Automation Workflows

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.

Sequence for Installation of Routed Optical Networking Components

We recommend this installation sequence:

Note Cisco Crosswork Network Controller (Crosswork Optimization Engine, CAT) and Cisco Optical Network Controller are the minimum required components for the Routed Optical Networking solution.

- Install Cisco Optical Network Planner. Cisco Optical Network Planner 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 Crosswork Network Controller 3.0 applications (Crosswork Optimization Engine, CAT, Hi). For more information, see Cisco Crosswork Infrastructure 4.1 and Applications Installation Guide.

- Install Cisco Optical Network Controller 1.1. For more information, see Cisco Optical Network Controller 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* .

- 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 4.0*, Cisco Network Services Orchestrator DLM Service Pack Installation Guide 4.1.0.

- Add SVO devices to Cisco Optical Network Controller for the optical service management. For more information, see Cisco Optical Network Controller 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 Optical Network Controller 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
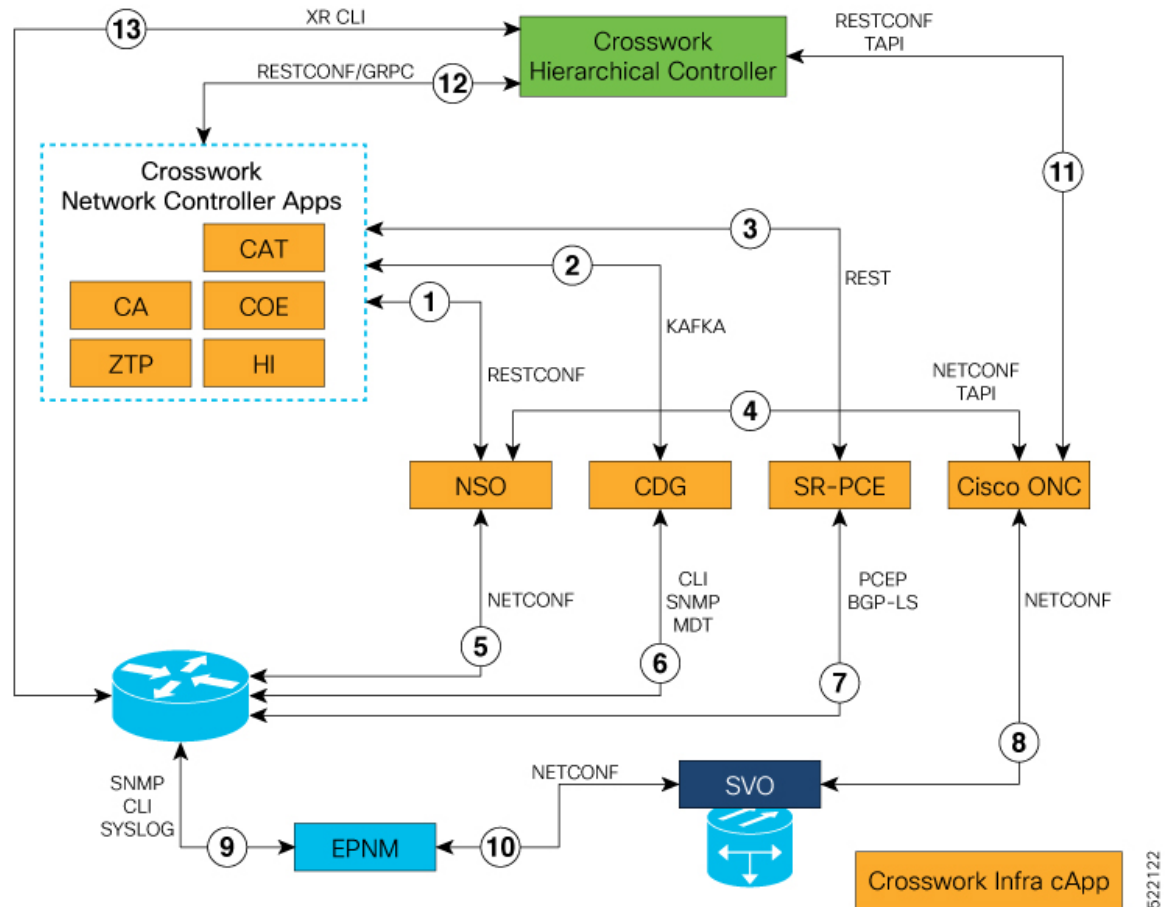
1.   Crosswork Network Controller discovers services. Crosswork Network Controller populates NSO with device information via RESTCONF and handles NSO provisioning requests. EMS collects fault and alarm data from devices.

2.   Crosswork Data Gateway sends device status to Crosswork Network Controller using Kafka. Crosswork Network Controller manages the Crosswork Data Gateway instance.

3.   SR-PCE sends SR-TE/RSVP-TE and topology information to Crosswork Network Controller via REST APIs.

4.   NSO discovers information from Cisco Optical Network Controller and provisions to Cisco Optical Network Controller via NETCONF TAPI.

5.   NSO manages XR router configuration using NETCONF.

6.   Crosswork Data Gateway 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 Optical Network Controller manages the SVO and NCS 1010 network nodes via NETCONF and gNMI. Cisco Optical Network Controller communicates with Cisco Optical Site Manager for NCS 1010

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. Crosswork Hierarchical Controller receives PM data using ONC RPC.

12. Crosswork Hierarchical Controller discovers IGP nodes and topology and provisions services using Crosswork Network Controller NB API. Crosswork Hierarchical Controller receives PM data using GRPC.

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:

In this section, a service provisioning example has been provided. This example uses the Cisco NSO Routed Optical Networking Core Function Pack for service provisioning.

• 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
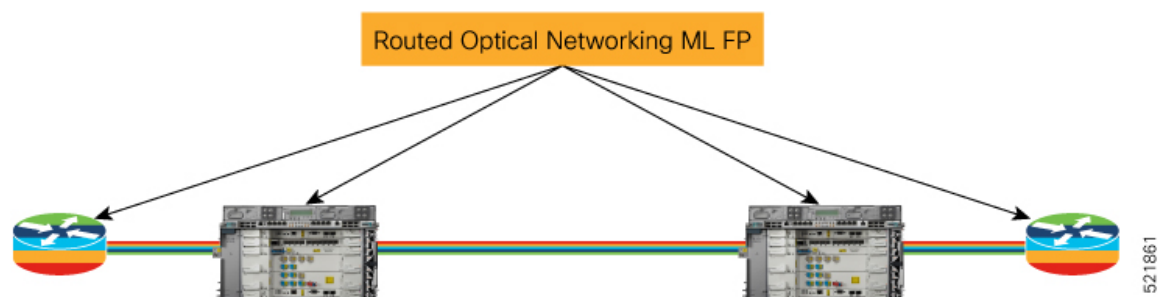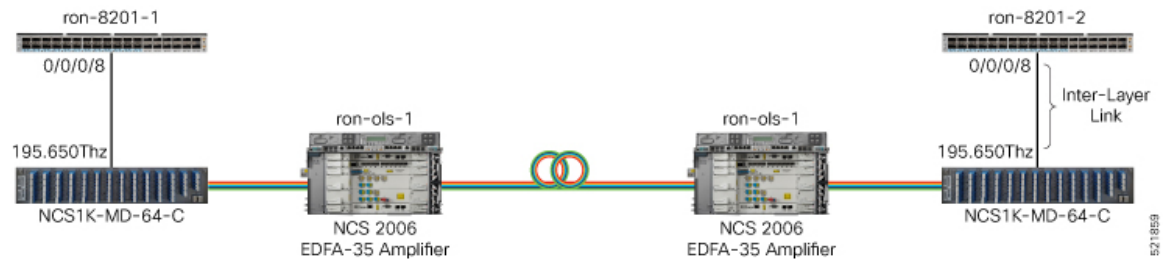
1. Define the inter-layer links.

```
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 Optical Network Controller. This value may be user defined too.
TX Power	Supplied by Cisco Optical Network Controller. This value may be user defined too.
IP Addressing	10.2.1.10/31 and 10.2.1.11/31 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 10.2.1.10/31
      !
    !
   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 10.2.1.11/31
     !
    !
   !
```

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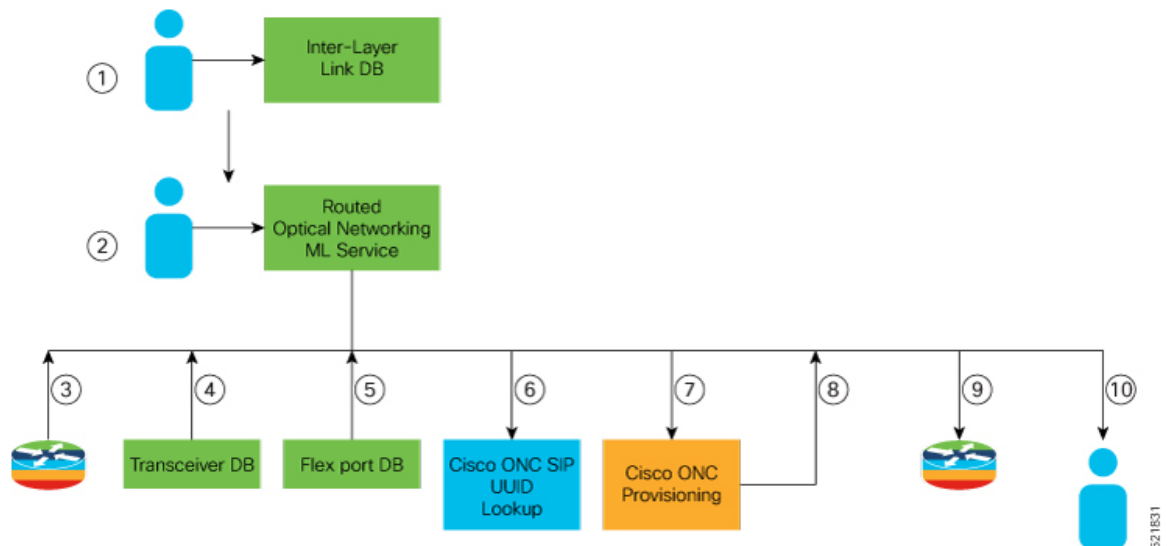
The workflow of the Routed Optical Networking ML service is as follows:

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 Optical Network Controller TAPI using the INVENTORY_ID.

7. The Routed Optical Networking ML service sends a TAPI connectivity-service request to Optical Network Controller for optical provisioning using SIPs and ZR/ZR+ application IDs.

8. Cisco Optical Network Controller returns the state after the provisioning is complete. Cisco Optical Network Controller 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)
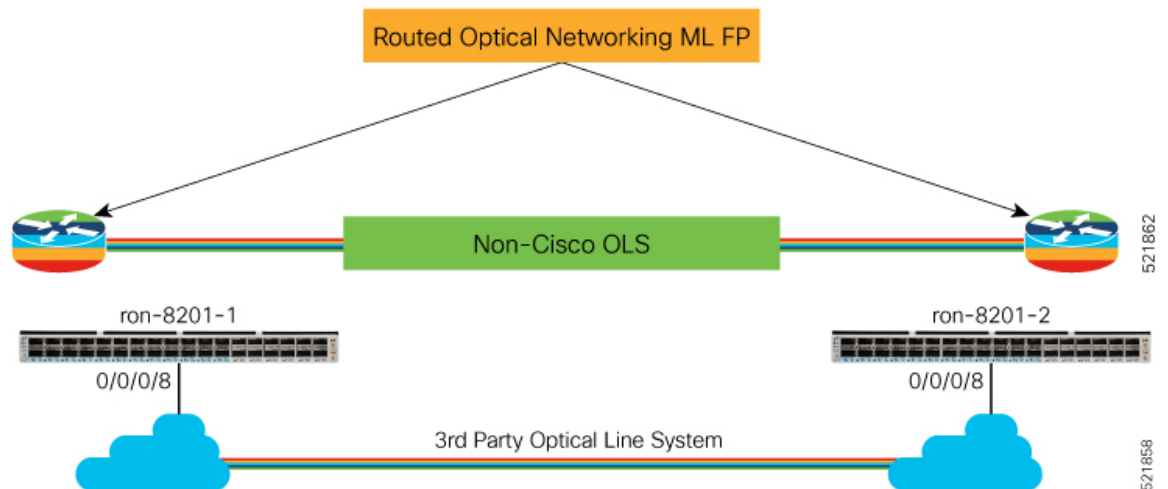
1. Create Routed Optical Networking ML Service with the following parameters:

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	10.2.1.10/31 and 10.2.1.11/31 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 10.2.1.10/31
 !
!
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 10.2.1.11/31
 !
 !
!
```

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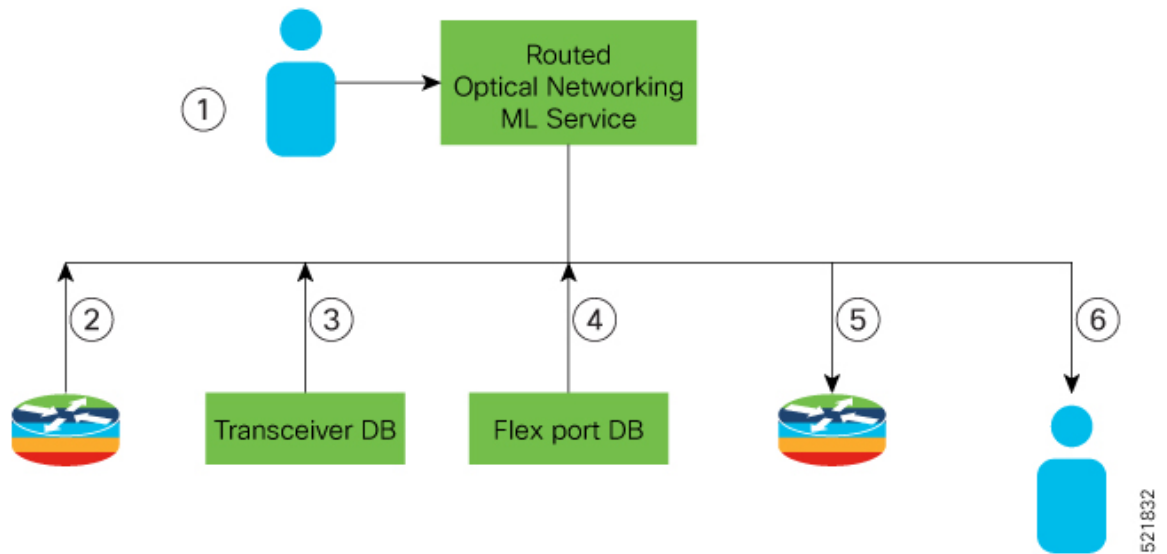
The workflow of the Routed Optical Networking ML service is as follows:

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 Crosswork Network Controller.

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
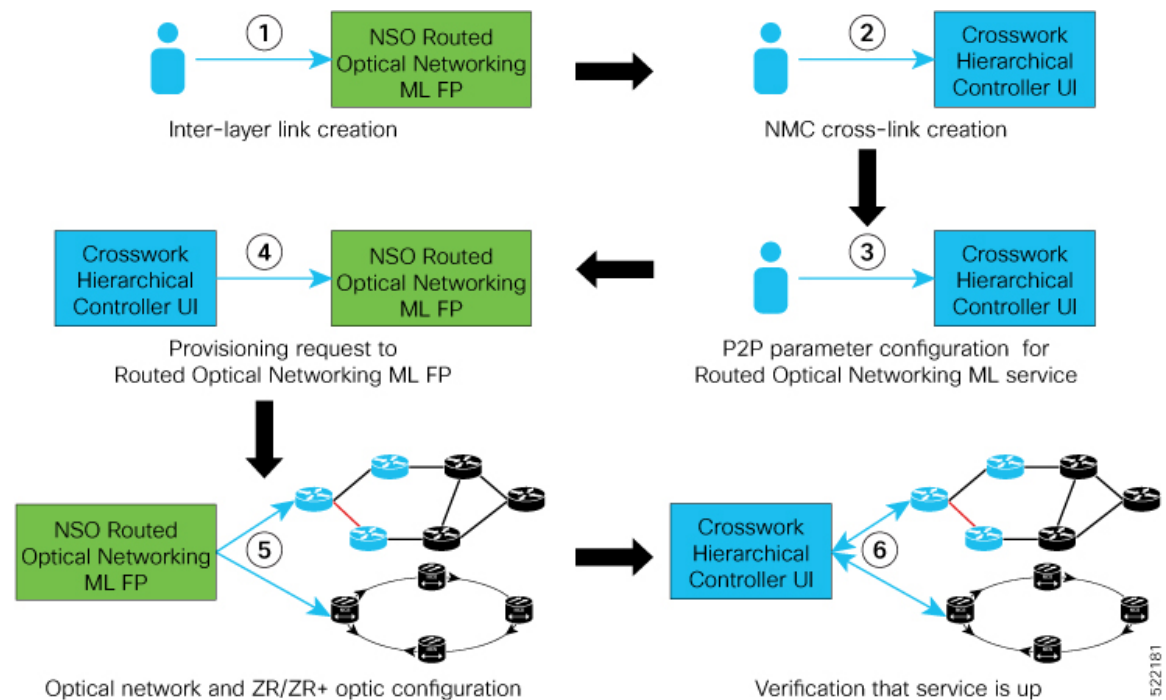
Troubleshoot Provisioning Issues

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     FLEXO_GIDM = 0
FLEXO-MM = 0    FLEXO-LOM = 0   FLEXO-RDI = 0
FLEXO-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(min)    Th(min)   (min)  Th(max)
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    TCA      Threshold    TCA
                                             (min)        (enable) (max)        (enable)
PreFEC BER : 1.5E-03   1.5E-03    1.6E-03    0E-15        NO       0E-15        NO
PostFEC BER : E-15     0E-15      0E-15      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
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-second30fecs/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: **

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

```
admin@ncs# show ron ron-ml-plan ron_poc_demo_195200 plan
                                                                                                            POST ACTION
                                              BACK        STATUS
TYPE                           NAME           TRACK  GOAL  CODE    STATE                           STATUS    WHEN                 ref  STATUS
-------------------------------------------------------------------------------------------------------------------------------------------
self                           self           false  -    RON-304 init                            reached   2021-06-13T15:32:32  -    create-reached
                                                                   ready                           failed    2021-06-13T15:32:32  -    -
optical-controller             Optical-Controller false -  RON-304 init                            reached   2021-06-13T15:32:32  -    -
                                                                   cisco-ron-cfp-nano-plan-services:config-apply reached 2021-06-13T15:32:32  -    -
                                                                   ready                           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 -     -    -
                                                                   ready                           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 -     -    -
                                                                   ready                           not-reached -                  -    -
```

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

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 logs display both the provisioning flow and the rollback flow.

Figure 10: Crosswork Hierarchical Controller UI - Operations Tab