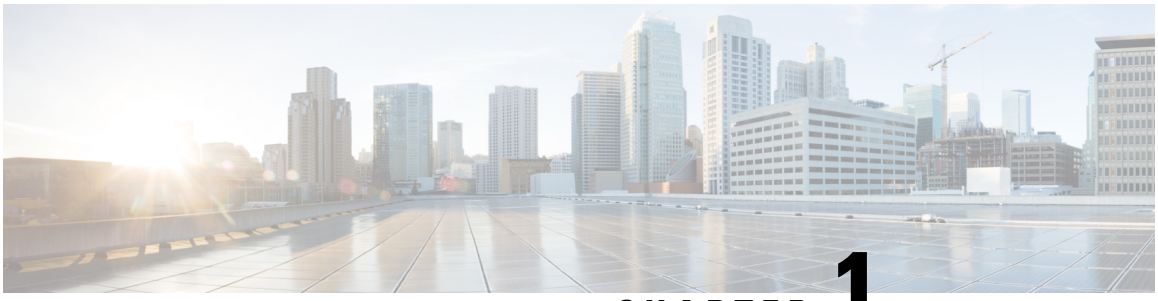
Cisco Routed Passive Optical Network Deployment Guide, Release 24.1.x

First Published: 2024-03-14

Last Modified: 2024-06-14

Americas Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
http://www.cisco.com
Tel: 408 526-4000
800 553-NETS (6387)
Fax: 408 527-0883

CONTENTS



CHAPTER 1

Cisco Routed PON Solution Overview

With the advancements in broadband technology, the customer demands have expanded to high-resolution audio and video playback, seamless audio and video streaming, immersive Virtual Reality (VR) experiences, and responsive gaming. These applications need substantial bandwidth and minimal latency to operate effectively. Currently, these requirements are met by employing an Optical Line Terminal (OLT) chassis, which connects at the access layer of the network.

Cisco's Routed PON Solution is a transformational approach that condenses the OLT chassis into a pluggable form factor. The solution becomes a part of the access router by plugging the Cisco PON SFP+ into 10G ports of NCS540, NCS5500, and NCS5700 series routers. You have the option to utilize a scalable model based on your bandwidth requirements, choosing between PON pluggable optics or Ethernet optics for your requirements.

This solution provides a network infrastructure that supports future upgrades, enabling a transition from a 10G pluggable OLT to a 25G variant when it becomes available. This solution not only uses the advanced features and capabilities of the Cisco routers but also capitalizes on the cost efficiency of PON networks. Since it uses passive devices, it doesn't require an extra power supply, leading to lower overall power consumption in the network.

The transceiver module acts as a substitute for the OLT chassis, managing the entire optical span within the access network. The Cisco PON OLT is compatible with various Optical Network Terminals (ONTs) on the market, provided they adhere to the ONU Management and Control Interface (OMCI) standard. This port-by-port network expansion approach eliminates the need for adding fixed line cards to a chassis-based OLT, allowing for a more capital-efficient network growth strategy.

Some of the advantages of the solution are:

- The transceiver module removes the need of any 3rd-party hardware for OLTs, thereby reducing the dependency on 3rd-party vendors and streamlining the network infrastructure.
- The transceiver module is a pluggable OLT that is inserted into the router. The cost of the OLT is lower than the OLT Chassis, hence reducing the cost of deployment.
- Since the device is a pluggable transceiver module, this significantly reduces the physical footprint of the network.
- Use of the PON Manager to deploy and upgrade the Routed PON solution saves time due to the use of a single point of management.

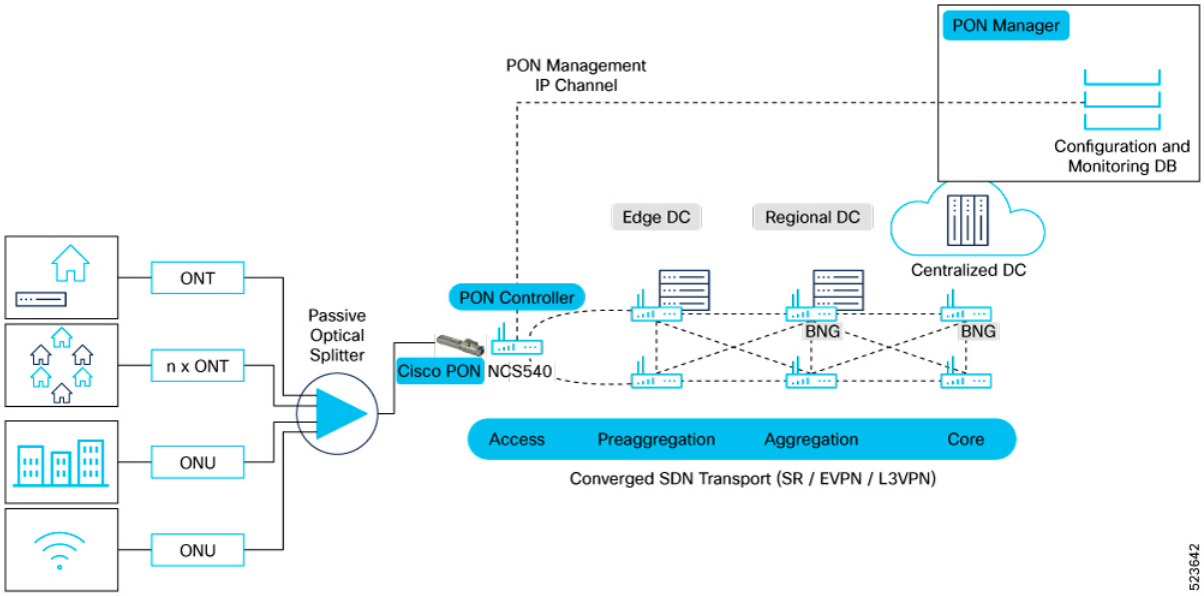
This release supports the PON Controller on the following Cisco router variants:

- N540-24Z8Q2C-SYS

- N540-ACC-SYS
- N540X-16Z4G8Q2C-A, N540X-16Z4G8Q2C-D
- N540-28Z4C-SYS-A, N540-28Z4C-SYS-D
- N540-24Q8L2DD-SYS
- NCS-55A1-24Q6H-SS
- NCS-55A2-MOD-S
- NCS-57C1-48Q6D

Cisco Routed PON Architecture

Figure 1: Cisco Routed PON solution



The solution involves integrating the Cisco PON pluggable OLT into the 10G Ethernet ports found on the Cisco NCS 540, NCS 5500, and NCS 5700 routers. The PON manager and its corresponding database are hosted on either an external system or specialized hardware, which can be located within the core network infrastructure or hosted on a cloud platform. The PON controller establishes a protected link facilitating the exchange of data between the PON manager and the network's OLTs and ONUs. A more in-depth examination of these individual elements of the solution follows.

- Components of the Cisco Routed PON Solution, on page 2

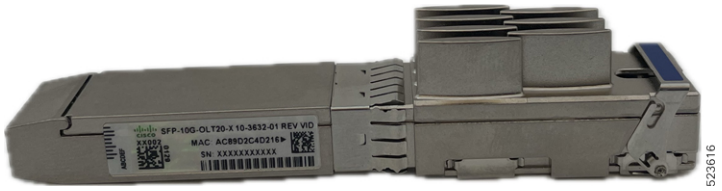
Components of the Cisco Routed PON Solution

The Various components of the solution are:

Cisco PON pluggable OLT

The Cisco PON pluggable OLT features a hot-swappable SFP+ design that enables the deployment of a software-defined broadband network. It incorporates a 10G Ethernet to XGS PON MAC Bridge IC along with a Layer 1 optical transceiver. This integration facilitates the module's connection from a PON network to a dedicated Ethernet SFP+ port on routers. The system is capable of supporting 10G data transmission speeds both upstream and downstream.

Figure 2: PON Transceiver Module



Technical specifications of the Cisco PON pluggable OLT are:

Table 1: Cisco PON pluggable OLT Technical Specifications

Dimension (H x W x D)	8.55mm x 13.4mm x 80.65mm
PID	SFP-10G-OLT20-X
Data rate	Symmetric rates: 8G upstream/8G downstream
Connector Type	SC/UPC
Maximum Distance	20 km
Operating Temperature	-20°C to 75°C
Typical Power Consumption	3.2W
Average Launch Power	4 dbm min 7 dbm max
ODN Class	N2
Cable Type	Single Mode Fiber

Cisco PON Manager

The Cisco PON manager is a web application and an accompanying REST API that provides a graphical user interface for managing the PON network. The PON manager is used to set up the OLTs and ONUs, as well as downloading firmware updates for both the OLTs and ONUs. The REST API accompanies the web application for the purposes of providing access to MongoDB for managing PON users and the PON network. The PON manager facilitates:

- Alarm management
- Dashboard view
- Device monitoring and statistic

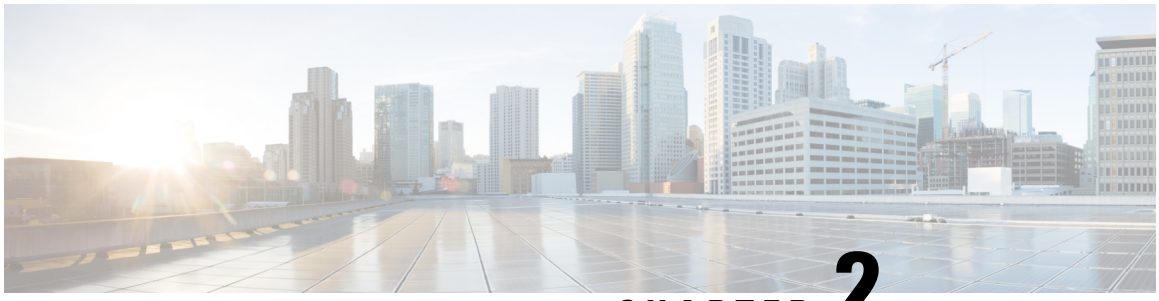
- Device provisioning and management
- Service configuration
- User management
- Database management

MongoDB database

The MongoDB datastore contains all of the configuration, state, statistics, alarms, and logging data for the devices in the PON network. Northbound interfaces, such as the Routed PON Manager and the customer applications interface with MongoDB to provision and retrieve monitoring information for devices in the PON network. MongoDB serves as the interface between the PON Manager and the PON Controller.

Cisco PON Controller

Cisco PON Controller is a light-weight application which runs as a docker container on each NCS540, NCS 5500, and NCS 5700 devices. Various configurations applied to the OLTs and ONTs in the network are fetched from the MongoDB database and provisioned on the OLT ONUs by the PON Controller. At each polling cycle, the PON controller collects state information, statistics, alarms, and logs from devices and reports the information to higher layer applications through MongoDB.



CHAPTER 2

Deploying the Cisco Routed PON Solution

Completing the implementation of the Cisco Routed PON Solution requires setting up the various components that make up the system. At a high level, the steps to configure the Cisco Routed PON Solution are as follows:

1. Install the Cisco PON pluggable OLT.
2. Install and configure the Cisco PON Manager.
3. Install and configure the MongoDB database.
4. Configure and activate the Cisco PON Controller.

Install the Cisco PON Pluggable OLT

For steps to install the Cisco PON pluggable OLT refer to *Install and Remove Transceiver Modules* in the Cisco NCS 540 Router Hardware Installation Guide.

Install and Configure the PON Manager

For steps to install the PON Manager, refer to *PON Manager Installation* in the *Cisco Routed PON Installation Guide*.

Install and Configure the MongoDB database

For steps to install the MongoDB database, refer to *MongoDB Installation* in the *Cisco Routed PON Installation Guide*.

Configuring the PON Controller

The PON Controller is installed on a Docker container on the router. The PON Controller installation package is stored either on the hard disk of the router or on a network server to which the router has access.

To configure the PON controller, follow the steps:

Install the PON Controller on Cisco IOS XR7 OS

For the Cisco Routers using the Cisco IOS XR7 framework, execute the following commands to install the software package:

Note This section is applicable for the following routers:

- N540X-16Z4G8Q2C-A, N540X-16Z4G8Q2C-D
- N540-28Z4C-SYS-A, N540-28Z4C-SYS-D
- N540-24Q8L2DD-SYS
- NCS-57C1-48Q6D

1. Execute the following command to confirm if the PON Controller package is present in the router:

   ```
   show install active summary | i pon
   ```

   Sample Output

   ```
   RP/0/RP0/CPU0:PON-Rtr1-CrLk#show install active summary | i pon
   Tue Feb 27 08:45:29.246 UTC
   xr-pon-ctlr                                              24.1.1.40Iv1.0.1-1
   ```

   If the PON Controller isn't present, the command won't return any value.

2. If the PON Controller isn't present refer to the appropriate guide for steps to download and configure additional packages. The steps to configure an additional package might differ based on the router model.

   - For NCS 5500 or NCS 5700 router, refer to *Install Optional Packages to Provide Additional Functionality* in System Setup and Software Installation Guide for Cisco NCS 5500 Series Routers.
   - For NCS 540 router, refer to *Install Optional Packages to Provide Additional Functionality* in System Setup and Software Installation Guide for Cisco NCS 540 Series Routers.

Install the PON Controller on Cisco IOS XR OS

This section provides the steps to configure Cisco PON Controller software in the routers using the IOS XR framework.

Note This section is applicable for the below routers:

- N540-24Z8Q2C-SYS
- N540-ACC-SYS
- NCS-55A1-24Q6H-SS
- NCS-55A2-MOD-S

1. Execute the following command to confirm if the PON Controller package is present in the router:

   ```
   show install active | i pon
   ```

   Sample Output

   ```
   RP/0/RP0/CPU0:PON-Rtr5-Peyto#show install active | i pon
   Tue Feb 27 08:44:53.345 UTC
   ncs5500-pon-ctlr-1.0.0.0-r241140I
   ncs5500-pon-ctlr-1.0.0.0-r241140I
   ```

   If the PON Controller isn't present, the command doesn't return any values.

2. If the PON Controller isn't present refer to the appropriate guide for steps to download and configure additional packages. The steps to configure an additional package might differ based on the router model.
   - For NCS 5500 or NCS 5700 router, refer to *Install Packages* in System Setup and Software Installation Guide for Cisco NCS 5500 Series Routers.
   - For NCS 540 router, refer to *Install Packages* in System Setup and Software Installation Guide for Cisco NCS 540 Series Routers.

Activating the PON Controller

After installing up the PON Controller in the router, you need to activate it by connecting to MongoDB and applying additional configurations to the controller.

Before you begin:

- Ensure that you have synchronized the XR clock with that of an NTP server.

  The steps to configure an NTP server might differ based on the router model. Refer to the appropriate guide for steps to configure an NTP server.
  - For NCS 5500 or NCS 5700 routers, refer to *Configuring Network Time Protocol* in System Management Configuration Guide for Cisco NCS 5500 Series Routers.
  - For NCS 540 router, refer to *Synchronize Router Clock with NTP Server* in System Setup and Software Installation Guide for Cisco NCS 540 Series Routers.

- Ensure that Linux Networking is configured on the router as given below:

  ```
  linux networking
   vrf default
    address-family ipv4
     default-route software-forwarding
  ```

```
   source-hint default-route interface MgmtEth0/RP0/CPU0/0
  !
 !
!
```

The steps to configure Linux Networking might differ based on the router model. Refer to the appropriate guide for steps to configure an NTP server.

- For NCS 5500 or NCS 5700 routers, refer to *Packet I/O on IOS XR* in Application Hosting Configuration Guide for Cisco NCS 5500 Series Routers.
- For NCS 540 router, refer to *Setup the Linux Network for Application Hosting* in Application Hosting Configuration Guide for Cisco NCS 540 Series Routers.

- Ensure that the MongoDB server is reachable from your router by executing the following command:

```
bash ping <IP address of the MongoDB server>
```

Sample Output

```
RP/0/RP0/CPU0:PON-Rtr5-Peyto#bash ping 192.0.2.0
Tue Feb 27 09:17:53.046 UTC
RP/0/RP0/CPU0:Feb 27 09:17:53.087 UTC: bash_cmd[66952]: %INFRA-INFRA_MSG-5-RUN_LOGIN :
 User lab logged into shell from con0/RP0/CPU0
PING 192.0.2.0 (192.0.2.0) 56(84) bytes of data.
64 bytes from 192.0.2.0: icmp_seq=1 ttl=64 time=0.820 ms
64 bytes from 192.0.2.0: icmp_seq=2 ttl=64 time=0.769 ms
64 bytes from 192.0.2.0: icmp_seq=3 ttl=64 time=0.703 ms
```

Edit the parameters in the **PonCntlInit.json** that is part of the PON Controller package establish connection with the MongoDB server. A sample **PonCntlInit.json** is included in the PON Controller package.

A sample **PonCntlInit.json** is given below:

```
{
    "CNTL": {
        "Auth": false,
        "CFG Version": "R4.0.0",
        "DHCPv4": false,
        "DHCPv6": false,
        "PPPoE": false,
        "UMT interface": "tibitvirt",
        "Maximum CPEs Allowed": 0,
        "Maximum CPE Time": 0
    },
    "DEBUG": {},
    "JSON": {
        "databaseDir": "/opt/cisco/poncntl/database/",
        "defaultDir": "/opt/cisco/poncntl/database/"
    },
    "Local Copy": {
        "CNTL-STATE": false,
        "OLT-STATE": false,
        "ONU-STATE": false
    },
    "Logging": {
        "Directory": "/var/log/tibit",
        "FileCount": 2,
        "FileSize": 5120000,
        "Tracebacks": false,
        "Timestamp": false,
        "Facility" : "user"
    },
    "MongoDB": {
```

```
        "auth_db": "cisco_users",
        "auth_enable": false,
        "ca_cert_path": "/etc/cisco/ca.pem",
        "compression": false,
        "write_concern": "default",
        "host": "192.0.2.0",                                <-- mongoDB server IP Address
        "name": "cisco_pon_controller",
        "password": "",
        "port": "27017",                                    <-- mongoDB port
        "tls_enable": false,                                <-- field to enable TLS based
connection
        "username": "",
        "dns_srv": false,
        "db_uri": "",
        "replica_set_enable": false,
        "replica_set_name": "rs0",
        "replica_set_hosts":
            [
            "192.0.2.3:27017",                              <-- mongoDB replica set 1
            "192.0.2.4:27999",                              <-- mongoDB replica set 2
            "mongo02.example.com:17999"
            ],
        "validate_cfg": true
    },
    "databaseType": "MongoDB",
    "interface": "veth_pon_glb",
    "interface_namespace": ""
}
```

1. Change the **host** IP address parameter to the IP address of your MongoDB server.
2. (Optional) To enable secure connection between the PON Controller and the MongoDB server, change the value for **tls_enable** to **true**.

   If a secure connection is enabled, you'll need to configure the **username** and **password** parameters as well.
3. If you have configured a replica set for MongoDB, change the IP address for the MongoDB replica set.
4. Copy and paste the **PonCntlinit.json** file to either the hard disk of the router or to your network folder.

   When copying the file to the hard disk of the router, it is stored in `/misc/disk1` by default.
5. Confugure Controller using CLI:

   - **CLI**

     Execute the **`cfg-file`** command to initiate the PON controller, the command is used to load the PON controller application on the router.

     Syntax

     ```
     cfg-file <tftp transfer protocol>/package_path/ or harddisk/package_path/ vrf
     <vrf-name> tls-pem <tftp transfer protocol>/pem_file_path/
     ```

Parameter	Decription
tftp transfer protocol	TFTP server IP address.

Parameter	Decription
package_path	Location of the .json file. **Note** If a custom VRF is used for management connectivity, include the VRF name as part of the package path.
Harddisk	Harddisk of the router. If the .json file is located on the harddisk, provide the path to on the harddisk.
vrf	Specifies VPN routing and forwarding (VRF).
vrf-name	Name of a VRF used for MongoDB connectivity.
tls-pem	Specifies that TLS is used.
pem_file_path	Path of the .pem file. This can either be stored on the router harddisk or a TFTP server.

Example:

```
RP/0/RP0/CPU0:ios(config)#pon-ctlr cfg-file
tftp://192.0.2.0/auto/tftp-users2/user2/PonCntlInit.json vrf default tls-pem
tftp://192.0.2.0/auto/tftp-blr-users2/user/rootCA.pem
```

6. Ensure that the main interface for the SFP is in active.

   For example, if the Cisco PON pluggable OLT is inserted in the port 0/0/0/5:

   ```
   RP/0/RP0/CPU0:ios(config)#interface TenGigE0/0/0/5
   RP/0/RP0/CPU0:ios(config-if)#no shutdown
   ```

7. Create a subinterface with ID 4090 on the port where the small form-factor pluggable is inserted. The subinterface is required to receive the control packets between the PON Controller and the Cisco PON pluggable OLT.

   ```
   interface TenGigE0/0/0/5.4090
   encapsulation dot1q 4090
   ```

   When the subinterface is created, the PON controller discovers the OLTs and ONUs in the network.

   ```
   RP/0/RP0/CPU0:ios#run
   Thu Oct 19 08:04:53.799 UTC
   [xr-vm_node0_RP0_CPU0:~]$docker ps
   CONTAINER ID IMAGE COMMAND CREATED STATUS PORTS NAMES
   7909570b4803 cisco-poncntl.xr:R4.0.0 "/usr/bin/supervisor…" 26 hours ago Up 26 hours
   pon_ctlr
   [xr-vm_node0_RP0_CPU0:~]$docker logs pon_ctlr --tail 50
   2023-10-19 08:07:33.482 INFO PonCntl Total Controllers: 1 OLTs: 1 ONUs: 1
   RP/0/RP0/CPU0:ios(config-if)#no shutdown
   ```

8. Run the *lldp* command to enable Link Layer Discovery Protocol (LLDP) for the OLT port. This helps in the discovery of the OLTs and ONUs in the PON Manager.

   ```
   RP/0/RP0/CPU0:ios(config)# lldp
   ```

9. Confirm if the PON Controller, OLT, and ONU details are displayed in the PON Manager.

Note If the Controller summary displays **Status:** as **offline,** then match the UTC clock on your router to that of the Cisco UCS server.

For more information on PON Controller, refer to *PON Controller* in the *Cisco Routed PON Installation Guide*.