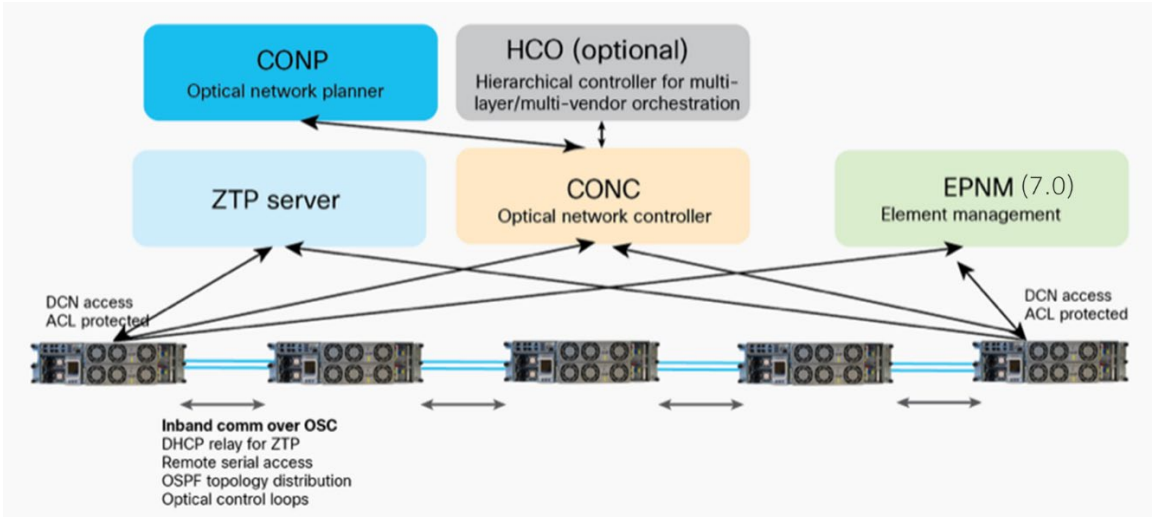
CHAPTER 3

Turning up Cisco NCS 1010 Line Systems

This chapter describes steps to turn up an NCS 1010 node.

Management and Automation Architecture

The following figure shows a high level management and automation architecture and options for NCS 1010. You can pick and choose the components to satisfy your specific management needs. Cisco Optical Network Planner (CONP) is a planning tool that can be used to design and onboard NCS 1010 nodes. Cisco Optical Network Controller (CONC) is an optical domain controller that can provide SDN functionality for NCS 1010 networks. Optionally a hierarchical SDN controller (HCO) can be used to provide multi-domain orchestration and automation. Cisco EPN Manager provides device lifecycle management functions. Zero Touch Provisioning (ZTP) can be used to automate booting and initial node provisioning.



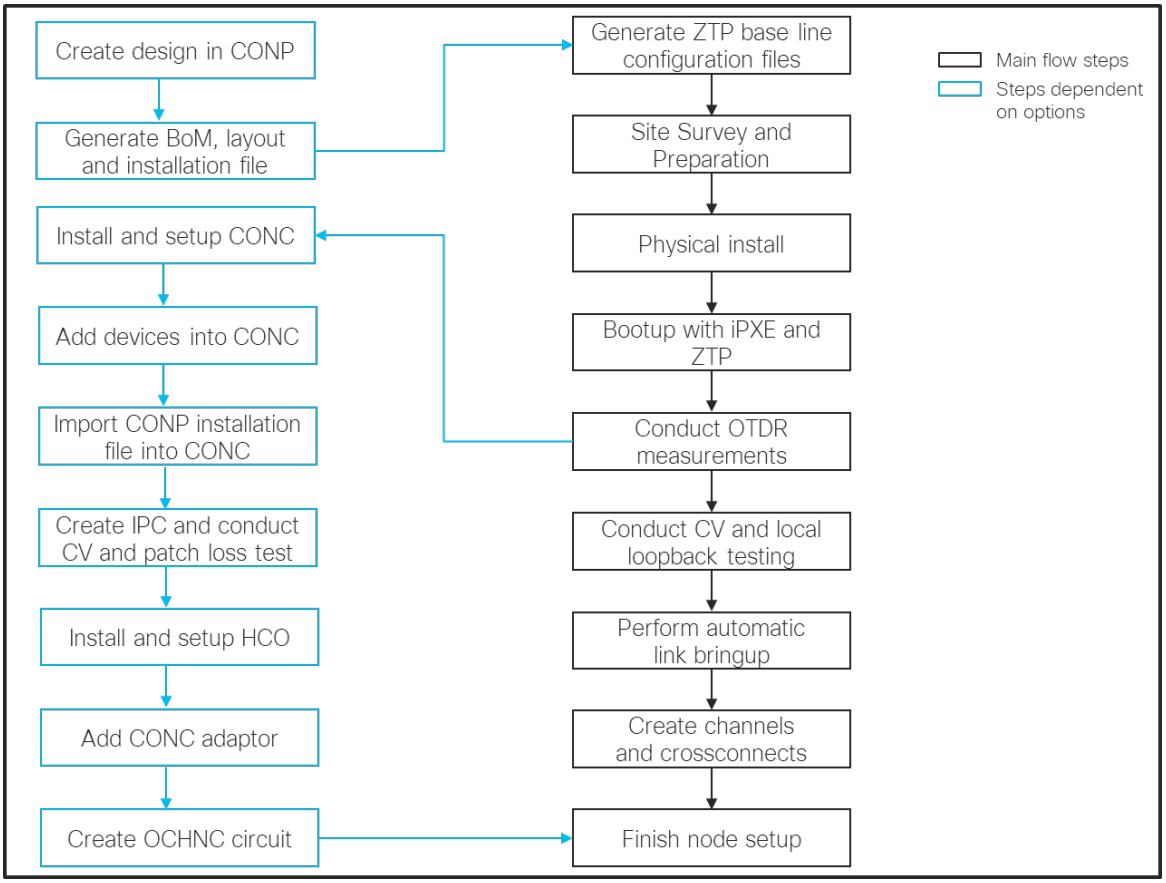
NCS 1010 nodes can be turned up in many different ways. The following three methods are available for consideration as additional automation capabilities are being developed:

CLI	CONC	CONC+HCO
• Node bringing up with IOS-XR CLI only • Applicable for simple network setup • Device by device configuration and verfications	• CONP for design, layout, and installation file • Single point of management through CONC • Preferred for multi-degree sites • Circuit provisioning may be via API	• Complete workflow with Cisco automation packages • Applicable if customers purchase HCO • GUI-driven provisioning, visualization and assurance

This document touches upon all three methods where applicable.

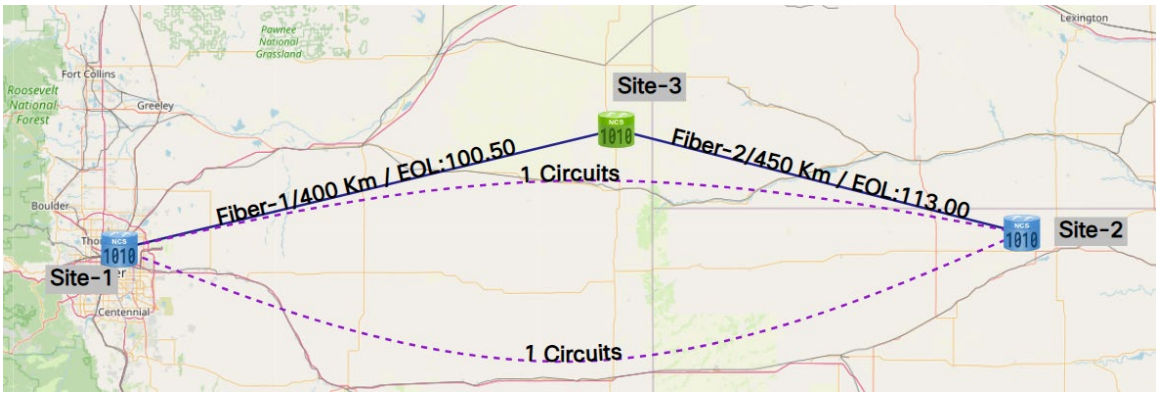
Turnup Workflow

Because of different turnup options, there are a few different workflows available. The following chart shows one such workflow. In particular, the main workflow steps focus on using CLI to turn up the nodes. Optionally you may leverage the management packages to enhance the main workflow. The rest of the document will go into more details on many of these steps.



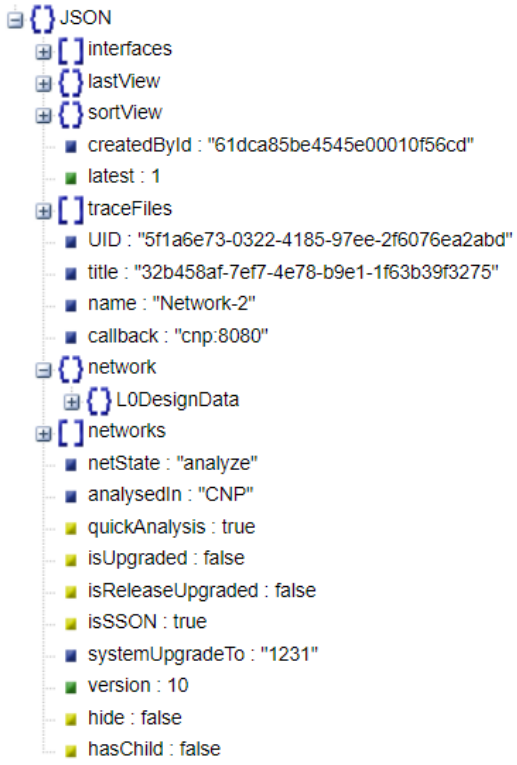
Design with CONP

If you choose to use CONP to assist with turnup, you may start the process by creating a NCS 1010 network design. You begin by creating a new Network by selecting NCS 1010 as L0 Network Platform. An NCS 1010 site can be one of the three site types: ROADM, OLA or Passthrough. The following figure shows a 3 site point-to-point design with two terminal sites and one ILA site.



Alien wavelength from DCO can be specified at the circuit level by setting the optical source. A JSON configuration file can be generated and imported into CONC for bulk provisioning.

The following figure shows the high level structure of the JSON file:

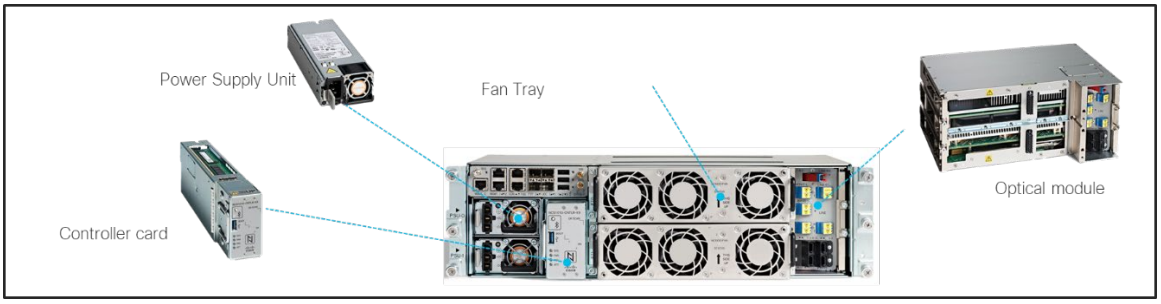


The following figure shows a partial view of the expanded networks section of the JSON file:

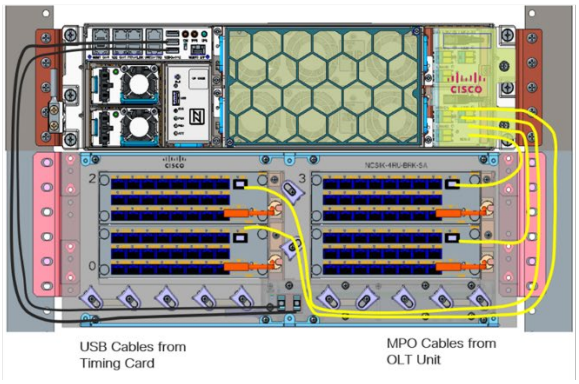
```
networks
  0
    childKey : "defaultNetwork"
    UID : "defaultNetwork"
    SRLG
    handoffGroups
    errorInfo
    site
      0
        entityType : "Site"
        UID : "78dabc2b-bf43-470e-b848-2943050e2c42"
        label : "Site-1"
        type : "ROADM"
        preEquipDegree : "no"
        xCoordinate : -104.90141317248344
        yCoordinate : 39.836857150512934
        businessStatus : "FUTURE"
        siteAddress : ""
        CLLICode : ""
        networkStatus : "UNDISCOVERED"
        sitePositionLock : false
        equipment
          location
            0
              UID : "5aa417ec-3bb9-4ebf-99a1-4ca8b7e67a03"
              xCoordinate : -107.15854067355394
              yCoordinate : 39.59982731413431
              rack
                0
                  entityType : "Rack"
                  UID : "rack-dc22b9f0-c269-405d-8230-cd5e59bc5679"
                  rackNumber : "1"
                  front
                    shelf
                      0
                        UID : "shelf-065c28f1-7a58-4e82-b562-987d0d5805b2"
                        pid : "NCS1010-SA="
                        type : "NCS1010-SYS"
                        shelfName : "NCS1010-SYS"
                        shelfNumber : "1"
```


Physical Install

NCS 1010 chassis can be installed in 19" and 23" racks, and the ETSI rack. It supports DC and AC power supplies with 1050W AC and DC PSU Options. The field replaceable units are shown in the following figure. More detailed descriptions of the installation are available from the Cisco documentation, https://www.cisco.com/c/en/us/td/docs/optical/ncs1010/hardware/guide/b-ncs1010-hardware-guide/m-install-ncs-1010.html.

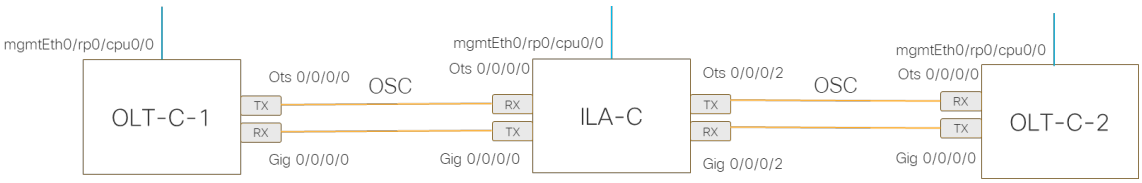


The following is another view of the installation.



DCN Connectivity

NCS 1010 nodes can be managed through an Ethernet management port or OSC (Optical Supervisory Channel) port. The following figure shows one example of network connectivity. In this simple 3-node network, all three nodes are connected via management Ethernet to an external router (gateway) and they are also connected over OSC, where a Gigabit Ethernet payload is provided.



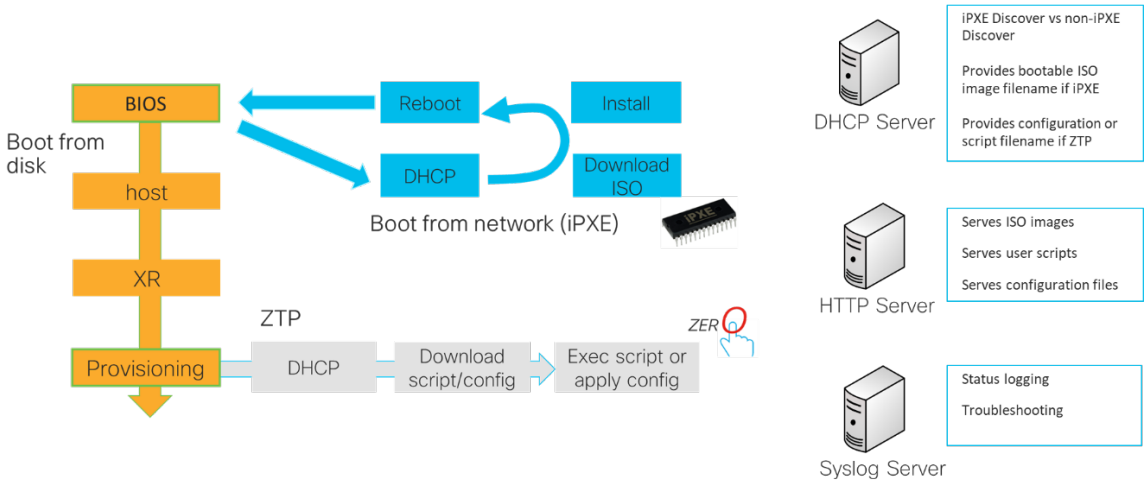
The following configuration snippet shows IOS-XR configuration commands for a gateway NCS 1010 node. OSPF is enabled over the OSC (for example, GigabitEthernet0/0/0/0 on OLT-C-1).

```
hostname OLT-C-1
!
interface Loopback0
 ipv4 address 1.1.1.1 255.255.255.255
!
interface MgmtEth0/RP0/CPU0/0
 ipv4 address 11.10.10.10 255.255.192.0
!
interface GigabitEthernet0/0/0/0
 ipv4 address 10.10.10.1 255.255.255.252
!
router static
 address-family ipv4 unicast
  0.0.0.0/0 11.10.10.1
 !
!
router ospf 1
 distribute link-state
 router-id 1.1.1.1
 network point-to-point
 area 0
  network point-to-point
  interface Loopback0
  !
  interface MgmtEth0/RP0/CPU0/0
   passive enable
  !
  interface GigabitEthernet0/0/0/0
  !
```

Automated Booting with iPXE and ZTP

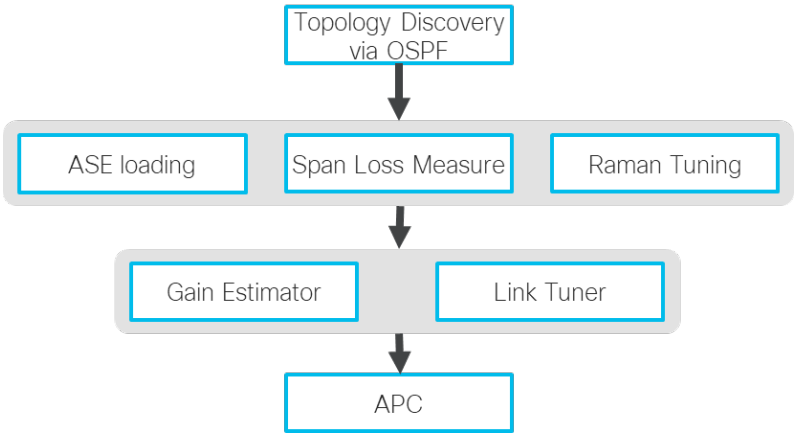
NCS 1010 supports IOS-XR iPXE and ZTP for automated booting and initial provisioning. The following figure shows the high level workflow and servers that may be used in such a setup. Detailed procedure to setup and configure ZTP is available from Cisco documentation:

https://www.cisco.com/c/en/us/td/docs/optical/ncs1010/77x/configuration/guide/b-ncs1010-system-setup-guide/m-bring-up-ncs1010.html?dtid=osscdc000283.

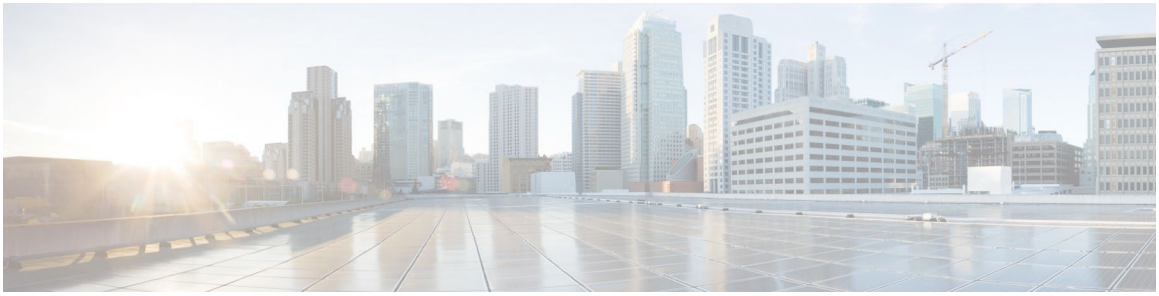


Automatic Link Bringup

Automatic Link Bringup is part of the Optical Line Control (OLS), and is a process to go through a set of measurements and tuning to bring up all the links. In particular, it will measure optical parameters of the spans at power-up and compute set points, and enable optical applications such as Raman tuning, link tuner, gain estimator, and APC (Automatic Power Control). The following figure shows the key components and process of the Automatic Link Bringup:



Through IOS-XR CLI, users may configure this feature through a single command of `automatic-link-bringup` under `optical-line-control`. Users may also overwrite following parameters through configurations for a port under `optical-line-control`: measured span loss, fiber type, spectral density, and span length.

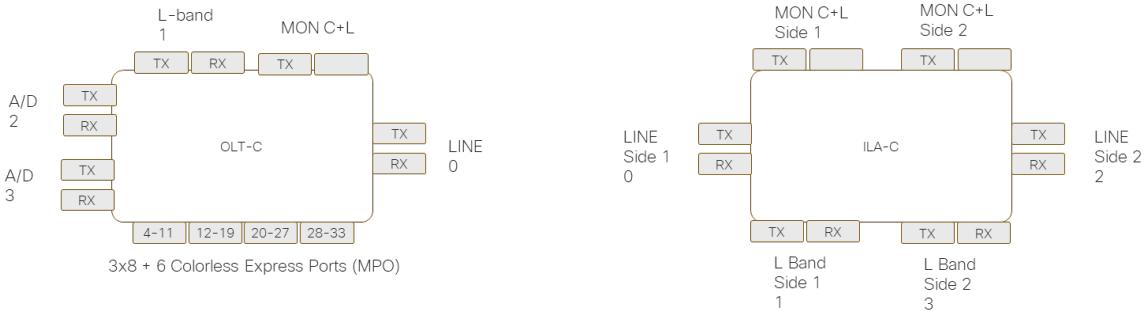


CHAPTER 4

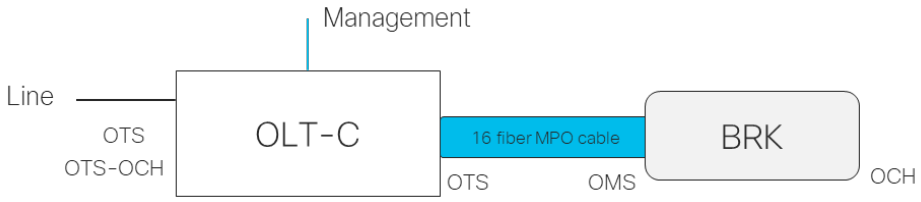
Configuration Details and Management

Port Numbering and Cabling

Each NCS 1010 node provides a set of ports for interconnections. The following figure shows the types of ports and port numbering for OLT-C and ILA-C. L-band chassis has similar port structure minus the L-band Add/Drop ports that are only available on the C-band chassis.



The following figure shows the port naming on a sample setup. The line and each add/drop port are of the type OTS (Optical Transport Section). The composite port on the add/drop panel is an OMS (Optical Multiplex Section) port. An OMS port can map to one or more OCH (Optical Channel) ports. The OTS-OCH is an optical channel into an OTS port.



The representation of OLT-C ports in IOS-XR is provided in the following table:

Port	Use
MgmtEth0/RP0/CPU0/0-2	100 M Ethernet for management
GigabitEthernet0/0/0/0	Gigabit Ethernet port for OSC
ots 0/0/0/0	Line port
ots 0/0/0/1	L-band A/D
ots 0/0/0/2-3	LC A/D
ots 0/0/0/4-33	MPO A/D
ots-och 0/0/0/0/1-N	Och from the Line
oms 0/shelf/slot/port	COM ports for passive shelves connected to the USB
och 0/shelf/slot/port	LC ports on a passive shelf

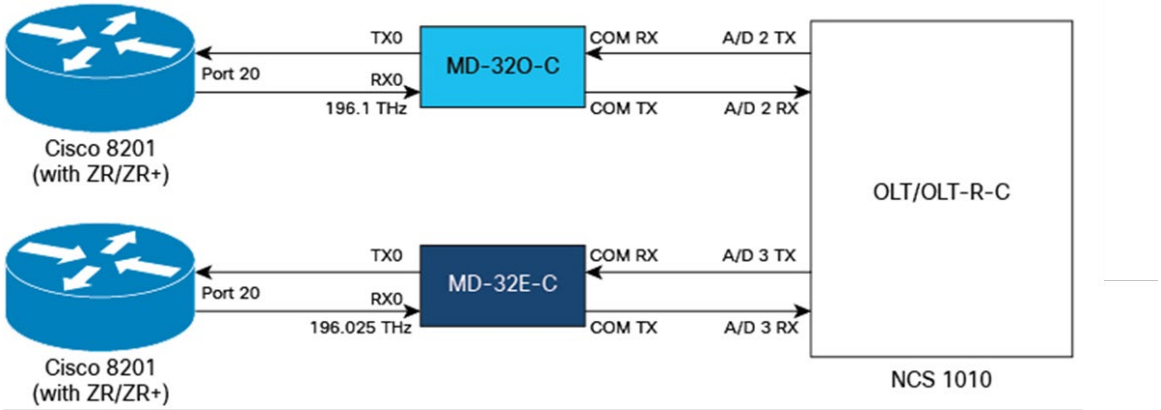
The ots-och controllers are created by the OLT cross-connects. The passive shelf OMS port numbering follows these rules:

- Shelf ID is USB port ID
- Slot ID is panel location on the shelf. Always 0 for the MD-32 panels
- Port ID is the LC port number for the MD-32 panels. BRK OMS port numbering is dependent on the BRK type due to different splitters (couplers). See Chapter 5 for more details.

The ILA-C ports are numbered in a similar manner without OMS ports and with two sides:

Port	Use
MgmtEth0/RP0/CPU0/0-2	100 M Ethernet for management
GigabitEthernet0/0/0/0, 2	Gigabit Ethernet ports for OSC
ots 0/0/0/0	Side 1 Line port
ots 0/0/0/1	Side 1 L-band A/D
ots 0/0/0/2	Side 2 Line port
ots 0/0/0/3	Side 2 L-band A/D
ots-och 0/0/0/0/1-N	Och, if crossconnect configured

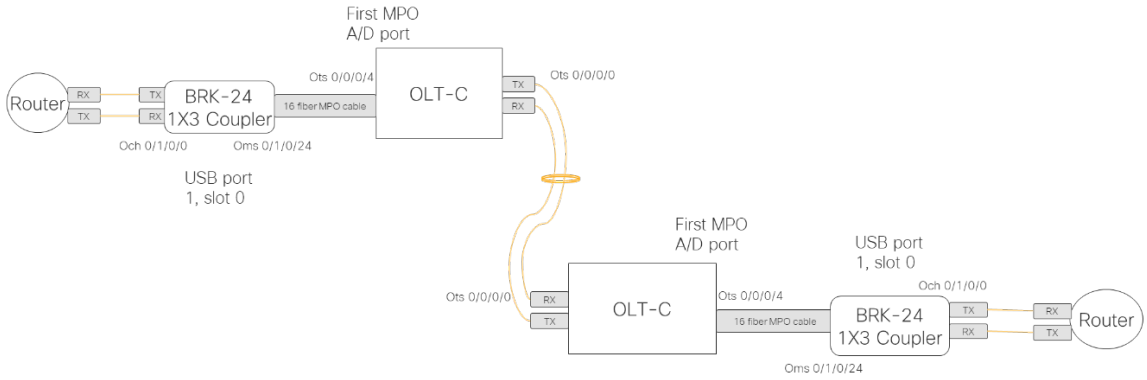
The following is an example of point-to-point colored add/drop (showing one site) with both MD-32 Odd and MD-32 Even filters.



The following table shows an example of NCS 1010 port mapping using the MD-32 filters. The MD-32 panels are connected to USB ports 2 and 3 (shown as shelf numbers in IOS-XR) in this example.

OTS Port	OMS Port (COM)	OCH Port
Ots 0/0/0/2	Oms 0/2/0/32	Och 0/2/0/0 -31
Ots 0/0/0/3	Oms 0/3/0/32	Och 0/3/0/0 -31

The following is an example of making a point-to-point connection between two routers using BRK-24 panels.



The following example shows port numbering where 4 BRK-24 panels are connected to the 4 MPO A/D ports. Because BRK-24 is a 1:3 splitter panel, one OMS port maps to 3 OCH ports. For example, port 24 maps to ports 0-2.

A/D 4-11

OTS Port	OMS Port (COM)	OCH Port
Ots 0/0/0/4	Oms 0/1/0/24	Och 0/1/0/0-2
Ots 0/0/0/5	Oms 0/1/0/25	Och 0/1/0/3-5
Ots 0/0/0/6	Oms 0/1/0/26	Och 0/1/0/6-8
Ots 0/0/0/7	Oms 0/1/0/27	Och 0/1/0/9-11
Ots 0/0/0/8	Oms 0/1/0/28	Och 0/1/0/12-14
Ots 0/0/0/9	Oms 0/1/0/29	Och 0/1/0/15-17
Ots 0/0/0/10	Oms 0/1/0/30	Och 0/1/0/18-20
Ots 0/0/0/11	Oms 0/1/0/31	Och 0/1/0/21-23

A/D 12-19

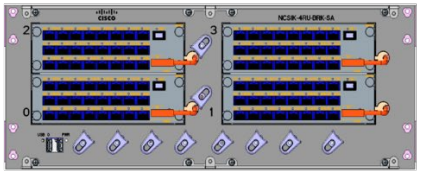
OTS Port	OMS Port (COM)	OCH Port
Ots 0/0/0/12	Oms 0/1/1/24	Och 0/1/1/0-2
Ots 0/0/0/13	Oms 0/1/1/25	Och 0/1/1/3-5
Ots 0/0/0/14	Oms 0/1/1/26	Och 0/1/1/6-8
Ots 0/0/0/15	Oms 0/1/1/27	Och 0/1/1/9-11
Ots 0/0/0/16	Oms 0/1/1/28	Och 0/1/1/12-14
Ots 0/0/0/17	Oms 0/1/1/29	Och 0/1/1/15-17
Ots 0/0/0/18	Oms 0/1/1/30	Och 0/1/1/18-20
Ots 0/0/0/19	Oms 0/1/1/31	Och 0/1/1/21-23

A/D 20-27

OTS Port	OMS Port (COM)	OCH Port
Ots 0/0/0/20	Oms 0/1/2/24	Och 0/1/2/0-2
Ots 0/0/0/21	Oms 0/1/2/25	Och 0/1/2/3-5
Ots 0/0/0/22	Oms 0/1/2/26	Och 0/1/2/6-8
Ots 0/0/0/23	Oms 0/1/2/27	Och 0/1/2/9-11
Ots 0/0/0/24	Oms 0/1/2/28	Och 0/1/2/12-14
Ots 0/0/0/25	Oms 0/1/2/29	Och 0/1/2/15-17
Ots 0/0/0/26	Oms 0/1/2/30	Och 0/1/2/18-20
Ots 0/0/0/27	Oms 0/1/2/31	Och 0/1/2/21-23

A/D 28-44

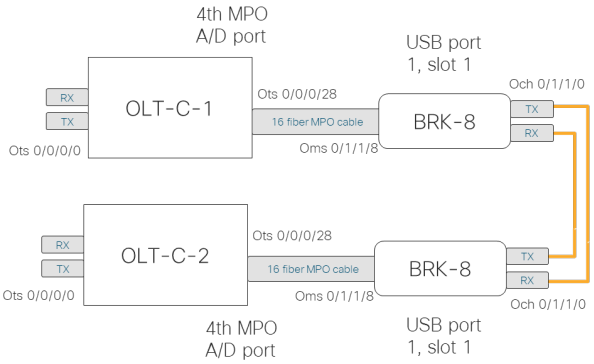
OTS Port	OMS Port (COM)	OCH Port
Ots 0/0/0/28	Oms 0/1/3/24	Och 0/1/3/0-2
Ots 0/0/0/29	Oms 0/1/3/25	Och 0/1/3/3-5
Ots 0/0/0/30	Oms 0/1/3/26	Och 0/1/3/6-8
Ots 0/0/0/31	Oms 0/1/3/27	Och 0/1/3/9-11
Ots 0/0/0/32	Oms 0/1/3/28	Och 0/1/3/12-14
Ots 0/0/0/33	Oms 0/1/3/29	Och 0/1/3/15-17



Mounting of panels in this example
- NCS1k-BRK-SA shelf connected to USB port 1
- Four BRK-24 panels mounted in slot locations of 0, 1, 2, 3
- The use of BRK-24 for the last MPO port gives you 18 A/D ports (90 ports total in this example)

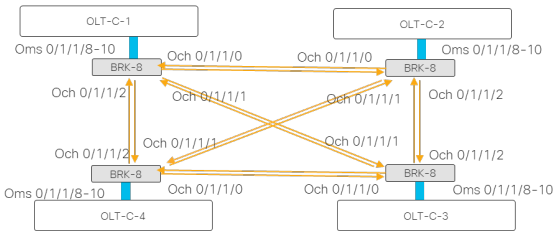
The following is an example of interconnecting two OLT-C shelves with two BRK-8 panels.

NCS 1010 Device	OTS Port	OMS Port (COM)	OCH Port
OLT-C-1	Ots 0/0/0/28	Oms 0/1/1/8	Och 0/1/1/0
OLT-C-1	Ots 0/0/0/29	Oms 0/1/1/9	Och 0/1/1/1
OLT-C-1	Ots 0/0/0/30	Oms 0/1/1/10	Och 0/1/1/2
OLT-C-1	Ots 0/0/0/31	Oms 0/1/1/11	Och 0/1/1/3
OLT-C-1	Ots 0/0/0/32	Oms 0/1/1/12	Och 0/1/1/4
OLT-C-1	Ots 0/0/0/33	Oms 0/1/1/13	Och 0/1/1/5
OLT-C-2	Ots 0/0/0/28	Oms 0/1/1/8	Och 0/1/1/0
OLT-C-2	Ots 0/0/0/29	Oms 0/1/1/9	Och 0/1/1/1
OLT-C-2	Ots 0/0/0/30	Oms 0/1/1/10	Och 0/1/1/2
OLT-C-2	Ots 0/0/0/31	Oms 0/1/1/11	Och 0/1/1/3
OLT-C-2	Ots 0/0/0/32	Oms 0/1/1/12	Och 0/1/1/4
OLT-C-2	Ots 0/0/0/33	Oms 0/1/1/13	Och 0/1/1/5



The following shows an example of interconnecting four OLT-C shelves using four BRK-8 panels.

NCS 1010 Device	OTS Port	OMS Port (COM)	OCH Port
OLT-C-1	Ots 0/0/0/28	Oms 0/1/1/8	Och 0/1/1/0
OLT-C-1	Ots 0/0/0/29	Oms 0/1/1/9	Och 0/1/1/1
OLT-C-1	Ots 0/0/0/30	Oms 0/1/1/10	Och 0/1/1/2
OLT-C-2	Ots 0/0/0/31	Oms 0/1/1/8	Och 0/1/1/0
OLT-C-2	Ots 0/0/0/32	Oms 0/1/1/9	Och 0/1/1/1
OLT-C-2	Ots 0/0/0/33	Oms 0/1/1/10	Och 0/1/1/2
OLT-C-3	Ots 0/0/0/28	Oms 0/1/1/8	Och 0/1/1/0
OLT-C-3	Ots 0/0/0/28	Oms 0/1/1/9	Och 0/1/1/1
OLT-C-3	Ots 0/0/0/28	Oms 0/1/1/10	Och 0/1/1/2
OLT-C-4	Ots 0/0/0/28	Oms 0/1/1/8	Och 0/1/1/0
OLT-C-4	Ots 0/0/0/28	Oms 0/1/1/9	Och 0/1/1/1
OLT-C-4	Ots 0/0/0/28	Oms 0/1/1/10	Och 0/1/1/2



Channel Configuration

NCS 1010 channel IOS-XR configuration in a terminal is done in two steps:

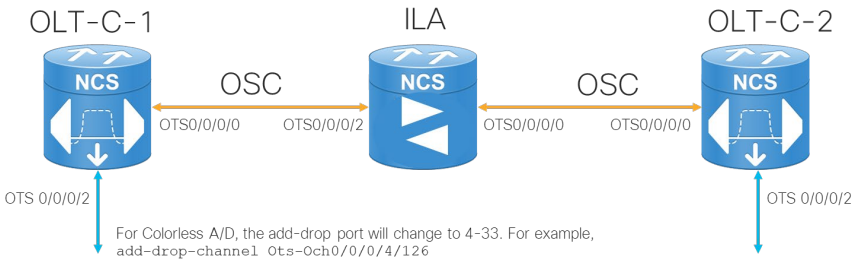
1. Create a channel under `hw-module`. The channel ID is a locally significant representation of a channel and does not need to map to an OIF channel number or to another node. The `centre-frequency` needs to be matched end to end. This configuration is only required on a terminal node but may be configured on an ILA node if you wish to monitor the channel PM on the ILA
2. Create a crossconnect to map the channel to an A/D port. The channel created in Step 1 is available for crossconnect under ots-och.

The following is a sample configuration for a point-to-point channel of 196.025 THz using a fixed MD-32 filter connected to port 2. The exact LC port on the MD-32 panel for client is known based on the `centre-frequency`, where 196.025 THz maps to port 0 of NCS1K-MD-32E-C (see MD-32 channel mapping for details). Channel ID 126 is used on one terminal to represent the wavelength while the ID is 63 on the other terminal. They do not need to match. The channel frequency must match end to end.

OLT-C-1:
```
hw-module location 0/0/NXR0
 terminal-ampli
  grid-mode flex
   channel-id 126 centre-freq 196.025 width 75.0
  !
controller Ots-Och0/0/0/0/126
 add-drop-channel Ots-Och0/0/0/2/126
!
```

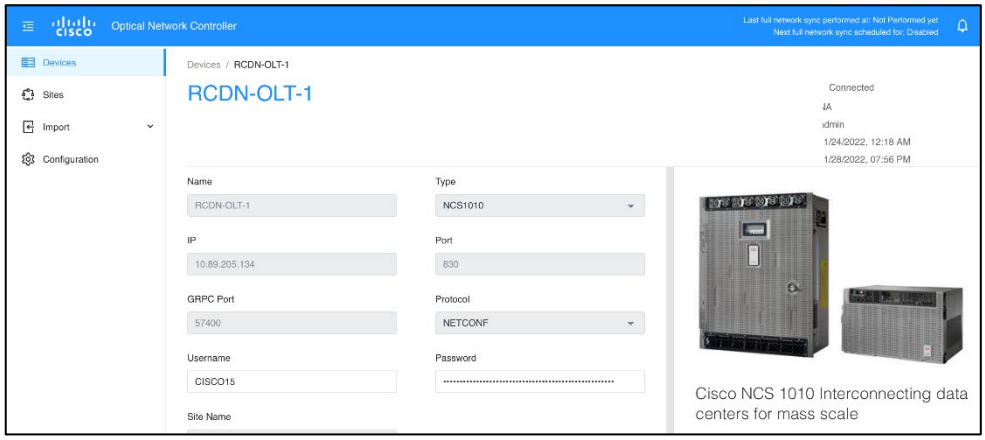
ILA (Optional Config):
```
hw-module location 0/0/NXR0
 inline-ampli
  grid-mode flex
   channel-id 16 centre-freq 196.025 width 75.0
  !
```

OLT-C-2:
```
hw-module location 0/0/NXR0
 terminal-ampli
  grid-mode flex
   channel-id 63 centre-freq 196.025 width 75.0
  !
 controller Ots-Och0/0/0/0/63
 add-drop-channel Ots-Och0/0/0/2/63
!
```



CONC Management

CONC is Cisco's optical controller with limited UI capabilities. It is intended to be used as a domain controller for HCO. Devices must be first added into CONC before management. NCS 1010 devices can be added individually or through a bulk import with an Excel file. Network design can be imported from a CONP JSON file. The site name must match between what is in CONC and in CONP.



Nodes are organized under a site. The following functions are available:

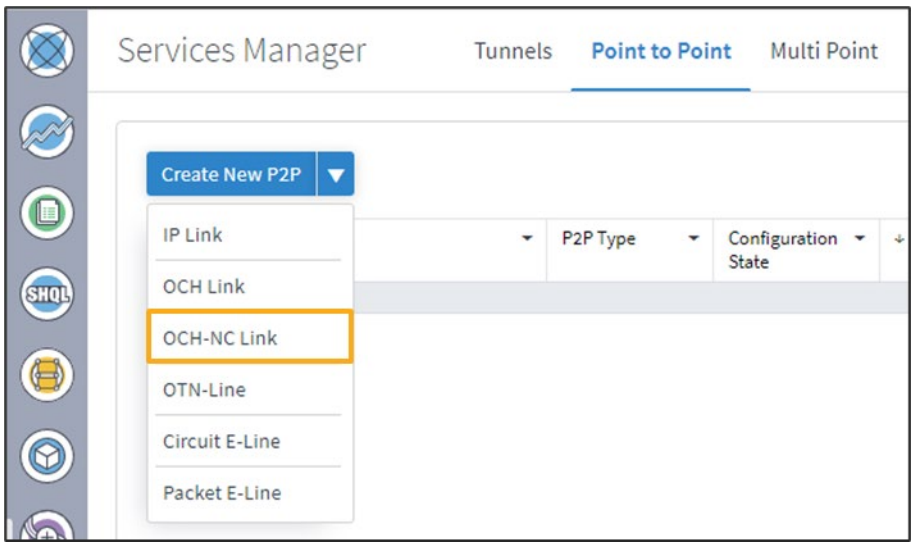
- Alarms: Active alarms

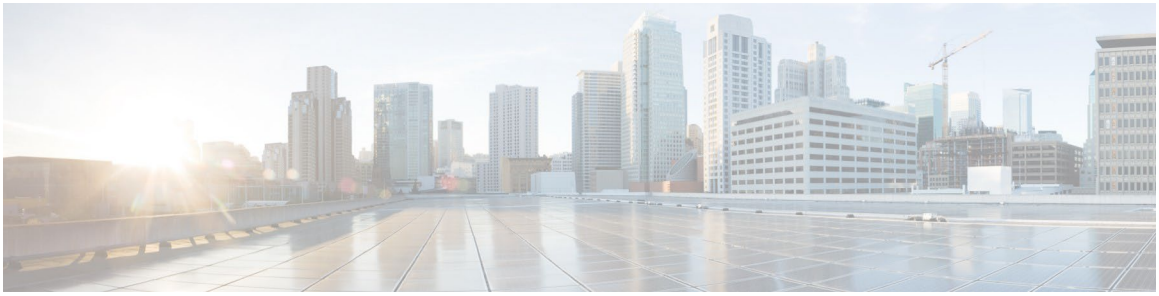
- Inventory: Equipment inventory
- Internal patch cord (IPC): IPC can be created in CONC between a line port and A/D port or imported as part of the CONP design. For each IPC connection, you can verify connection and patch loss. IPC in CONC is required to build an OCHNC circuit by the HCO.

HCO Management

HCO provides multilayer network discovery, provisioning, and assurance. HCO communicates with CONC through the CONC adaptor, which uses T-API (Transport API) standard API developed by ONF. HCO can retrieve equipment and topology information from the network and provision connectivity services across the transport network domain. Auto discovery of nodes takes place once nodes are fully discovered in CONC. HCO will fetch full data of nodes by default at every 180 sec, can be set with “Polling Cycle” to 120 sec. HCO associates nodes to Sites, similar to CONC and CONP.

The following figure shows a screenshot to use HCO to create an OCH-NC circuit.



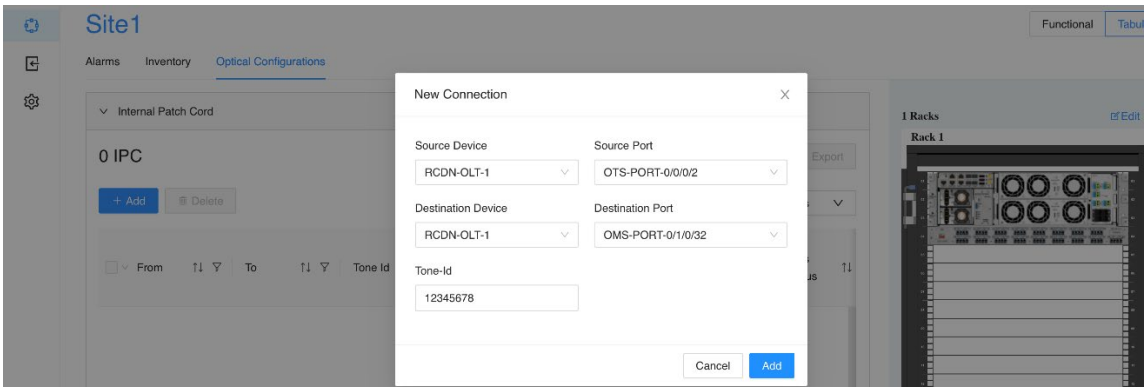


CHAPTER 5

Connectivity Verification

Introduction

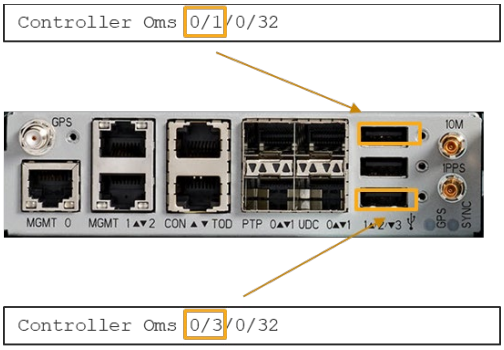
Connectivity Verification (CV) uses an out of band (OOB) or in-band tone to verify the optical connectivity between a line port and an A/D port. CV can be conducted via CLI or CONC. Internal Patch Cord (IPC) is representation of connection between NCS 1010 and a Passive Patch Panel and required to perform Connection Verification via CONC. The following figure shows an example of IPC creation in CONC.



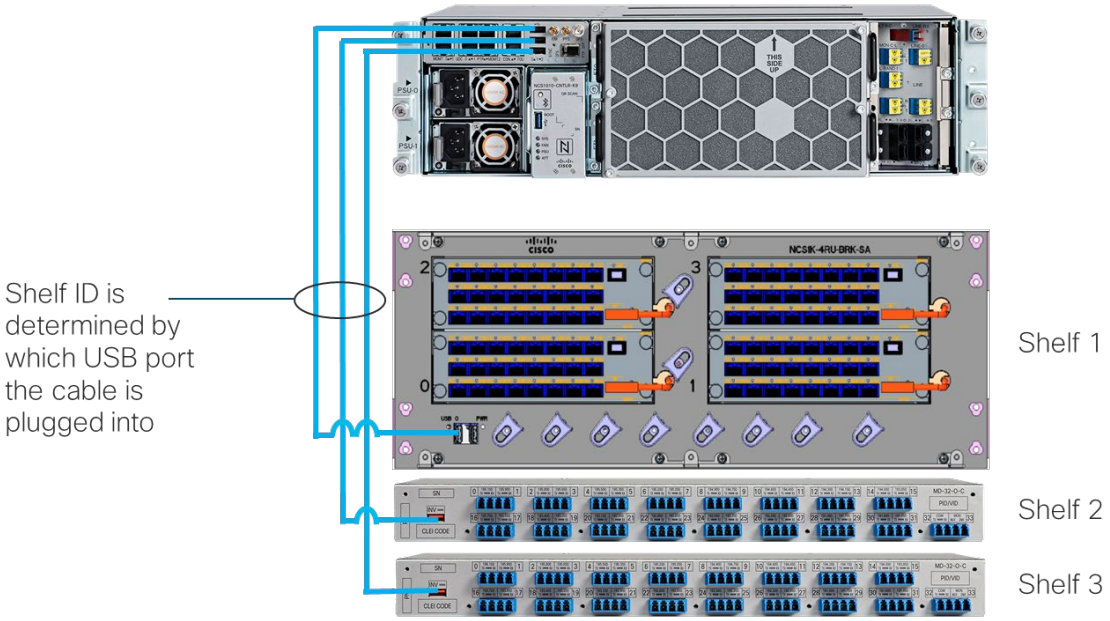
Passive shelves must be powered through the USB ports on the NCS 1010 chassis.

Passive Shelf Numbering via USB

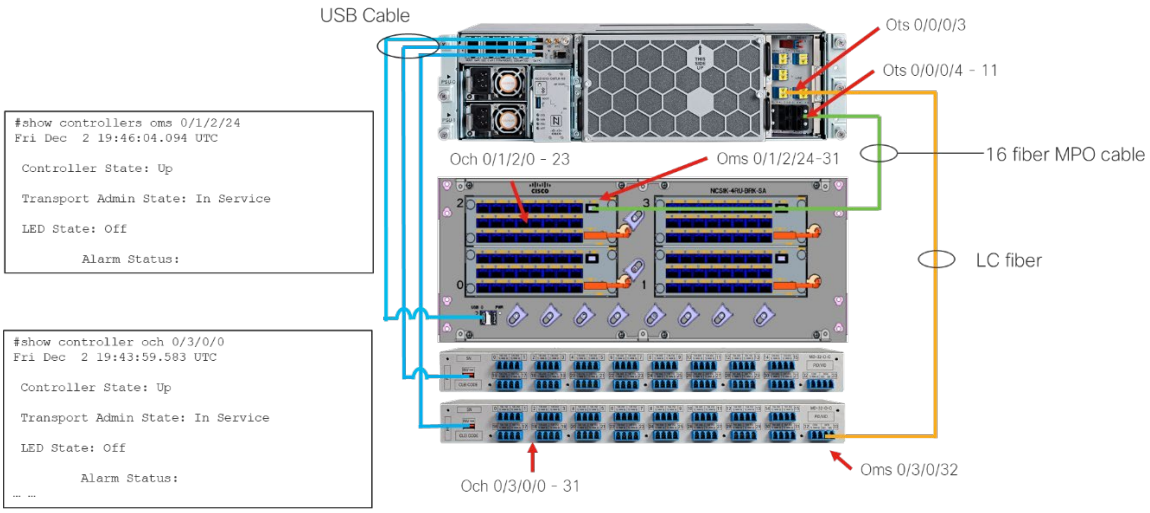
Each NCS 1010 chassis provides 3 USB ports, numbered 1-3. This port number becomes the passive shelf ID, as shown in the following figure.



The following figure shows an example of three shelves connected to the 3 USB ports.

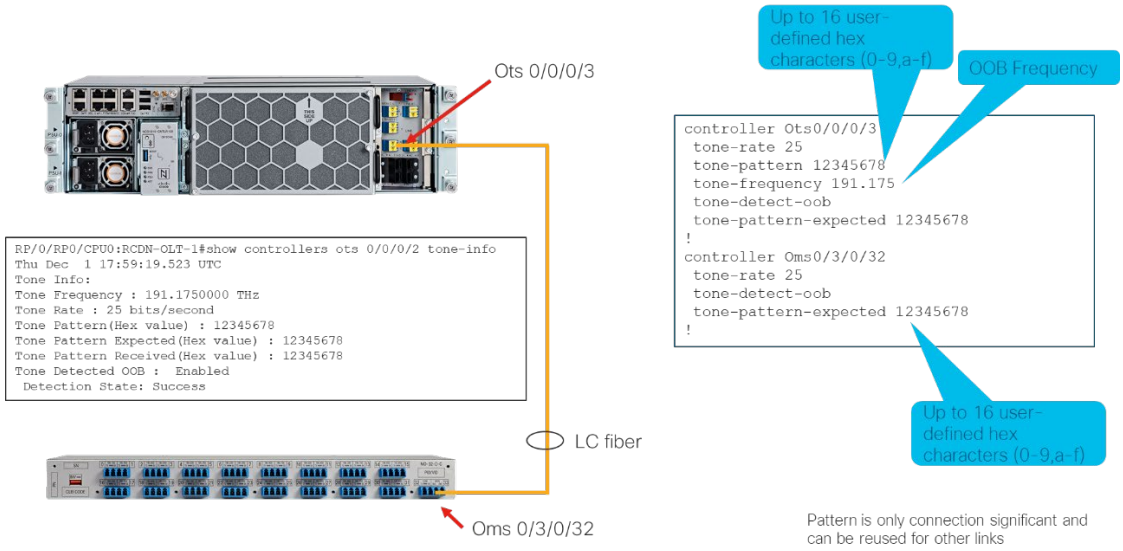


The following is a more detailed example of cabling for CV:



Configuration

CV configuration example is shown in the following figure. A few configuration options are available, including tone rates, tone patterns, and tone frequencies.



The OMS COM port ID is dependent on the passive panel type. The following table shows the OMS port numbering for all of the passive panels. A 1:3 splitter for example means one OMS port maps to 3 OCH ports, such as port 24 maps to ports 0-2. Note that if BRK-8 is connected to the last MPO Add/Drop port of an OLT, only the first 6 fiber ports are available, so the useable OMS ports are 8-13.

	Splitter Coupler	OCH	COM (OMS)
MD-32	N/A	0-31	32
BRK-24	1:3	0-23	24-31
BRK-16	1:2	0-15	16-23
BRK-8	N/A	0-7	8-15

Triggering CV

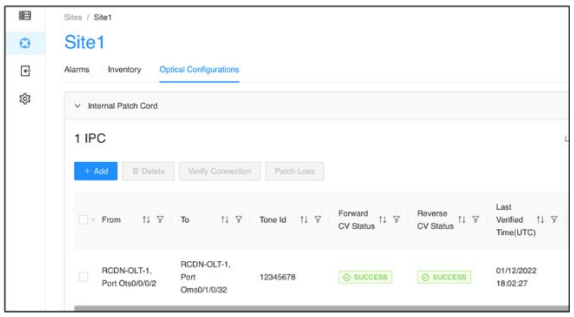
CV can be triggered from IOS-XR CLI or from CONC.

- IOS-XR CLI

```
RP/0/RP0/CPU0:RCDN-OLT-1#tone-pattern controller  ots 0/0/0/2 start
Fri Dec  2 20:02:37.128 UTC
Tone pattern started
```

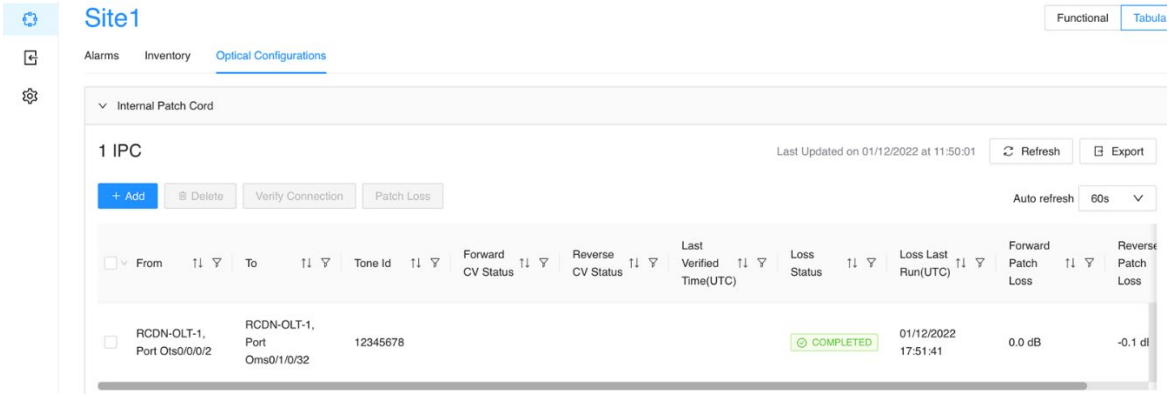
```
RP/0/RP0/CPU0:RCDN-OLT-1#show controllers ots 0/0/0/2 tone-info
Thu Dec  1 17:59:19.523 UTC

Tone Info:

Tone Frequency : 191.1750000 THz

Tone Rate : 25 bits/second

Tone Pattern(Hex value) : 12345678

Tone Pattern Expected(Hex value) : 12345678

Tone Pattern Received(Hex value) : 12345678

Tone Detected OOB :  Enabled

 Detection State: Success
```

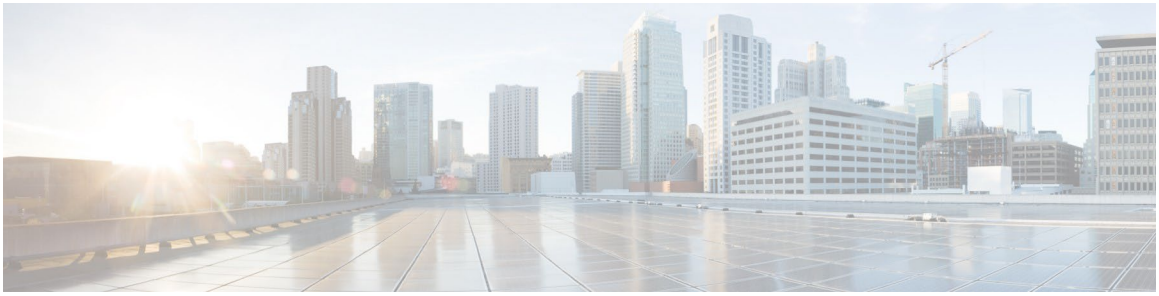
- CONC



Patch Loss Verification via CONC

CONC also provides a patchcord loss verification tool for a configured IPC.





CHAPTER 6

Measuring OTDR

The built-in OTDR (Optical Time Domain Reflectometer) can be enabled to scan either Tx or Rx directions using the IOS-XR CLI. The process goes through these steps: measuring, data processing, data ready.

The following capture shows the commands to start and stop the scanning for the Tx direction.

```
RP/0/RP0/CPU0:RCDN-OLT-1#otdr-start controller ots 0/0/0/0 tx
Fri Dec  2 21:14:27.872 UTC
OTS OTDR Scan Started at TX
```

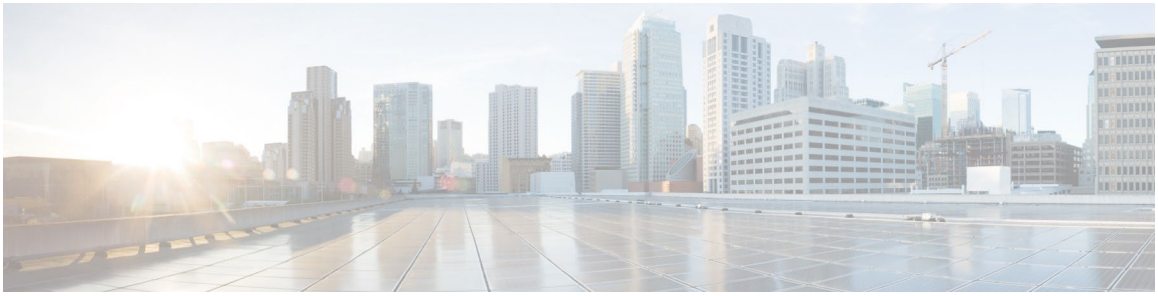
```
RP/0/RP0/CPU0:RCDN-OLT-1#otdr-stop controller ots 0/0/0/0 tx
Fri Dec  2 21:20:31.326 UTC
OTS OTDR Scan Stopped at TX
```

```
RP/0/RP0/CPU0:RCDN-OLT-1#show controllers ots 0/0/0/0 otdr-info tx
Fri Dec  2 21:14:40.463 UTC

        Scan Direction: TX

        Scan Status: Measuring

        Event Type Legend:  NR:Non-Reflective  R:Reflective
FE:Fiber-End  ER:Excess-Reflection
```

```
RP/0/RP0/CPU0:RCDN-OLT-1#show controllers ots 0/0/0/0 otdr-info tx
Fri Dec  2 21:16:26.775 UTC

        Scan Direction: TX

        Scan Status: Data Processing

        Event Type Legend:  NR:Non-Reflective  R:Reflective
FE:Fiber-End  ER:Excess-Reflection
```

The following capture shows a sample scanning report.

```
RP/0/RP0/CPU0:RCDN-OLT-1#show controllers ots 0/0/0/0 otdr-info tx
Fri Dec  2 21:17:12.688 UTC

        Scan Direction: TX

        Scan Status: Data Ready

        SOR file: /harddisk:/otdr/RCDN-OLT-1_NCS1010_OTDR_Ots0_0_0_0_TX_20221202-211638.sor

        Total Events detected: 1

        Scan Timestamp: Fri Dec  2 21:16:38 2022 UTC

        Event Type Legend:  NR:Non-Reflective  R:Reflective  FE:Fiber-End  ER:Excess-Reflection

        Event#      |  Detected Event(s)       |  Location(m)     |  Accuracy(m)     |  Magnitude(dB)   |  Attenuation/km(dB)
        1           |  NR FE                   |  0.0000          |  2.00            |  0.00            |  0.00
```



APPENDIX

IOS-XR Commands

This section lists some of the common IOS-XR commands to manage an NCS 1010 node. Detailed show command output examples are also provided for your information.

Command Summary

General Commands

Command	Description and Use
show version	IOS-XR version, hardware, and chassis
show inventory	Hardware PIDs
show platform	Chassis hardware modules and NCS1010 module 0/0/NXR0
show hw-module fpd	Hardware component firmware version
show environment	Chassis environment readings and alarm thresholds
show alarms brief system active	Active alarms
show ipv4 interface brief	IPv4 interface summary
show ospf neighbor	OSPF neighbors
show route	Routing table

Optical Commands

Command	Description and Use
show olc {span-loss | raman-tuning | gain-estimator | link-tuner }	Optical line control
show olc apc	automatic power control
show olc apc-local regulation-info	per channel regulation, including ASE and OCh
show hw-module location 0/0/NXR0 terminal-ampli	channel creation
show controllers osc 0/0/0/0	OSC information
show controllers ots-Och 0/0/0/0/N	channel crossconnect
show controllers ots 0/0/0/0 otdr-info { tx | rx }	OTDR information
show controllers ots 0/0/0/0 raman-info	RAMAN information

Detail Command Examples

Span Loss

```
RP/0/RP0/CPU0:RCDN-ILA-1#show olc span-loss
Fri Dec  2 20:51:08.196 UTC

Controller name                           : Ots0/0/0/0
Neighbour RID                             : 1.1.1.1
Rx Span Loss                              : 15.8 dB
Rx Span Loss (with pumps off)             : NA
Rx Span Loss (with pumps off) measured at : NA
Estimated Rx Span Loss                    : NA
Tx Span Loss                              : 14.6 dB
Tx Span Loss (with pumps off)             : NA
Tx Span Loss (with pumps off) measured at : NA
Estimated Tx Span Loss                    : NA


Controller name                           : Ots0/0/0/2
Neighbour RID                             : 3.3.3.3
Rx Span Loss                              : 14.7 dB
Rx Span Loss (with pumps off)             : NA
Rx Span Loss (with pumps off) measured at : NA
Estimated Rx Span Loss                    : NA
Tx Span Loss                              : 14.3 dB
Tx Span Loss (with pumps off)             : NA
Tx Span Loss (with pumps off) measured at : NA
Estimated Tx Span Loss                    : NA
```

APC Regulation

```
RP/0/RP0/CPU0:RCDN-OLT-1#show olc apc-local regulation-info
Fri Dec  2 20:54:47.142 UTC
Controller            : Ots0/0/0/0
Domain Manager        : 3.3.3.3
Internal Status       : IDLE
Direction             : RX
PSD Minimum           : -24.0 (dBm/12.5 GHz)
Gain Range            : Normal
Last Correction       : 2022-12-01 19:17:23


  Device Parameters                        Min           Max           Configuration           Operational
=============================================================================================================
  Ingress Ampli Gain (dB)           :      12.0          25.0          20.5                    20.5
  Ingress Ampli Tilt (dB)           :      -5.0          1.2           0.4                     0.4
  RX  Ampli Power (dBm)             :       -            25.0           -                      24.4
  RX  VOA Attenuation (dB)          :      0.0           0.0           0.0                     0.0
  Ingress WSS/DGE Attenuation (dB)  :      0.0           25.0           -                       -
```

```
 Channel Center     Channel     Channel     Channel     Spectrum     Ampli-Input      Target         Current        Discrepancy    Channel Slice
    Frequency         Width       ID         Source      Slice Num       PSD            PSD            PSD                           Attn Config
      (THz)           (GHz)                                          (dBm/12.5 GHz) (dBm/12.5 GHz) (dBm/12.5 GHz)     (dB)          (dB)
=============================================================================================================================================
   191.375000       75.00        -          ASE          13           -21.0           -             -25.5          0.0           25.0
   191.449997       75.00        -          ASE          37           -21.2           -             -25.6          0.0           25.0
… …

   195.949997       75.00        -          ASE          1477         -20.1           -             -25.0          0.0           25.0
   196.024994       75.00        63         OCh          1501         -20.2          -9.4           -9.1           -0.2          4.9
   196.100006       75.00        -          ASE          1525         -20.0           -             -24.7          0.0           25.0

... ...

ASE - Noise Loaded Channel
OCh - Optical Channel
```

Channel Configuration for OLT

```
hw-module location 0/0/NXR0
 terminal-ampli
  grid-mode flex
   channel-id 126 centre-freq 196.025 width 75.0
  !
controller Ots-Och0/0/0/0/126
 add-drop-channel Ots-Och0/0/0/2/126
!
```

Configured channel:

```
 RP/0/RP0/CPU0:RCDN-OLT-2#show hw-module location 0/0/nxR0 terminal-ampli
 Tue Nov 29 19:50:00.559 UTC

 Legend:
 NXC    - Channel not cross-connected
 ACTIVE - Channel cross-connected to data port
 ASE    - Channel filled with ASE
 FAILED - Data channel failed, pending transition to ASE

 Location:             0/0/NXR0

 Status:               Provisioned

 Flex Grid Info

 Channel Number      Centre Frequency(THz)       Channel Width(GHz)    Channel Status
 63                  196.025000                  75.000                ACTIVE
```

Channel Configuration for ILA

```
hw-module location 0/0/NXR0
 inline-ampli
  grid-mode flex
   channel-id 16 centre-freq 196.025 width 75.0
  !
```

Configured channel:

```
RP/0/RP0/CPU0:ILA#show hw-module location 0/0/NXR0 inline-ampli
Wed Nov 30 15:04:06.825 UTC

Location:             0/0/NXR0

Status:               Provisioned

Flex Grid Info

Channel Number      Centre Frequency(THz)       Channel Width(GHz)       Channel Status
          16            196.025000                  75.000                ACTIVE
```

Line Port Controller

```
RP/0/RP0/CPU0:RCDN-OLT-1#show controllers ots 0/0/0/0
Fri Dec  2 21:05:51.441 UTC

 Controller State: Up

 Transport Admin State: In Service

 LED State: Green

         Alarm Status:
         -------------
         Detected Alarms: None


         Alarm Statistics:
         -----------------
         RX-LOS-P = 2
         RX-LOC = 0
         TX-POWER-FAIL-LOW = 2
         INGRESS-AUTO-LASER-SHUT = 0
         INGRESS-AUTO-POW-RED = 0
         INGRESS-AMPLI-GAIN-LOW = 0
         INGRESS-AMPLI-GAIN-HIGH = 0
         EGRESS-AUTO-LASER-SHUT = 0
         EGRESS-AUTO-POW-RED = 0
         EGRESS-AMPLI-GAIN-LOW = 0
         EGRESS-AMPLI-GAIN-HIGH = 0
         HIGH-TX-BR-PWR = 0
         HIGH-RX-BR-PWR = 0
         SPAN-TOO-SHORT-TX = 0
         SPAN-TOO-SHORT-RX = 0
```

```
Parameter Statistics:
        --------------------
        Total RX Power(C+L) = 3.89 dBm
        Total TX Power(C+L) = 18.99 dBm
        Total RX Power = 3.98 dBm
        Total TX Power = 19.06 dBm
        RX Signal Power = 3.89 dBm
        TX Signal Power = 18.99 dBm
        TX VOA Attenuation = 3.5 dB
        Ingress Ampli Gain = 20.5 dB
        Ingress Ampli Tilt = 0.4 dB
        Ingress Ampli Gain Range = Normal
        Ingress Ampli Safety Control mode = auto
        Ingress Ampli OSRI = OFF
        Ingress Ampli Force APR = OFF
        Egress Ampli Gain = 21.0 dB
        Egress Ampli Tilt = -1.3 dB
        Egress Ampli Safety Control mode = auto
        Egress Ampli OSRI = OFF
        Egress Ampli Force APR = OFF
        Egress Ampli BR = ENABLE



        Configured Parameters:
        -------------
        TX VOA Attenuation = 0.0 dB
        Ingress Ampli Gain = 12.0 dB
        Ingress Ampli Tilt = 0.0 dB
        Ingress Ampli Gain Range = Normal
        Ingress Ampli Safety Control mode = auto
        Ingress Ampli OSRI = OFF
        Ingress Ampli Force APR = OFF
        Egress Ampli Gain = 16.0 dB
        Egress Ampli Tilt = 0.0 dB
        Egress Ampli Safety Control mode = auto
        Egress Ampli OSRI = OFF
        Egress Ampli Force APR = OFF
        Egress Ampli BR = ENABLE
        BR High Threshold = -17.0 dBm
```

Line port channel:

```
RP/0/RP0/CPU0:RCDN-OLT-1#show controllers ots-Och 0/0/0/0/126
Fri Dec  2 21:08:53.942 UTC

 Controller State: Up

 Transport Admin State: In Service

         Alarm Status:
         -------------
         Detected Alarms: None



         Parameter Statistics:
         ---------------------
         Total RX Power = -14.20 dBm
         Total TX Power = 0.69 dBm


         Cross Connect Info:
         ---------------------
         Add-Drop Channel  = Ots-Och0/0/0/2/126




         Configured Parameters:
         -------------
```

Add/Drop Controller

```
RP/0/RP0/CPU0:RCDN-OLT-134-0#show controller Ots0/0/0/2
Wed Jan 11 22:32:28.633 UTC

 Controller State: Up

 Transport Admin State: In Service

 LED State: Red

         Alarm Status:
         -------------
         Detected Alarms: None


         Alarm Statistics:
         -----------------
         RX-LOS-P = 0
         RX-LOC = 0
         TX-POWER-FAIL-LOW = 2
         INGRESS-AUTO-LASER-SHUT = 0
         INGRESS-AUTO-POW-RED = 0
         INGRESS-AMPLI-GAIN-LOW = 0
         INGRESS-AMPLI-GAIN-HIGH = 0
         EGRESS-AUTO-LASER-SHUT = 0
         EGRESS-AUTO-POW-RED = 0
         EGRESS-AMPLI-GAIN-LOW = 0
         EGRESS-AMPLI-GAIN-HIGH = 0
         HIGH-TX-BR-PWR = 0
         HIGH-RX-BR-PWR = 0
         SPAN-TOO-SHORT-TX = 0
         SPAN-TOO-SHORT-RX = 0
```

```
         Parameter Statistics:
         ---------------------
         Total RX Power = -3.60 dBm
         Total TX Power = 3.09 dBm
         Ingress Ampli Gain = 16.0 dB
         Ingress Ampli Tilt = 0.0 dB



         Configured Parameters:
         -------------
         Ingress Ampli Gain = 16.0 dB
         Ingress Ampli Tilt = 0.0 dB
```

Add/drop channel:

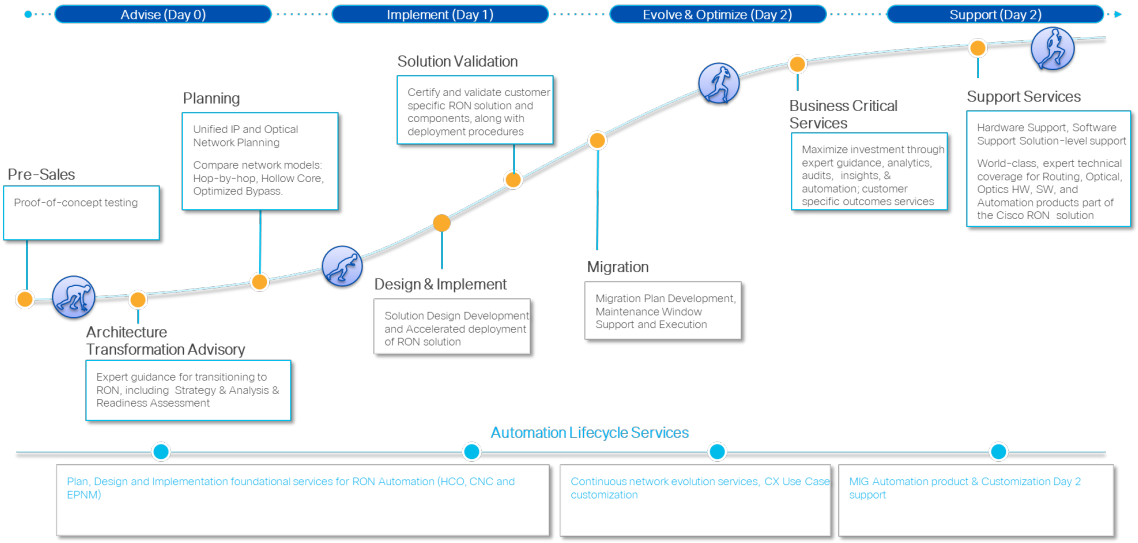
```
RP/0/RP0/CPU0:RCDN-OLT-134-0#show controller Ots-Och0/0/0/2/175
Wed Jan 11 22:29:37.057 UTC

 Controller State: Up

 Transport Admin State: In Service

         Alarm Status:
         -------------
         Detected Alarms: None



         Parameter Statistics:
         ---------------------
         Total RX Power = -4.70 dBm
         Total TX Power = -1.00 dBm


         Cross Connect Info:
         -------------------
         line Channel  = Ots-Och0/0/0/0/175




         Configured Parameters:
         -------------
```

OSC Controller

```
RP/0/RP0/CPU0:RCDN-OLT-1#show controllers osc 0/0/0/0
Fri Dec  2 21:01:29.940 UTC

 Controller State: Up

 Transport Admin State: In Service

 Laser State: On

         Alarm Status:
         -------------
         Detected Alarms: None


         Alarm Statistics:
         -----------------
         RX-LOS-P = 0
         TX-POWER-FAIL-LOW = 0

         Parameter Statistics:
         ---------------------
         Total TX Power = 0.89 dBm
         Total RX Power = -13.40 dBm



         Configured Parameters:
         -------------
```

CX Services

This section lists some of CX services available for implementing Routed Optical Networking (RON) solution and Cisco NCS 1010 in particular. Cisco CX created a portfolio of services to help customers accelerate the RON adoption.



For implementing a NCS 1010 network, the Design and Implementation service allows faster deployment at scale with reduced risks and lower costs using CX automation and best-practices.

Details

- Designed to enable customers deploy Cisco OLS by offering Design and Implement services for deploying NCS 1010 OLT and ILA platforms
- Deliverables & Services
  - SRD, SDD, NIP, NRFU, NIP & NRFU Execution Support, Post Implementation support

Scope

- SDD – OLS design including NCS1010 commissioning parameters
- SDD – Information to provision optical circuits including Signal Flow Diagram
- NIP – NCS 1010 platform configuration in accordance with SDD
- NIP Execution - Implement NCS1010 OLS and provision circuits.
- NRFU Testing – NCS1010 equipment commissioning test and Network / Circuit tests for conformance to ready-for-service state