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Juniper Unified PON - Integrated PON Controller on ACX5400 Line of Routers

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About this Deployment Guide

Use this guide to deploy Unified passive optical network (PON) solution. You will learn how to deploy Unified PON by integrating Juniper Networks® 10GbE optical line terminal (OLT) small form factor pluggable plus (SFP+) transceiver with the Juniper Networks® ACX5400 line of Universal Metro Routers.

Juniper Unified PON Architecture Overview

IN THIS SECTION

Juniper Unified PON integrates a 10GbE OLT SFP+ transceiver, a PON controller, and a PON manager to provide a complete network management solution. With this solution, you can provision and monitor the 10GbE OLT SFP+ transceiver devices, as well as the third-party optical network units (ONUs) compliant with the 10GbE Gigabit PON (GPON) and Ethernet PON (EPON) standards.

Benefits of Integrating Juniper Unified PON with the 10GbE OLT SFP+ Transceiver

- The router-integrated OLT solution reduces the cost of deployment.
- The OLT solution creates an open standards-based system without vendor lock-in to ONUs as opposed to earlier PON systems. This solution provides deployment flexibility.
- The OLT solution enables easy installation and upgrades and creates a single point of management.
- The OLT modules can be used to create higher density or more flexible integrated solutions.

Juniper Unified PON Architecture

This section describes the various components of the Juniper Unified PON architecture.

10GbE OLT SFP+ Transceiver

The 10GbE OLT SFP+ transceiver connects to the 10GbE ports on the ACX5400 line of routers, instantaneously enabling 10GbE symmetrical PON access on the router. The transceiver eliminates the need for additional hardware as the router functions as the OLT, substantially lowering the cost of deployment. A single OLT supports up to 128 ONU devices providing improved database bandwidth assignment and latency performance over traditional chassis-based architectures. The OLT solution addresses the PON physical layer, mandatory access control (MAC), and state-polling functionality at the network edge. Behind the OLT, the network normally contains Ethernet switches for aggregation and a router to the Internet. To install the 10GbE OLT SFP+ transceiver on the ACX5400 line of routers, see "Replace an Optical Line Terminal Transceiver " on page 3.

PON Controller

PON controller is a stateless management controller and a device driver application for configuring and monitoring the end points in a PON solution network. The PON controller runs at a certain configurable interval. The database in the PON manager serves as the northbound API for the PON controller. The PON controller applies configurations to the OLT and the ONU devices from documents stored in the database. At each polling cycle, the PON controller also collects state information, statistics, and logs from devices and reports the information to higher layer applications through the PON manager database. The PON manager and the NETCONF interface manage the PON controller through the database.

PON Manager

The PON manager is a web application that provides a GUI for provisioning and managing the PON network. The PON manager enables you to do the following tasks:

- Manage alarms.
- Provide a dashboard view summary of PON network conditions.
- Monitor devices and their statistics.
- Provision and manage devices.
- Diagnose and troubleshoot errors through logs.
- PON Controller database management.
- PON manager user management.

- Configure services including VLANs, service-level agreements (SLAs), 802.1X authentication, and DHCP relay.

The PON manager is responsible for configuring the OLTs and ONUs, and also to download firmwares to the OLTs and ONUs. For more information on PON manager (WebUI) and database, see MicroClimate™ Management System [MCMS] PON Manager (WebUI) User Guide.

Database

The database provides a datastore for the PON network management system. The database contains all the configurations, states, statistics, alarms, and log data for the devices in the PON network. Northbound interfaces such as the PON manager, NETCONF Server, and applications interface with the database to provision and to retrieve monitoring information for devices in the PON network. The database serves as the interface between the PON manager, NETCONF, and the PON controller. The PON Controller reads the configuration information from the database and then programs the OLT and ONU devices accordingly.

The PON Controller periodically collects state information from devices in the PON network and updates the monitoring data to the database. The PON manager reads the monitoring data from the database and displays it in the web application.

NETCONF Server

The NETCONF Server provides a standard NETCONF interface and APIs for managing the PON network. The NETCONF Server interfaces with the database. The NETCONF solution supports standard Broadband Forum (BBF) TR-383 and TR-385 YANG models for configuring subscriber services for the PON network. In addition to standard YANG models, YANG models provide a complete NETCONF management solution for PON Controllers, OLTs, and ONUs. For more information on NETCONF Server, see MicroClimate™ Management System [MCMS] Netconf Server Interface User Guide.

Replace an Optical Line Terminal Transceiver

IN THIS SECTION

The hot-pluggable integrated 10GbE PON OLT transceivers, with built-in Ethernet-to-10G PON MAC bridging, connect directly to the SFP+ ports on supported ACX Series routers. The OLT SFP+ transceiver is designed to interoperate with a broad range of popular third-party ONU devices. Due to thermal, power, and mechanical considerations, you must insert the OLT SFP+ transceiver only in the upper-row 10GbE ports of the ACX5400 line of routers.

NOTE: When you insert the OLT SFP+ transceiver on the upper-row ports of the router, the external heatsink fins of the OLT extend above the chassis top plane by 1.9mm and use up rack space above the chassis.

Install an OLT SFP+ Transceiver

The transceivers for Juniper Networks devices are hot-removable and hot-insertable field-replaceable units (FRUs). You can remove and replace them without powering off the device or disrupting the device functions.

1. Wrap and fasten one end of the electrostatic discharge (ESD) wrist strap around your bare wrist, and connect the other end of the strap to a site ESD point.
2. If the transceiver is not covered with a rubber safety cap, then cover it with a rubber safety cap.

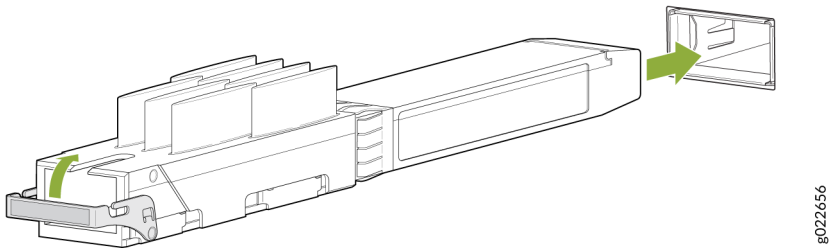
   WARNING: Do not leave a fiber-optic transceiver uncovered except when inserting or removing a cable. The rubber safety cap keeps the port clean and prevents accidental exposure to laser light.
3. If the port in which you want to install the transceiver is covered with a dust cover, remove the dust cover and save it in case you need to cover the port later.

   If you are hot-swapping a transceiver, wait for at least 10 seconds after removing the transceiver from the port before installing a new transceiver.

   CAUTION: Before you slide the transceiver into the port, ensure that the transceiver is aligned correctly. Misalignment might cause the pins to bend, making the transceiver unusable.
4. Using both hands, carefully insert the transceiver in the empty port.

   The connectors must face the chassis.
5. Slide the transceiver in gently until it is fully seated.

Figure 1: Insert an OLT Transceiver



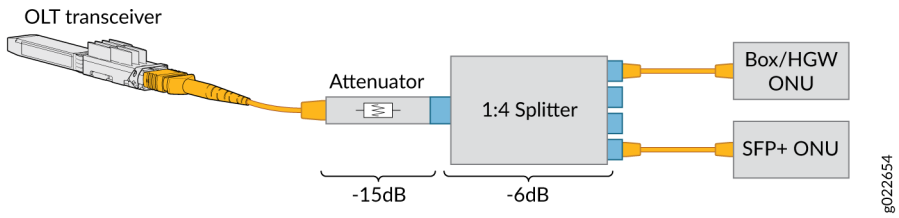
6. Remove the rubber safety cap from the transceiver and the end of the cable, and insert the cable into the transceiver.
7. If there is a cable management system, arrange the cable in the cable management system to prevent the cable from dislodging or developing stress points. Secure the cable so that it does not support its own weight as it hangs to the floor. Place excess cable out of the way in a neatly coiled loop in the cable management system. Placing fasteners on the loop helps to maintain its shape.

CAUTION: Do not let a fiber-optic cable hang free from the connector. Do not allow fastened loops of cable to dangle, which stresses the cable at the fastening point.

CAUTION: Avoid bending a fiber-optic cable beyond its minimum bend radius. An arc smaller than a few inches in diameter can damage the cable and cause problems that are difficult to diagnose.

WARNING: Do not connect the OLT directly to ONUs such as a home gateway (HGW) without proper attenuation. The OLT can get permanently damaged unless it is connected with minimum 16dB attenuation (20dB recommended). A combination of attenuator and splitters can provide the required attenuation.

Figure 2: Combination of Attenuators and Splitters



HGW—Home Gateway

Remove an OLT SFP+ Transceiver

Before you begin to remove a transceiver from a device, ensure that you have taken the necessary precautions for safe handling of lasers (see Laser and LED Safety Guidelines and Warnings).

Ensure that you have the following parts and tools available:

- An antistatic bag or an antistatic mat
- Rubber safety caps to cover the transceiver and fiber-optic cable connector
- A dust cover to cover the port or a replacement transceiver

The transceivers for Juniper Networks devices are hot-removable and hot-insertable FRUs. You can remove and replace them without powering off the device or disrupting the device functions.

1. Place the antistatic bag or antistatic mat on a flat, stable surface.
2. Wrap and fasten one end of the ESD wrist strap around your bare wrist, and connect the other end of the strap to a site ESD point.
3. Label the cable connected to the transceiver so that you can reconnect it correctly.

WARNING: Do not look directly into a fiber-optic transceiver or into the ends of fiber-optic cables. Fiber-optic transceivers and fiber-optic cables connected to transceivers emit laser light that can damage your eyes.

WARNING: Do not leave a fiber-optic transceiver uncovered except when inserting or removing a cable. The rubber safety cap keeps the port clean and prevents accidental exposure to laser light.

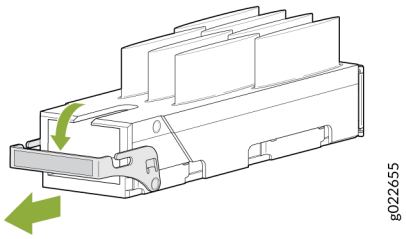
4. Remove the cable connected to the transceiver.
5. Cover the transceiver and the end of each fiber-optic cable connector with a rubber safety cap immediately after disconnecting the fiber-optic cables.
6. If there is a cable management system, arrange the cable in the cable management system to prevent it from dislodging or developing stress points. Secure the cable so that it does not support its own weight as it hangs to the floor. Place excess cable out of the way in a neatly coiled loop in the cable management system. Placing fasteners on the loop helps to maintain its shape.

CAUTION: Do not bend the fiber-optic cable beyond its minimum bend radius. An arc smaller than a few inches in diameter can damage the cable and cause problems that are difficult to diagnose.

7. By using your fingers, pull open the ejector lever on the transceiver to unlock the transceiver.

CAUTION: Before removing the transceiver, make sure that you open the ejector lever completely until you hear it click. This prevents damage to the transceiver.

Figure 3: Remove an OLT Transceiver



8. Grasp the transceiver ejector lever and gently slide the transceiver approximately 0.5 in. (1.3 cm) straight out of the port.

> **CAUTION**: To prevent ESD damage to the transceiver, do not touch the connector pins at the end of the transceiver.

9. By using your fingers, grasp the body of the transceiver and pull it straight out of the port.
10. Place the transceiver in the antistatic bag or on the antistatic mat placed on a flat, stable surface.
11. Place the dust cover over the empty port or install the replacement transceiver.

Example: Deploy Juniper Unified PON by Configuring the PON Controller on the ACX5400 Line of Routers

IN THIS SECTION

Use this example to learn how to deploy Juniper Unified PON by integrating the PON controller with the ACX5400 line of routers connected with the 10GbE OLT SFP+ transceiver.

> **NOTE**: Installing and configuring PON manager, NETCONF Server, and database are beyond the scope of this document. See the MicroClimate™ Management System [MCMS] Installation Guide, MicroClimate™ Management System [MCMS] PON Manager (WebUI) User Guide, and MicroClimate™ Management System [MCMS] Netconf Server Interface User Guide for information.

Requirements

This example uses the following hardware and software components:

- ACX5448 router running Junos OS Release 21.3R1 or later.
- PON controller running on the ACX5448 Routing Engine.
- PON manager, NETCONF server, and database hosted on an external hardware (x86 system) in the core network or cloud. For PON manager, NETCONF server, and database installation, see MicroClimate™ Management System [MCMS] Installation Guide.
- 10GbE OLT SFP+ transceiver connected to the ACX5448 router's 10GbE port.
- ONUs connected to the OLT with proper attenuation.

> **NOTE**: You must not connect the OLT directly to ONUs without proper attenuation. The OLT can get permanently damaged unless it is connected with minimum 16dB attenuation (20dB recommended). A combination of attenuator and splitters can provide the required attenuation.

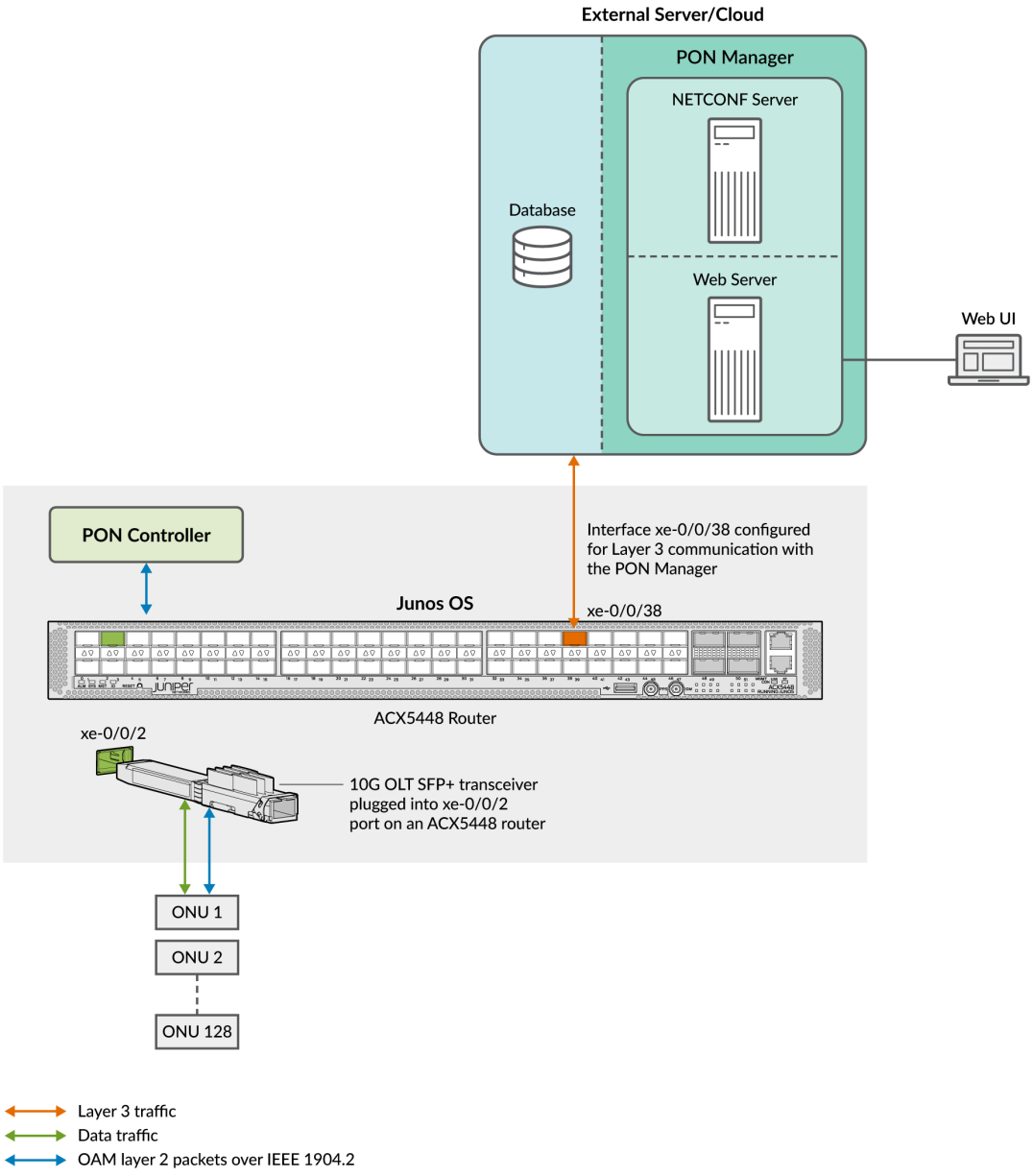
Overview

IN THIS SECTION

The following topology (figure on page 10) depicts Juniper Unified PON. The PON controller comes preinstalled with the Junos® operating system (OS) on the ACX5400 line of routers. It provides a secure communication channel between the PON manager and the OLTs and ONUs. The PON controller uses a Layer 2 connection to communicate with OLTs and ONUs. You must insert the 10GbE OLT SFP+ transceiver into the 10GbE port on the ACX5400 line of routers.

Topology

Figure 4: PON Controller on the ACX5448 Router



In this topology, you connect the 10GbE OLT SFP+ transceiver to the 10GbE port on the ACX5448 router. Junos OS that runs on the ACX5448 router detects the 10GbE OLT SFP+ transceiver and creates the interface. The interface is automatically deleted when you remove the transceiver.

The PON manager, NETCONF server, and the database are hosted on an external system or hardware that are deployed at the core network or on the cloud. The database stores the profiles, states, statistics for PON controllers, OLTs, and ONUs. The PON manager connects to the 10GbE port of the ACX5448 router.

The PON controller provides a secure communication channel between the PON manager and the OLTs and ONUs. The PON controller runs on the Routing Engine.

Layer 2 interfaces and bridging configured on the ACX5448 router are connected to the 10GbE OLT SFP+ transceiver. Layer 3 interfaces configured on the ACX5448 router are connected to the PON manager hosted on an external system in the core network or cloud.

Configuration

IN THIS SECTION

To configure the interfaces and the PON controller on the ACX5448 router, perform the following tasks.

Configure Layer 2 Interfaces and Bridging

The PON controller uses a Layer 2 connection to communicate with OLT and ONUs. Layer 2 connection is a separate Layer 2 control path between the Routing Engine and Packet Forwarding Engine (em4 interface). The PON controller uses Layer 2 broadcast packets to discover OLTs. OLTs respond with their MAC address.

OLTs use 1904.2 frames with special control customer VLAN (C-VLAN) (0x8100:4090) to separate control traffic from data traffic. OLTs must be configured to a single bridge domain. The Layer 2 filter traps the 1904.2 packets from the OLT and ONU to the host path and forwards the packets to the Routing Engine.

Step-by-Step Procedure

The following example requires you to navigate various levels in the configuration hierarchy. For information about navigating the CLI, see the CLI User Guide.

To configure Layer 2 interfaces and bridging on the ACX5448 router:

1. Configure Layer 2 interfaces and enable VLAN tagging.

```
user@host#set interfaces xe-0/0/2 description OLT3
user@host#set interfaces xe-0/0/2 flexible-vlan-tagging
user@host#set interfaces xe-0/0/2 encapsulation flexible-ethernet-services
user@host#set interfaces xe-0/0/2 ether-options ethernet-switch-profile tag-protocol-id 0x8100
user@host#set interfaces xe-0/0/2 unit 0 encapsulation vlan-bridge
user@host#set interfaces xe-0/0/2 unit 0 vlan-id 4090
```

2. Configure VLAN and bridge domain.

> **NOTE**: You must configure only one bridge domain for all the OLTs.

```
user@host#set vlans bd description BD_OLT
user@host#set vlans bd interface xe-0/0/2.0
user@host#set vlans bd no-local-switching
user@host#set vlans bd switch-options no-mac-learning
```

Configure Layer 3 Interfaces

The PON controller uses a Layer 3 (IP Transport Layer Security (TLS)) connection to communicate with the PON manager. Layer 3 packets with destination as PON manager are sent to the Routing Engine–Packet Forwarding Engine control path (em5 interface). Incoming Layer 3 packets from the PON manager are sent to the host path of the Packet Forwarding Engine. From the host path, the packets are sent over the Layer 3 connection.

Step-by-Step Procedure

The following example requires you to navigate various levels in the configuration hierarchy. For information about navigating the CLI, see the CLI User Guide.

To configure Layer 3 interfaces on the ACX5448 router:

1. Configure Layer 3 interfaces to enable PON Manager communication.

```
user@host#set interfaces xe-0/0/38 unit 0 family inet address 192.168.1.1/24
```

2. Configure the static route and next hop to reach the PON manager.

```
user@host#set routing-options autonomous-system 69
user@host#set routing-options static route 192.168.10.3/32 next-hop 192.168.1.2
```

Configure the PON Controller

To configure the PON controller, you must:

- Configure the management VLAN on the port where the 10GbE OLT SFP+ transceiver is inserted.
- Configure the Layer 3 path to reach the external PON manager.
- Configure VLAN ID, TPID, IP address, destination port, and username and password.
- Configure certificate-path, the path to the certificate file copied to the router at the **/var/tmp/** directory. The certificate file must be of the file format **.pem**. For information on creating certificate files, see MicroClimate™ Management System [MCMS] Installation Guide.

Step-by-Step Procedure

The following example requires you to navigate various levels in the configuration hierarchy. For information about navigating the CLI, see the CLI User Guide.

To configure the PON controller on the ACX5448 router:

1. Configure the management VLAN.

```
user@host#set chassis pon-controller vlan 0x8100.4090
```

2. Configure the Layer 3 path to reach the PON manager by setting the IP address, username, and password.

```
user@host#set chassis pon-controller manager ip-address 192.168.1.10
user@host#set chassis pon-controller manager destination-port 27017
```

```
user@host#set chassis pon-controller manager secure-connection username <username>
user@host#set chassis pon-controller manager secure-connection password <password>
```

NOTE: Use the username and password that is configured on the PON manager for authentication for a secure connection.

3. Configure certificate-path, the path to the certificate file copied to the router. The certificate file must be of the file format **.pem**: For example, **pon-certificate.pem**.

```
user@host#set chassis pon-controller manager secure-connection certificate-path /var/tmp/pon-certificate.pem
user@host#set chassis pon-controller manager secure-connection auth-db tibit_users
user@host#set chassis pon-controller manager secure-connection db-name tibit_pon_controller
```

Configure the Operations Script

You can use the operations script (**show-pon.py**) to check the status of the PON controller and OLTs.

Step-by-Step Procedure

The following example requires you to navigate various levels in the configuration hierarchy. For information about navigating the CLI, see the CLI User Guide.

To configure the operations script, you must:

1. Generate a sha-256 checksum string on the **show-pon.pyc** file.

```
user@host#file checksum sha-256 /var/db/scripts/op/show-pon.pyc
```

NOTE: The operations script (**show-pon.pyc**) is placed at the**/var/db/scripts/op/** directory path.

2. Configure the operations script (**show-pon.pyc**) using the following command:

```
user@host#set system scripts op file show-pon.pyc command show-pon checksum sha-256
<sha256_string>
```

NOTE: Replace <sha256_string> with the actual sha-256 checksum string.

Verification

IN THIS SECTION

Verify the OLT Interfaces

IN THIS SECTION

Purpose

Verify that the OLT interfaces are identified by the Junos OS running on the ACX5448 router.

Action

From operational mode, run the `show chassis hardware` CLI command.

```
Hardware inventory:
Item             Version  Part number  Serial number     Description
Chassis                                XM3620440051      ACX5448-M
Midplane         REV 09   650-092523   XM3620440051      ACX5448-M
PEM 0            REV 05   740-053352   1GD1A131368       JPSU-850W-AC-AFO
PEM 1            REV 05   740-053352   1GD1A131366       JPSU-850W-AC-AFO
Routing Engine 0          BUILTIN      BUILTIN           RE-ACX-5448
DFEB
FPC 0                     BUILTIN      BUILTIN           FPC BUILTIN
  MIC 0                                                  44x1GE/44x10GE MACSEC
    PIC 0                 BUILTIN      BUILTIN           44x1GE/44x10GE MACSEC
      Xcvr 0      REV 01   740-117808   OLT-E8B470700BA6  SFP+-10G-PON-OLT-10KM
```

Meaning

In the `show chassis hardware` output, you can see the OLT interface **Xcvr** is identified.

Verify the Status of the PON Controller

IN THIS SECTION

Purpose

Verify the status of the PON controller.

Action

From operational mode, run the operations script `op show-pon` CLI command.

```
Current Time: 2021-08-18 19:20:43 UTC
PON-Controller Status: Active
Configured Local State: Enabled
Control Plane Interface: em4, Enabled, Physical link is Up
Last known PON-Controller State:
    "Alarm": {
        "0-EMERG": [],
        "1-ALERT": [],
        "2-CRIT": [],
        "3-ERROR": [],
        "4-WARNING": [],
        "5-NOTICE": [],
        "6-INFO": [],
        "7-DEBUG": []
    "CNTL": {
        "Start Time": "2021-08-18 19:14:41.684880",
        "Version": "R2.0.4"
    },
    "System Status": {
        "e8:b4:70:70:00:1e": {
            "Port": "xe-0/0/2",
            "OLT State": "Unspecified",
            "ONU Active Count": 0,
            "ONUs": {}
        },
        "e8:b4:70:70:02:36": {
            "Port": "xe-0/0/40",
            "OLT State": "Unspecified",
            "ONU Active Count": 0,
            "ONUs": {}
        }
    },
    "Time": "2021-08-18 19:20:39.741646",
    "_id": "44:ec:ce:20:2f:b9"
}
```

Meaning

In the `op show-pon` output, you can see the PON controller status as **Active**.

Verify the PON Controller Output Log

IN THIS SECTION

Purpose

Verify the PON controller output log (**stdout.log**) for any failures or state changes.

Action

From operational mode, run the `show log /var/log/isfpjad.child.stdout.log` command.

```
Jun 16 23:11:17 host newsyslog[92927]: logfile turned over due to size>20480K
2021-06-16 23:11:17.514 INFO     PonCntl      ***** Main Loop Starting for 44:ec:ce:20:2f:b9
*****
2021-06-16 23:11:17.515 INFO     PonCntl      Running PON Controller Version: R2.0.4
2021-06-16 23:11:17.754 INFO     TAPI         Discovering UMT Topology for 3 seconds...
2021-06-16 23:11:21.479 INFO     PonCntl      >>> OLT e8:b4:70:70:00:1e  (Existing)
2021-06-16 23:11:21.481 INFO     PonCntl      >>> OLT e8:b4:70:70:00:1e  Loop Starting
2021-06-16 23:11:21.481 INFO     PonCntl      >>> OLT e8:b4:70:70:02:36  (Existing)
2021-06-16 23:11:21.482 INFO     PonCntl      >>> OLT e8:b4:70:70:02:36  Loop Starting
2021-06-16 23:11:23.599 INFO     PonCntl      >>> OLT e8:b4:70:70:00:1e  Loop Ending
(0:00:02.118161)
2021-06-16 23:11:23.599 INFO     PonCntl      >>> OLT e8:b4:70:70:02:36  Loop Ending
(0:00:02.117260)
PON-CNTL: System Status at end of Loop
{
    "e8:b4:70:70:00:1e": {
        "OLT State": "Unspecified",
        "ONU Active Count": 0,
```

```
        "ONUs": {}
    }
}
```

Meaning

In the PON controller output log, you can view the version of the PON controller and the MAC addresses of the OLTs connected to the device. Logs from the PON controller are available at **/var/log/isfpjad.child.stdout.log**. You can monitor **/var/log/tibit/ponCntl.log** for any failures in the PON controller.