Subscriber Management

This chapter provides information about various types of subscriber sessions, namely IPoE and PPPoE, and IP addressing by DHCP. Also, on how the point-point frames are tunnelled across the network using the Layer 2 Tunneling Protocol.

Subscriber Session Overview

To enable subscribers to access the network resources, the network has to establish a session with the subscriber. A subscriber session represents the logical connection between the customer premise equipment (CPE) and the network resource. Each session establishment comprises the following phases:

- Establishing a connection—in this phase CPE finds the cnBNG with which to communicate.
- Authenticating and authorizing the subscriber—in this phase, cnBNG authenticates the subscribers and authorizes them to use the network. This phase is performed with the help of the RADIUS server.
- Giving the subscriber an identity—in this phase, the subscriber is assigned an identity, the IP address.
- Monitoring the session—in this phase, cnBNG ascertains that the session is up and running.

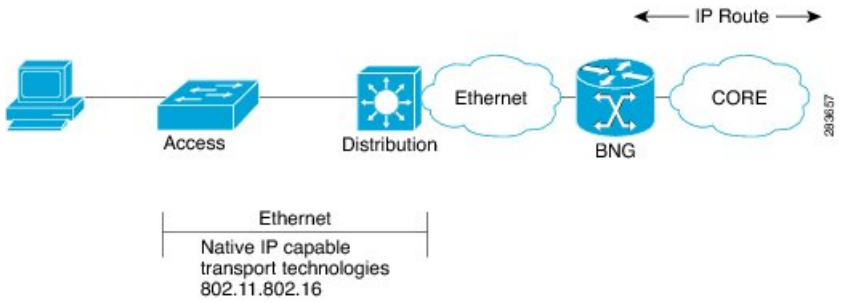
The subscriber sessions are established over the subscriber interfaces, which are virtual interfaces. It's possible to create only one interface for each subscriber session. A port can contain multiple VLANs, each of which can support multiple subscribers. cnBNG creates subscriber interfaces for each kind of session. These interfaces are named based on the parent interface, such as bundle-ether 2.100.pppoe312. The subscribers on bundle interfaces (or bundle-VLANs) allow redundancy and are managed on the cnBNG route processor (RP).

There are two mechanisms to establish a subscriber session, namely, IPoE and PPPoE.

IPoE Session

In an Internet over Ethernet (IPoE) subscriber session, subscribers run IPv4 or IPv6 on the CPE device and connect to the cnBNG through a Layer-2 aggregation. IP subscriber sessions that connect through a Layer-2 aggregation network are called L2-connected. IPoE subscriber sessions are always terminated on cnBNG and then routed into the service provider network. IPoE relies on DHCP to assign the IP address.

Figure 1: IPoE Session



cnBNG supports both DHCP v4 and DHCP v6 subscriber sessions.

Limitations

The following are the limitations:

- L3 routed subscribers are not supported.
- Geo redundancy or subscriber redundancy is not supported.
- Line card or physical port termination-based subscribers are not supported.

Configuration Example

```
Router#configure
Router(config)#interface Bundle-Ether1.1
Router(config-subif)#ipv4 point-to-point
Router(config-subif)#ipv4 unnumbered Loopback1
Router(config-subif)#ipv6 enable
Router(config-subif)#encapsulation dot1q 1
Router(config-subif)#ipsubscriber
Router(config-cnbng-nal-ipsub)#ipv4 l2-connected
Router(config-cnbng-nal-ipsub-l2conn)#initiator dhcp
Router(config-cnbng-nal-ipsub-l2conn)#exit
Router(config-cnbng-nal-ipsub)#ipv6 l2-connected
Router(config-cnbng-nal-ipsub-ipv6-l2conn)#initiator dhcp
Router(config-cnbng-nal-ipsub-ipv6-l2conn)#commit
```

Running Configuration

```
Router#show running-config interface be1.1
interface Bundle-Ether1.1
 ipv4 point-to-point
 ipv4 unnumbered Loopback1
 ipv6 enable
```

```
encapsulation dot1q 1
ipsubscriber
 ipv4 l2-connected
  initiator dhcp
 !
 ipv6 l2-connected
  initiator dhcp
 !
!
```

PPP over Ethernet (PPPoE)

The Point-to-Point Protocol (PPP) is used for communications between two nodes, like a client and a server. The PPP provides a standard method for transporting multiprotocol datagrams over point-to-point links. It defines an encapsulation scheme, a link layer control protocol (LCP), and a set of network control protocols (NCPs) for different network protocols that can be transmitted over the PPP link.

One of the methods to establish PPP connection is by the use of PPPoE. In a PPPoE session, the PPP protocol runs between the CPE and cnBNG. The Home Gateway (which is part of the CPE) adds a PPP header (encapsulation) that is terminated at the cnBNG.

PPPoE Discovery

The PPPoE discovery-stage protocol consists of basic packet exchange between the subscriber and server (cnBNG). The following is the list of the various PPPoE Active Discovery (PAD) messages:

- PPPoE Active Discovery Initiation (PADI)—The CPE broadcasts to initiate the process to discover cnBNG.
- PPPoE Active Discovery Offer (PADO)—The cnBNG responds with an offer.
- PPPoE Active Discovery Request (PADR)—The CPE requests to establish a connection.
- PPPoE Active Discovery Session confirmation (PADS)—cnBNG accepts the request and responds by assigning a session identifier (Session-ID).
- PPPoE Active Discovery Termination (PADT)—Either CPE or cnBNG terminates the session.

PPoE Sessions

The PPPoE sessions are of the following types:

- PPPoE PPP Terminated sessions Terminated (PTA)
- PPPoE L2TP Access Concentrator Sessions (LAC)
- L2TP Network Server Sessions (LNS)

Majority of the digital subscriber line (DSL) broadband deployments use Point-to-Point Protocol over Ethernet (PPPoE) sessions to provide subscriber services. These sessions terminate the Point-to-Point Protocol (PPP) link and provide all the features, service, and billing on the same node. These sessions are called PPP Terminated (PTA) sessions. See PPPoE PPP Terminated and Aggregation Sessions (PPPoE-PTA), on page 4.

There are some wireline subscriber deployments in the wholesale retail model where ISPs work with others to provide the access and core services separately. In such cases, the subscribers are tunneled between wholesale

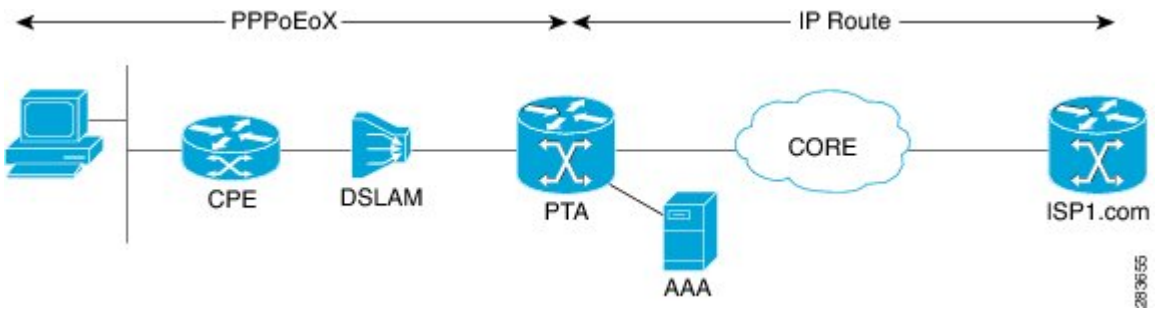
and retail ISPs using the Layer 2 Tunneling Protocol (L2TP), a client-server protocol. See L2TP Access Concentrator Sessions (LAC), on page 5 and L2TP Network Server Sessions (LNS), on page 10.

Note For the functioning of PPP PTA and PPP LAC session, the RADIUS server must be set up to authenticate and forward sessions as necessary. There's no local authentication available on cnBNG.

PPPoE PPP Terminated and Aggregation Sessions (PPPoE-PTA)

In a PPPoE-PPP Termination and Aggregation (PTA) session, the PPP encapsulation is terminated on cnBNG. After it's terminated, cNBNG routes the traffic to the service provider using IP routing. A typical PTA session is depicted in this figure.

Figure 2: PPPoE-PTA Session



PPPoE session configuration information is contained in PPPoE profiles. After a profile is defined, it's assigned to an access interface. Multiple PPPoE profiles can be created and assigned to multiple interfaces. A global PPPoE profile can also be created; the global profile serves as the default profile for any interface that has not been assigned a specific PPPoE profile.

The PPP PTA session is typically used in the Network Service Provider (retail) model where the same service operator provides the broadband connection to the subscriber and also manages the network services.

Limitations

The following are the limitations:

- L3 routed subscribers are not supported.
- Geo redundancy or subscriber redundancy is not supported.
- Line card or physical port termination-based subscribers aren't supported.

Configure PPPoE-PTA Session

The following section describes the steps to configure PPPoE-PTA sessions:

- Configure the access-interface
- Enable PPPoE

Configuration Example

```
Router#configure
Router(config)#interface Bundle-Ether1.1
Router(config-subif)#ipv4 point-to-point
Router(config-subif)#ipv4 unnumbered Loopback1
Router(config-subif)#ipv6 enable
Router(config-subif)#encapsulation dot1q 1

/* Enable PPPoE */
Router(config-subif)#pppoe enable
Router(config-subif)#commit
```

Running Configuration

```
Router#show running-config interface be1.1
interface Bundle-Ether1.1
 ipv4 point-to-point
 ipv4 unnumbered Loopback1
 ipv6 enable
 encapsulation dot1q 1

 pppoe enable
!
```

L2TP Access Concentrator Sessions (LAC)

Table 1: Feature History Table

Feature Name	Release Information	Feature Description
Enable LAC on Cloud Native BNG	Release 25.2.1	You can now enable the cloud-native BNG user plane to act as an L2TP Access Concentrator (LAC) on these Cisco ASR 9000 5th Generation High-Density Ethernet line cards and fixed routers, facilitating the tunneling of point-to-point frames between a remote system or LAC client and an LNS. • A99-32X100GE-X-SE • A9K-20HG-FLEX-SE • A9K-8HG-FLEX-SE • A9K-4HG-FLEX-SE • Cisco ASR 9902 Router • Cisco ASR 9903 Router

Feature Name	Release Information	Feature Description
Enable LAC on Cloud Native BNG	Release 7.4.2	This feature enables the cloud native BNG user plane to become an L2TP access concentrator (LAC), allowing you to tunnel point-to-point frames between the remote system or LAC client and an LNS located at a wholesaler. This functionality provides highly flexible deployments options to suit different customer use-cases and needs. To enable this feature, use the **l2tp enable** command.

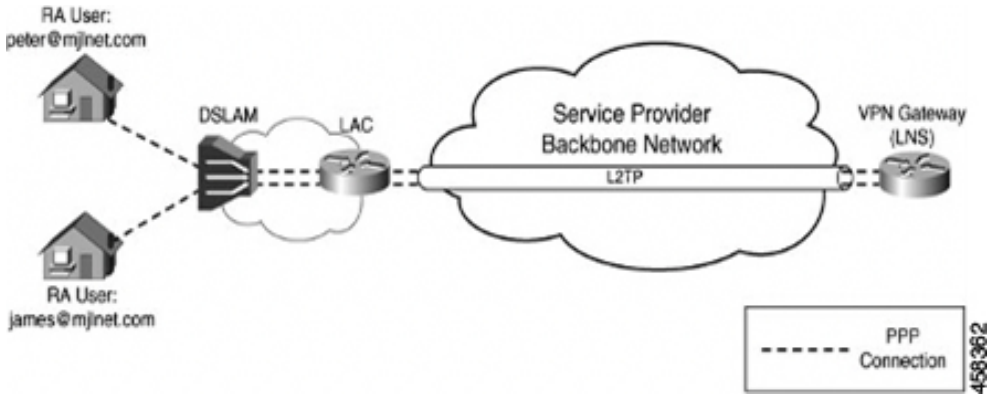
L2TP encapsulates and tunnels the PPP Layer 2 frames through a Layer 3 network. With L2TP, you can have a layer 2 connection to an access concentrator. The concentrator then tunnels individual PPP frames to the Network Access Server (NAS). This allows the processing of PPP packets on different devices. L2TP can be used to make all multilink channels terminate at a single NAS. Thus-allowing multilink operation even when the calls are spread across distinct physical NASs.

In cnBNG, L2TP uses the following two components to perform the hand-off task of the subscriber traffic to the Internet service provider (ISP).

- L2TP Access Concentrator (LAC)—The L2TP enables subscribers to dial into the LAC, which extends the PPP session to the LNS. cnBNG provides LAC.
- L2TP Network Server (LNS)—The L2TP extends PPP sessions over an arbitrary network to a remote network server that is, the LNS. The ISP provides LNS.

The following image depicts the overall topology of LAC and LNS:

Figure 3: Topology of LAC and LNS



The remote user initiates a PPP connection across the cloud to a LAC. The LAC acts as a client and then tunnels the PPP connection across the Internet to an LNS that acts as a server.

L2TP utilizes two types of messages, control messages and data messages. Control messages are used in the establishment, maintenance, and clearing of tunnels and calls. Data messages are used to encapsulate PPP frames over the tunnel.

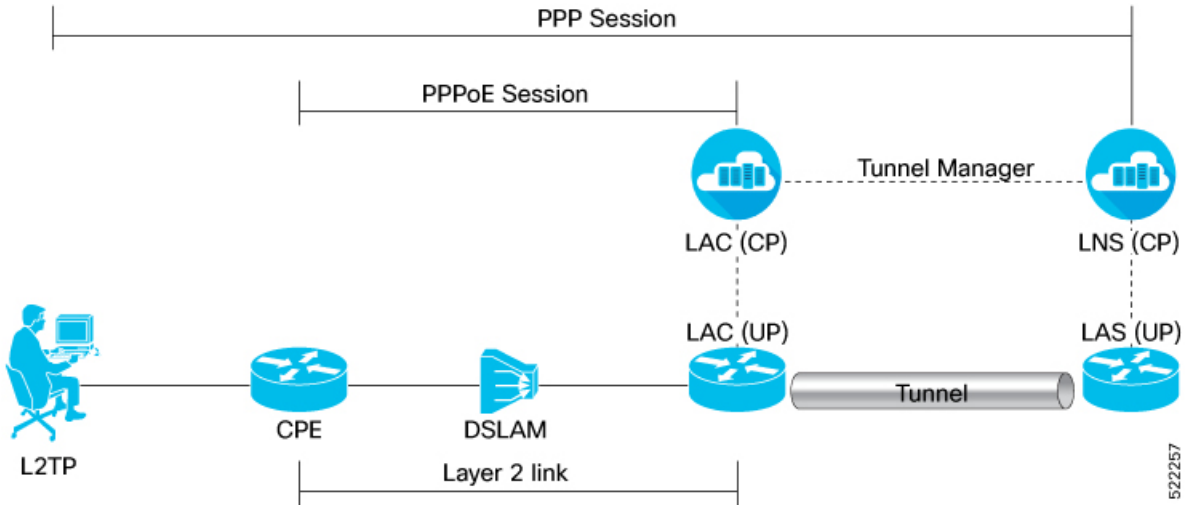
```
+--------------------+
| PPP Frames         |
```

```
+--------------------+    +-----------------------+
| L2TP Data Messages|    | L2TP Control Messages |
+--------------------+    +-----------------------+
| L2TP Data Channel |    | L2TP Control Channel  |
| (unreliable)      |    | (reliable)            |
+-------------------------------------------------+
|      Packet Transport (UDP, FR, ATM)      |
+-------------------------------------------------+
```

PPP frames are passed over an unreliable data channel that is encapsulated first by an L2TP header. Then a Packet Transport such as UDP. Control messages are sent over a reliable L2TP Control Channel, which transmits packets in-band over the same Packet Transport.

During a PPP LAC session, the PPPoE encapsulation terminates on cnBNG; however, the PPP packets travel beyond cnBNG to LNS through the L2TP tunnel. A typical LAC session is depicted in the following figure.

Figure 4: LAC Session



Both LAC and LNS sessions use L2TP protocol for negotiation and creation of L2TP sessions.

For more information on the LAC high-level work flow, see the *L2TP Subscriber Management* chapter in the *Cloud Native BNG Control Plane Configuration Guide*.

The PPP LAC session is used in the wholesaler model, where the network service provider is a separate entity from the local access network provider. In this kind of setup, the access network provider owns the LAC and the network service provider owns the LNS.

- Network service provider performs access authentication, manage and provide IP addresses to subscribers, and are responsible for overall service.
- The access network prover is responsible for providing the last-mile digital connectivity to the customer, and for passing on the subscriber traffic to the service provider.

Limitations for LAC Sessions

The following are the limitations for the LAC sessions:

- Tunnel specific statistics are not supported.

- LAC and LNS cannot coexist on the same node.
- IPv6 L2TP tunnel is not supported.
- L2TP tunnel keep alive or hello packet offload is not supported.
- Setting of type of service is not supported.
- Multicast group is not supported.
- L2TP packet segmentation or reassemble is not supported.
- The following features aren't supported:
  - Access Control List (ACL)
  - Quality of Service (QoS)
  - Policy-based Routing (PBR)
  - Unicast Reverse Path Forwarding (uRPF)
  - ICMP unreachable

Configure LAC Sessions

This section describes how to configure the LAC session on the cnBNG user plane.

- Enable L2TP
- Establish PPPoE connection

Configuration Example

Enable L2TP:

```
Router#configure
Router(config)#cnbng-nal location 0/1/CPU0

Router(config-cnbng-nal-local)#hostidentifier RTR1

Router(config-cnbng-nal-local)#up-server ipv4 192.0.2.1 gtp-port 15002 pfcp-port 15003
vrf default
Router(config-cnbng-nal-local)#cp-server primary ipv4 198.51.100.1

Router(config-cnbng-nal-local)#enable-test-server

Router(config-cnbng-nal-local)#disconnect-history file-logging-enable

Router(config-cnbng-nal-local)#cp-association retry-count 5

Router(config-cnbng-nal-local)#l2tp enable

Router(config-cnbng-nal-local)#l2tp-tcp-mss-adjust 1400
```

Establish PPPoE connection:

```
Router(config-cnbng-nal-local)#interface Bundle-Ether1.1
```

```
Router(config-subif)#ipv4 address 192.11.1.1 255.255.255.0

Router(config-subif)#ipv6 enable

Router(config-subif)#encapsulation dot1q 1

Router(config-subif)#ppoe enable
Router(config-subif)#commit
Router(config-subif)#exit
Router(config)#exit
```

Running Configuration

```
Router#show running-config

cnbng-nal location preconfigure 0/1/CPU0
 l2tp-tcp-mss-adjust 1400
 hostidentifier RTR1
 up-server ipv4 192.0.2.1 gtp-port 15002 pfcp-port 15003 vrf default
 cp-server primary ipv4 198.51.100.1
 disconnect-history file-logging-enable
 cp-association retry-count 5
 l2tp enable
 enable-test-server
!
interface Bundle-Ether1
!
interface Bundle-Ether1.1
 ipv4 address 192.11.1.1 255.255.255.0
 ipv6 enable
 encapsulation dot1q 1
 pppoe enable
!
```

L2TP Network Server Sessions (LNS)

Table 2: Feature History Table

Feature Name	Release Information	Feature Description
Enable LNS on Cloud Native BNG	Release 25.2.1	You can now enable the cloud-native BNG (cnBNG) to act as an L2TP Network Server (LNS), allowing the termination of tunnels or subscriber sessions initiated by the LAC client on the following Cisco ASR 9000 5th Generation High-Density Ethernet line cards: • A99-32X100GE-X-SE • A9K-20HG-FLEX-SE • A9K-8HG-FLEX-SE • A9K-4HG-FLEX-SE This feature is also supported on these fixed routers: • Cisco ASR 9902 Router • Cisco ASR 9903 Router
Enable LNS on Cloud Native BNG	Release 7.4.2	This feature enables cloud native BNG (cnBNG) to act as an L2TP Network Server (LNS) located at the wholesaler and allows you to terminate the tunnel or the subscriber sessions initiated by the LAC client. The cnBNG LNS solution offers control and user plane separation (CUPS) and cloud-native advantages for next-generation subscriber services in operator networks where subscribers connect directly to a retailer. To enable this feature, use the **lns enable** command.

L2TP Network Server (LNS) resides at one end of an L2TP tunnel and acts as a peer to the LAC. An LNS acts like an L2TP server that terminates the incoming tunnel from the L2TP LAC. An LNS is the logical termination point of the PPP session that is being tunneled from the client by the LAC.

LNS sessions are similar to PTA sessions in the overall functionality. Instead of the PPPoE protocol, here the First-Sign-Of-Life (FSOL) packets are the L2TP Incoming-Call-Request (ICRQ) messages.

For more information on the LNS high-level workflow, see the *L2TP Subscriber Management* chapter in the *Cloud Native BNG Control Plane Configuration Guide*.

Limitations for LNS Sessions

The following are the limitations for the LNS sessions:

- IPv6 L2TP tunnel is not supported.
- L2TP tunnel keep alive or hello packet offload is not supported.
- Tunnel statistics are not supported.
- Termination on non bundle-ether is not supported (for example, PWHE, physical interface).
- Termination of the VLAN interface is not supported.
- Supports parent interface only and not subinterface.
- L2TP packet segmentation or reassemble is not supported.
- Parent interface SVLAN policy must be different for other interfaces on the chassis.
- The following features are not supported:
  - Unicast Reverse Path Forwarding (uRPF)
  - Lawful Intercept (LI)

Configure LNS Sessions

This section describes how to configure the LNS session on the cnBNG user plane.

Configuration Example

To enable L2TP:

```
Router#configure
Router(config)#cnbng-nal location 0/0/CPU0
Router(config-cnbng-nal-local)#hostidentifier RTR1
Router(config-cnbng-nal-local)#up-server ipv4 192.0.2.1 gtp-port 15002 pfcp-port 15003
vrf default
Router(config-cnbng-nal-local)#cp-server primary ipv4 198.51.100.1
Router(config-cnbng-nal-local)#enable-test-server
Router(config-cnbng-nal-local)#disconnect-history file-logging-enable
Router(config-cnbng-nal-local)#cp-association retry-count 5
Router(config-cnbng-nal-local)#l2tp enable << Enble L2TP
Router(config-cnbng-nal-local)#commit
Router(config-cnbng-nal-local)#exit
Router(config)#
```

To establish the LNS session:

```
Router(config)#interface bundle-ether 1.1
Router(config-subif)#service-policy output SVLAN subscriber-parent subscriber-group
resourceid 4 << To allow maximum capacicty on the linecard
Router(config-subif)#ipv4 address 192.5.1.1 255.255.255.0
Router(config-subif)#ipv6 enable
```

```
Router(config-subif)#lns enable << Establish LNS session
Router(config-subif)#commit
Router(config-subif)#exit
```

Note To allow maximum capacity on the linecard, we recommend you to use the **service-policy output SVLAN subscriber-parent subscriber-group resourceid** command in the main interface.

Running Configuration

```
Router#show running-config

cnbng-nal location preconfigure 0/0/CPU0
 hostidentifier RTR1
 up-server ipv4 192.0.2.1 gtp-port 15002 pfcp-port 15003 vrf default
 cp-server primary ipv4 198.51.100.1
 disconnect-history file-logging-enable
 cp-association retry-count 5
 l2tp enable
 enable-test-server
!
interface Bundle-Ether1.1
 service-policy output SVLAN subscriber-parent subscriber-group resourceid 4
 ipv4 address 192.11.1.1 255.255.255.0
 ipv6 enable
 lns enable
!
```

Enable SLAAC for PPPoE Subscriber Sessions

The PPPoE support for SLAAC is a network protocol functionality that

- enables the use of the Point-to-Point Protocol over Ethernet (PPPoE) to establish network connections,
- facilitates Stateless Address Autoconfiguration (SLAAC) for IPv6 addresses,
- allows seamless integration of IPv6 address configuration in PPPoE environments, and
- allows networks to function without requiring a DHCPv6 server, as periodic Router Advertisements (RA) inform hosts of the active prefixes on a link.

Table 3: Feature History Table

Feature Name	Release Information	Feature Description
Enable SLAAC for PPPoE Subscriber Sessions	Release 24.4.1	You can achieve seamless connectivity for Customer Premise Equipment (CPEs) using Stateless Address Auto-Configuration (SLAAC) with PPPoE for IPv6 address assignment. This method enables CPEs to automatically configure IPv6 addresses without relying on a DHCP server. By leveraging SLAAC, devices can self-assign addresses based on the IPv6 prefix from the router, simplifying address configuration and reducing administrative overhead. Previously, PPPoE only supported DHCPv6 for IPv6 address assignment. The feature introduces these changes: **CLI:** • **slaac** **YANG Data Models:** • `Cisco-IOS-XR-ptp-cfg.yang` (see GitHub, YANG Data Models Navigator)

Key Concepts

- Point-to-Point Protocol over Ethernet (PPPoE): The PPPoE is a network protocol that encapsulates PPP frames inside Ethernet frames, enables multiple hosts on an Ethernet LAN to share a common internet connection while supporting IPv6 address configuration methods like DHCPv6 and SLAAC, and is often used by ISPs for authentication, session management, and scalable user connections. For more information on PPPoE, see PPP over Ethernet (PPPoE).
- Stateless Address Autoconfiguration (SLAAC): The SLAAC is an IPv6 stateless autoconfiguration mechanism that enables hosts to configure addresses autonomously without requiring manual intervention or additional servers, allows routers to broadcast prefixes that identify subnets, and permits hosts to create unique interface identifiers to form their addresses when combined with these prefixes.

SLAAC versus DHCPv6

SLAAC and DHCPv6 are two methods for assigning IPv6 IANA addresses to devices on a network. Although DHCPv6 support has been available for PPPoE, starting with Cisco IOS XR Release 24.4.1, we have now extended PPPoE support to include SLAAC.

Attributes	SLAAC (Stateless Address Autoconfiguration)	DHCPv6
Definition	Devices generate their own IPv6 addresses using a combination of locally available information and information advertised by routers. Routers send Router Advertisements (RAs) containing network prefix information.	A DHCPv6 server assigns IPv6 addresses and provides configuration information to devices on the network. It can also handle Prefix Delegation (PD) for distributing network prefixes.
Key Attributes	• No need for a dedicated server. • Minimal configuration required.	• Requires a dedicated DHCPv6 server. • Provides centralized control over IP address assignment.
Where used	• Small to medium-sized networks where ease of configuration is a priority. • Networks without a need for centralized control over IP address assignment.	• Large networks where centralized management of IP addresses is necessary. • Networks that need to use prefix delegation for hierarchical address distribution.

Configure SLAAC for PPPoE Subscriber Sessions

Configure SLAAC as the IPv6 address protocol with PPPoE to allow routers to generate their IPv6 addresses autonomously.

Procedure

Step 1 Enable SLAAC for PPPoE subscriber sessions on the access interface.

Example:

```
Router#configure
Router(config)#interface Bundle-Ether1.1
Router(config-subif)# service-policy output spd subscriber-parent resource-id 0
Router(config-subif)#ipv4 point-to-point
Router(config-subif)#ipv4 unnumbered Loopback1
Router(config-subif)#ipv6 enable
Router(config-subif)#encapsulation dot1q 1
Router(config-subif)# cnbng-nal ipv6 nd
Router(config-cnbng-nal)# ra-initial 0 16
```

```
Router(config-cnbng-nal-ra)# slaac
Router(config-cnbng-nal-ra)#exit
```

Step 2 Enable PPPoE on the access interface.

Example:

```
Router#configure
Router(config)#interface Bundle-Ether1.1
Router(config-subif)#pppoe enable
Router(config-subif)#commit
```

Step 3 Verify the configuration using the show run configuration.

Example:

```
Router#show run inter be1.1
interface Bundle-Ether1.1
 service-policy output spd subscriber-parent resource-id 0
 ipv4 point-to-point
 ipv4 unnumbered Loopback101
 ipv6 enable
 encapsulation dot1q 1
 cnbng-nal ipv6 nd
  ra-initial 0 16
  slaac
 !
 pppoe enable
!
```

Step 4 Once the subscribers are up, verify the IPv6 SLAAC prefix:

Example:

```
Router#show cnbng-nal subscriber all detail internal

=====================
Location: 0/RSP0/CPU0
=====================
Interface:                 Bundle-Ether1.1.pppoe2147483744
UPID:                      0x80000060
CPID:                      0x02239afc
Type:                      PPPoE
PPPOE Session Id:          00047194
PPP Params Info:
  Retry-count:             7
  Local-magic-number:      0xb6adb742
  peer-magic-number:       0xeac13140
  keep-alive-interval:     60
  MTU:                     0x000005dc
  Is-encap-string-ready:   TRUE
  Total KA Req Sent:       1550
  Total KA Resp Recv:      1550
  Total KA Req Recv:       0
  Total KA Resp Sent:      0
  PPP-flags:               0x00000000
IPv4 Address:              206.0.1.23
IPv4 Framed Route:
IPv6 IANA Address:         ::
IPv6 IAPD Prefix:          ::/0
IPv6 Slaac Prefix:         901:0:0:xxxx::/64
CPE link local Address:    ::
IPv6 Framed Route:
IPv4 State:                UP, Tue Oct 20 11:48:14 2024
IPv6 State:                UP, Tue Oct 20 11:48:14 2024
```

```
:
:
:
Attribute List: 0x55a6dfd0bc90
1:  ipv6-enable     len=  4  value= 1(1)
2:  nd-ra-initial   len=  3  value= 0.16
3:  nd-cnbng-ra-info len= 19  value= 901:0:0:xxxx::/64.1
4:  ip-vrf          len= 33  value= RJIL-VRF-OLT-MGMT
5:  inacl           len= 14  value= iACL_BNG_IPv4
6:  outacl          len= 14  value= iACL_BNG_IPv4
7:  ipv6_inacl      len= 14  value= iACL_BNG_IPv6
8:  ipv6_outacl     len= 14  value= iACL_BNG_IPv6
9:  strict-rpf      len=  4  value= 1(1)
10:  ipv6-strict-rpf len=  4  value= 1(1)
11:  ipv4-icmp-unreachable len=  4  value= 1(1)
12:  ipv6-unreachable len=  4  value= 1(1)
13:  ipv4-mtu        len=  4  value= 1492(5d4)
14:  ipv6-mtu        len=  4  value= 1492(5d4)
15:  ipv4-unnumbered len=  9  value= Loopback1
16:  sub-ipv4-gateway len= 12  value= 206.0.0.1/32
Last Transaction Result: SUCCESS
Session Accounting:        enabled
```

RADIUS-Based Policing - QoS shape-rate parameterization

RADIUS-Based Policing (RaBaPol) is a network management method that allows the activation of cnBNG subscriber services using customized parameters rather than default settings.

Table 4: Feature history

Feature Name	Release Information	Description
RADIUS-Based Policing - QoS shape-rate parameterization	Release 25.2.1	You can now dynamically manage your cnBNG subscriber services through RADIUS-based activation. With RADIUS-Based Policing (RaBaPol), you can customize service parameters, such as the QoS shape-rate, according to your requirements, giving you greater control over service management.

Parameterization of QoS shape-rate

RaBaPol supports the customization of the QoS shape-rate parameter. This parameter can be sent to the cnBNG Control Plane (CP) by the RADIUS server either during the initial connection setup as Cisco VSAs in an Access Accept message, or through Change of Authorization (CoA) messages.

Handling service changes and errors

If a service associated with a subscriber needs a change in the variable list, deactivate the current service using CoA Session-Disconnect and activate the updated service using CoA Session-Activate process. If an error occurs during feature activation, the cnBNG UP reverts all features and associated variable lists to their previous states.

Benefits of RADIUS-Based Policing

The RADIUS-Based Policing feature provides these benefits.

- **Dynamic activation**: Enables dynamic and flexible service activation based on RADIUS messages.
- **QoS customization**: Allows for the customization of QoS parameters to meet specific subscriber needs.
- **Policy merging**: Supports the merging of QoS policies from multiple dynamic templates for a subscriber.
- **Error rollback**: Provides rollback capabilities to previous states in case of errors during service activation.

Use case for QoS-based service activation

This use case illustrates how to manage and customize network QoS settings when a subscriber starts a session.

1. **Subscriber session initiation**: A user starts a session with specific credentials and settings, such as a username, password, and protocol type. For example,

```
user-cpe@abc.com         Password="abc"
            Framed-Protocol=PPP,
            Service-Type=Framed-User
              .....
               Cisco-avpair = "subscriber:sa=DEFAULT-QOS(shape-rate=120000)
```

2. **AAA server communication**: The Authentication, Authorization, and Accounting (AAA) server sends an Access-Accept message to the cnBNG. This message specifies the service name, action type, and a list of variables with their values, like the QoS shape-rate.
3. **Policy configuration**: The service name from the AAA message maps to a feature-template on the cnBNG's control plane, and the specified QoS shape-rate is used to override the default settings on the cnBNG's user plane. The policy merges these custom values with default values, retaining defaults where no specific values are provided.
4. **Service activation via CoA**: Alternatively, service activation can be achieved using CoA, which involves removing the old policy and configuring a new, merged policy in the hardware.

Limitations of configuring RADIUS-Based Policing

This limitation applies to the RADIUS-Based Policing feature:

- Service modifications with different RaBaPol configurations are not supported.

Configure QoS shape-rate parameterization

To establish QoS shape-rate parameterization, use the **shape average $var_name = value** command in the policy-map class configuration mode on the cnBNG User Plane (UP). This customization is feature-dependent and requires specific syntax and semantics. For QoS, a dollar sign ($) is added as a prefix to the **shape-rate** variable, and the default value, along with the variables, is configured in the policy-map definition.

Follow these steps to configure QoS shape-rate parameterization.

Procedure

Step 1 Define a feature template with the desired QoS configuration on the cnBNG CP.

Example:

```
config
 profile feature-template feature_template_name
  qos
      in-policy qos_input_policy_name
      out-policy qos_output_policy_name
      merge-level integer
   exit
 exit
```

This is a sample configuration.

```
config
  profile feature-template DEFAULT-QOS
    qos
     in-policy hqos-policy1
     out-policy hqos-policy2
     merge-level 10
   exit
  exit
```

Step 2 Configure the policy map with a shape-rate value, on the cnBNG UP.

Example:

```
config
 policy-map policy_map_name
    class class-default
       shape average $shape-rate =  rate (units)
    exit
    end-policy-map
 exit
```

This is a sample configuration.

```
config
  policy-map hqos-policy2
      class class-default
          shape average $shape-rate = 100000 kbps
      exit
      end-policy-map
  exit
```

This example enables QoS features for DEFAULT-QOS and configures the associated template with outgoing policies. The default value of shape-rate (the rate at which traffic is shaped) is set to 100000 kbps.

Step 3 Add the user profile to the USER file in the RADIUS server.

Example:

```
user-cpe@example.com         Password="abc"
              Framed-Protocol=PPP,
```

```
Service-Type=Framed-User
        .....
Cisco-avpair = "subscriber:sa=DEFAULT-QOS(shape-rate=120000)”
```

This specified QoS shape-rate value (for example, 120000) overrides the default value configured on the cnBNG UP.

Step 4 Use the **show subscriber session detail** command on the Control Plane to verify the configuration.

Example:

```
show subscriber session detail
```

```
subscriber-details
{
  "subResponses": [
    {
      "subLabel": "16777218",
      "mac": "cc11.0000.0001",
      "acct-sess-id": "01000002",
      "upf": "asr9k-1",
      "port-id": "Bundle-Ether1",
      "up-subs-id": "1",
      "sesstype": "ppp",
      "state": "established",
      "subCreateTime": "Fri, 15 Nov 2024 03:34:47 UTC",
      "pppAuditId": 3,
      "transId": "2",
      "subcfgInfo": {
      "activatedServices": [
          {
            "serviceName": "DEFAULT-QOS",
            "serviceAttrs": {
              "attrs": {
                "accounting-list": "automation-aaaprofile",
                "acct-interval": "900",
                "service-acct-enabled": "true",
                "service-parameters": "shape-rate=120000",
                "sub-qos-policy-in": "hqos-policy1",
                "sub-qos-policy-out": "hqos-policy2"
              }
} } ] } } ] }
```

Step 5 Use the **show policy-map applied interface** command on the User Plane to view sessions configured with RaBaPol.

Example:

```
bng# show policy-map applied interface Bundle-Ether1.1.pppoe100

Input policy-map applied to Bundle-Ether1.1.pppoe100:

  policy-map hqos-policy1
   class class-default
    police rate 200 kbps
    !
   !

Output policy-map applied to Bundle-Ether1.1.pppoe100:

  policy-map hqos-policy2
   class class-default
    shape average $shape-rate = 100000 kbps
   !
```

Shared Policy Instance

Shared Policy Instance (SPI) is a mechanism that enables the allocation of a single set of QoS resources to groups of cnBNG sub-interfaces and bundle sub-interfaces, and shares these resources across sub-interfaces, multiple Ethernet flow points (EFPs), or bundle interfaces.

Table 5: Feature history

Feature Name	Release Information	Description
Shared Policy Instance	Release 25.2.1	You can now allocate and share a single set of QoS resources across multiple cnBNG sub-interfaces and bundle sub-interfaces. By using a single QoS policy instance across multiple sub-interfaces, you can enable aggregate shaping to one rate, promoting streamlined bandwidth management.

Efficient QoS policy sharing across sub-interfaces: SPI allows you to share a single QoS policy instance among multiple sub-interfaces to maintain a unified rate through aggregate shaping. Sub-interfaces sharing the QoS policy must belong to the same physical interface. The number of sub-interfaces can range from two to the maximum supported by the port.

Limitations of configuring Shared Policy Instance

Session consistency within S-VLAN interface

Sessions sharing the same SPI must remain within the same S-VLAN interface.

Service accounting

Service accounting is not supported for services configured with an SPI.

SPI name change requirements

- If you modify the policy-map associated with an SPI, you must also change the SPI name.
- Avoid the following scenarios:
  - Applying a new policy with the same policy-map name but a different SPI name to a subscriber who already has an SPI policy applied. The system will reject this configuration.
  - Applying a new policy with a different policy-map name but the same SPI name. The system will reject this configuration as well.

CoA service-update request limitation

When a service policy with a user profile configuration that includes an SPI is enabled, you cannot simultaneously use an SPI in a CoA service-update request.

Configure Shared Policy Instance

To implement SPI, you must configure a complete hierarchical policy-map that includes both parent and child policies. The SPI name can be defined and linked to a feature template or downloaded from a RADIUS server.

There are two main ways to configure these policies:

- Using a feature template
- Using a RADIUS server

Configure a QoS policy with SPI using a feature template

Follow these steps to configure a QoS policy with shared policy instance in the input and output direction using a feature template.

Procedure

Step 1 Define a feature template on the Control Plane (CP) that includes the SPI configuration.

Example:

```
config
  profile feature-template feature_template_name
    qos
        in-policy qos_input_policy_name
          in-shared-policy-instance spi_name
        out-policy qos_output_policy_name
          out-shared-policy-instance spi_name
     exit
  exit
```

This is a sample configuration on the cnBNG CP.

```
config
   profile feature-template DEFAULT-QOS
      qos
         in-policy hqos-policy1
           in-shared-policy-instance spi1
         out-policy hqos-policy2
           out-shared-policy-instance spi2
     exit
  exit
```

Step 2 Configure traffic policing on the cnBNG UP to monitor the traffic rate and apply actions (such as dropping or remarking packets) when the traffic exceeds the allowed limit.

Example:

```
config
  policy-map policy_map_name
     class class-default
        police rate value
     exit
```

```
    end-policy-map
  exit
```

This is a sample configuration.

```
policy-map hqos-policy1
  class class-default
    police rate 1024 kbps
  exit
  end-policy-map
exit
```

Step 3 Configure traffic shaping for a specific interface on the cnBNG UP.

Example:

```
config
  policy-map policy_map_name
    class class-default
       shape average value
    exit
    end-policy-map
  exit
```

This is a sample configuration.

```
policy-map hqos-policy2
  class class-default
    shape average 4096 kbps
  exit
  end-policy-map
exit
```

Step 4 Use the **show subscriber session detail** command on the Control Plane to verify the configuration.

Example:

```
bng# show subscriber session detail
subscriber-details
{
  "subResponses": [
    {
      "subLabel": "16777220",
      "mac": "0011.9400.0001",
      "acct-sess-id": "01000004",
      "upf": "asr9k-1",
      "port-id": "Bundle-Ether1.1",
      "up-subs-id": "3",
      "sesstype": "ppp",
      "state": "established",
      "subCreateTime": "Fri, 15 Nov 2024 04:18:51 UTC",
      "pppAuditId": 3,
      "transId": "2",
      "subcfgInfo": {
        "committedAttrs": {
        "activatedServices": [
          {
            "serviceName": "DEFAULT-QOS",
            "serviceAttrs": {
              "attrs": {
                "accounting-list": "aaaprofile",
                "acct-interval": "900",
                "service-acct-enabled": "true",
```

```
        "sub-qos-policy-in": "hqos-policy1",
        "sub-qos-policy-out": "hqos-policy2",
        "sub-qos-spi-in": "spi1",
        "sub-qos-spi-out": "spi2"
      }
    } } ] } ] }
```

Configure a QoS policy with SPI using a RADIUS server

Follow these steps to configure a QoS policy with SPI using a RADIUS server.

Procedure

Step 1 Configure a policy map that can be shared to one or more interfaces to specify a service policy, on the cnBNG UP.

Example:

```
config
  policy-map policy_map_name1
      class class-default
         police rate value
      exit
      end-policy-map
  exit

policy-map policy_map_name2
      class class-default
         shape average value
      exit
      end-policy-map
  exit
```

This is a sample configuration.

```
config
  policy-map hqos-policy1
      class class-default
          police rate 1024 kbps
      !
      end-policy-map
  !
  policy-map hqos-policy2
      class class-default
          shape average 4096 kbps
      !
      end-policy-map
  !
```

Step 2 Add the QoS policy with the SPI name to the USER file in the RADIUS server.

Example:

```
abc@example.com Cleartext-Password:= "xyz"
cisco-avpair += "sub-qos-policy-in=hqos-policy1 shared-policy-instance spi1",
cisco-avpair += "sub-qos-policy-out=hqos-policy2 shared-policy-instance spi2",
```

Step 3 Use the **show subscriber session detail** command to verify the configuration of a subscriber with a user-profile that includes both QoS and SPI settings, on the cnBNG CP.

Example:

```
bng# show subscriber session detail
subscriber-details
      {
      "subResponses": [
      {
      "subLabel": "16777221",
      "mac": "cc11.0000.0001",
      "acct-sess-id": "01000005",
      "upf": "asr9k-1",
      "port-id": "Bundle-Ether1",
      "up-subs-id": "4",
      "sesstype": "ppp",
      "state": "established",
      "subCreateTime": "Fri, 15 Nov 2024 04:35:15 UTC",
      "pppAuditId": 3,
      "transId": "2",
      "subcfgInfo": {
        "committedAttrs": {
          "attrs": {
            "accounting-list": "aaaprofile",
            "acct-interval": "900",
            "addr-pool": "pool-ISP",
            "ppp-authentication": "pap,chap",
            "ppp-ipcp-reneg-ignore": "true",
            "ppp-ipv6cp-reneg-ignore": "true",
            "ppp-lcp-delay-seconds": "1",
            "ppp-lcp-reneg-ignore": "true",
            "service-type": "Framed(2)",
            "session-acct-enabled": "true",
            "sub-qos-policy-in": "hqos-policy1 shared-policy-instance spi1",
            "sub-qos-policy-out": "hqos-policy2 shared-policy-instance spi2",
            "vrf": "default"
          }
        } } } ] }
```

Step 4 Use the **show cnbng-nal subscriber all detail** command to display sessions with user-profile having QoS and SPI, on the cnBNG UP.

Example:

```
show cnbng-nal subscriber all detail
Interface:                Bundle-Ether1.1.pppoe4
UPID:                     0x00000004
CPID:                     0x01000005
Type:                     PPPoE
PPPOE Session Id:         00000006

Attribute List: 0x175d470
1:  ipv4-unnumbered len=  9  value= Loopback0
2:  sub-qos-policy-in len= 59  value= hqos-policy1 shared-policy-instance spi1
3:  sub-qos-policy-out len= 63  value= hqos-policy2 shared-policy-instance spi2
```