



## Automation Workflows

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This chapter describes the installation and communication sequence of the Routed Optical Networking components. The chapter also includes some Routed Optical Networking ML service provisioning examples.

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## Sequence for Installation of Routed Optical Networking Components

We recommend this installation sequence:



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**Note** Cisco CNC (COE, CAT) and Cisco ONC are the minimum required components for the Routed Optical Networking solution.

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- Install Cisco ONP. Cisco ONP is used to determine the optical layer feasibility and components used to support the network. A BoM is generated for hardware to be utilized in the planned deployment. For more information, see [Cisco Optical Network Planner Installation Guide](#).
- Install the router and optical hardware as specified in the network design. Complete the physical wiring between all the components. For more information see, [Deployment Topologies](#).
- Install SVO to manage the NCS 2000 optical components. Create SVO instances to manage NCS 2000 devices. For more information, see [Cisco NCS 2000 Series SVO Configuration Guide, Release 12.2](#).
- Install the Crosswork Infrastructure 4.0, Crosswork Data Gateway, and supporting CNC 3.0 applications (COE, CAT, Hi). For more information, see [Cisco Crosswork Infrastructure 4.1 and Applications Installation Guide](#).
- Install Cisco ONC 1.1. For more information, see [Cisco ONC 1.1 Configuration Guide](#).
- Install EPNM 5.1.3. EMS to manage the physical router and the optical network nodes. For more information, see [Installation Guide for Cisco Evolved Programmable Network Manager 5.1.3](#).

- Install Cisco NSO 5.5.2.9, Routed Optical Networking Multi-layer Function Pack 1.0, and Crosswork DLM function pack. Optionally, install the Cisco Transport SDN Function pack for SR-TE and xVPN service management. For more information, see the [Cisco Network Services Orchestrator Installation Guide](#), [Cisco NSO Routed Optical Networking Core Function Pack Installation Guide](#), [Cisco NSO Transport-SDN Function Pack Bundle User Guide 3.0](#), [Cisco NSO Transport-SDN Function Pack Bundle User Guide 4.1](#), [Cisco Network Services Orchestrator DLM Service Pack Installation Guide 4.1.0](#).
- Add SVO devices to Cisco ONC for the optical service management. For more information, see [Cisco ONC 1.1 Configuration Guide](#).

Install SR-PCE in the network for SR-TE or RSVP-TE discovery and visualization.

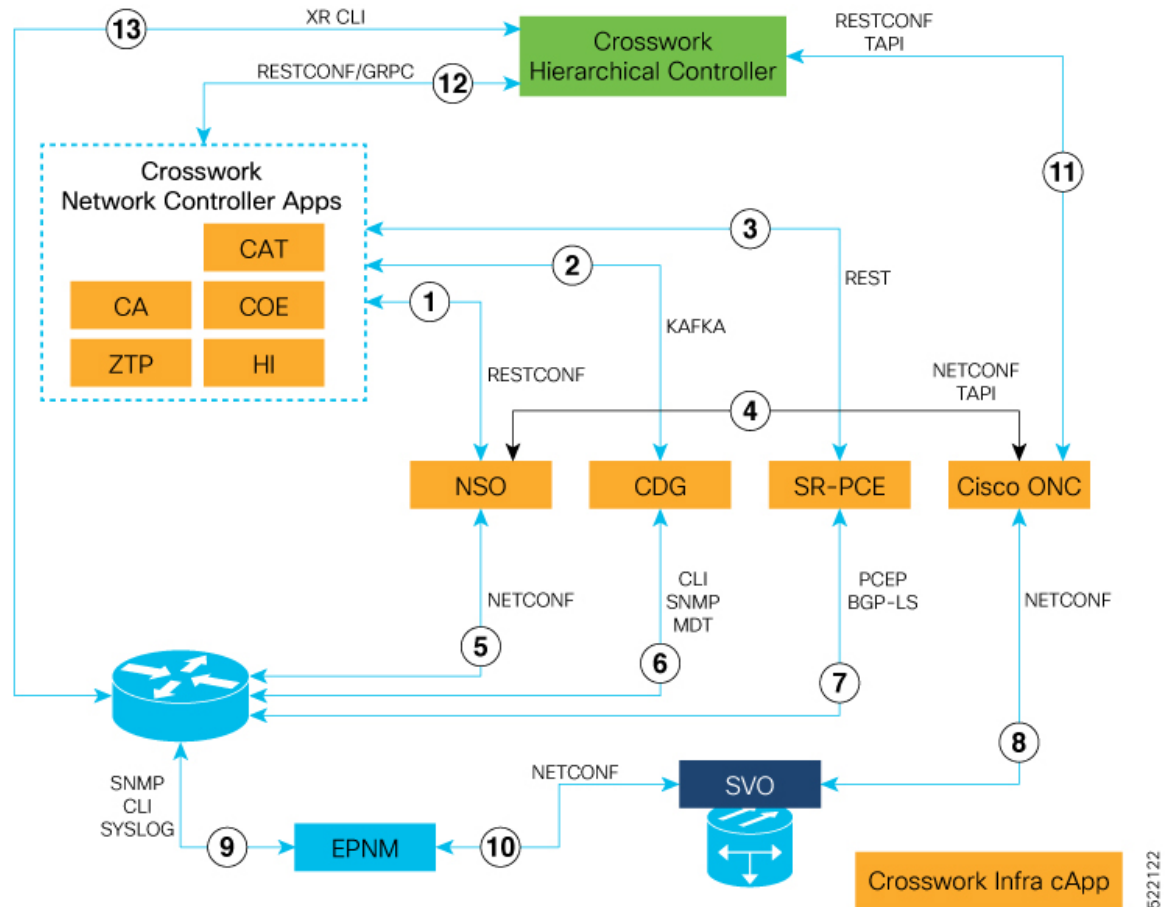
- Add NSO, SR-PCE, and Cisco routers to the Crosswork cluster. For more information, see [Add Cisco NSO Providers](#), [Add Cisco SR-PCE Providers](#), [Adding Devices to Inventory](#).

Add the Cisco ONC instance as a device in NSO to support end-to-end multi-layer provisioning. For more information, see the [Cisco NSO Routed Optical Networking Core Function Pack User Guide](#).

## Communication Sequence

This diagram displays the communication sequence between the Routed Optical Networking components:

Figure 1: Routed Optical Networking Communication Flow



1. CNC discovers services. CNC populates NSO with device information via RESTCONF and handles NSO provisioning requests.
2. CDG sends device status to CNC using Kafka. CNC manages the CDG instance.
3. SR-PCE sends SR-TE/RSVP-TE and topology information to CNC via REST APIs.
4. NSO discovers information from Cisco ONC and provisions to Cisco ONC via NETCONF TAPI.
5. NSO manages XR router configuration using NETCONF.
6. CDG collects network information from XR routers using CLI, SNMP, and MDT.
7. SR-PCE acts as a network PCE and collects IGP topology information from the network using PCEP and BGP-LS.
8. Cisco ONC manages the SVO network nodes via NETCONF.
9. EPNM performs router inventory, SWIM, fault, and performance data collection using SNMP, CLI, and SYSLOG.
10. EPNM performs optical inventory, SWIM, fault, and performance data collection via NETCONF.

11. Crosswork Hierarchical Controller discovers optical equipment, topology, and services and provisions optical services via TAPI.
12. Crosswork Hierarchical Controller discovers IGP nodes and topology and provisions services using CNC NB API.
13. Crosswork Hierarchical Controller collects the inventory data for ZR/ZR+ optics discovery using XR adapter directly from routers. This is also used to verify successful provisioning.



**Note** Routed Optical Networking components are not required in all the deployments.

## Service Provisioning Examples

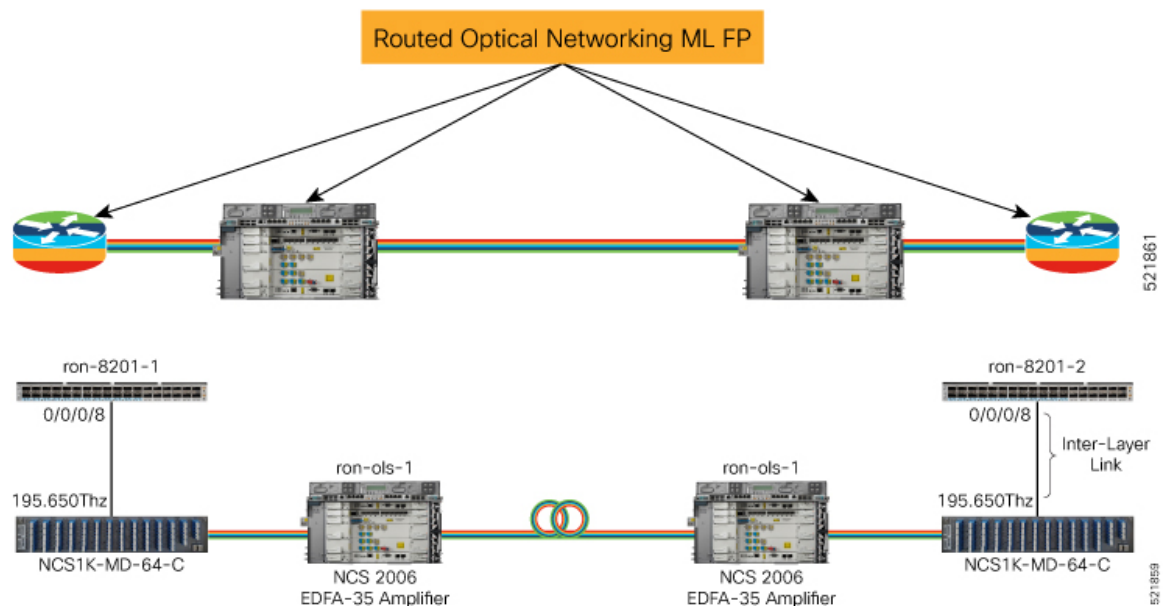
In this section, two service provisioning examples have been provided. These examples use the Cisco NSO Routed Optical Networking Core Function Pack for service provisioning. The examples are:

- Cisco routers with ZR or ZR+ transceivers and NCS 2000 optical devices.
- Cisco routers with ZR or ZR+ transceivers only. This example does not involve optical provisioning.

### Provision End-to-end Service (Cisco Routers with ZR/ZR+ Optics and NCS 2000 Devices)

These diagrams display a network that contains Cisco routers with ZR or ZR+ optics and NCS 2000 devices.

**Figure 2: Cisco Routers (with ZR/ZR+ Optics) and NCS 2000 Devices**



1. Define the inter-layer links.

```
ron inter-layer-link ron-8201-1 0/0/0/8
  site "Los Angeles"
  ols-domain network-element ron-ols-1
```

```

ols-domain optical-add-drop 1/2007/1/18,17
ols-domain optical-controller onc-cw-100
!
ron inter-layer-link ron-8201-2 0/0/0/8
site Phoenix
ols-domain network-element ron-ols-2
ols-domain optical-add-drop 1/2007/1/18,17
ols-domain optical-controller onc-cw-100
!

```



**Note** The add drop port on ron-ols-1 in R/S/I/P format is 1/2007/1/17,18. Two ports are configured for both RX and TX but a single port can also be given.

In the function pack, the network-element and optical-add-drop is converted into the TAPI inventory format.

```
ron-ols-1 and 1/2007/1/18,17 = /ne=ron-ols-1/r=1/sh=2007/sl=1/s_sl=0/p=18,17
```

2. Create Routed Optical Networking ML service with following parameters:

Input	Value
End-points	ron-8201-1, ron-8201-2
Model	Transponder (1x400G mode)
Bandwidth	400G
Frequency	Supplied by Cisco ONC. This value may be user defined too.
TX Power	Supplied by Cisco ONC. This value may be user defined too.
IP Addressing	41.2.1.10/31 and 41.2.1.11/31 on FourHundredGigE 0/0/0/8

```

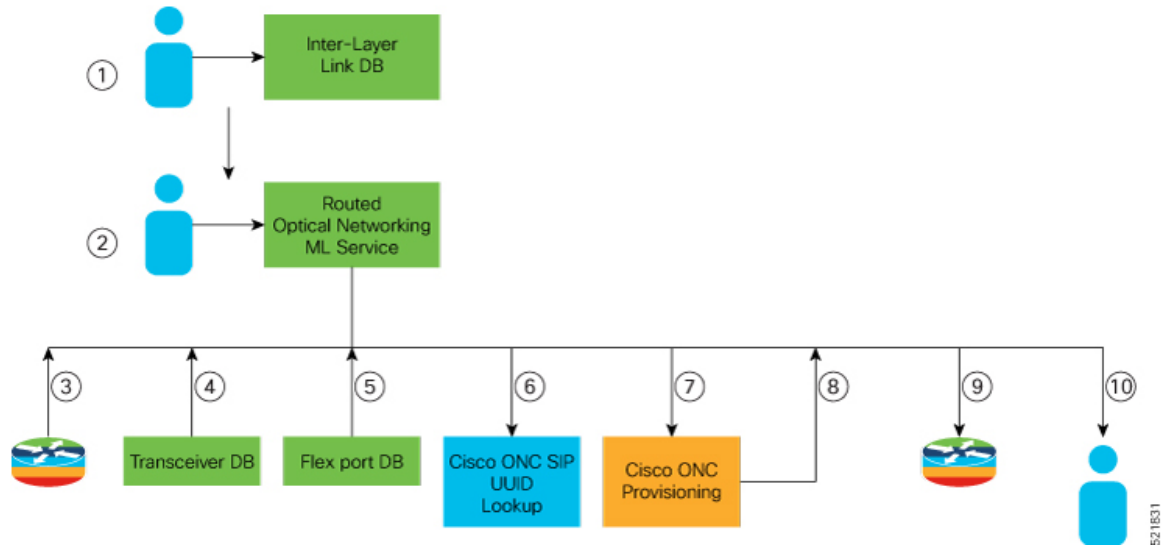
ron ron-ml ron-8201-1_ron-8201-2
mode transponder
bandwidth 400
ols-domain service-state UNLOCKED
end-point ron-8201-1
terminal-device-optical line-port 0/0/0/8
ols-domain end-point-state UNLOCKED
terminal-device-packet interface 0
ip-address v4 41.2.1.10/31
!
!
end-point ron-8201-2
terminal-device-optical line-port 0/0/0/8
ols-domain end-point-state UNLOCKED
terminal-device-packet interface 0
ip-address v4 41.2.1.11/31
!
!
!

```

### NSO Routed Optical Networking ML Service

This diagram displays the NSO Routed Optical Networking ML service workflow for an end-to-end service (Cisco routers with ZR/ZR+ optics and NCS 2000 devices).

**Figure 3: NSO Routed Optical Networking ML Service Sequence**



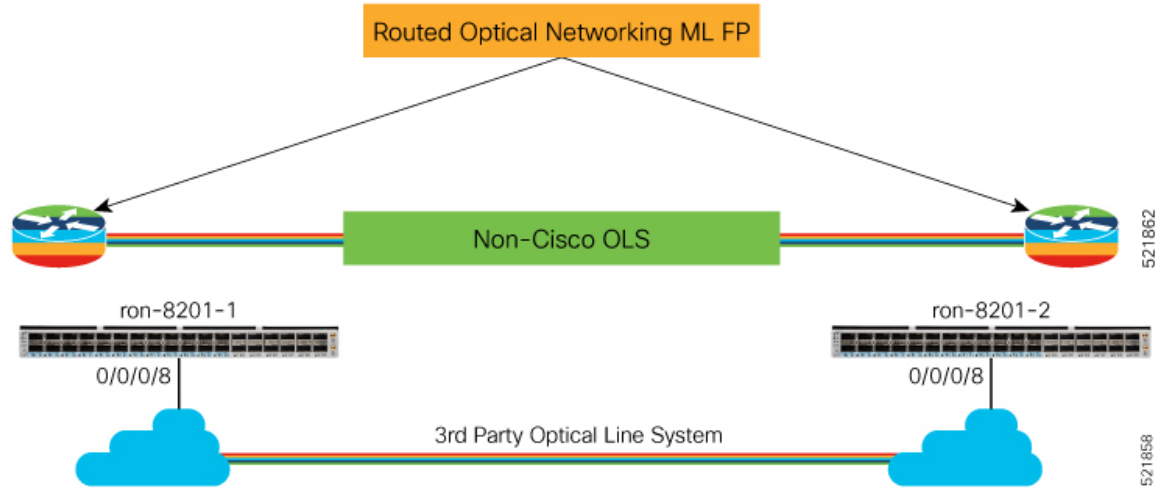
The workflow of the Routed Optical Networking ML service is as follows:

1. User populates the inter-Layer link DB for each router end-point.
2. User initiates the Routed Optical Networking ML provisioning request.
3. The Routed Optical Networking ML service retrieves the transceiver and line card PIDs for each router end-point using Cisco YANG models.
4. The Routed Optical Networking ML service compares the received transceiver PIDs and determines if the transceivers can support the service.
5. The Routed Optical Networking ML service compares the received line card PIDs, and determines if the line cards need to be configured.
6. If there is no explicit SIP UUID, the Routed Optical Networking ML service performs a lookup for the SIP via the ONC TAPI using the INVENTORY\_ID.
7. The Routed Optical Networking ML service sends a TAPI connectivity-service request to ONC for optical provisioning using SIPs and ZR/ZR+ application IDs.
8. Cisco ONC returns the state after the provisioning is complete. Cisco ONC optionally returns the wavelength and TX power if these parameters are not user-defined.
9. The Routed Optical Networking ML service provisions the router optics ports. It optionally performs bundle and IP configuration using the Cisco YANG models.
10. The Routed Optical Networking ML service stores the service information as NSO operational data and also returns the service state to user.

### Provision End-to-end Service (Cisco Routers with ZR/ZR+ Optics Only)

These diagrams display a network that contains Cisco routers with ZR or ZR+ optics and a non-Cisco optical line system.

**Figure 4: Cisco Routers (with ZR/ZR+ Optics)**



1. Create Routed Optical Networking ML Service with the following parameters:

Input	Value
End-points	ron-8201-1, ron-8201-2
Model	Transponder (1x400G mode)
Bandwidth	400G
Frequency	1952000
TX Power	-12dB on both endpoints
IP Addressing	41.2.1.10/31 and 41.2.1.11/31 on FourHundredGigE 0/0/0/8

```

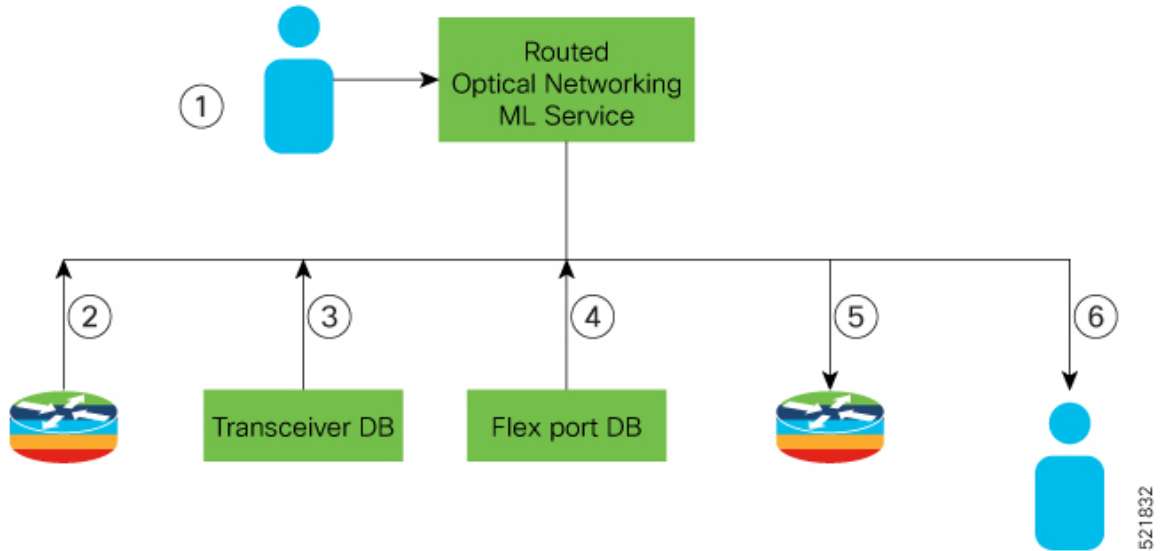
ron ron-ml ron-8201-1_ron-8201-2
mode transponder
bandwidth 400
circuit-id "Router Only"
frequency 1952000
end-point ron-8201-1
terminal-device-optical line-port 0/0/0/8
terminal-device-optical transmit-power -120
terminal-device-packet interface 0
ip-address v4 41.2.1.10/31
!
!
end-point ron-8201-2
terminal-device-optical line-port 0/0/0/8
terminal-device-optical transmit-power -120
terminal-device-packet interface 0
ip-address v4 41.2.1.11/31
!

```

### NSO Routed Optical Networking ML Service

This diagram displays the NSO Routed Optical Networking ML service workflow for an end-to-end service (only Cisco routers with ZR/ZR+ optics).

Figure 5: NSO Routed Optical Networking ML Service Sequence



The workflow of the Routed Optical Networking ML service is as follows:

1. User initiates the Routed Optical Networking ML provisioning request.
2. The Routed Optical Networking ML service retrieves the transceiver and line card PIDs for each router end-point using Cisco native YANG models.
3. The Routed Optical Networking ML service compares the received transceiver PIDs and determines if the transceivers can support the service.
4. The Routed Optical Networking ML service compares the received line card PIDs, and determines if the line cards must be configured.
5. The Routed Optical Networking ML service provisions the router optics ports. It optionally performs bundle and IP configuration using the Cisco YANG models.
6. The Routed Optical Networking ML service stores the service information as NSO operational data and also returns the service state to user.

## Crosswork Hierarchical Controller Provisioning Workflow

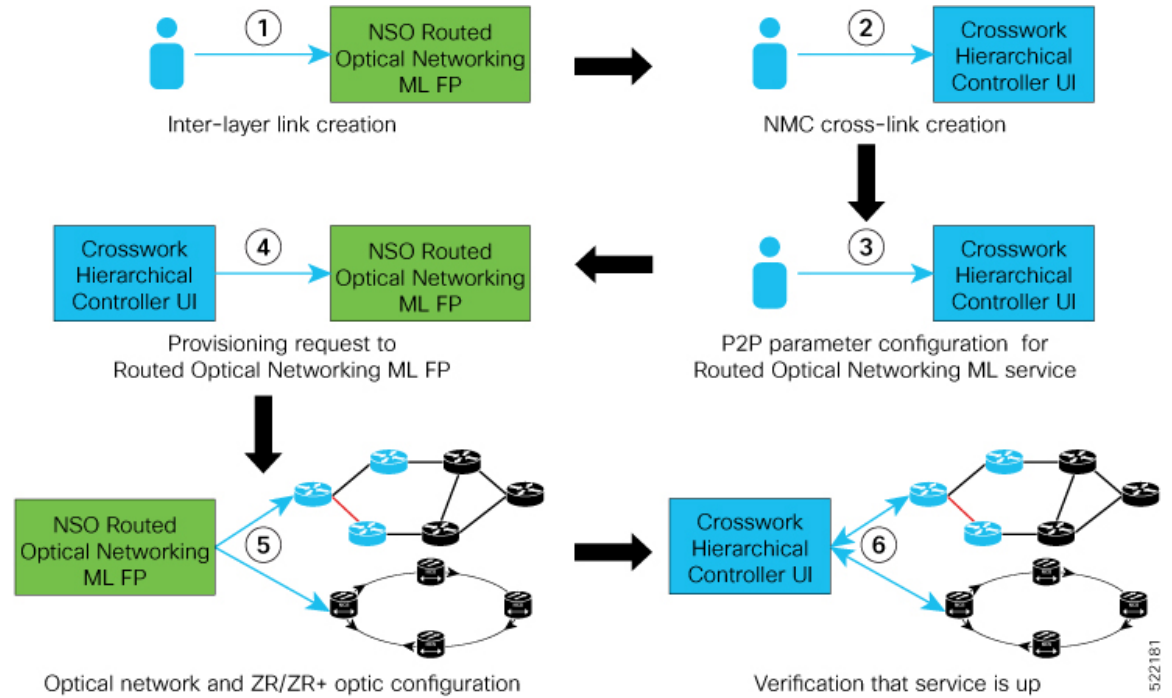
This section describes the workflow for provisioning the Routed Optical Networking circuit in the Crosswork Hierarchical Controller GUI via the CNC.





**Note** The workflow does not support provisioning an end-to-end service in a network that contains Cisco routers with ZR or ZR+ optics and a non-Cisco optical line system.

**Figure 6: Crosswork Hierarchical Controller Provisioning Workflow**



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## Troubleshoot Provisioning Issues

### Provisioning on ZR or ZR+ Optics

- To check the controller state on the router, use:

```
RP/0/RP0/CPU0:ron-8201-1#show controllers optics 0/0/0/20
Thu Jun  3 15:34:44.098 PDT
```

**Controller State: Up**

Transport Admin State: In Service

Laser State: On

**LED State: Green**

FEC State: FEC ENABLED

Optics Status

```
Optics Type: QSFPDD 400G ZR
DWDM carrier Info: C BAND, MSA ITU Channel=10, Frequency=195.65THz,
Wavelength=1532.290nm
```

Alarm Status:

-----

**Detected Alarms: None**

LOS/LOL/Fault Status:

Alarm Statistics:

-----

```

HIGH-RX-PWR = 0          LOW-RX-PWR = 0
HIGH-TX-PWR = 0          LOW-TX-PWR = 4
HIGH-LBC = 0             HIGH-DGD = 1
OOR-CD = 0               OSNR = 10
WVL-OOL = 0              MEA = 0
IMPROPER-REM = 0
TX-POWER-PROV-MISMATCH = 0
Laser Bias Current = 0.0 %
Actual TX Power = -7.17 dBm
RX Power = -9.83 dBm
RX Signal Power = -9.18 dBm
Frequency Offset = 9 MHz

```

```

RP/0/RP0/CPU0:ron-8201-1#show controllers coherentDSP 0/0/0/20
Thu Jun  3 15:38:04.565 PDT

```

```

Port                               : CoherentDSP 0/0/0/20
Controller State                     : Up
Inherited Secondary State           : Normal
Configured Secondary State          : Normal
Derived State                         : In Service
Loopback mode                         : None
BER Thresholds                       : SF = 1.0E-5  SD = 1.0E-7
Performance Monitoring               : Enable
Bandwidth                             : 400.0Gb/s

```

Alarm Information:

```

LOS = 8 LOF = 0 LOM = 0
OOF = 0 OOM = 0 AIS = 0
IAE = 0 BIAE = 0          SF_BER = 0
SD_BER = 0                BDI = 0 TIM = 0
FECMISMATCH = 0 FEC-UNC = 0 FLEXP_GIDM = 0
FLEXP-MM = 0 FLEXP-LOM = 0 FLEXP-RDI = 0
FLEXP-LOF = 2
Detected Alarms                : None

```

Bit Error Rate Information

```

PREFEC BER                       : 1.5E-03
POSTFEC BER                       : 0.0E+00
Q-Factor                           : 9.40 dB

```

**Q-Margin** : **2.20dB**

OTU TTI Received

FEC mode : C\_FEC

- To gather the performance measurement data, use:

```

RP/0/RP0/CPU0:ron-8201-1#show controllers optics 0/0/0/20 pm current 30-sec optics 1
Thu Jun  3 15:39:40.428 PDT

```

Optics in the current interval [15:39:30 - 15:39:40 Thu Jun 3 2021]

```

Optics current bucket type : Valid
      MIN      AVG      MAX      Operational Configured TCA      Operational
Configured TCA
      Th(max)  (max)
LBC[% ]      : 0.0      0.0      0.0      0.0      NA      NO      100.0      NA
      NO
OPT[dBm]     : -7.17     -7.17     -7.17     -15.09     NA      NO      0.00      NA
      NO
OPR[dBm]     : -9.86     -9.86     -9.85     -30.00     NA      NO      8.00      NA
      NO
CD[ps/nm]    : -489      -488      -488      -80000     NA      NO      80000     NA
      NO
DGD[ps ]    : 1.00      1.50      2.00      0.00      NA      NO      80.00     NA
      NO
SOPMD[ps^2] : 28.00     38.80     49.00     0.00      NA      NO      2000.00   NA
      NO
OSNR[dB]     : 34.90    35.12    35.40    0.00      NA      NO      40.00     NA
      NO
PDL[dB]      : 0.70      0.71      0.80      0.00      NA      NO      7.00      NA
      NO
PCR[rad/s]   : 0.00      0.00      0.00      0.00      NA      NO      2500000.00 NA
      NO
RX_SIG[dBm]  : -9.23    -9.22    -9.21    -30.00     NA      NO      1.00      NA
      NO
FREQ_OFF[Mhz]: -2         -1         4         -3600     NA      NO      3600      NA
      NO
SNR[dB]      : 16.80     16.99     17.20     7.00      NA      NO      100.00    NA
      NO

```

```

RP/0/RP0/CPU0:ron-8201-1#show controllers coherentDSP 0/0/0/20 pm current 30-sec fec
Thu Jun 3 15:42:28.510 PDT

```

```

g709 FEC in the current interval [15:42:00 - 15:42:28 Thu Jun 3 2021]

```

```

FEC current bucket type : Valid
  EC-BITS      : 20221314973      Threshold : 83203400000      TCA(enable)
  : YES
  UC-WORDS    : 0      Threshold : 5      TCA(enable)
  : YES

```

	MIN	AVG	MAX	Threshold (min)	TCA (enable)	Threshold (max)	TCA (enable)
PreFEC BER	1.5E-03	1.5E-03	1.6E-03	0E-15	NO	0E-15	NO
PostFEC BER	<b>E-15</b>	<b>0E-15</b>	<b>0E-15</b>	0E-15	NO	0E-15	NO
Q[dB]	9.40	9.40	9.40	0.00	NO	0.00	NO
Q_Margin[dB]	2.20	2.20	2.20	0.00	NO	0.00	NO

```

Last clearing of "show controllers OTU" counters never

```

This table contains the streaming telemetry sensor paths and the information fields that you receive from them.

Sensor path	Information Fields
Cisco-IOS-XR-controller-optics-oper:optics-oper/optics-ports/optics-port/optics-info	alarm-detected, baud-rate, dwdm-carrier-frequency, controller-state, laser-state, optical-signal-to-noise-ratio, temperature, voltage
Cisco-IOS-XR-controller-optics-oper:optics-oper/optics-ports/optics-port/optics-lanes/optics-lane	receive-power, receive-signal-power, transmit-power

Sensor path	Information Fields
Cisco-IOS-XR-controller-otu-oper:otu/controllers/controller/info	bandwidth, ec-value, post-fec-ber, pre-fec-ber, qfactor, qmargin, uc
Cisco-IOS-XR-pmengine-oper:performance-management/optics/optics-ports/optics-port/optics-current/optics-second30/optics-second30-optics/optics-second30-optic	dd_average, dgd_average, opr_average, opt_average, osnr_average, pcr_average, pmd_average, rx-sig-pow_average, snr_average, sopmd_average
Cisco-IOS-XR-pmengine-oper:performance-management/otu/otu-ports/otu-port/otu-current/otu-second30/otu-second30fec/otu-second30fec	ec-bits_data, post-fec-ber_average, pre-fec-ber_average, q_average, qmargin_average, uc-words_data



**Note** The performance management sensor paths show the sensor path for a 30-second performance measurement (PM) interval. They also support 15 minutes and 24 hours. To access these options, replace `second30` in the sensor path with `minute15` and `hour24` respectively.

## NSO Provisioning

The following figure displays a successful provisioning scenario.

**Figure 7: \*\***

```
admin@ncs# show ron ron-ml-plan 030f63ab_84fb_4ff1_9871_6c1421f99b0f
```

TYPE	NAME	BACK TRACK	GOAL	STATUS CODE	STATE	STATUS	WHEN	POST ACTION ref	ACTION STATUS
self	self	false	-	RON-200	init	reached	2021-06-11T16:47:25	-	create-reached
optical-controller	Optical-Controller	false	-	RON-200	ready	reached	2021-06-11T16:47:53	-	-
					init	reached	2021-06-11T16:47:30	-	-
cisco-ron-cfp-nano-plan-services:router	ron-8201-1	false	-	RON-200	ready	reached	2021-06-11T16:47:30	-	-
					cisco-ron-cfp-nano-plan-services:config-apply	reached	2021-06-11T16:47:47	-	-
cisco-ron-cfp-nano-plan-services:router	ron-8201-2	false	-	RON-200	ready	reached	2021-06-11T16:47:47	-	-
					cisco-ron-cfp-nano-plan-services:config-apply	reached	2021-06-11T16:47:53	-	-
cisco-ron-cfp-nano-plan-services:router	ron-8201-2	false	-	RON-200	init	reached	2021-06-11T16:47:47	-	-
					cisco-ron-cfp-nano-plan-services:config-apply	reached	2021-06-11T16:47:53	-	-

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The following figure displays a failed provisioning scenario, due to an error in the Cisco ONC provisioning.

```
admin@ncs# show ron ron-ml-plan ron_poc_demo_195200 plan
```

TYPE	NAME	BACK TRACK	GOAL	STATUS CODE	STATE	STATUS	WHEN	POST ACTION ref	ACTION STATUS
self	self	false	-	RON-304	init	reached	2021-06-13T15:32:32	-	create-reached
optical-controller	Optical-Controller	false	-	RON-304	ready	failed	2021-06-13T15:32:32	-	-
					init	reached	2021-06-13T15:32:32	-	-
cisco-ron-cfp-nano-plan-services:router	ron-poc-8201-1	false	-	-	ready	reached	2021-06-13T15:32:32	-	-
					cisco-ron-cfp-nano-plan-services:config-apply	failed	2021-06-13T15:32:32	-	-
cisco-ron-cfp-nano-plan-services:router	ron-poc-8201-1	false	-	-	init	not-reached	-	-	-
					cisco-ron-cfp-nano-plan-services:config-apply	not-reached	-	-	-
cisco-ron-cfp-nano-plan-services:router	ron-poc-8201-2	false	-	-	ready	not-reached	-	-	-
					cisco-ron-cfp-nano-plan-services:config-apply	not-reached	-	-	-
cisco-ron-cfp-nano-plan-services:router	ron-poc-8201-2	false	-	-	init	not-reached	-	-	-
					cisco-ron-cfp-nano-plan-services:config-apply	not-reached	-	-	-

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## Crosswork Hierarchical Controller Provisioning

In the event of a failed configuration, the configuration state transitions to FAILED. The Last Operation is in the **Rollback** stage where it rolls back the configuration.

Figure 8: Crosswork Hierarchical Controller UI - Operations Tab

The screenshot displays the 'Operations' tab for a service. At the top, there is a table with columns: Name, PDP Type, Configuration State, Creation Date, Endpoint A, Endpoint B, Speed (Gbps), Operational State, Last 24h Operations, and Last Operation. A single entry is shown with a 'FAILED' status.

Below the table, the details for the failed operation are shown. The 'Action' column shows 'Create IP Link' with a 'Rollback' button and a 'Done' status. The 'Creation Date' is '25-10-2021 20:28:22 UTC' and the 'Last Update' is '25-10-2021 20:34:08 UTC'.

The 'Errors' section is expanded, showing the following details:

- UUID: ef73b555541a0124099737943ab27
- Action: Create IP Link
- Service Intent GUID: 514f5365656414d13096737943ab27
- Service GUID Name: Source UI
- Created at: 25-10-2021 20:28:22 UTC
- Last Updated at: 25-10-2021 20:34:08 UTC
- Status: Rollback ✓ Done

The 'Data' section contains a large JSON object with the following structure:

```

{
  "name": "ron-8201-1_-_FourHundredGigE0/0/18_to_rou-ncs57b1-1_-_FourHundredGigE0/0/24_1635193658342",
  "description": "None",
  "customer_name": "None",
  "template_name": "default-template",
  "endpoint_configuration_list": [{"ip_address": "100.18.18.18/31", "ip_guid": "PO3cisco-ncs57b1-1_FourHundredGigE0/0/18"}, {"ip_address": "100.18.18.18/31", "ip_guid": "PO3cisco-ncs57b1-1_FourHundredGigE0/0/24"}],
  "src_inventory_guid": "N3cisco-ncs57b1-1_FourHundredGigE0/0/18",
  "dest_inventory_guid": "N3cisco-ncs57b1-1_FourHundredGigE0/0/24",
  "ip_link_type": "Create new link",
  "new_link_data": {"ip_allocation_policy": "1", "should_create_as_link": "False", "ip_subnet": "100.18.18.18/31"},
  "log_data": {"event": "guid": "None"},
  "path_criteria": {},
  "direct_operations": "False",
  "include_list": [],
  "exclude_list": [],
  "path_policy": "None",
  "src_inv_guid": "N3cisco-ncs57b1-1_FourHundredGigE0/0/18",
  "dest_inv_guid": "N3cisco-ncs57b1-1_FourHundredGigE0/0/24"
}

```

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After clicking the service, you can click on ERRORS to check the reason for failure. In this case, the discovery of the operational state exceeded the discovery timeout. The reason for this is, one end of the link was in a loopback state, which did not prohibit the provisioning of the ports, but affected the reachability between the two endpoints.

Figure 9: Crosswork Hierarchical Controller UI - Operations Tab

The screenshot displays the 'Errors' section of the 'Operations' tab. The 'Action' column shows 'Create IP Link' with a 'Rollback' button and a 'Done' status. The 'Creation Date' is '25-10-2021 20:28:22 UTC' and the 'Last Update' is '25-10-2021 20:34:08 UTC'.

The 'Errors' section is expanded, showing the following error message:

- [25-10-2021 20:34:00 UTC] Discovery took too long
- Full error message: Discovery took too long

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The logs display both the provisioning flow and the rollback flow.

Figure 10: Crosswork Hierarchical Controller UI - Operations Tab

The screenshot displays the 'Logs' section of the 'Operations' tab. The 'Action' column shows 'Create IP Link' with a 'Rollback' button and a 'Done' status. The 'Creation Date' is '25-10-2021 20:28:22 UTC' and the 'Last Update' is '25-10-2021 20:34:08 UTC'.

The 'Logs' section is expanded, showing the following logs:

- Normal Flow
  - Adapter #1: cnc30 ✓
  - create ip-link
  - create ip-link response
- Rollback Flow
  - Adapter #1: cnc30 ✓
  - delete ip-link
  - delete ip-link response

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