Establishing Subscriber Sessions

A subscriber accesses network resources through a logical connection known as subscriber session. This chapter provides information about various types of subscriber sessions, namely IPoE and PPPoE, and IP addressing by DHCP.

Table 1: Feature History for Establishing Subscriber Sessions

Release	Modification
Release 4.2.0	Initial release
Release 5.3.0	BNG Subscriber Templates feature was introduced.
Release 5.3.2	Support of Parameterized QoS (PQoS) feature for line card subscribers was added.
Release 5.3.1	Support of Geo Redundancy for PPPoE sessions was added.
Release 5.3.3	Option to prevent default ARP entry creation for a subscriber interface was introduced.
Release 6.0.1	IPv6 router advertisements on IPv4 subscriber interface is introduced.

This chapter covers these topics:

Subscriber Session Overview

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

Note

When packets arrive on an access interface, an attempt is made to link that packet to a subscriber context.

- For PPPoE sessions the Source MAC of the CPE, Access interface and PPPoE Session ID are used to match the remote peer to a subscriber interface.
- For IPoE sessions the Source MAC, Access interface and IP address are verified against the DHCP binding to find a matching subscriber interface.

If there is no match, the packet is mapped against the access (sub-)interface. Considering that the access interface in IPoE designs is IP enabled (eg via an IP-Unnumbered configuration) that packets are processed like regular IP. In order to secure your BNG access interface, you will want to apply either uRPF or an Access-List blocking everything but DHCP incoming on the access interface to limit remote subscribers for which we don't have an interface created from accessing network resources.

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

The subscribers are not configured directly on BNG. Instead, a framework is created on which subscriber features and subscriber sessions are started and stopped dynamically. The framework consists of control policies and dynamic templates, which perform these functions:

- Control policy determines the action BNG takes when specific events, such as receipt of a session start request, or failure of authentication, occurs. The action is determined by the class-map defined in the control policy. The action involves activating dynamic templates.
- Dynamic template contains a set of CLI commands that are applied to a subscriber session. Multiple dynamic templates can be activated, one at a time, on the same subscriber interface. Also, the same dynamic template can be activated on multiple subscriber interfaces through different control policies.

Service providers can deploy subscribers over VLAN in these ways:

- 1:1 VLAN model—This model depicts a scenario where one dedicated VLAN is available for each customer. Each VLAN is an q-in-q VLAN where the inner VLAN tag represents the subscriber and the outer VLAN tag represents the DSLAM.
- N:1 VLAN model—This model depicts a scenario where multiple subscribers are available on a shared VLAN. The VLAN tags represent the DSLAM or the aggregation device.

- Ambiguous VLANs —This model allows the operator to specify a large number of VLANs in a single CLI line. Using ambiguous VLAN, a range of inner or outer tags (or both) can be configured on a VLAN sub-interface. This is particularly useful for the 1:1 model, where every subscriber has a unique value for the set of VLAN tags. For more information about ambiguous VLANs, see Subscriber Session on Ambiguous VLANs.

The subscriber sessions are established over the subscriber interfaces, which are virtual interfaces. It is possible to create only one interface for each subscriber session. A port can contain multiple VLANs, each of which can support multiple subscribers. BNG 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 bundles (or bundle-VLANs) interfaces allow redundancy, and are managed on the BNG route processor (RP).

For details on subscriber session limit, see Subscriber Session Limit , on page 97.

To provide network redundancy and load balancing, the service provider can deploy multiple links between the DSLAM and the BNG. The individual links can be grouped into ether-bundles, including VLANs over ether-bundles, or link aggregation groups (LAGs). The subscriber sessions can be active on any link within the bundle or group. If a BNG is deployed in a LAG configuration, all traffic for one subscriber should be configured to traverse one link of the ether-bundle. Load-balancing is achieved by putting different subscribers on different links.

There are two mechanisms to establish a subscriber session, namely, IPoE and PPPoE. These are discussed next in the next topics.

Line card (LC) subscribers are supported in BNG. For details, see Line Card Subscribers, on page 93.

BNG supports interface based static sessions, where all traffic belonging to a particular VLAN sub-interface is treated as a single session. For details, see Static Sessions, on page 95.

Note

- If a **clear subscriber session all** command is issued with the intend to clear all the subscriber sessions and if a route processor fail over (RPFO) occurs while the session bring down is in progress, then it is recommended to re-run the same command post RPFO, to ensure all the remaining sessions, if any, are brought down.
- Do not add or delete any Virtual Routing and Forwarding (VRF) configuration when the subscriber sessions are being brought up or brought down. Otherwise, there can be issues while creating new subscriber sessions that can lead to system instability.
- With packet-triggered session initiator configured, new sessions (for subscriber session with already activated state or subscriber sessions which are duplicating the credentials of already activated subscribers) are attempted even before clearing the previous session. This happens while clearing a subscriber session (either using CoA or using **clear subscriber session** command) when the user is sending traffic. From Cisco IOS XR Software Release 5.2.2 and later, if a packet-triggered session gets to an error state (Access-Reject or feature programming error) during session establishment procedure, then a penalty of two minutes is applied to that subscriber. That is, BNG does not accept a new session from the same subscriber for a time period of two minutes. This avoids hogging of system resources by a DoS attack. The penalty remains the same if the session was cleared either using CoA or using clear subscriber session command. For IP-initiated sessions, the subscribers can disconnect either based on the idle timeout or based on the portal logout. For idle timeout scenario, the penalty does not have any impact, because the penalty is applicable only if the subscriber sends traffic while the session is being cleared. In a portal logout scenario, a CoA is triggered by the portal. If subscriber sends traffic when the CoA is received, then the two-minute penalty is applied to that subscriber; else there is no penalty.

  From Cisco IOS XR Software Release 5.3.0 and later, the penalty is reduced to 10 seconds only for scenarios where the previous session of the same subscriber is in **disconnecting** state. For other scenarios, the penalty remains as two minutes.

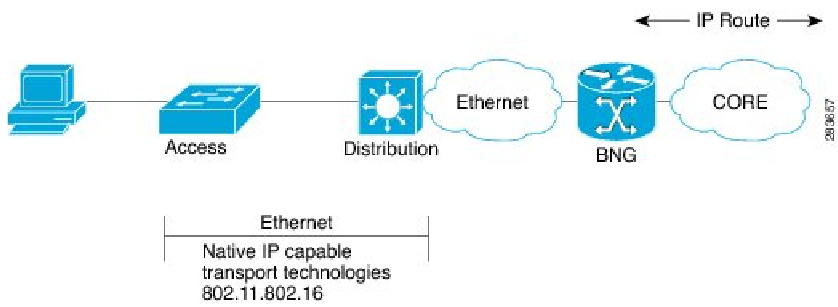
Restrictions

- If the subscriber's VRF is taken from the access interface's VRF value, then the VRF, configured in the dynamic template used by the subscriber, must match. If the two VRFs do not match, then the session would not work properly.
- ACL logging on BNG dynamic template is not supported.

Establishing IPoE Session

In an IPoE subscriber session, subscribers run IPv4 or IPv6 on the CPE device and connect to the BNG through a Layer-2 aggregation or Layer-3 routed network. IP subscriber sessions that connect through a Layer-2 aggregation network are called L2-connected and sessions that connect through routed access network are called L3-connected or routed subscriber sessions. IPoE subscriber sessions are always terminated on BNG and then routed into the service provider network. IPoE relies on DHCP to assign IP address. A typical IPoE session is depicted in the following figure.

Figure 1: IPoE Session



The process of provisioning an IPoE session involves:

- Enabling the processing of IPv4 or IPv6 protocol on an access interface. See Enabling IPv4 or IPv6 on an Access Interface, on page 6.

  Note For subscriber deployments, it is recommended that Dynamic ARP learning be disabled in the access-interface, using the **arp learning disable** command in the access-interface configuration mode.

- Creating dynamic template that contains the settings for the IPoE sessions. See Creating Dynamic Template for IPv4 or IPv6 Subscriber Session, on page 7.
- Creating policy-map to activate dynamic template. See Creating a Policy-Map to Run During IPoE Session, on page 9.
- Enabling IPoE subscriber creation on access interface by activating service-policy. The service-policy will apply the policy-map on the access interface. See Enabling IPoE Subscribers on an Access Interface, on page 10.

For details on routed subscriber sessions, see Routed Subscriber Sessions, on page 13.

BNG supports IPoE subscriber session-restart. For details, see Subscriber Session-Restart, on page 64.

To limit the default ARP entry creations, see Prevent Default ARP Entry Creation for a Subscriber Interface, on page 22.

Note If an access interface in BNG is configured to support only packet (PKT) triggered sessions, or both DHCP and PKT triggered sessions, then a burst of traffic with unique flows can affect the BNG router in terms of processing each packet to determine if it is an IPoE (PKT triggered) packet. New subscriber sessions cannot be established in these scenarios and this can in turn lead to system instability. Therefore, it is mandatory to configure static lpts policer for **unclassified rsp** protocol, on each of the line cards (LCs), such that the traffic rate does not exceed 150 pps per LC. The rate configured is applied at network processor (NP). Therefore, for an LC with 4 NPs, the rate should be configured as 38 (150/4), to achieve a traffic rate of 150 pps. For example, `lpts punt police location 0/RSP0/CPU0 protocol unclassified rsp rate 38`.

Restrictions

Enabling IPoE subscribers on an access-interface is subjected to a restriction that packet-triggered L2 sessions (**initiator unclassified-source**) are not supported for IPv6.

Enabling IPv4 or IPv6 on an Access Interface

Perform these tasks to enable IPv4 and IPv6 processing on an access interface. In this example, the IPv4 is being provisioned on an unnumbered bundle-interface.

SUMMARY STEPS

1. **configure**
2. **interface** *type* *interface-path-id*
3. **arp learning disable**
4. **ipv4 unnumbered** *interface-type* *interface-instance*
5. **ipv6 enable**
6. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**interface** *type* *interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config)# interface Bundle-Ether100.10`	Enters interface configuration mode for the bundle-interface.
Step 3	**arp learning disable** **Example:** `RP/0/RSP0/CPU0:router(config-if)# arp learning disable`	Disables arp learning for the access-interface.
Step 4	**ipv4 unnumbered** *interface-type* *interface-instance* **Example:** `RP/0/RSP0/CPU0:router(config-if)# ipv4 unnumbered loopback 5`	Enables IPv4 processing on a unnumbered interface without assigning an explicit IPv4 address to that interface. Instead, the IP address is borrowed from the loopback interface. For the "ipv4 unnumbered" command, you must specify another interface in the same router that has been assigned an IP address and whose status is displayed as “up” for the **show interfaces** command.
Step 5	**ipv6 enable** **Example:** `RP/0/RSP0/CPU0:router(config-if)# ipv6 enable`	Enables IPv6 processing on an unnumbered interface that has not been assigned an explicit IPv6 address. **Note** This step not only enables IPv6 processing on the interface, but also assigns an IPv6 link-local unicast address to it.

	Command or Action	Purpose
Step 6	**commit**	

Enabling IPv4 or IPv6on an Access Interface: Examples

```
//Enabling IPv4 on an Access Interface

configure
interface Bundle-Ether100.10
arp learning disable
ipv4 unnumbered loopback 5
!
!
end


//Enabling IPv6 on an Access Interface

configure
interface Bundle-Ether100.10
arp learning disable
ipv6 enable
!
!
end
```

Creating Dynamic Template for IPv4 or IPv6 Subscriber Session

Perform this task to create a dynamic template for IPv4 or IPv6 subscriber session. As an example, in this dynamic template you will specify the MTU value for the IPv4 or IPv6 session and enable uRPF. The uRPF ensures that the traffic from malformed or forged IPv4 source addresses are not accepted on the subscriber interface. For more information about uRPF feature, see uRPF.

SUMMARY STEPS

1. **configure**
2. **dynamic-template**
3. **type** { **ipsubscriber** | **ppp** | **service** } *dynamic-template-name*
4. **timeout idle** *value* [**threshold** *duration*] [**traffic** {**both** | **inbound** | **outbound**}]
5. **accounting aaa list default type session periodic-interval** *value* **dual-stack-delay** *value*
6. {**ipv4** | **ipv6**} **mtu** *mtu-bytes*
7. {**ipv4** | **ipv6**}**verify unicast source reachable-via rx**
8. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	

	Command or Action	Purpose
Step 2	**dynamic-template** **Example:** `RP/0/RSP0/CPU0:router(config)# dynamic-template`	Enters the dynamic-template configuration mode.
Step 3	**type** { **ipsubscriber** | **ppp** | **service** } *dynamic-template-name* **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template)# type ipsubscriber ipsub1`	Creates a dynamic-template with an user-defined name for IP subscriber.
Step 4	**timeout idle** *value* [**threshold** *duration*] [**traffic** {**both** | **inbound** | **outbound**}] **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template-type)# timeout idle 600 threshold 2 traffic both`	IPv4 or IPv6 or Dual-stack Subscribers support idle timeout feature. **Note** You can configure a **monitor** action under the idle timeout event for a subscriber policy, to prevent the termination of subscriber sessions when the idle timeout period expires.
Step 5	**accounting aaa list default type session periodic-interval** *value* **dual-stack-delay** *value* **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template)# accounting aaa list default type session periodic-interval 60 dual-stack-delay 1`	Configures the subscriber accounting feature.

Step 6	{**ipv4** | **ipv6**} **mtu** *mtu-bytes*
	Example:
	`RP/0/RSP0/CPU0:router(config-dynamic-template-type)# ipv4 mtu 678`
	`RP/0/RSP0/CPU0:router(config-dynamic-template-type)# ipv6 mtu 548`
		Sets IPv4 or IPv6 maximum transmission unit (MTU). The range is from 68 to 65535 bytes. The MTU value defines the largest packet size that can be transmitted during the subscriber session.

Step 7	{**ipv4** | **ipv6**}**verify unicast source reachable-via rx**
	Example:
	`RP/0/RSP0/CPU0:router(config-dynamic-template-type)# ipv4 verify unicast source reachable-via rx`
	`RP/0/RSP0/CPU0:router(config-dynamic-template-type)# ipv6 verify unicast source reachable-via rx`
		Enables uRPF for packet validation that performs source address reachability check.

Step 8	**commit**	

Creating Dynamic Template for IPv4 or IPv6 Subscriber Session: Examples

```
//Creating Dynamic Template for IPv4 Subscriber Session

configure
dynamic-template
type ipsubscriber ipsub1
timeout idle 600
accounting aaa list default type session periodic-interval 60 dual-stack-delay 1
ipv4 mtu 678
ipv4 verify unicast source reachable-via rx
!
!
end
```

```
//Creating Dynamic Template for IPv6 Subscriber Session

configure
dynamic-template
type ipsubscriber ipsub1
timeout idle 600 threshold 2 traffic both
accounting aaa list default type session periodic-interval 60 dual-stack-delay 1
ipv6 mtu 678
ipv6 verify unicast source reachable-via rx
!
!
end
```

Creating a Policy-Map to Run During IPoE Session

Perform this task to create a policy-map that will activate a predefined dynamic-template during an IPoE subscriber session. As an example, this policy-map activates a dynamic template, and applies a locally defined authorization setting, during a session-start event.

SUMMARY STEPS

1. **configure**
2. **policy-map type control subscriber** *policy_name*
3. **event session-start match-first**
4. **class type control subscriber** *class_name* **do-until-failure**
5. *sequence_number* **activate dynamic-template** *dynamic-template_name*
6. *sequence_number* **authorize aaa list default format** *format_name* **password** *password*
7. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**policy-map type control subscriber** *policy_name* **Example:**	Creates a new policy map of the type "control subscriber" with the name "IPoE_policy".

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config)# policy-map type control subscriber IPoE_policy`	
Step 3	**event session-start match-first** **Example:** `RP/0/RSP0/CPU0:router(config-pmap)# event session-start match-first`	Defines an event (session start) for which actions will be performed.
Step 4	**class type control subscriber** *class_name* **do-until-failure** **Example:** `RP/0/RSP0/CPU0:router(config-pmap-e)# class type control subscriber class-default do-until-failure`	Configures the class to which the subscriber has to be matched. When there is a match, executes all actions until a failure is encountered.
Step 5	*sequence_number* **activate dynamic-template** *dynamic-template_name* **Example:** `RP/0/RSP0/CPU0:router(config-pmap-c)# 1 activate dynamic-template ipsub1`	Allows authentication of the subscriber to be triggered using the complete structure username.
Step 6	*sequence_number* **authorize aaa list default format** *format_name* **password** *password* **Example:** `RP/0/RSP0/CPU0:router(config-pmap-c)# 1 authorize aaa list default format RM_User password Cisco`	Allows authorization of the subscriber to be triggered using the domain name of the subscriber. Also, provides domain format-rule, which helps to parse the domain from a complete structured username.
Step 7	**commit**	

Creating a Policy-Map to Run During IPoE Session: An example

```
configure
policy-map type control subscriber IPoE_policy
event session-start match-first
class type control subscriber class-default do-until-failure
1 activate dynamic-template ipsub1
1 authorize aaa list default format RM_User password Cisco
!
!
end
```

Enabling IPoE Subscribers on an Access Interface

Perform this task to enable IPoE subscriber creation on an access interface.

SUMMARY STEPS

1. **configure**
2. **interface** *interface-type* *interface-path-id*
3. **arp learning disable**
4. {**ipv4** | **ipv6**} **address** {*ipv4_address* | *ipv6_address*} *ipsubnet_mask*
5. **service-policy** **type control subscriber** *policy-name*
6. **encapsulation** **dot1q** *value*
7. **ipsubscriber** {**ipv4** | **ipv6**}**l2-connected**
8. **initiator** **dhcp**
9. **initiator** **unclassified-source [address-unique]**
10. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	

Step 2	**interface** *interface-type* *interface-path-id*
	Example:
	`RP/0/RSP0/CPU0:router(config)# interface Bundler-Ether400.12`
		Configures an interface and enters interface configuration mode.
		• The type argument specifies an interface type. For more information on interface types, use the question mark (?) online help function.
		• The instance argument specifies either a physical interface instance or a virtual instance.
		  • The naming notation for a physical interface instance is rack/slot/module/port. The slash (/) between values is required as part of the notation.
		  • The number range for a virtual interface instance varies depending on the interface type.

Step 3	**arp learning disable** **Example:** `RP/0/RSP0/CPU0:router(config-if)# arp learning disable`	Disables arp learning for the access-interface.

Step 4	{**ipv4**	**ipv6**} **address** {*ipv4_address*	*ipv6_address*} *ipsubnet_mask*
			Example:
			`RP/0/RSP0/CPU0:router(config-subif)# ipv4 address 3.5.1.1 255.255.0.0`
			or
			Example:
			`RP/0/RSP0/CPU0:router(config-subif)# ipv6 address 1144:11`
				Sets the IPv4 address or an IPv6 address for an interface.

	Command or Action	Purpose
Step 5	**service-policy type control subscriber** *policy-name* **Example:** `RP/0/RSP0/CPU0:router(config-subif)# service-policy type control subscriber PL4`	Associates a subscriber control service policy to the interface. **Note** Refer to the "Configuring a Subscriber Policy Map" procedure to create a PL4 policy-map.
Step 6	**encapsulation dot1q** *value* **Example:** `RP/0/RSP0/CPU0:router(config-subif)# encapsulation dot1q 40`	Defines the matching criteria to map 802.1Q frames ingress on an interface to the appropriate service instance. The value ranges from 1 to 4094.

Step 7	**ipsubscriber** {**ipv4** | **ipv6**}**l2-connected**
	Example:
	`RP/0/RSP0/CPU0:router(config-subif)# ipsubscriber ipv4 l2-connected`
	or
	Example:
	`RP/0/RSP0/CPU0:router(config-subif)# ipsubscriber ipv6 l2-connected`
		Enables creations of L2-connected IPv4 or IPv6 subscribers on the sub-interface.
		Note It is not recommended to remove these call flow-initiated configurations, after subscriber sessions are active:
		• For an IPoE subscriber session, you must not delete the **ipsubscriber ipv4 l2-connected initiator dhcp** command from the sub-interface
		• For a packet-triggered subscriber session, you must not delete the **ipsubscriber ipv4 l2-connected initiator unclassified-source** command from the sub-interface.

Step 8	**initiator dhcp**
	Example:
	`RP/0/RSP0/CPU0:router(config-subif-ipsub-ipv4-l2conn)# initiator dhcp`
	or
	Example:
	`RP/0/RSP0/CPU0:router(config-subif-ipsub-ipv6-l2conn)# initiator dhcp`
		Configures DHCP as the first-sign-of-life (FSOL) protocol for IP subscriber.

Step 9	**initiator unclassified-source [address-unique]** **Example:** `RP/0/RSP0/CPU0:router(config-subif-ipsub-ipv4-l2conn)# initiator unclassified-source`	Configures unclassified packets as the first-sign-of-life (FSOL) for IPv4 subscriber. The **address-unique** option enables subscriber IP uniqueness check during FSOL processing, thereby preventing invalid sessions from creating interfaces. This option is available from Cisco IOS XR Software Release 5.2.2 and later.

	Command or Action	Purpose
		Note • The **initiator unclassified-source** option is not supported for IPv6. • If multiple initiators are used, use a policy or class map to prevent overlap of the IP addresses for the different sources.
Step 10	**commit**	

Enabling IPoE Subscribers on an Access Interface: Examples

```
configure
interface Bundler-Ether400.12
arp learning disable
ipv4 address 3.5.1.1 255.255.0.0
service-policy type control subscriber PL4
encapsulation dot1q 40
ipsubscriber ipv4 l2-connected
initiator dhcp
initiator unclassified-source
!
!
end
```

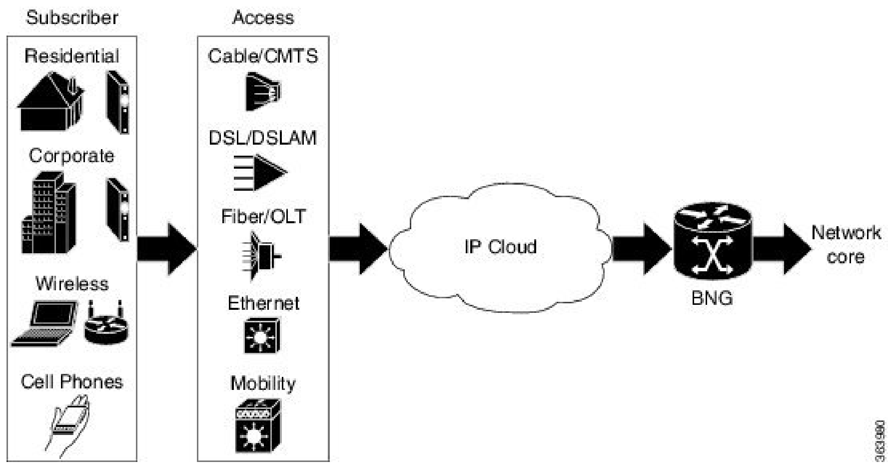
```
configure
interface Bundler-Ether400.12
arp learning disable
ipv6 address 4444:34
service-policy type control subscriber PL4
encapsulation dot1q 40
ipsubscriber ipv6 l2-connected
initiator dhcp
!
!
end
```

Routed Subscriber Sessions

BNG supports L3 or routed subscriber sessions (DHCP-initiated and Packet-triggered), where IP subscribers are connected through a routed access network. The policies and services on the routed subscriber sessions are applied in a similar manner as with L2 subscriber sessions.

This figure shows a typical routed subscriber session network model:

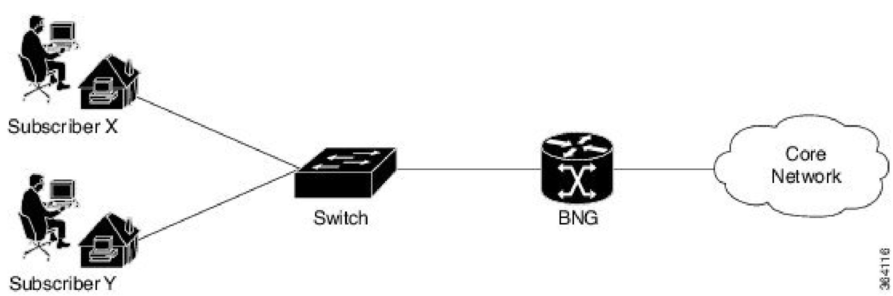
Figure 2: Routed Subscriber Session Network Model



L2-connected subscribers are either directly attached to the physical interfaces of BNG or connected to BNG through a Layer 2 access network, such as a bridged or a switched network. Each user device here is a unique subscriber session. In case there is a routed CPE, the CPE owns the subscriber session on the BNG, and all devices behind the CPE performs NAT. The CPE holds the start of the session to BNG. The subscriber is keyed on the MAC address. Because there is a switched network, the BNG directly sees the MAC address of the device.

This figure shows a typical L2-connected subscriber session:

Figure 3: L2-connected Subscriber Session



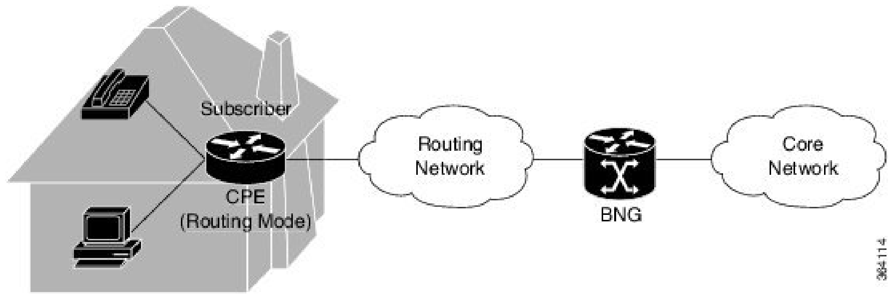
Whereas, routed subscribers are connected to BNG through routed device(s). The devices behind the CPE's MAC address are not visible to BNG. The subscriber is no longer keyed on MAC address. Instead, ip-address is used to key the subscriber session of the device.

In a typical L3 routed aggregation model, the CPE uses NAT to cover up the devices behind the routed CPE. The BNG sees a subscriber session that is initiated and linked to the WAN interface of the routed CPE.

With this routed subscriber session functionality, you can connect devices and create subscriber sessions that are behind a routed CPE.

This figure shows a typical routed subscriber session:

Figure 4: Routed Subscriber Session



To configure an access-interface to host routed subscriber sessions, see Configuring Routed Subscriber Sessions, on page 20.

Routed subscriber sessions come up only if a summary route is added on BNG. The summary route can be either statically configured, or created through some of the routing protocols like OSPF or EIGRP. The summary route VRF must be same as the access-interface VRF in BNG. Modifying or deleting a summary route that is pointing to the subscriber access-interface, while the subscriber sessions are active, may cause a minimal traffic disruption due to route re-convergence. Therefore, it is recommended that the summary route pointing to the subscriber access-interface be modified or deleted only after deleting the sessions that are using that static summary route.

DHCP-initiated Routed Subscriber Sessions

BNG supports DHCPv4-initiated routed subscriber sessions.

DHCP Interaction

The DHCP pool IP address range in BNG must be in compliance with the summary route address range. This DHCP pool IP address range must also match the IP address subnet of the first hop router, which acts as the DHCP relay or proxy. The route for this particular address range must be configured in BNG, so that BNG can reach the subnet of the first hop router, and eventually reach the subscriber.

The subscriber route need not be explicitly added. It is added internally by the BNG process, when the subscriber session is up.

For routed subscriber sessions, the DHCP server should be configured locally on ASR9K router itself, or a DHCP radius proxy should be used. Proxy mode to an external DHCP server is not supported. For details on the call flow of a DHCPv4-initiated session, see Call Flow of DHCPv4-initiated Routed Subscriber Sessions, on page 16.

Session Initiator and Session Identifier

Routed sessions should use IP-based session in-band initiator; whereas L2 connected sessions can have **unclassified-mac** as session in-band initiator. Only DHCPv4 initiated sessions are supported.

Access Interface Features

Although features like ACL and Netflow may be configured on the access-interface, they do not get applied on the subscriber traffic under the respective access-interface. Which features get applied on the subscriber interface is decided based on the dynamic-template configurations under the interface or through RADIUS profile.

VRF Mapping

Routed subscriber sessions support VRF mapping, which allows subscriber to be in a different VRF other than the access-interface VRF. The DHCP pool VRF in BNG must be same as the subscriber VRF, whereas the summary route VRF must be same as the access-interface VRF in BNG. During subscriber creation, information from the dynamic-template or RADIUS is used to set the subscriber VRF. Because access-interface is not used to classify subscriber traffic, the IP address given to subscriber in a given access-interface must be a non-overlapping address.

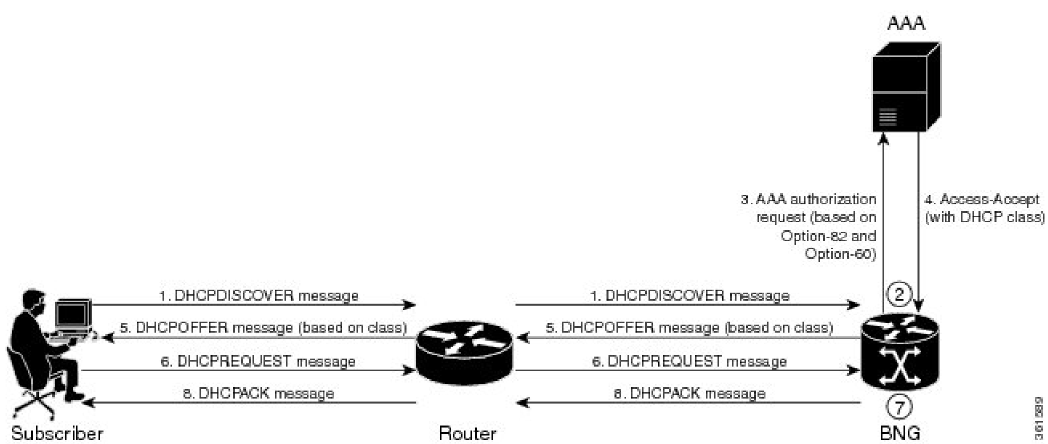
Non-Subscriber Traffic

Because DHCP is the only session initiator for a routed subscriber, a non-subscriber packet is routed as a normal packet on an access-interface. For such packets, the features on access interface are applicable as normal. To prevent such traffic, you should deploy ACL on the access interface.

Call Flow of DHCPv4-initiated Routed Subscriber Sessions

This figure shows a call flow of DHCPv4-initiated routed subscriber session:

Figure 5: Call Flow of DHCPv4-initiated Routed Subscriber Session



These are the detailed steps involved in the DHCPv4 call flow :

1. The subscriber connects to the network and sends a DHCPDISCOVER broadcast packet on the network. The first hop router, configured as a DHCP relay or a DHCP proxy, processes the DHCPDISCOVER message and unicasts it to the BNG that acts as a DHCP server.
2. The BNG creates the subscriber session in its policy plane, and executes the policy rules on the session.
3. As per the policy rule, the BNG sends an AAA authorization request based on Option-82 and Option-60 to the RADIUS server.
4. The RADIUS server replies to the BNG with an Access-Accept message containing DHCP class information that is used for the subscriber IP address assignment.
5. The DHCP server on the BNG uses the DHCP class information in the Access-Accept message to allocate an IP address from an appropriate address pool, and sends a DHCPOFFER message to the subscriber.
6. The subscriber accepts the IP address and sends a DHCPREQUEST message back to the BNG.
7. The BNG assigns IPv4 address to the subscriber; from this point onwards, the session on the BNG starts accepting traffic from the subscriber.

8. The BNG sends a DHCPACK message to the subscriber.

The first hop router can act as either a DHCP relay or a DHCP proxy. In the case of a DHCP proxy, the first hop router maintains the DHCP binding, and it also acts as a DHCP server to the subscriber.

When a DHCP binding is deleted, the BNG session associated with it is also deleted. Because DHCPv4 is the only session initiator, IP address changes cannot happen without having the DHCP server run on BNG. Therefore, in the case of an IP address change, the DHCP deletes the previous session and creates a new session.

Packet-triggered Routed Subscriber Sessions

BNG supports packet-triggered IPv4 and IPv6 routed subscriber sessions. Also, packet-triggered FSOL IPv4 and IPv6 on the same access interface are supported.

Note This feature is available from Cisco IOS XR Software Release 5.2.2 and later.

Session Initiator and Session Identifier

The **unclassified-ip** is used as the initiator for packet-triggered IPv4 and IPv6 routed subscriber sessions. The routed session is identified by subscriber-prefix and prefix-length.

In the case of dual-stack (that is, if both address-families are enabled on a CPE), two separate sessions are created on BNG - one for IPv4 and another for IPv6. Also, if RADIUS profile has dual-stack configuration, the entire configuration does not take effect; only the profile for the address-family takes effect.

The access interface features and VRF mapping for packet-triggered routed subscriber sessions remain the same as that for DHCP-initiated sessions.

For IPv6 packet-triggered routed subscribers, you can perform CoA using session identifier as standard **Framed-IPv6-Prefix** or AVpair **addrv6** RADIUS attribute.

Configuring Packet-triggered Routed Subscriber Sessions

This command is configured on the access interface, to make all the subscribers coming on that interface to routed subscribers:

```
ipsubscriber ipv4 routed
  initiator unclassififed-ip

ipsubscriber ipv6 routed
  initiator unclassififed-ip [prefix-len]
```

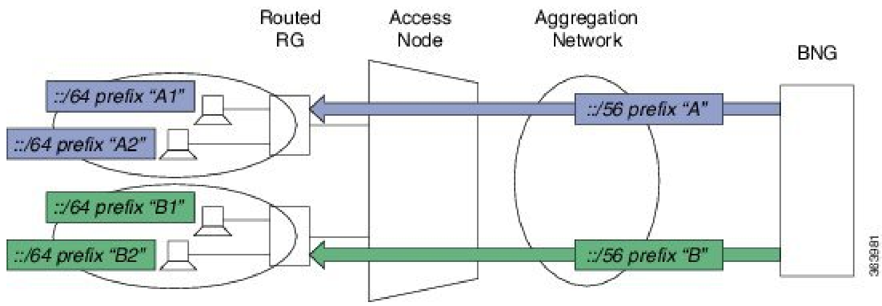
Here, *prefix-len* is the prefix-length of subscriber route. By default, this value is 32 and 128 for IPv4 and IPv6 subscribers respectively.

For a sample deployment topology and use-case scenario of packet-triggered routed subscriber sessions, see Routed Subscriber Deployment Topology and Use Cases.

Deployment Model for IPv6 Routed Network

This figure depicts a typical TR-177 routed IPv6 residential gateway deployment:

Figure 6: TR-177 Routed IPv6 Residential Gateway Deployment



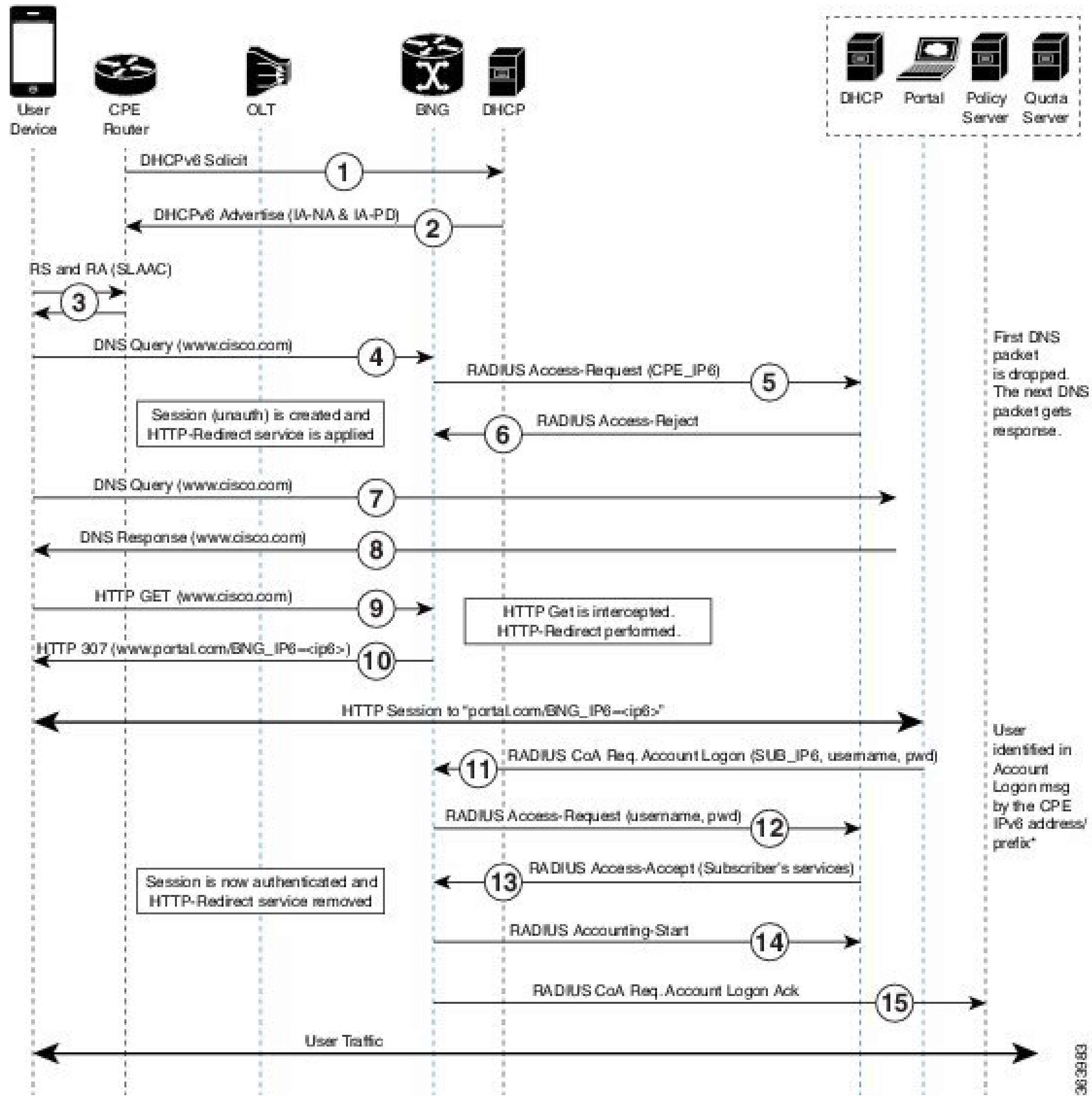
Here, the BNG router acts as a DHCPv6 server, proxy or relay (the DHCP functions can be off-box also) with IA-NA and IA-PD option enabled. BNG allocates both IA-NA and IA-PD non-shared different prefix (/56) for different access networks. Routed Residential Gateway (RG) uses the IA-NA address for itself. Again, Routed RG uses the IA-PD prefix (/56) to distribute different delegated prefixes (/64) to different LAN segments attached to it, using SLAAC or DHCPv6. When the end subscriber starts sending packets, the subscriber session is triggered on BNG.

In another deployment scenario, CPEs with /128 prefix-Len are terminated on BNG. Here, each subscriber is individually authenticated on BNG.

Call Flow of IPv6 Routed Subscriber Session

This figure depicts a typical call flow of web-logon packet-triggered IPv6 routed subscriber session in BNG:

Figure 7: Call Flow of Web-logon IPv6 Routed Subscriber Session



Restrictions for Routed Subscriber Sessions

Support for BNG routed subscriber sessions is subjected to these restrictions:

- Overlapping IP addresses are not supported on the same access-interface.
- Overlapping IP addresses are not supported on the same VRF.
- DHCP-initiated IPv6 sessions are not supported.
- Dual-stack sessions are not supported.
- DHCP lease query is not supported.
- Line card subscribers are not supported.
- For IPv4, BNG cannot be used as DHCP server or proxy to lease IPv4 addresses to IPv4-routed packet-triggered subscribers.

- For IPv6, on-box DHCPv6 server or DHCPv6 proxy can be used to lease IPv6 PD addresses to CPE; but not to end subscribers.
- Because Neighbor Discovery (ND) is point-to-point, ND-triggered sessions (Router Solicitation) are not supported.
- A maximum of only 1 ECMP path is supported for each covering route.

Configuring Routed Subscriber Sessions

Perform this task to configure routed subscriber sessions on an access-interface:

Before you begin

Configuring routed subscriber session in BNG is subjected to these guidelines:

- You must configure dynamic or static routes on the router for subscriber IP addresses. These routes should be configured in such a way that they are synchronized with the way DHCP assigns the IP addresses.

For DHCP-initiated sessions:

- To authorize the subscriber on session-start, you must configure policy-map with a policy having Option-82 (**circuit-id** and **remote-id**) and Option-60 as identifiers.

For Packet-triggered sessions:

- While creating the route (also called as cover route), the route prefix must be smaller than the subscriber prefix. Else, the subscriber route does not install, and the session fails. The cover route must be installed in the access-vrf.

SUMMARY STEPS

1. **configure**
2. **interface** *type interface-path-id*
3. **ipsubscriber** {**ipv4** | **ipv6**} **routed**
4. **initiator** {**dhcp** | **unclassified-ip** [**prefix-len** *prefix-len*]}
5. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config)# interface bundle-ether101.201`	Specifies an access-interface and enters the interface configuration mode.

	Command or Action	Purpose
Step 3	**ipsubscriber** {**ipv4** | **ipv6**} **routed** **Example:** `RP/0/RSP0/CPU0:router(config-if)# ipsubscriber ipv4 routed`	Configures the access-interface to accept routed subscriber sessions.

Step 4	**initiator** {**dhcp** | **unclassified-ip** [**prefix-len** *prefix-len*]}
	Example:
	`RP/0/RSP0/CPU0:router(config-if)# initiator dhcp`
	or
	`RP/0/RSP0/CPU0:router(config-if)# initiator unclassified-ip`
		Configures the session initiator as DHCP or unclassified-ip, for routed subscribers.
		Note • DHCP-initiated IPv6 sessions are not supported.
		• **prefix-len** option is applicable only for packet-triggered (initiator unclassified-ip) IPv6 sessions.

Step 5	**commit**	

Configuring Routed Subscriber Sessions: An example

DHCP-initiated routed subscriber sessions:

```
 interface Bundle-Ether101.201
 vrf vpn1
 ipv4 address 10.1.1.1 255.255.255.0
 service-policy type control subscriber ROUTED_POLICY
 encapsulation dot1q 201 second-dot1q 301
 ipsubscriber ipv4 routed
  initiator dhcp
 !
!

//Configuring static summary route
!
router static
 address-family ipv4 unicast
  14.0.0.0/16 12.0.0.2
 !

//Configuring DHCP address pool
!
pool vrf default ipv4 ROUTED_POOL1
 network 14.0.0.0/16
 exclude 14.0.0.1 0.0.0.0
!
```

Packet-triggered routed subscriber sessions:

```
interface Bundle-Ether1.201
 ipv4 address 15.15.15.1 255.255.255.0
 ipv6 address 15:15:15::1/64
 service-policy type control subscriber PL
 encapsulation dot1q 201
```

```
 ipsubscriber ipv4 routed
  initiator unclassified-ip
 !
 ipsubscriber ipv6 routed
  initiator unclassified-ip
 !
!
```

Prevent Default ARP Entry Creation for a Subscriber Interface

In certain deployment scenarios, the subscriber access-interfaces are unnumbered and the associated loopback interface may have multiple secondary IP addresses. These unnumbered interfaces inherit all attributes, including the secondary IP addresses, from the loopback interface. This creates multiple local ARP entries per subscriber interface and the ARP table may extend beyond the supported scale in such scenarios. You can now prevent such default ARP entry creations by using the **subscriber arp scale-mode-enable** command. This functionality does not impact the existing ARP behavior for the subscribers.

Configuration Example

```
Router(config)# subscriber arp scale-mode-enable
```

Establishing PPPoE Session

The PPP protocol is mainly used for communications between two nodes, like a client and a server. The PPP protocol provides a standard method for transporting multi-protocol diagrams 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. The LCP is used to configure and maintain the data link. PPP peers can use the LCP to negotiate various link layer properties or characteristics. The NCP is used to establish and configure the associated network protocol before data packets for the protocol can be transmitted.

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

CPE detects and interacts with BNG using various PPPoE Active Discovery (PAD) messages listed here:

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

In redundant BNG setups, where the PPPoE client is connected to multiple BNGs, the PADI message sent by the CPE is received on all BNGs. Each BNG, in turn, replies with a PADO message. You must configure Smart Server Selection on BNG to allow subscribers to select one of the BNGs in a multi-BNG setup. Refer PPPoE Smart Server Selection, on page 42

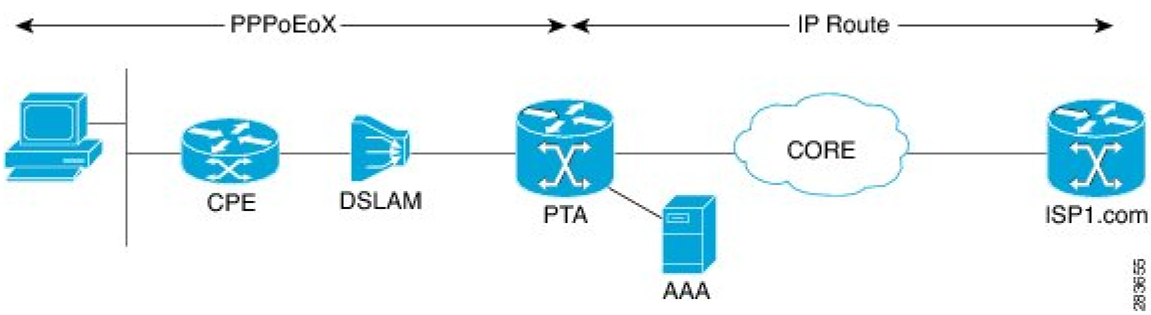
The BNG provides configuration flexibility to limit and throttle the number of PPPoE sessions requests, based on various parameters. For details, see PPPoE Session Limit, on page 44 and PPPoE Session Throttle, on page 46.

The PPPoE session are of two types, PPP PTA and PPP LAC. 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 is no local authentication available on BNG. The PPP PTA and PPP LAC sessions are explained in the sections, Provisioning PPP PTA Session, on page 23 and Provisioning PPP LAC Session, on page 29.

Provisioning PPP PTA Session

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

Figure 8: PTA Session



PPPoE session configuration information is contained in PPPoE profiles. After a profile has been defined, it can be 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. The process of provisioning a PPP PTA session involves:

- Creating a PPPoE profile for PPPoE session. See, Creating PPPoE Profiles, on page 23.
- Creating dynamic template that contains the various settings for the PPPoE sessions. See, Creating a PPP Dynamic-Template, on page 24.
- Creating policy-map to activate the dynamic template. See, Creating a Policy-Map to Run During PPPoE Session, on page 25.
- Enabling subscriber creation, and apply the PPPoE profile and service-policy on the access interface. See, Applying the PPPoE Configurations to an Access Interface, on page 28.

  The subscriber creation function must be explicitly enabled on BNG. Unless this function is enabled, the system will not attempt subscriber classification. As a result, the packets get forwarded based on the incoming interface mode.

Creating PPPoE Profiles

Perform this task to create PPPoE profiles. The PPPoE profile will later be applied to an access interface.

SUMMARY STEPS

1. **configure**
2. **pppoe bba-group** *bba-group name*
3. **service name** *service_name*
4. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**pppoe bba-group** *bba-group name* **Example:** `RP/0/RSP0/CPU0:router(config)# pppoe bba-group bba_1`	Creates a PPPoE profile with an user-specified name.
Step 3	**service name** *service_name* **Example:** `RP/0/RSP0/CPU0:router(config-bbagroup)# service name service_1`	Indicates the service that is requested by the subscriber. Repeat this step for each service name that you want to add to the subscriber profile.
Step 4	**commit**	

Creating PPPoE Profiles: An example

```
configure
pppoe bba-group bba_1
service name service_1
!
!
end
```

Creating a PPP Dynamic-Template

Perform this task to create a PPP dynamic-template. As an example, this dynamic-template is created to apply PAP and CHAP authentication methods.

SUMMARY STEPS

1. **configure**
2. **dynamic-template type ppp** *dynamic_template_name*
3. **ppp authentication pap**
4. **ppp authentication chap**
5. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**dynamic-template type ppp** *dynamic_template_name* **Example:** `RP/0/RSP0/CPU0:router(config)# dynamic-template type ppp ppp_pta_template`	Creates a dynamic-template with user-defined name for PPP session.
Step 3	**ppp authentication pap** **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template-type)# ppp authentication pap`	Enables the use of PAP type authentication during link negotiation by Link Control Protocol (LCP).
Step 4	**ppp authentication chap** **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template-type)# ppp authentication chap`	Enables the use of CHAP type authentication during link negotiation by Link Control Protocol (LCP).
Step 5	**commit**	

Creating a PPP Dynamic-Template: An example

```
configure
dynamic-template type ppp ppp_pta_template
ppp authentication pap
ppp authentication pap chap
!
!
end
```

Creating a Policy-Map to Run During PPPoE Session

Perform this task to create a policy-map that will activate a PPP dynamic-template during a PPPoE subscribers session. As an example, this policy-map activates a dynamic template during a session-start event. Also, this policy-map applies a locally-defined authorization setting during a session-activate event.

SUMMARY STEPS

1. **configure**
2. **policy-map type control subscriber** *policy_name*
3. **event session-start match-all**
4. **class type control subscriber** *class_name* **do-until-failure**
5. *sequence_number* **activate dynamic-template** *dynamic-template_name*
6. **event session-activate match-all**
7. **class type control subscriber** *class_name* **do-until-failure**

8. *sequence_number* **authenticate aaa list default**
9. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**policy-map type control subscriber** *policy_name* **Example:** `RP/0/RSP0/CPU0:router(config)# policy-map type control subscriber PPPoE_policy`	Creates a new policy map of the type "control subscriber" with the user-defined name "PPPoE_policy".
Step 3	**event session-start match-all** **Example:** `RP/0/RSP0/CPU0:router(config-pmap)# event session-start match-all`	Defines an event (session start) for which actions will be performed.
Step 4	**class type control subscriber** *class_name* **do-until-failure** **Example:** `RP/0/RSP0/CPU0:router(config-pmap-e)# class type control subscriber pta_class do-until-failure`	Configures the class to which the subscriber is to be matched. When there is a match, executes all actions until a failure is encountered.
Step 5	*sequence_number* **activate dynamic-template** *dynamic-template_name* **Example:** `RP/0/RSP0/CPU0:router(config-pmap-c)# 1 activate dynamic-template ppp_pta_template`	Activates the dynamic-template with the specified dynamic template name.
Step 6	**event session-activate match-all** **Example:** `RP/0/RSP0/CPU0:router(config-pmap)# event session-activate match-all`	Defines an event (session activate) for which actions are performed.
Step 7	**class type control subscriber** *class_name* **do-until-failure** **Example:** `RP/0/RSP0/CPU0:router(config-pmap-e)# class type control subscriber PPP_class do-until-failure`	Configures the class to which the subscriber is to be matched. When there is a match, executes all actions until a failure is encountered.
Step 8	*sequence_number* **authenticate aaa list default** **Example:**	Allows authentication of the subscriber to be triggered using the complete structure username.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-pmap-c)# 1 authenticate aaa list default`	
Step 9	**commit**	

Creating a Policy-Map to Run During PPPoE Session: An example

```
configure
policy-map type control subscriber policy1
event session-start match-all
class type control subscriber pta_class do-until-failure
1 activate dynamic-template template1
!
!
event session-activate match-all
class type control subscriber pta_class1 do-until-failure
1 activate dynamic-template ppp_pta_template
end-policy-map
```

Modifying VRF for PPPoE Sessions

BNG does not support modification of VRF using single dynamic template activated on session start. In order to change the VRF for PPPoE sessions from RADIUS, you must split the dynamic template. One dynamic template must be activated in session-start (for PPP parameters). The other dynamic template must contain L3 parameters and it must be enabled on session-activate event after the authenticate step.

This example shows a sample dynamic template configuration and a policy-map configuration for such a VRF transfer scenario, where some PPPoE users must be terminated in a different VRF than the normal user VRF. In order to do so, the user sends two AV-Pairs through RADIUS.

```
dynamic-template
type ppp PPP_TPL                    ===> Layer 3 interface
ppp authentication chap
ppp ipcp peer-address pool IPv4
ipv4 unnumbered Loopback100         ===> Loopback in Global Routing Table
type ppp PPP_TPL_NO_LO              ===> Layer 2 interface
ppp authentication chap

policy-map type control subscriber BNG_PPPOE
event session-activate match-first
class type control subscriber PPP do-until-failure
10 authenticate aaa list default
 20 activate dynamic-template PPP_TPL
event session-start match-first
class type control subscriber PPP do-until-failure
10 activate dynamic-template PPP_TPL_NO_LO
```

Here, the Layer 2 dynamic template is created first, and only PPP authentication is done on it. Therefore, the RADIUS request is sent. The RADIUS returns the attributes and then the BNG proceeds to the next step, that is, session-activate. In session-activate, another dynamic template interface which has layer 3 configuration is used. But, because the BNG has already received the RADIUS attribute for the user, it uses the ipv4 unnumbered contained in the RADIUS profile, rather than the one configured directly under the Layer 3 dynamic template.

Applying the PPPoE Configurations to an Access Interface

Perform this task to apply the PPPoE profiles and the policy-maps to an access interface. The completion of this task enables the receiving of PPPoE traffic on the interface.

Before you begin

You must perform this task after performing the Creating PPPoE Profiles, on page 23.

SUMMARY STEPS

1. **configure**
2. **interface** *type interface-path-id*
3. **service-policy type control subscriber** *policy_name*
4. **pppoe enable bba-group** *bbagroup_name*
5. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config)# interface Bundle-Ether 5.1`	Enters interface configuration mode for the bundle-interface.
Step 3	**service-policy type control subscriber** *policy_name* **Example:** `RP/0/RSP0/CPU0:router(config-if)# service-policy type control subscriber PL1`	Associates a subscriber control service policy to the interface.
Step 4	**pppoe enable bba-group** *bbagroup_name* **Example:** `RP/0/RSP0/CPU0:router(config-if)# pppoe enable bba-group bba_1`	Enables PPPoE on the bundle-ether interface and specifies the PPPoE profile named bba_1 to be used on this interface. **Note** It is not recommended to remove the call flow-initiated configurations, after subscriber sessions are active. Therefore, you must not delete the **pppoe enable** command from the sub-interface, while the PPPoE sessions are up.
Step 5	**commit**	

Applying the PPPoE Configurations to an Access Interface: An example

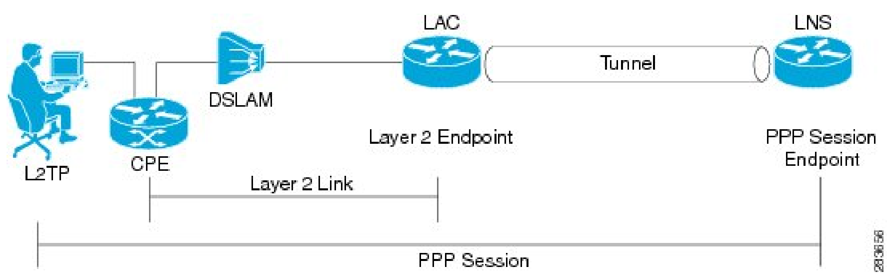
```
configure
interface Bundle-Ether100.10
service-policy type control subscriber PL1
pppoe enable bba-group bba_1
```

```
!
!
end
```

Provisioning PPP LAC Session

In a PPP LAC session, the PPP session is tunneled to a remote network server by BNG, using Layer 2 Tunneling Protocol (L2TP). BNG performs the role of L2TP Access Concentrator (LAC), as it puts the subscriber session in the L2TP tunnel. The device on which the tunnel terminates is called L2TP Network Server (LNS). During a PPP LAC session, the PPPoE encapsulation terminates on BNG; however, the PPP packets travel beyond BNG to LNS through the L2TP tunnel. A typical LAC session is depicted in Figure 1.

Figure 9: LAC Session



The PPP LAC session is used in the Access Network Provider (wholesale) model, where the network service provider (NSP) is a separate entity from the local access network provider (ANP). NSPs perform access authentication, manage and provide IP addresses to subscribers, and are responsible for overall service. The ANP is responsible for providing the last-mile digital connectivity to the customer, and for passing on the subscriber traffic to the NSP. In this kind of setup, the ANP owns the LAC and the NSP owns the LNS.

A PPP LAC session establishes a virtual point-to-point connection between subscriber device and a node in the service provider network. The subscriber dials into a nearby L2TP access connector (LAC). Traffic is then securely forwarded through the tunnel to the LNS, which is present in service provider network. This overall deployment architecture is also known as Virtual Private Dial up Network (VPDN).

The process of provisioning a PPP LAC session involves:

- Defining a template with specific settings for the VPDN. See, Configuring the VPDN Template, on page 30.
- Defining the maximum number of VPDN sessions that can be established simultaneously. See, Configuring Maximum Simultaneous VPDN Sessions, on page 32.
- Activating the logging of VPDN event messages. See, Activating VPDN Logging, on page 33.
- Specifying the method to apply calling station-ID. See, Configuring Options to Apply on Calling Station ID, on page 34.
- Specifying the session-ID. See, Configuring L2TP Session-ID Commands, on page 35.
- Defining specific settings for the L2TP class. See, Configuring L2TP Class Options, on page 35.
- Preventing creation of additional VPDN sessions. See, Configuring Softshut for VPDN, on page 38.

This is a sample user-profile for L2TP LAC:

```
abc_xyz@domain.com Password="abc"
    Service-Type = Outbound-User,
    Tunnel-Type = L2TP,
    Tunnel-Medium-Type = IP,
    Cisco-avpair = "vpdn:ip-addresses=3.3.3.3",
    Cisco-avpair = "vpdn:source-ip=1.1.1.1"
```

Note For L2TP LAC session to be up, the user-profile coming from the RADIUS server to the BNG must have **Service-Type = Outbound-User** configured for the user.

Reassembly of fragmented L2TP data packets is enabled on LAC to prevent these packets from getting dropped. See, L2TP Reassembly on LAC, on page 38

A PPP LAC session supports stateful switchover (SSO) along with non-stop routing (NSR) to reduce traffic loss during RP failover. For more information, see L2TP Access Concentrator Stateful Switchover, on page 40

Restrictions for PPP LAC

- PPPoE LAC is not supported with LC subscribers.
- Provisioning PPP LAC session is subjected to a restriction that only ASR 9000 Enhanced Ethernet Line Cards are supported as core facing line cards.
- A maximum of 19 LNS IP address can be configured in the user-profile for L2TP LAC sessions. This means there can be up to 19 IP addresses assigned to the Tunnel-Server-Endpoint argument for traffic to be securely forwarded through the L2TP tunnel.

  Note If there are more than 19 LNS IP addresses, they are rejected, which means the previous 19 addresses are not overwritten with the new addresses.

Configuring the VPDN Template

Perform this task to configure the vpdn template:

SUMMARY STEPS

1. **configure**
2. **vpdn template**
3. **l2tp-class** *class_name*
4. **tunnel busy timeout** *timeout_value*
5. **caller-id mask-method remove match** *match_substring*
6. **dsl-line-info-forwarding**
7. **ip tos** *type_of_service_value*
8. **vpn id** *value*
9. **vpn vrf** *vrf_name*
10. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**vpdn template** **Example:** `RP/0/RSP0/CPU0:router(config)# vpdn template`	Enters the VPDN template sub-mode.
Step 3	**l2tp-class** *class_name* **Example:** `RP/0/RSP0/CPU0:router(config-vpdn-template)# l2tp-class class_temp`	Configures the l2tp class command.
Step 4	**tunnel busy timeout** *timeout_value* **Example:** `RP/0/RSP0/CPU0:router(config-vpdn-template)# tunnel busy timeout 456`	Configure l2tp tunnel busy list commands. The busy timeout value ranges from 60-65535.
Step 5	**caller-id mask-method remove match** *match_substring* **Example:** `RP/0/RSP0/CPU0:router(config-vpdn-template)# caller-id mask-method remove match m1`	Configures options to apply on calling station id by masking the characters by the match substring specified.
Step 6	**dsl-line-info-forwarding** **Example:** `RP/0/RSP0/CPU0:router(config-vpdn-template)# dsl-line-info-forwarding`	Forwards the DSL Line Info attributes.
Step 7	**ip tos** *type_of_service_value* **Example:** `RP/0/RSP0/CPU0:router(config-vpdn-template)# ip tos 56`	Sets IP ToS value for tunneled traffic. The service value ranges from 0 to 255.
Step 8	**vpn id** *value* **Example:** `RP/0/RSP0/CPU0:router(config-vpdn-temp)# vpn id 3333:33`	Specifies tunnel for a vpn and configures the vpn id with the value 3333:33. The value ranges from 0-ffffff in hexadecimal.
Step 9	**vpn vrf** *vrf_name* **Example:** `RP/0/RSP0/CPU0:router(config-vpdn-template)# vpn vrf vrf_1`	Configures the vpn vrf name.

	Command or Action	Purpose
Step 10	**commit**	

Configuring the VPDN Template: An example

```
configure
l2tp-class class hello-interval 100
vpdn
template l2tp-class class //template default will be used and display in show run
template tunnel busy timeout 567
l2tp-class class

vpdn
template default
l2tp-class class
!
end
```

Configuring Maximum Simultaneous VPDN Sessions

Perform this task to configure the maximum simultaneous vpdn sessions for session limiting per tunnel:

SUMMARY STEPS

1. **configure**
2. **vpdn**
3. **session-limit** *number_of_sessions*
4. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**vpdn** **Example:** `RP/0/RSP0/CPU0:router(config)# vpdn`	Enables VPDN and enters the VPDN sub-mode.
Step 3	**session-limit** *number_of_sessions* **Example:** `RP/0/RSP0/CPU0:router(config-vpdn)# session-limit 200`	Configures the maximum simultaneous VPDN sessions. The range is from 1 to 131072. **Note** If limit is configured after a number of sessions are up, then those sessions remain up irrespective of the limit.
Step 4	**commit**	

Configuring Maximum Simultaneous VPDN Sessions: An example

```
configure
vpdn
session-limit 200
!
end
```

Activating VPDN Logging

Perform this task to activate logging of VPDN event information. When VPDN event logging is enabled, VPDN event messages are logged as the events occur.

Note Tunnel start and stop records are generated without any tunnel statistics.

SUMMARY STEPS

1. **configure**
2. **vpdn**
3. **logging** [**cause**| **cause-normal** | **dead-cache** | **local** | **tunnel-drop** | **user**]
4. **history failure**
5. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**vpdn** **Example:** `RP/0/RSP0/CPU0:router(config)# vpdn`	Enters the VPDN sub-mode.

Step 3	**logging** [**cause**| **cause-normal** | **dead-cache** | **local** | **tunnel-drop** | **user**]
	Example:
	`RP/0/RSP0/CPU0:router(config-vpdn)# logging local`
	`RP/0/RSP0/CPU0:router(config-vpdn)# logging user`
	`RP/0/RSP0/CPU0:router(config-vpdn)# logging cause`
	`RP/0/RSP0/CPU0:router(config-vpdn)# logging tunnel-drop`
		Enables the logging of generic VPDN events.

Step 4	**history failure** **Example:** `RP/0/RSP0/CPU0:router(config-vpdn)# history failure`	Enables logging of VPDN failure events to the history failure table.

	Command or Action	Purpose
Step 5	**commit**	

Activating VPDN Logging: An example

```
configure
vpdn
history failure
logging local
logging user
logging cause-normal
logging tunnel-drop
logging dead-cache
!
end
```

Configuring Options to Apply on Calling Station ID

Perform this task to configure options to apply on calling station ID. The calling station ID provides detailed information about the originator of the session, such as the phone number of the originator, the Logical Line ID (LLID) used to make the connection on the LAC, or the MAC address of the PC connecting to the network.

SUMMARY STEPS

1. **configure**
2. **vpdn**
3. **caller-id mask-method remove match** *match_name*
4. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**vpdn** **Example:** `RP/0/RSP0/CPU0:router(config)# vpdn`	Enters the VPDN sub-mode.
Step 3	**caller-id mask-method remove match** *match_name* **Example:** `RP/0/RSP0/CPU0:router(config-vpdn)# caller-id mask-method remove match match_class`	Suppresses the calling station ID for all users. If there is a ‘match’ option, then calling station ID only for users which have the ‘match-string’ in their username is suppressed. **Note** This command an also be run under the vpdn template configuration mode.
Step 4	**commit**	

Configuring Options to Apply on Calling Station ID: An example

```
configure
vpdn //or vpdn template
caller-id mask-method remove match match_call
!
end
```

Configuring L2TP Session-ID Commands

Perform this task to configure L2TP session-id commands.

SUMMARY STEPS

1. **configure**
2. **vpdn**
3. **l2tp session-id space hierarchical**
4. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**vpdn** **Example:** `RP/0/RSP0/CPU0:router(config)# vpdn`	Configures vpdn.
Step 3	**l2tp session-id space hierarchical** **Example:** `RP/0/RSP0/CPU0:router(config-vpdn)# l2tp session-id space hierarchical`	Enables the hierarchical session-ID allocation algorithm.
Step 4	**commit**	

Configuring L2TP Session-ID Commands: An example

```
configure
vpdn
l2tp session-id space hierarchical
!
end
```

Configuring L2TP Class Options

Perform this task to configure the various options for L2TP class.

SUMMARY STEPS

1. **configure**
2. **l2tp-class** *class_name*
3. **authentication** [**disable** | **enable**]
4. **congestion control**
5. **digest** [**check disable** |**hash** { **MD5** | **SHA1** } | **secret** { **0** | **7** | **LINE** }]
6. **hello-interval** *interval_duration*
7. **hostname** *host_name*
8. **receive-window** *size*
9. **retransmit initial** [**retries** | *retries_number* | **timeout** {**max** *max_seconds* | **min** *min_seconds* }
10. **timeout** [**no-user**{ *timeout_value* | **never** } | **setup** *setup_value*]
11. **tunnel accounting** *accounting_method_list_name*
12. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**l2tp-class** *class_name* **Example:** `RP/0/RSP0/CPU0:router(config)# l2tp-class class1`	Configures the L2TP class command.
Step 3	**authentication** [**disable** | **enable**] **Example:** `RP/0/RSP0/CPU0:router(config-l2tp-class)# authentication disable`	Enables the tunnel authentication. The Enable and Disable options enables or disables the L2TP tunnel authentication.
Step 4	**congestion control** **Example:** `RP/0/RSP0/CPU0:router(config-l2tp-class)# congestion control`	Enables L2TP congestion control.

Step 5	**digest** [**check disable** |**hash** { **MD5** | **SHA1** } | **secret** { **0** | **7** | **LINE** }]
	Example:
	`RP/0/RSP0/CPU0:router(config-l2tp-class)# digest check disable`
	`RP/0/RSP0/CPU0:router(config-l2tp-class)# digest hash MD5`
	`RP/0/RSP0/CPU0:router(config-l2tp-class)# digest secret 0`
		Messages the Digest configuration for L2TPv3 control connection.

Step 6	**hello-interval** *interval_duration* **Example:**	Sets HELLO message interval for specified amount of seconds.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-l2tp-class)# hello-interval 45`	
Step 7	**hostname** *host_name* **Example:** `RP/0/RSP0/CPU0:router(config-l2tp-class)# hostname local_host`	Sets the local hostname for control connection authentication.
Step 8	**receive-window** *size* **Example:** `RP/0/RSP0/CPU0:router(config-l2tp-class)# receive-window 56`	Receives window size for the control connection. The range is from 1 to 16384.

Step 9	**retransmit initial** [**retries** | *retries_number* | **timeout** {**max** *max_seconds* | **min** *min_seconds* }
	Example:
	`RP/0/RSP0/CPU0:router(config-l2tp-class)# retransmit initial retries 58`
	`RP/0/RSP0/CPU0:router(config-l2tp-class)# retransmit initial timeout max 6`
		Receives window size for the control connection. The range is from 1 to 16384.

Step 10	**timeout** [**no-user**{ *timeout_value* | **never** } | **setup** *setup_value*]
	Example:
	`RP/0/RSP0/CPU0:router(config-l2tp-class)# timeout no-user 56`
	`RP/0/RSP0/CPU0:router(config-l2tp-class)# retransmit setup 60`
		Receives window size for the control connection. The timeout value range, in seconds, is from 0 to 86400. The setup value range is from 60 to 6000.

Step 11	**tunnel accounting** *accounting_method_list_name* **Example:** `RP/0/RSP0/CPU0:router(config-l2tp-class)# tunnel accounting acc_tunn`	Configures the AAA accounting method list name.
Step 12	**commit**	

Configuring L2TP Class Options: An example

```
configure
l2tp-class class1
authentication enable
congestion-control
digest check disable
hello-interval 876
hostname l2tp_host
```

```
receive-window 163
retransmit initial timeout 60
timeout no-user 864
tunnel accounting aaa_l2tp
!
end
```

Configuring Softshut for VPDN

Perform this task to configure softshut for vpdn.

SUMMARY STEPS

1. **configure**
2. **vpdn**
3. **softshut**
4. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**vpdn** **Example:** `RP/0/RSP0/CPU0:router(config)# vpdn`	Enters the VPDN sub-mode.
Step 3	**softshut** **Example:** `RP/0/RSP0/CPU0:router(config-vpdn)# softshut`	Ensures that no new sessions are allowed.
Step 4	**commit**	

Configuring Softshut for VPDN: An example

```
configure
vpdn
softshut
!
end
```

L2TP Reassembly on LAC

The L2TP Reassembly feature on L2TP Access Concentrator (LAC) ensures reassembly of fragmented L2TP data packets in the intervening network, between the LAC and L2TP Network Server (LNS). Data packets are fragmented when they exceed the Maximum Transmission Unit (MTU) of the IPv4 core. Enabling this feature prevents the fragmented packets from getting dropped and ensures the subsequent forwarding of these data packets.

When L2TP Reassembly feature is disabled on LAC, fragmented data packets are dropped. The feature does not affect the reassembly of non-L2TP packets. To ensure that packets for non-L2TP applications are properly reassembled regardless of whether load balancing occurs for each packet, it is recommended that:

- A separate loopback address be configured only for L2TP traffic. No other applications on the router should use this IP address.
- Multiple loopback addresses be used for L2TP, but no other applications across all VRFs should use these addresses.

In cases of reassembly errors or fragmentation timeout, the maximum period a traffic flow is kept, before it is forwarded to the Route Switch Processor (RSP) is 250ms.

Restrictions

Enabling L2TP reassembly feature is subjected to these restrictions:

- Only ASR 9000 Enhanced Ethernet Line Cards support L2TP reassembly feature
- Only IPv4 fragmented packets are reassembled
- Only packets with two fragments are reassembled
- The fragments must not overlap
- The fragmented IP headers must not contain options
- The fragmented L2TP packets must be delivered to the same line card. In other words, the intervening network must not use per packet load balancing schemes that make the fragments arrive on different line cards. On the other hand, the reassembly of non-L2TP packets is not affected even when the packets arrive on different line cards

Enabling L2TP Reassembly on LAC

Perform this task to enable L2TP reassembly on L2TP Access Concentrator (LAC):

SUMMARY STEPS

1. **configure**
2. **vpdn**
3. **l2tp reassembly**
4. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**vpdn** **Example:** `RP/0/RSP0/CPU0:router(config)# vpdn`	Enters the VPDN configuration mode.

	Command or Action	Purpose
Step 3	**l2tp reassembly** **Example:** `RP/0/RSP0/CPU0:router(config-vpdn)# l2tp reassembly`	Enables L2TP reassembly on LAC.
Step 4	**commit**	

Enabling L2TP Reassembly on LAC: An example

```
configure
vpdn
l2tp reassembly
!
end
```

L2TP Access Concentrator Stateful Switchover

The L2TP Access Concentrator Stateful Switchover (LAC SSO) feature establishes one of the RPs as the active processor, designates the other RP as the standby processor, and then synchronizes critical state information between them. In specific Cisco networking devices that support dual RPs, LAC SSO takes advantage of RP redundancy to increase network availability.

LAC SSO supports non-stop routing (NSR) for VPDN and L2TP protocols in the event of a RP failover. The NSR provides the ability to guarantee reliable L2TP and VPDN synchronization between active and standby RPs. In case of RP fail-over, all VPDN and L2TP tunnels and sessions information are preserved without impacting the L2TP network peer. Also, peer networking devices do not experience routing flaps, and therefore reduce loss of service outages for customers. When VPDN and LAC SSO are enabled, all the tunnels and sessions are mirrored to the backup RP.

Enabling LAC SSO

Perform this task to enable LAC/VPDN SSO feature:

SUMMARY STEPS

1. **configure**
2. **vpdn**
3. **redundancy**
4. **commit**
5. **show vpdn redundancy**
6. **show vpdn redundancy mirroring**
7. **show l2tpv2 redundancy**
8. **show l2tpv2 redundancy mirroring**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	

	Command or Action	Purpose
Step 2	**vpdn** **Example:** `RP/0/RSP0/CPU0:router(config)# vpdn`	Enters vpdn configuration mode.
Step 3	**redundancy** **Example:** `RP/0/RSP0/CPU0:router(config-vpdn)# redundancy`	Enters vpdn redundancy configuration mode.
Step 4	**commit**	
Step 5	**show vpdn redundancy** **Example:** `RP/0/RSP0/CPU0:router# show vpdn redundancy`	Displays all vpdn redundancy related information.
Step 6	**show vpdn redundancy mirroring** **Example:** `RP/0/RSP0/CPU0:router# show vpdn redundancy mirroring`	Displays vpdn related mirroring statistics.
Step 7	**show l2tpv2 redundancy** **Example:** `RP/0/RSP0/CPU0:router# show l2tpv2 redundancy`	Displays L2TP redundancy related information.
Step 8	**show l2tpv2 redundancy mirroring** **Example:** `RP/0/RSP0/CPU0:router# show l2tpv2 redundancy mirroring`	Displays L2TP related mirroring statistics.

Enabling LAC SSO: Example

```
configure
  vpdn
    redundancy
      process-failures switchover
end
```

Enabling RPFO on Process-failures

In the event of an application or process crash, if VPDN NSR is enabled, an RP failover is triggered and a new primary RP process restarts without traffic loss.

The VPDN NSR is disabled by default. Perform these steps to enable RPFO:

SUMMARY STEPS

1. **configure**
2. **nsr process-failures switchover**
3. **vpdn**
4. **redundancy**
5. **process-failures switchover**
6. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**nsr process-failures switchover** **Example:** `RP/0/RSP0/CPU0:router(config)# l2tp nsr process-failures switchover`	Enables VPDN non-stop routing.
Step 3	**vpdn** **Example:** `RP/0/RSP0/CPU0:router(config)# vpdn`	Enters vpdn configuration mode.
Step 4	**redundancy** **Example:** `RP/0/RSP0/CPU0:router(config-vpdn)# redundancy`	Enters vpdn redundancy configuration mode.
Step 5	**process-failures switchover** **Example:** `RP/0/RSP0/CPU0:router(config-vpdn-redundancy)# process-failures switchover`	Forces a switchover in case of a process failure.
Step 6	**commit**	

PPPoE Smart Server Selection

The PPPoE Smart Server Selection (PADO delay) feature in BNG allows the PPPoE client to control the selection of BNG for session establishment, in a multi-BNG setup. The feature provides the option for configuring a delay in sending PADO messages from BNG, in response to the PADI messages received from the PPPoE clients. This, in turn, helps in establishing a priority order and load balancing across all BNGs.

When establishing a PPPoE session in a multi-BNG setup, the clients broadcast their PADI messages to all BNGs. When the BNGs reply with a PADO message, the subscriber selects a BNG, and sends a PADR message to the BNG with which a session needs to be established. Most PPPoE clients send a PADR message to the BNG from which it received the first PADO message. By configuring the Smart Server Selection feature on BNG, a delay is added to the PADO messages sent from the BNG, based on the properties of the PADI messages received from the PPPoE clients. This delay in receiving the PADO packets, in turn, gives the PPPoE client the flexibility of effectively selecting the appropriate BNG to which the PADR message is to be sent.

Configuration options for Smart Server Selection

- Allows configuring a specific delay for the PADO message sent from BNG.
- Allows configuring a delay for the PADO message sent from BNG, based on the Circuit-ID, Remote-ID and Service-Name contained in the incoming PADI message.
- Allows Circuit-ID and Remote-ID tag matching, with strings up to 64 characters in length.
- Allows partial matching on Circuit-ID, Remote-ID, and Service-Name contained in the incoming PADI message.

For configuring the delay for a PADO message, see Configuring PADO Delay, on page 43.

Configuring PADO Delay

Perform this task to configure a delay for PPPoE Active Discovery Offer (PADO) message, or in other words, enabling Smart Server Selection feature for a PPPoE BBA-Group in BNG.

Note If multiple delays match a particular subscriber, Circuit-ID matches are preferred to Remote-ID matches, which, in turn, are preferred to Service-Name matches.

SUMMARY STEPS

1. **configure**
2. **pppoe bba-group** *bba-group-name*
3. Use these commands to configure the PADO delay based on a specific delay value, Circuit-ID, Remote-ID, and Service-Name respectively:
   - **pado delay** *delay*
   - **pado delay circuit-id** {*delay* | {**string** | **contains**} *string delay*}
   - **pado delay remote-id** {*delay* | {**string** | **contains**} *string delay*}
   - **pado delay service-name** {**string** | **contains**} *string delay*
4. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**pppoe bba-group** *bba-group-name* **Example:**	Enters the PPPoE BBA-Group configuration mode.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config)# pppoe bba-group bba_1`	

Step 3	Use these commands to configure the PADO delay based on a specific delay value, Circuit-ID, Remote-ID, and Service-Name respectively:
	• **pado delay** *delay*
	• **pado delay circuit-id** {*delay* | {**string** | **contains**} *string delay*}
	• **pado delay remote-id** {*delay* | {**string** | **contains**} *string delay*}
	• **pado delay service-name** {**string** | **contains**} *string delay*
	Example:
	`RP/0/RSP0/CPU0:router(config-bbagroup)# pado delay 500`
	`RP/0/RSP0/CPU0:router(config-bbagroup)# pado delay circuit-id 200`
	`RP/0/RSP0/CPU0:router(config-bbagroup)# pado delay remote-id string circuit4`
	`RP/0/RSP0/CPU0:router(config-bbagroup)# pado delay service-name contains service 9950`
		Sets the PADO delay in milliseconds based on:
		• A specific *delay* value
		• Circuit-ID received in PADI
		• Remote-ID received in PADI
		• Service-Name received in PADI
		The *delay* range is from 0 to 10000.
		The **string** option delays the PADO message, when the Circuit-ID (or Remote-ID or Service-Name) received in the PADI message matches the configured *string* value.
		The **contains** option delays the PADO message, when the Circuit-ID (or Remote-ID or Service-Name) received in the PADI message contains the configured *string* value.

Step 4	**commit**	

Configuring PPPoE PADO delay : An example

```
 pppoe bba-group bba_1
 pado delay 500
 pado delay remote-id 100
 pado delay circuit-id string circuit4 8000
 pado delay service-name contains service 9950
!
end
```

PPPoE Session Limit, Throttle and In-flight-window

PPPoE Session Limit

The PPPoE Session Limit support limits the number of PPPoE sessions that can be created on a BNG router. As a result, it reduces excessive memory usage by the BNG router for virtual access.

This offers additional configuration flexibility on the BNG router by limiting the number of PPPoE sessions for each:

- Line card
- Parent interface

- Peer MAC address
- Peer MAC address under individual access interface
- Circuit-ID
- Remote-ID
- Combination of Circuit-ID and Remote ID
- Access interface using the same Inner VLAN tag
- Access interface using the same Outer VLAN tag.
- Access interface using the same Inner and Outer VLAN tags

The PPPoE Session Limit support also limits the number of Inter Working Function (IWF) sessions for each peer MAC address and for each peer MAC address under individual access interface.

See, Configuring PPPoE Session Limit, on page 45.

Configuring PPPoE Session Limit

Perform this task to configure PPPoE session limit for a PPPoE BBA-Group in BNG.

SUMMARY STEPS

1. **configure**
2. **pppoe bba-group** {*bba-group name*}
3. **sessions** {**access-interface** | **circuit-id** | **circuit-id-and-remote-id** | **inner-vlan** | {{**mac** | **mac-iwf**} [**access-interface**] }} | **max** | **outer-vlan** | **remote-id** | **vlan**} **limit** *limit-count* [**threshold** *threshold-count*]
4. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**pppoe bba-group** {*bba-group name*} **Example:** `RP/0/RSP0/CPU0:router(config)# pppoe bba-group bba_1`	Enters the specific PPPoE BBA-Group configuration mode.
Step 3	**sessions** {**access-interface** | **circuit-id** | **circuit-id-and-remote-id** | **inner-vlan** | {{**mac** | **mac-iwf**} [**access-interface**] }} | **max** | **outer-vlan** | **remote-id** | **vlan**} **limit** *limit-count* [**threshold** *threshold-count*] **Example:**	Configures the PPPoE session limits. If the optional argument, **threshold** is configured, a log message is generated when the PPPoE session limit exceeds the *threshold-count* value. The *limit-count* value and *threshold-count* value ranges from 1 to 65535. The default value is 65535.

	Command or Action	Purpose

	`RP/0/RSP0/CPU0:router(config-bbagroup)# sessions access-interface limit 1000`
	`RP/0/RSP0/CPU0:router(config-bbagroup)# sessions mac access-interface limit 5000 threshold 4900`
	`RP/0/RSP0/CPU0:router(config-bbagroup)# sessions circuit-id limit 8000 threshold 7500`	

Step 4	**commit**	

Configuring PPPoE Session Limit: An example

```
configure
pppoe bba-group bba1
 sessions circuit-id limit 8000 threshold 7500
 sessions access-interface limit 1000
 sessions mac access-interface limit 5000 threshold 900
!
end
```

PPPoE Session Throttle

The PPPoE Session Throttle support on BNG limits the number of PPPoE session requests coming to BNG within a specified period of time. This, in turn, ensures that the session establishment of other client requests coming to the BNG server is not impacted.

This offers configuration flexibility in the BNG router by throttling the number of session requests based on one of these:

- Peer MAC address
- Peer MAC address under individual access interface
- Circuit-ID
- Remote-ID
- A combination of Circuit-ID and Remote ID
- Inner VLAN tag under individual access interface
- Outer VLAN tag under individual access interface
- Inner and Outer VLAN tag under individual access interface

The PPPoE session throttle support also throttles the number of Inter Working Function (IWF) session requests for each peer MAC address under an individual access interface.

See, Configuring PPPoE Session Throttle, on page 46.

Configuring PPPoE Session Throttle

Perform this task to configure PPPoE session throttle for a PPPoE BBA-Group in BNG.

SUMMARY STEPS

1. **configure**
2. **pppoe bba-group** *bba-group name*
3. **sessions** {**circuit-id** | **circuit-id-and-remote-id** | **inner-vlan** | {**mac** [**access-interface**] } | {**mac-iwf** {**access-interface**}} | **outer-vlan** | **remote-id** | **vlan**} **throttle** *request-count request-period blocking-period*
4. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**pppoe bba-group** *bba-group name* **Example:** `RP/0/RSP0/CPU0:router(config)# pppoe bba-group bba_1`	Enters the PPPoE BBA-Group configuration mode.

Step 3	**sessions** {**circuit-id** | **circuit-id-and-remote-id** | **inner-vlan** | {**mac** [**access-interface**] } | {**mac-iwf** {**access-interface**}} | **outer-vlan** | **remote-id** | **vlan**} **throttle** *request-count request-period blocking-period*
	Example:
	`RP/0/RSP0/CPU0:router(config-bbagroup)# sessions circuit-id throttle 1000 50 25`
	`RP/0/RSP0/CPU0:router(config-bbagroup)# sessions mac-iwf access-interface throttle 5000 100 50`
		Configures the PPPoE session throttles.
		The *request-count* value ranges from 1 to 65535.
		The *request-period* value ranges from 1 to 100.
		The *blocking-period* value ranges from 1 to 100.

Step 4	**commit**	

Configuring PPPoE Session Throttle: An example

```
configure
pppoe bba-group bba1
 sessions circuit-id throttle 1000 50 25
 sessions mac-iwf access-interface throttle 5000 100 50
!
```

PPPoE In-flight-window

PPPoE in-flight-window is an enhancement to limit the number of PPPoE sessions in BNG that are in progression towards established state. The in-flight-window option sets the PPPoE process queue to a particular limit per LC and per RP, thereby providing a better control of incoming PPPoE sessions to BNG.

To enable this feature, use **pppoe in-flight-window** command in the global configuration mode.

Note The recommended in-flight-window *size* for RP-based subscribers is 200, and that for LC-based subscribers is 50. Values higher than these are not recommended for production deployment, as it can lead to system instability.

Configuration Example for PPPoE In-flight-window

```
Router# configure
Router(config)# pppoe in-flight-window 200
Router(config)#commit
```

Activating IPv6 Router Advertisement on a Subscriber Interface When IPv4 Starts

BNG introduces the ability to automatically trigger an IPv6 router advertisement on an IPv4 subscriber interface. This feature can be used by subscriber interfaces that are on a dual stack network and are enabled for IPv6 processing.

To configure this feature you can either use dynamic templates through CLI or configure RADIUS user profile attributes. This feature is only supported for subscriber sessions that use the IPoE protocol.

In a BNG dual stack network, an IPv4 session is initiated first followed by an IPv6 session request. After receiving the DHCP IPv6 request, the DHCP server allocates an IPv6 address.

Creating Dynamic Template for Enabling IPv6 Router Advertisement on an IPv4 Susbscriber Interface

Perform this task to create a dynamic template to enable IPv6 router advertisements on a subscriber interface:

SUMMARY STEPS

1. **configure**
2. **dynamic-template**
3. **type ipsubscriber** *dynamic template name*
4. **ipv6 nd start-ra-on-ipv6-enable**
5. **show ipv6 nd idb interface** *subscriber interface* **detail location** *member location*

DETAILED STEPS

Step 1 **configure**

Step 2 **dynamic-template**

Enters the dynamic template configuration.

Example:

```
RP/0/RSP0/CPU0:router(config)#dynamic-template
```

Step 3 **type ipsubscriber** *dynamic template name*

Creates a dynamic template with a user-defined name for an ipsubscriber service.

Example:

```
RP/0/RSP0/CPU0:router(config-dynamic-template)#type ipsubscriber ipoe_ipv6
```

Step 4 **ipv6 nd start-ra-on-ipv6-enable**

Enables IPv6 router advertisement capability if ipv6-enable is already configured, instead of waiting for the dual stack to boot up.

Example:

```
RP/0/RSP0/CPU0:router(config-dynamic-template)#type ipsubscriber ipoe_ipv6 start-ra-on-ipv6-enable
```

Step 5 **show ipv6 nd idb interface** *subscriber interface* **detail location** *member location*

Example:

```
RP/0/RSP0/CPU0:router##show ipv6 nd idb interface bundle-ether 50.11.ip3 d
RA flag: 0x1, Unicast RA send: FALSE, Initial RA count: 3, RA pkts sent count: 4
```

Displays the RA packets sent from the subscriber interface.

Making DHCP Settings

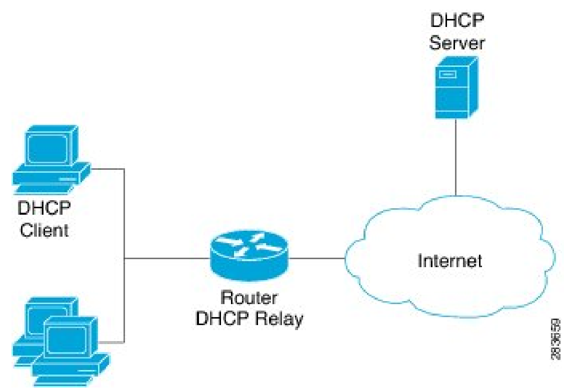
Note For detailed information on the DHCP features and configurations supported on ASR9K router, refer to the *Implementing the Dynamic Host Configuration Protocol* chapter in the *IP Addresses and Services Configuration Guide for Cisco ASR 9000 Series Routers*. For a complete list of DHCP commands supported on ASR9K router, refer to the *DHCP Commands* chapter in the *IP Addresses and Services Command Reference for Cisco ASR 9000 Series Routers*.

The Dynamic Host Configuration Protocol (DHCP) is a network protocol used to configure network devices so that they can communicate on an IP network. There are three distinct elements in a DHCP network:

- DHCP client—It is the device that seeks IP configuration information, such as IP address.
- DHCP server—It allocates IP address from its address pool to the DHCP client.
- DHCP relay or DHCP proxy—It passes IP configuration information between the client and server. It is used when DHCP client and DHCP server are present on different networks.

Initially, the DHCP client (which is a CPE) does not possess an IP address. As a result, it sends a L2 broadcast request to get an IP address. Acting as the relay agent, BNG processes the request and forwards it to the DHCP server. BNG also forwards responses from the DHCP server back to the DHCP client, ensuring that the end device gets correct IP configuration information. A typical DHCP layout is depicted in this figure.

Figure 10: DHCP Network



The DHCP server allocates IP addresses for only a configurable period of time known as the lease period. If a client device needs to retain the IP address for a period longer than the lease period, then the client must renew the lease before it expires. To renew the lease, the client sends a unicast request to the DHCP server. On receiving the request message, the server responds with an acknowledgment, and the client's lease is extended by the lease time specified in the acknowledgment message.

When a control policy is applied to an access interface, it becomes a subscriber access interface. Otherwise, it is a DHCP standalone interface. For the standalone interface, DHCP adds routes to RIB and populates ARP entries, based on the configuration.

For the subscriber access interface, DHCP uses the policy-plane to determine whether the IP subscriber session should be created for a client binding. This is determined based on whether a valid control policy is applied to the access-interface on which the client binding is created. If a subscriber session is created, then a route is added for the subscriber interface, but no ARP requests are sent out from that subscriber interface.

BNG can be configured to either act as DHCP proxy or DHCP server in the DHCP network.

Note DHCP relay is not supported for BNG.

Enabling DHCP Proxy

As the DHCP proxy, BNG performs all the functions of a relay and also provides some additional functions. In the proxy mode, BNG conceals DHCP server details from DHCP clients. BNG modifies the DHCP replies such that the client considers the proxy to be the server. In this state the client interacts with BNG as if it is the DHCP server.

BNG procures IP leases from the DHCP server and keeps it in its pool. When the client needs to renew its lease, it unicasts the lease renewal request directly to the BNG, assuming it to be the server. BNG renews the lease by allocating the lease from its lease pool.

This way the DHCP proxy splits the lease management process into two phases:

- Server to Proxy (Proxy Lease)
- Proxy to Client (Client lease)

The two phase lease management has these features:

- Shorter client lease times and longer proxy lease times.
- High frequency lease management (renews) at network edge.
- Low frequency lease management (renews) at centralized server.

The benefits of DHCP proxy are:

- Reduced traffic between BNG and DHCP server.
- Quicker client response to network outages.

Configuring DHCP proxy on BNG involves these phases:

- Creating a proxy profile. The profile contains various proxy settings. These settings are applied when the profile is attached to an interface. To create a proxy profile, see Configuring DHCP IPv4 Profile Proxy Class, on page 51
  - Specifying client lease period. The client should renew the lease before the completion of this time period, otherwise the lease expires. To specify the client lease period within a proxy profile, see Configuring the Client Lease Time, on page 54.
  - Specifying remote-ID. The remote-ID is used by the proxy to identify the host that had sent the DHCP request. To define a remote-id within a proxy profile, see Configuring a Remote-ID, on page 53.
- Specifying circuit-ID for an interface. The circuit-ID is used by the proxy to identify the circuit in which the DHCP request was received. Later, DHCP proxy uses it for relaying DHCP responses back to the proper circuit. The circuit-ID is defined for an interface. To define it, see Configuring a Circuit-ID for an Interface, on page 52.
- Attaching proxy profile to an interface. See, Attaching a Proxy Profile to an Interface, on page 55

Configuring DHCP IPv4 Profile Proxy Class

Perform this task to define DHCP.

SUMMARY STEPS

1. **configure**
2. **dhcp ipv4**
3. **profile** *profile-name* **proxy**
4. **class** *class-name*
5. **commit**
6. **show dhcp ipv4 proxy profile name** *name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**dhcp ipv4** **Example:**	Enters the IPv4 DHCP configuration mode.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config)# dhcp ipv4`	
Step 3	**profile** *profile-name* **proxy** **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4)# profile profile1 proxy`	Enters the proxy profile configuration mode. The DHCP Proxy makes use of the class information to select a subset of parameters in a given profile.
Step 4	**class** *class-name* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4-profile)# class blue`	Creates a DHCP proxy profile class and enters the proxy profile class mode.
Step 5	**commit**	
Step 6	**show dhcp ipv4 proxy profile name** *name* **Example:** `RP/0/RSP0/CPU0:routershow dhcp ipv4 proxy profile name profile1`	(Optional) Displays the details proxy profile information.

Configuring a Circuit-ID for an Interface

Perform this task to configure a circuit-id for an interface.

SUMMARY STEPS

1. **configure**
2. **dhcp ipv4**
3. **interface** *type* *interface-path-id*
4. **proxy information option format-type circuit-id** *value*
5. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**dhcp ipv4** **Example:** `RP/0/RSP0/CPU0:router(config)# dhcp ipv4`	Enters DHCP IPv4 configuration submode.
Step 3	**interface** *type* *interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4)# interface Bundle-Ether 355`	Configures the interface and enters the interface configuration mode.
Step 4	**proxy information option format-type circuit-id** *value* **Example:**	Configures the circuit-id for this interface.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-dhcpv4)# proxy information option format-type circuit-id 7`	
Step 5	**commit**	

Configuring a Circuit-ID for an Interface: An example

```
configure
dhcp ipv4
interface Bundle-Ether100.10
proxy information option format-type circuit-id 7
 !
!
end
```

Configuring a Remote-ID

Perform this task to configure a remote-ID.

SUMMARY STEPS

1. **configure**
2. **dhcp ipv4**
3. **profile** *profile-name* **proxy**
4. **relay information option remote-id** *value*
5. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**dhcp ipv4** **Example:** `RP/0/RSP0/CPU0:router(config)# dhcp ipv4`	Enters the IPv4 DHCP configuration mode.
Step 3	**profile** *profile-name* **proxy** **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4)# profile profile1 proxy`	Creates a DHCP proxy profile.
Step 4	**relay information option remote-id** *value* **Example:** `RP/0/RSP0/CPU0:router(config-if)# relay information option remote-id 9`	Inserts relay agent information for remote id suboptions such as remote-ID value.
Step 5	**commit**	

Configuring a Remote-ID: An example

```
configure
dhcp ipv4
profile profile1 proxy
relay information option remote-id 9
 !
!
end
```

Configuring the Client Lease Time

Perform this task to configure the client lease time. It defines the time period after which the client lease expires.

SUMMARY STEPS

1. **configure**
2. **dhcp ipv4**
3. **profile** *profile-name* **proxy**
4. **lease proxy client-lease-time** *value*
5. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**dhcp ipv4** **Example:** `RP/0/RSP0/CPU0:router(config)# dhcp ipv4`	Enters the IPv4 DHCP configuration mode.
Step 3	**profile** *profile-name* **proxy** **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4)# profile profile1 proxy`	Creates a DHCP profile.
Step 4	**lease proxy client-lease-time** *value* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4-proxy-profile)# lease proxy client-lease-time 600`	Configures a client lease time for each profile. The minimum value of the lease proxy client time is 300 seconds.
Step 5	**commit**	

Configuring the Client Lease Time: An example

```
configure
dhcp ipv4
profile profile1 proxy
lease proxy client-lease-time 600
```

```
 !
!
end
```

Attaching a Proxy Profile to an Interface

Preform this task to attach a proxy profile to an interface. After it is attached, the various settings specified in the proxy profile take effect on the interface.

SUMMARY STEPS

1. **configure**
2. **dhcp ipv4**
3. **interface** *type* *interface-path-id* **proxy profile** *profile-name*
4. **commit**
5. **show dhcp ipv4 proxy profile name** *name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**dhcp ipv4** **Example:** `RP/0/RSP0/CPU0:router(config)# dhcp ipv4`	Enters the IPv4 DHCP configuration mode.
Step 3	**interface** *type* *interface-path-id* **proxy profile** *profile-name* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4)# interface Bundle-Ether 344 proxy profile profile1`	Enters the Interface configuration mode and assigns a proxy profile to an interface.
Step 4	**commit**	
Step 5	**show dhcp ipv4 proxy profile name** *name* **Example:** `RP/0/RSP0/CPU0:router# show dhcp ipv4 proxy profile name profile1`	(Optional) Displays the details proxy profile information.

Attaching a Proxy Profile to an Interface: An example

```
configure
dhcp ipv4
interface Bundle-Ether100.10 proxy profile profile1
proxy information option format-type circuit-id 7
 !
!
end
```

DHCPv4 Server

DHCP server accepts address assignment requests and renewals and assigns the IP addresses from predefined groups of addresses contained within Distributed Address Pools (DAPS). DHCP server can also be configured to supply additional information to the requesting client such as the IP address of the DNS server, the default router, and other configuration parameters. DHCP server can accept broadcasts from locally attached LAN segments or from DHCP requests that have been forwarded by other DHCP relay agents within the network.

The DHCP proxy performs all the functions of a relay and also provides some additional functions. The DHCP proxy conceals DHCP server details from DHCP clients. The DHCP proxy modifies the DHCP replies such that the client considers the proxy to be the server. In this state, the client interacts with the proxy as if it is the DHCP server.

The pool is configured under server-profile-mode and server-profile-class-sub-mode. The class-based pool selection is always given priority over profile pool selection.

Enabling DHCP Server

BNG can be configured to act as a DHCPv4 Server. To create a DHCPv4 Server profile, see Configuring DHCPv4 Server Profile, on page 56.

For more information on DHCPv4 Server configuration, see *Implementing the Dynamic Host Configuration Protocol* chapter in the *IP Addresses and Services Configuration Guide for Cisco ASR 9000 Series Routers*.

Configuring DHCPv4 Server Profile

Perform this task to configure the DHCPv4 Server.

SUMMARY STEPS

1. **configure**
2. **dhcp ipv4**
3. **profile** *profile-name* **server**
4. **bootfile** *boot-file-name*
5. **broadcast-flag policy** *unicast-always*
6. **class** *class-name*
7. **exit**
8. **default-router** *address1 address2 ... address8*
9. **lease** { **infinite** | *days minutes seconds* }
10. **limit lease** { **per-circuit-id** | **per-interface** | **per-remote-id** } *value*
11. **netbios-name server** *address1 address2 ... address8*
12. **netbios-node-type** { **number** | **b-node** | **h-node** | **m-node** | **p-node** }
13. **option** *option-code* { **ascii** *string* | **hex** *string* | **ip** *address* }
14. **pool** *pool-name*
15. **requested-ip-address-check disable**
16. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	

Step 2	**dhcp ipv4**
	Example:
	`RP/0/RSP0/CPU0:router(config) # dhcp ipv4`
	`RP/0/RSP0/CPU0:router(config-dhcpv4)#`
		Enables DHCP for IPv4 and enters DHCP IPv4 configuration mode.

Step 3	**profile** *profile-name* **server**
	Example:
	`RP/0/RSP0/CPU0:router(config-dhcpv4 )# profile TEST server`
	`RP/0/RSP0/CPU0:router(config-dhcpv4-server-profile)#`
		Enters the server profile configuration mode.

Step 4	**bootfile** *boot-file-name* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4-server-profile)# bootfile b1`	Configures the boot file.
Step 5	**broadcast-flag policy** *unicast-always* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4-server-profile)# broadcast-flag policy unicast-always`	Configures the broadcast-flag policy to unicast-always.

Step 6	**class** *class-name*
	Example:
	`RP/0/RSP0/CPU0:router(config-dhcpv4-server-profile)# class Class_A`
	`RP/0/RSP0/CPU0:router(config-dhcpv4-server-profile-class)`
		Creates and enters server profile class configuration submode.

Step 7	**exit** **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4-server-profile-class)#`	Exits the server profile class submode.

	Command or Action	Purpose
	`exit` `RP/0/RSP0/CPU0:router(config-dhcpv4-server-profile)#`	
Step 8	**default-router** *address1 address2 ... address8* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4-server-profile)# default-router 10.20.1.2`	Configures the name of the default-router or the IP address.
Step 9	**lease** {**infinite** | *days minutes seconds* } **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4-server-profile)# lease infinite`	Configures the lease for an IP address assigned from the pool.
Step 10	**limit lease** {**per-circuit-id** | **per-interface** | **per-remote-id** } *value* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4-server-profile)# limit lease per-circuit-id 23`	Configures the limit on a lease per-circuit-id, per-interface, or per-remote-id.
Step 11	**netbios-name server** *address1 address2 ... address8* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4-server-profile)# netbios-name-server 10.20.3.5`	Configures the NetBIOS name servers.
Step 12	**netbios-node-type** {**number** | **b-node** | **h-node** | **m-node** | **p-node** } **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4-server-profile)# netbios-node-type p-node`	Configures the type of NetBIOS node.
Step 13	**option** *option-code* {**ascii** *string* | **hex** *string* | **ip** *address*} **Example:**	Configures the DHCP option code.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-dhcpv4-server-profile)# option 23 ip 10.20.34.56`	
Step 14	**pool** *pool-name* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4-server-profile)# pool pool1`	Configures the Distributed Address Pool Service (DAPS) pool name.
Step 15	**requested-ip-address-check disable** **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4-server-profile)# requested-ip-address-check disable`	Validates a requested IP address.
Step 16	**commit**	

Specifying DHCP Lease Limit

The DHCP lease limit feature allows you to limit the number of DHCP bindings on an interface. A binding represents the mapping between the MAC address of the client and the IP address allocated to it. The lease limit can be specified for each Circuit-ID, or Remote-ID, or interface.

The lease limit can be configured through a DHCP proxy profile. When this profile is attached to an interface, bindings up to the configured limit on that interface are allowed. For example, if a profile with a per-circuit lease limit of 10 bindings is assigned to four interfaces, then for each unique Circuit-ID, there would be 10 bindings allowed for each interface.

If the lease limit is lowered below the current number of existing bindings, then the existing bindings are allowed to persist, but no new bindings are allowed to be created until the number of bindings drops below the new lease limit.

If the lease limit is specified from the AAA server, as part of Change of Authorization (CoA) or Access-Accept message, then the DHCP lease limit configured through the proxy profile is overridden. In this case, the most recent session limit, received from the AAA server, is taken as the current lease limit for the particular Circuit-ID. The lease limit set from the AAA server is cleared when there are no more client bindings associated with the Circuit-ID for which the lease limit is applied.

To specify the lease limit, see these procedures:

- Specifying the Lease Limit for a Circuit-ID, on page 60
- Specifying the Lease Limit for a Remote-ID, on page 60
- Specifying the Lease Limit for an Interface, on page 61

Specifying the Lease Limit for a Circuit-ID

Perform this task to specify the lease limit for each Circuit-ID.

SUMMARY STEPS

1. **configure**
2. **dhcp ipv4**
3. **profile** *profile-name* **proxy**
4. **limit lease per-circuit-id** *value*
5. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**dhcp ipv4** **Example:** `RP/0/RSP0/CPU0:router(config)# dhcp ipv4`	Enters the IPv4 DHCP configuration mode.
Step 3	**profile** *profile-name* **proxy** **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4)# profile profile1 proxy`	Creates a DHCP profile.
Step 4	**limit lease per-circuit-id** *value* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4-proxy-profile)# limit lease per-circuit-id 1000`	Specifies the lease limit for a Circuit-ID that is applied to an interface.
Step 5	**commit**	

Specifying the Lease Limit for a Circuit-ID: An example

```
configure
dhcp ipv4
profile profile1 proxy
limit lease per-circuit-id 1000
 !
!
end
```

Specifying the Lease Limit for a Remote-ID

Perform this task to specify the lease limit for each Remote-ID.

SUMMARY STEPS

1. **configure**

2. **dhcp ipv4**
3. **profile** *profile-name* **proxy**
4. **limit lease per-remote-id** *value*
5. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**dhcp ipv4** **Example:** `RP/0/RSP0/CPU0:router(config)# dhcp ipv4`	Enters the IPv4 DHCP configuration mode.
Step 3	**profile** *profile-name* **proxy** **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4)# profile profile1 proxy`	Creates a DHCP profile.
Step 4	**limit lease per-remote-id** *value* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4-proxy-profile)# limit lease per-remote-id 1340`	Specifies the lease limit for a Remote-ID that is applied to an interface.
Step 5	**commit**	

Specifying the Lease Limit for a Remote-ID: An example

```
configure
dhcp ipv4
profile profile1 proxy
limit lease per-remote-id 1340
 !
!
end
```

Specifying the Lease Limit for an Interface

Perform this task to specify the lease limit for each interface.

SUMMARY STEPS

1. **configure**
2. **dhcp ipv4**
3. **profile** *profile-name* **proxy**
4. **limit lease per-interface** *value*
5. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**dhcp ipv4** **Example:** `RP/0/RSP0/CPU0:router(config)# dhcp ipv4`	Enters the IPv4 DHCP configuration mode.
Step 3	**profile** *profile-name* **proxy** **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4)# profile profile1 proxy`	Creates a DHCP profile.
Step 4	**limit lease per-interface** *value* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv4-proxy-profile)# limit lease per-interface 2400`	Specifies the lease limit for each interface.
Step 5	**commit**	

Specifying the Lease Limit for an Interface: An example

```
configure
dhcp ipv4
profile profile1 proxy
limit lease per-interface 2400
 !
!
end
```

Understanding DHCP Option-82

DHCP Option 82 allows the DHCP server to generate IP addresses based on the location of the client device. This option defines these sub-options:

- Agent Circuit ID Sub-option—This sub-option is inserted by DSLAM and identifies the subscriber line in the DSLAM.
- Agent Remote ID Sub-option—This sub-option is inserted by DSLAM or BNG in an l2-connected topology. It is the client MAC address, but can be overridden. With the DHCP proxy or relay, the client MAC address is lost by the time the packet gets to the DHCP server. This is a mechanism that preserves the client MAC when the packet gets to the server.
- VPN identifier sub-option—This sub-option is used by the relay agent to communicate the VPN for every DHCP request that is sent to the DHCP server, and it is also used to forward any DHCP reply that the DHCP server sends back to the relay agent.
- Subnet Selection Sub-option—This sub-option allows the separation of the subnet from the IP address and is used to communicate with the relay agent. In a DHCP processing, the gateway address specifies

both the subnet on which a DHCP client resides, and the IP address that the server uses to communicate with the relay agent.

- Server Identifier Override Sub-option—This sub-option value is copied in the reply packet from the DHCP server, instead of the normal server ID address. This sub-option contains the incoming interface IP address, which is the IP address on the relay agent that is accessible from the client. Using this information, the DHCP client sends all renew and release packets to the relay agent, which in turn adds all of the VPN sub-options and forwards the renew and release packets to the original DHCP server.

Note The VPN Identifier, Subnet Selection, and Server Identifier Override sub-options are used by DHCP relay/proxy for supporting MPLS VPNs.

Option 82 Relay Information Encapsulation

When two relay agents are relaying messages between the DHCP client and DHCP server, the second relay agent (closer to the server), by default, replaces the first option 82 information with its own option 82. The remote ID and circuit ID information from the first relay agent is lost. In some deployment scenarios, it is necessary to maintain the initial option 82 from the first relay agent, in addition to the option 82 from the second relay agent.

The DHCP option 82 relay information encapsulation feature allows the second relay agent to encapsulate option 82 information in a received message from the first relay agent, if it is also configured to add its own option 82 information. This configuration allows the DHCP server to use option 82 information from both the relay agents.

Configuring DHCPv4 Class of Service (CoS)

BNG supports manual reset of Class of Service (CoS) value of DHCPv4 control packets sent on subscriber interfaces. By default, the outer and inner CoS values are set to 6. This feature allows to set or modify these CoS values sent by BNG.

The inner and outer Class of Service (CoS) values can be configured for DHCPv4 control packets. For broadcast packets, both the **inner-cos** and **outer-cos** commands can be used to configure CoS values. For unicast packets, the **inner-cos** command cannot be directly used. The outer CoS value configured using the **outer-cos** command is also set as the inner CoS value.

To reset the CoS values, use the **dhcp ipv4** [**inner-cos** | **outer-cos**] *value* command.

For more information about configuring the CoS values, see the *BNG DHCP Commands* chapter in the *Cisco ASR 9000 Series Aggregation Services Router Broadband Network Gateway Command Reference*.

DHCP RADIUS Proxy

BNG supports DHCP IPv4 RADIUS proxy for RADIUS-based authorization of DHCP leases. This is a RADIUS-based address assignment mechanism in which a DHCP server authorizes remote clients and allocates IP addresses, based on replies from a RADIUS server. For DHCP RADIUS proxy to work, you must configure the DHCPv4 server profile on the BNG interface.

These are the steps involved in the address assignment mechanism:

- The DHCP server sends DHCP client information to the RADIUS server.

- The RADIUS server returns all required information, primarily IPV4 address and subnet mask, to the DHCP server, in the form of RADIUS attributes.
- The DHCP server translates the RADIUS attributes into DHCP options and sends this information back in a DHCP OFFER message to the DHCP client.
- The DHCP binding is synchronized after the RADIUS server authorizes the client session.

If DHCPv4 IETF attributes: **Framed-IP-Address** and **Framed-IP-Netmask** are received from the RADIUS server, then they are preferred and used instead of allocating the IP address from the local pool.

Example:

```
Framed-IP-Address = 10.10.10.81,
Framed-IP-Netmask = 255.255.255.0,
```

If Cisco attribute: **VRF-ID** is received from the RADIUS server and configured on BNG, then it is used and preferred over local configuration.

Example:

```
Cisco-avpair = "vrf-id=RED"
```

If Cisco attributes: **ipv6:addrv6** and **delegated-prefix** are received from the RADIUS server, then they are preferred and used instead of allocating the IP address from the local pool.

Example:

```
Cisco-avpair = "ipv6:addrv6=2000:4:4::1",
Cisco-avpair = "delegated-prefix=3405:100:1015:2::/64"
```

Apart from these attributes, if the RADIUS server sends the **dhcp-class** attribute to the DHCP server, then that attribute value is used to decide other configuration parameters in the reply that is to be sent to the DHCP client. For example, if the DHCPv4 server profile has both Class A and Class B in it, and if RADIUS server sends a reply to the DHCP server with the class name as 'B', then instead of Class A, Class B is used to send the options back to the DHCP client.

Additional RADIUS server attributes are allowed, but not mandatory. The DHCP server ignores additional attributes that it does not recognize. If a RADIUS server user profile contains a required attribute that is empty, the DHCP server does not generate the DHCP options.

Subscriber Session-Restart

BNG supports IPoE subscriber session-restart, where the DHCP binding for a subscriber session is retained even after the session is deleted. The DHCP client still holds the initial IP address issued by BNG. Later, when the client sends data packets or a DHCP renew request, the session is re-created in BNG. This behavior applies to DHCPv4 sessions on RP or LC.

At the time of session deletion, the DHCP binding moves from the BOUND to the DISCONNECT state. The subscriber label is reset to 0x0 when the binding moves to the DISCONNECT state. Later, when the session is re-created, the binding state then moves back from the DISCONNECT to the BOUND. This re-created session has a new subscriber label and a new subscriber interface.

The binding stays in the DISCONNECT state, only till the lease time. If a data packet or renew request does not come before the lease time expires, then the session is cleared.

Session-restart behavior is applicable to session deletions triggered by idle timeout, or by an account-logoff procedure, where the trigger for deletion is any action other than the DHCP release from the client.

Session-restart is not applicable to session deletions done by the execution of the **clear subscriber session all** command. The DHCP bindings are removed in such cases.

For session deletion triggered by the DHCP client, both the session and the DHCP binding are deleted.

Note For session-restart to work, you must configure dual initiators (**initiator dhcp** and **initiator unclassified-source**) under the access-interface.

DHCP Session MAC Throttle

The ASR9K router supports the DHCP session MAC throttle feature. This feature limits the number of DHCP client requests reaching the ASR9K, based on the MAC address of the DHCP clients. This feature is supported for the DHCPv4 proxy, the DHCPv4 server, and the DHCPV6 proxy. The feature prevents a DHCP client from sending multiple DISCOVER packets to the ASR9K router, within short periods of time. This, in turn, prevents that client from impacting the session establishment of other DHCP clients.

A unique throttle entry is created in the system for each unique MAC address received on any interface where the profile is attached.

To configure the DHCP session MAC throttle feature, use the **sessions mac throttle** command in the respective DHCP profile configuration mode.

Configuring DHCP Session MAC Throttle: Example

```
dhcp ipv4
 profile p1 server
  sessions mac throttle 300 60 40
 !
 interface GigabitEthernet0/0/0/0 server profile p1
!
```

DHCPv6 Overview

The Dynamic Host Configuration Protocol for IPv6 (DHCPv6) enables DHCP servers to pass configuration parameters, such as IPv6 network addresses, to IPv6 nodes. It enables automatic allocation of reusable network addresses to the requesting clients, using the stateful address-configuration. Along with address and prefix allocation, DHCPv6 also offers additional configuration flexibility by assigning other configuration parameters such as DNS address, DNS domain name, AFTR address to IPv6 nodes in a network.

The basic DHCPv6 client-server concept is similar to using DHCP for IPv4 (DHCPv4). If a client wishes to receive configuration parameters, it sends out a request on the attached local network to detect the available DHCPv6 servers. Although DHCPv6 assigns IPv6 addresses or prefixes, name servers, and other configuration information very similar to that of DHCP for IPv4, these are certain key differences between DHCPv4 and DHCPv6. For example, unlike DHCPv4, address allocation in DHCPv6 is handled using a message option, DHCPv6 clients can request multiple addresses and prefixes in a single request, and DHCPv6 can request different lease times for the addresses and prefixes. These significant advantages of DHCPv6 make it a preferred protocol for address assignment.

IPv6 hosts use Stateless Address Auto-Configuration (SLAAC), a model in which the hosts generate their own addresses using a combination of local and router-advertised information.

The DHCPv6 has been standardized by the IETF through RFC 3315. This DHCPv6 protocol is a stateful counterpart to IPv6 Stateless Address Auto-Configuration (RFC 4862), and can be used separately, or concurrently with SLAAC, to obtain configuration parameters.

Note Prior to configuring DHCPv6, IPv6 must be enabled on the interface on which DHCPv6 is servicing and enable Neighbor Discovery (ND).

For more information about Neighbor Discovery (ND), refer to the "Implementing Network Stack IPv4 and IPv6" section in the *Cisco IOS XR IP Addresses and Services Configuration Guide*.

Restrictions

- DHCPv6 Proxy supports to a maximum of eight external DHCPv6 servers per proxy profile.
- Bulk lease query is not supported.
- DHCPv6 server is supported only with BNG configuration.

DHCPv6 Server and DHCPv6 Proxy

The DHCPv6 server always uses stateful address assignment. On receiving a valid request, the DHCPv6 server assigns IPv6 address or prefix and other configuration attributes such as domain name, domain name server (DNS) address to requesting clients.

A DHCPv6 Relay or Proxy forwards a DHCPv6 message from a client to a server. A DHCPv6 Relay can use either stateless or stateful address assignment. The DHCPv6 Stateless Relay agent acts as an intermediary to deliver DHCPv6 messages between clients and servers. The Relay does not store or keep track of information such as client addresses or the lease time. The DHCPv6 Relay is also known as a Stateless Relay. On the other hand, the DHCPv6 Stateful Relay agent, also known as DHCP proxy, not only forwards a DHCPv6 message from a client to the server, but also keeps track of the client's addresses and lease time. Hence, DHCPv6 Proxy is also known as Stateful Relay. DHCPv6 supports a standalone proxy.

DHCPv6 Proxy enables inserting remote-ID and interface-ID options. The DHCPv6 Proxy uses the interface-ID in addition to remote-ID to choose the interface on which to send the response towards client.

DHCPv6 can be enabled on different configuration modes. For more information about configuring DHCPv6 on different configuring modes, see Enabling DHCPv6 for Different Configuration Modes, on page 66. For more information about setting the DHCPv6 parameters, see Setting Up DHCPv6 Parameters, on page 69.

Note DHCP relay is not supported for BNG.

Enabling DHCPv6 for Different Configuration Modes

Perform this task to enable DHCPv6 for different configuration modes such as global, server profile, proxy profile configuration modes, and server profile class and proxy profile class sub-configuration modes.

SUMMARY STEPS

1. **configure**
2. **dhcp ipv6**
3. **profile** *server_profile_name* **server**
4. **class** *class-name*
5. **dns-server** *address*
6. **domain-name** *name*
7. **prefix-pool** *pool_name*
8. **address-pool** *pool_name*
9. **commit**
10. **interface** *type* *interface-path-id* **server profile** *profile_name*
11. **profile** *proxy_profile_name* **proxy**
12. **link-address** *ipv6_address*
13. **class** *class-name*
14. **helper-address** **vrf** *vrf_name* *ipv6_address*
15. **commit**
16. **interface** *type* *interface-path-id* **proxy profile** *profile_name*
17. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**dhcp ipv6** **Example:** `RP/0/RSP0/CPU0:router(config)# dhcp ipv6`	Configures DHCP for IPv6 and enters the DHCPv6 configuration mode.
Step 3	**profile** *server_profile_name* **server** **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6)# profile my-server-profile server`	Creates a DHCPv6 server profile and enters the DHCPv6 server profile sub-configuration mode.
Step 4	**class** *class-name* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6-server-profile)# class server-green`	Defines a class in a server profile and enters the server profile class sub-mode.
Step 5	**dns-server** *address* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6-server-profile)# dns-server 1111::1`	Defines a dns-server and the corresponding address in a server profile.
Step 6	**domain-name** *name* **Example:**	Defines a domain name in a server profile.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-dhcpv6-server-profile)# domain-name www.xyz.com`	
Step 7	**prefix-pool** *pool_name* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6-server-profile)# prefix_pool p1`	Configures a prefix pool in a server profile.
Step 8	**address-pool** *pool_name* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6-server-profile)# address_pool p1`	Configures an address pool in a server profile.
Step 9	**commit**	
Step 10	**interface** *type* *interface-path-id* **server profile** *profile_name* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6)# interface Bundle-Ether1.1 server profile my-server-profile`	Associates a DHCPv6 server configuration profile with an IPv6 interface.
Step 11	**profile** *proxy_profile_name* **proxy** **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6)# profile my-proxy-profile proxy`	Creates a DHCPv6 profile proxy and enters the DHCPv6 proxy sub-configuration mode.
Step 12	**link-address** *ipv6_address* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6)# link-address 5:6::78`	Specifies the IPv6 address to be filled in the link-address field of the Relay Forward message.
Step 13	**class** *class-name* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6-proxy-profile)# class proxy-red`	Defines a class in a proxy profile and enters the proxy profile class sub-mode.
Step 14	**helper-address** **vrf** *vrf_name* *ipv6_address* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6-proxy-profile)# helper-address vrf my-server-vrf 1:1:1::1`	Configures DHCPv6 address as a helper address to the proxy. **Note** The helper address can be configured only under the proxy profile and proxy profile class sub-modes.
Step 15	**commit**	
Step 16	**interface** *type* *interface-path-id* **proxy profile** *profile_name* **Example:**	Associates a DHCPv6 proxy configuration profile to an IPv6 interface.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-dhcpv6)# interface BundleEther100.1 proxy profile my-proxy-profile`	
Step 17	**commit**	

Enabling DHCPv6 for Different Configuration Modes: An example

```
configure
dhcp ipv6
profile my-server-profile server
link-address 5:6::78
class server-green
dns-server 1111::1
domain-name www.cisco.com
prefix-pool POOL_P6_2
address-pool POOL_A6_1

end
!!
configure
dhcp ipv6
interface GigabitEthernet 0/2/0/0 server profile my-server-profile
profile my-proxy-profile proxy
link-address 5:6::78
class proxy-red
helper-address 5661:11
end
!!
configure
dhcp ipv6
interface GigabitEthernet 0/2/0/0 proxy profile my-proxy-profile
end
!!
```

Setting Up DHCPv6 Parameters

Perform this task to set up DHCPv6 parameters such as address pool name, prefix pool name, DNS server, domain name, lease time, and helper address.

SUMMARY STEPS

1. **configure**
2. **dhcp ipv6**
3. **profile** *server_profile_name* **server**
4. **dns-server** *ipv6_address*
5. **domain-name** *domain_name*
6. **lease**
7. **helper-address** **vrf** *vrf_name* *ipv6_address*
8. **prefix-pool** *prefix-pool-name*
9. **address-pool** *address-pool-name*
10. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**dhcp ipv6** **Example:** `RP/0/RSP0/CPU0:router(config)# dhcp ipv6`	Configures DHCP for IPv6 and enters the DHCPv6 configuration mode.
Step 3	**profile** *server_profile_name* **server** **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6)# profile my-server-profile server`	Configures DHCPv6 server profile and enters the DHCPv6 server profile sub-configuration mode.
Step 4	**dns-server** *ipv6_address* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6-server-profile)# dns-server 1:1:1::1`	Configures the DNS server for DHCPv6 server profile. **Note** The DNS server name is defined in the class mode. If the same parameters are defined in the profile mode too, then the values defined in the class mode takes precedence.
Step 5	**domain-name** *domain_name* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6-server-profile)# domain-name my.domain.name`	Configures the DNS domain name for DHCPv6 server profile. **Note** The DNS server name is defined in the class mode. If the same parameters are defined in the profile mode too, then the values defined in the class mode takes precedence.
Step 6	**lease** **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6-server-profile)# lease 1 6 0`	Configures the lease time for a duration of 1 day, 6 hours, and 0 minutes.
Step 7	**helper-address vrf** *vrf_name ipv6_address* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6-proxy-profile)# helper-address vrf my-server-vrf 1:1:1::1`	Configures DHCPv6 address as a helper address to the proxy. **Note** The helper address can be configured only under the proxy profile and proxy profile class sub-modes.
Step 8	**prefix-pool** *prefix-pool-name* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6-server-profile-class)# prefix-pool my-server-delegated-prefix-pool`	Configures the prefix pool under the DHCPv6 server profile class sub-mode.
Step 9	**address-pool** *address-pool-name* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6-server-profile-class)# address-pool my-server-address-pool`	Configures the address pool under the DHCPv6 server profile class sub-mode.

	Command or Action	Purpose
Step 10	**commit**	

Setting Up DHCPv6 Parameters: An example

```
configure
dhcp ipv6
profile my-server-profile server
dns-server 1:1:1::1
domain-name my.domain.name
lease 1 6 0
class class1
prefix-pool my-server-delegated-prefix-pool
address-pool my-server-address-pool
end
!!
```

DHCPv6 Features

DHCPv6 is widely used in LAN environments to dynamically assign host IP addresses from a centralized server. This dynamic assignment of addresses reduces the overhead of administration of IP addresses. DHCPv6 also helps conserve the limited IP address space. This is because IP addresses no longer need to be permanently assigned to hosts; only those hosts that are connected to the network consume IP addresses.

The DHCPv6 features supported in BNG are:

High Availability Support for DHCPv6

High availability support for DHCPv6 includes:

Linecard Online Insertion and Removal

Linecard Online Insertion and Removal (OIR) enables you to replace faulty parts without affecting the system's operations. When a card is inserted, power is available on the card, and it initializes itself to start being operational.

Note DHCPv6 bindings are not affected by Linecard OIR.

Checkpoint and Shadow Database

The checkpoint and shadow database are actively maintained on the RSP and contains a copy of all bindings from all linecards. The checkpoint database has client or subscriber bindings from the subscribers over interfaces in its scope. The shadow database on the active RSP updates the standby shadow database.

DHCPv6 Hot Standby

DHCPv6 Hot Standby is a process that is supported only on RSPs. Whenever the active RSP stops responding, it is instantly replaced by a standby RSP. The standby RSP takes over processing when it becomes active.

DHCPv6 Prefix Delegation

The DHCPv6 prefix delegation is a mechanism of delegating IPv6 prefixes to a client. The prefix delegation feature can be used to manage link, subnet, and site addressing changes.

An Internet Service Provider (ISP) assigns prefix to a customer for use within the customer's network. Prefix delegation occurs between a provider edge (PE) device and customer premises equipment (CPE), using the DHCPv6 prefix delegation option. After the ISP has delegated prefixes to a customer, the customer may further subnet and assign prefixes to the links in the customer's network.

By default, the prefix delegation feature is always enabled.

IPv6 IPoE Subscriber Support

An IPv6 subscriber transmits IPv6 address that is created using the DHCPv6 protocol. The IPv6 subscribers run IPv6 on the CPE device and are connected to BNG through a Layer-2 network or through Layer-2 aggregation. The IPv6 subscribers are supported when they are directly connected to the BNG or through a Layer-2 aggregator.

To enable IPv6 IPoE subscriber support, the DHCPv6 profile needs to be explicitly configured on the subscriber interface. For more information, see Configuring IPv6 IPoE Subscriber Interface, on page 72.

FSOL Handling

The DHCPv6 First Sign of Life (FSOL) handling is only supported for IPoE sessions. DHCPv6 handles SOLICIT packet from client as FSOL packet for IPoE session validation and creation. The IPoE session gets created, as long as the configuration exists and the subscriber information is validated successfully.

Configuring IPv6 IPoE Subscriber Interface

Perform this task to configure IPoE subscriber interface.

SUMMARY STEPS

1. **configure**
2. **pool vrf** *name* **ipv6** *pool_name*
3. **address-range** *first_ipv6_address last_ipv6_address*
4. **pool vrf** *name* **ipv6** *pool_name*
5. **prefix-length** *length*
6. **prefix-range** *first_ipv6_address last_ipv6_address*
7. **commit**
8. **dhcp ipv6**
9. **interface** *type interface-path-id* **server profile** *profile_name*
10. **profile** *server_profile_name* **server**
11. **prefix-pool** *pool_name*
12. **address-pool** *pool_name*
13. **commit**
14. **dhcp ipv6**
15. **interface** *type interface-path-id* **proxy profile** *profile_name*
16. **profile** *server_profile_name* **proxy**
17. **helper-address vrf** *vrf_name ipv6_address*

18. **commit**
19. **dynamic-template type ipsubscriber** *dynamic_template_name*
20. **ipv6 enable**
21. **dhcpv6 address-pool** *pool_name*
22. **dhcpv6 delegated-prefix-pool** *pool_name*
23. **commit**
24. **class-map type control subscriber match-all** *class-map_name*
25. **match protocol dhcpv6**
26. **end-class-map**
27. **policy-map type control subscriber** *class-map_name*
28. **event session-start match-first**
29. **class type control subscriber** *class_name* **do-all**
30. *sequence_number* **activate dynamic-template** *dynamic-template_name*
31. **end-policy-map**
32. **commit**
33. **interface** *type interface-path-id*
34. **ipv4 address** *ipv4_address*
35. **ipv6 address** *ipv6_address*
36. **ipv6 enable**
37. **service-policy type control subscriber** *name*
38. **ipsubscriber ipv6 l2-connected**
39. **initiator dhcp**
40. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**pool vrf** *name* **ipv6** *pool_name* **Example:** `RP/0/RSP0/CPU0:router(config)# pool vrf default ipv6 pool1`	Configures the distributed address pool service.
Step 3	**address-range** *first_ipv6_address last_ipv6_address* **Example:** `RP/0/RSP0/CPU0:router(config-pool-ipv6)# address-range 2201:abcd:1234:2400:f800::1 2201:abcd:1234:2400:f800::fff`	Configures the address-range.
Step 4	**pool vrf** *name* **ipv6** *pool_name* **Example:** `RP/0/RSP0/CPU0:router(config)# pool vrf default ipv6 pool2`	Configures the distributed address pool service.
Step 5	**prefix-length** *length* **Example:**	Specifies the prefix-length to be used.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-pool-ipv6)# prefix-length 92`	
Step 6	**prefix-range** *first_ipv6_address last_ipv6_address* **Example:** `RP/0/RSP0/CPU0:router(config-pool-ipv6)# prefix-range 3301:1ab7:2345:1200:f800:: 3301:1ab7:2345:1200:f800:fff0::`	Specifies the prefix-range for allocation.
Step 7	**commit**	
Step 8	**dhcp ipv6** **Example:** `RP/0/RSP0/CPU0:router(config)# dhcp ipv6`	Configures DHCP for IPv6 and enters the DHCPv6 configuration mode.
Step 9	**interface** *type interface-path-id* **server profile** *profile_name* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6)# interface Bundle-Ether1.1 server profile foo`	Associates a DHCPv6 proxy configuration profile to an IPv6 interface.
Step 10	**profile** *server_profile_name* **server** **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6)# profile foo server`	Creates a DHCPv6 server profile and enters the DHCPv6 server profile sub-configuration mode.
Step 11	**prefix-pool** *pool_name* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6-server-profile)# prefix-pool pool2`	Configures a prefix pool in a server profile.
Step 12	**address-pool** *pool_name* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6-server-profile)# address-pool pool1`	Configures an address pool in the server profile.
Step 13	**commit**	
Step 14	**dhcp ipv6** **Example:** `RP/0/RSP0/CPU0:router(config)# dhcp ipv6`	Configures DHCP for IPv6 and enters the DHCPv6 configuration mode.
Step 15	**interface** *type interface-path-id* **proxy profile** *profile_name* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6)# interface Bundle-Ether1.1 proxy profile foo`	Associates a DHCPv6 proxy configuration profile to an IPv6 interface.

	Command or Action	Purpose
Step 16	**profile** *server_profile_name* **proxy** **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6)# profile foo proxy`	Creates a DHCPv6 server profile and enters the DHCPv6 server profile sub-configuration mode.
Step 17	**helper-address vrf** *vrf_name* *ipv6_address* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6-proxy-profile)# helper-address vrf my-server-vrf 1:1:1::1`	Configures DHCPv6 address as a helper address to the proxy. **Note** The helper address can be configured only under the proxy profile and proxy profile class sub-modes.
Step 18	**commit**	
Step 19	**dynamic-template type ipsubscriber** *dynamic_template_name* **Example:** `RP/0/RSP0/CPU0:router(config)# dynamic-template type ipsubscriber dhcpv6_temp`	Configures the dynamic template of type ipsubscriber and enters the dynamic template type configuration mode.
Step 20	**ipv6 enable** **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template-type)# ipv6 enable`	Enables IPv6 on an interface.
Step 21	**dhcpv6 address-pool** *pool_name* **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template-type)# dhcpv6 address-pool pool3`	Configures DHCPv6 address pool.
Step 22	**dhcpv6 delegated-prefix-pool** *pool_name* **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template-type)# dhcpv6 delegated-prefix-pool pool4`	Configures DHCPv6 delegated prefix pool.
Step 23	**commit**	
Step 24	**class-map type control subscriber match-all** *class-map_name* **Example:** `RP/0/RSP0/CPU0:router(config)# class-map type control subscriber match-all dhcpv6_class`	Configures the class map control subscriber with a match-any criteria.
Step 25	**match protocol dhcpv6** **Example:** `RP/0/RSP0/CPU0:router(config-cmap)# match protocol dhcpv6`	Configures match criteria for the class configured in the earlier step.

	Command or Action	Purpose
Step 26	**end-class-map** **Example:** `RP/0/RSP0/CPU0:router(config-cmap)# end-class-map`	Configures the end class map.
Step 27	**policy-map type control subscriber** *class-map_name* **Example:** `RP/0/RSP0/CPU0:router(config)# policy-map type control subscriber dhcpv6-policy`	Configures the subscriber control policy map.
Step 28	**event session-start match-first** **Example:** `RP/0/RSP0/CPU0:router(config-pmap)# event session-start match-first`	Configures the policy event with the match-first criteria.
Step 29	**class type control subscriber** *class_name* **do-all** **Example:** `RP/0/RSP0/CPU0:router(config-pmap-e)# class type control subscriber dhcpv6_class do-all`	Configures the class map control subscriber with a match-any criteria.
Step 30	*sequence_number* **activate dynamic-template** *dynamic-template_name* **Example:** `RP/0/RSP0/CPU0:router(config-pmap-c)# 20 activate dynamic-template dhcpv6_temp`	Activates actions related to dynamic template.
Step 31	**end-policy-map** **Example:** `RP/0/RSP0/CPU0:router(config-pmap-c)# end-policy-map`	Configures the end policy map.
Step 32	**commit**	
Step 33	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config)# interface Bundle-Ether1.1`	Configures an interface and enters the interface configuration mode.
Step 34	**ipv4 address** *ipv4_address* **Example:** `RP/0/RSP0/CPU0:router(config-if)# ipv4 address 11.11.11.2 255.255.255.0`	Configures the ipv4 address on an interface.
Step 35	**ipv6 address** *ipv6_address* **Example:** `RP/0/RSP0/CPU0:router(config-if)# ipv6 address 11:11:11::2/64`	Configures the ipv6 address on an interface.
Step 36	**ipv6 enable**	Enables IPv6 on an interface.

	Command or Action	Purpose
	Example: `RP/0/RSP0/CPU0:router(config-if)# ipv6 enable`	
Step 37	**service-policy type control subscriber** *name* **Example:** `RP/0/RSP0/CPU0:router(config-if)# service-policy type control subscriber dhcpv6_policy`	Associates a subscriber control service policy to the interface.
Step 38	**ipsubscriber ipv6 l2-connected** **Example:** `RP/0/RSP0/CPU0:router(config-if)# ipsubscriber ipv6 l2-connected`	Enables l2-connected IPv6 subscriber.
Step 39	**initiator dhcp** **Example:** `RP/0/RSP0/CPU0:router(config-if-ipsub-ipv6-l2conn)# initiator dhcp`	Configures IPv6 subscriber initiator.
Step 40	**commit**	

Configuring IPv6 IPoE Subscriber Interface: An example

```
configure
pool vrf default ipv6 pool1
 address-range 2201:abcd:1234:2400:f800::1 2201:abcd:1234:2400:f800::fff

pool vrf default ipv6 pool2
prefix-length 92
prefix-range 3301:1ab7:2345:1200:f800:: 3301:1ab7:2345:1200:f800:fff0::

dhcp ipv6
 interface GigabitEthernet0/3/0/0 server profile foo
 profile foo server
  prefix-pool pool2
  address-pool pool1
!
!
end

configure
dhcp ipv6
 interface GigabitEthernet0/3/0/0 proxy profile foo
 profile foo proxy
  helper address <v6 address of the server
!
!
dynamic-template type ipsubscriber dhcpv6_temp
  ipv6 enable
  dhcpv6 address-pool pool3
  dhcpv6 delegated-prefix-pool pool4
 !
!
!
class-map type control subscriber match-all dhcpv6_class
```

```
 match protocol dhcpv6
 end-class-map
!
policy-map type control subscriber dhcpv6_policy
 event session-start match-first
  class type control subscriber dhcpv6_class do-all
   20 activate dynamic-template dhcpv6_temp
!
!
end

configure
interface GigabitEthernet0/3/0/0
 ipv4 address 11.11.11.2 255.255.255.0
 ipv6 address 11:11:11::2/64
 ipv6 enable
 service-policy type control subscriber dhcpv6_policy
 ipsubscriber ipv6 l2-connected
  initiator dhcp
!
!
end
```

end

IPv6 PPPoE Subscriber Support

The PPPoE subscriber interfaces establish a PPP link with the subscriber, which is used for authentication and address assignment. The DHCPv6 server assigns the address or prefix to the PPPoE subscriber. Because the PPPoE subscriber interfaces are created dynamically, the DHCPv6 profile is applied to all the PPPoE interfaces created on the router, and not just a single PPPoE interface.

To enable PPPoE subscriber support, you have to configure the DHCPv6 profile globally or on all PPPoE interfaces. For more information, see Configuring IPv6 PPPoE Subscriber Interfaces, on page 78.

Configuring IPv6 PPPoE Subscriber Interfaces

Perform this task to configure PPPoE subscriber interfaces.

SUMMARY STEPS

1. **configure**
2. **dynamic-template type ppp** *dynamic_template_name*
3. **ppp authentication chap**
4. **ppp ipcp peer-address pool** *pool_name*
5. **ipv4 unnumbered** *interface-type interface-path-id*
6. **ipv6 enable**
7. **commit**
8. **class-map type control subscriber match-any** *class-map_name*
9. **match protocol ppp**
10. **end-class-map**
11. **commit**
12. **class-map type control subscriber match-all** *class-map_name*
13. **match protocol dhcpv6**
14. **end-class-map**

15. **commit**
16. **policy-map type control subscriber** *policy_name*
17. **event session-start match-first**
18. **class type control subscriber** *name* **do-all**
19. *sequence_number* **activate dynamic-template** *dynamic-template_name*
20. **end-policy-map**
21. **policy-map type control subscriber** *policy_name*
22. **event session-start match-all**
23. **class type control subscriber** *name* **do-all**
24. *sequence_number* **activate dynamic-template** *dynamic-template_name*
25. **end-policy-map**
26. **commit**
27. **interface** *type interface-path-id*
28. **description** *LINE*
29. **ipv6 enable**
30. **service-policy type control subscriber** *name*
31. **encapsulation dot1q 801**
32. **ipsubscriber ipv6 l2-connected**
33. **initiator dhcp**
34. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**dynamic-template type ppp** *dynamic_template_name* **Example:** `RP/0/RSP0/CPU0:router(config)# dynamic-template type ppp ppp_pta_template`	Configures the dynamic template of type ppp and enters the dynamic template type configuration mode.
Step 3	**ppp authentication chap** **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template-type)# ppp authentication chap`	Configures challenge handshake authentication protocol (chap) and sets PPP link authentication method.
Step 4	**ppp ipcp peer-address pool** *pool_name* **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template-type)# ppp ipcp peer-address pool p1`	Sets ipcp negotiation options and sets the peer address configuration option for the peer-address pool.
Step 5	**ipv4 unnumbered** *interface-type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template-type)# ipv4 unnumbered Loopback 1`	Enables IPv4 processing without an explicit address for an interface.

	Command or Action	Purpose
Step 6	**ipv6 enable** **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template-type)# ipv6 enable`	Enables IPv6 on an interface.
Step 7	**commit**	
Step 8	**class-map type control subscriber match-any** *class-map_name* **Example:** `RP/0/RSP0/CPU0:router(config)# class-map type control subscriber match-any pta_class`	Configures the class map control subscriber with a match-any criteria.
Step 9	**match protocol ppp** **Example:** `RP/0/RSP0/CPU0:router(config-cmap)# match protocol ppp`	Configures match criteria for the class configured in the earlier step.
Step 10	**end-class-map** **Example:** `RP/0/RSP0/CPU0:router(config-cmap)# end-class-map`	Configures the end class map.
Step 11	**commit**	
Step 12	**class-map type control subscriber match-all** *class-map_name* **Example:** `RP/0/RSP0/CPU0:router(config)# class-map type control subscriber match-all ipoe_test`	Configures the class map control subscriber with a match-all criteria.
Step 13	**match protocol dhcpv6** **Example:** `RP/0/RSP0/CPU0:router(config-cmap)# match protocol dhcpv6`	Configures match criteria for the class configured in the earlier step.
Step 14	**end-class-map** **Example:** `RP/0/RSP0/CPU0:router(config-cmap)# end-class-map`	Configures the end class map.
Step 15	**commit**	
Step 16	**policy-map type control subscriber** *policy_name* **Example:** `RP/0/RSP0/CPU0:router(config)# policy-map type control subscriber policy1`	Configures the subscriber control policy map.
Step 17	**event session-start match-first** **Example:**	Configures the policy event with the match-first criteria.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-pmap)# event session-start match-first`	
Step 18	**class type control subscriber** *name* **do-all** **Example:** `RP/0/RSP0/CPU0:router(config-pmap)# class type control subscriber ipoe_test1 do-all`	Configures the policy event with the match-first criteria.
Step 19	*sequence_number* **activate dynamic-template** *dynamic-template_name* **Example:** `RP/0/RSP0/CPU0:router(config-pmap-c)# 24 activate dynamic-template v6_test1`	Activates actions related to dynamic template.
Step 20	**end-policy-map** **Example:** `RP/0/RSP0/CPU0:router(config-pmap-c)# end-policy-map`	Configures the end policy map.
Step 21	**policy-map type control subscriber** *policy_name* **Example:** `RP/0/RSP0/CPU0:router(config)# policy-map type control subscriber policy1`	Configures the subscriber control policy map.
Step 22	**event session-start match-all** **Example:** `RP/0/RSP0/CPU0:router(config-pmap)# event session-start match-all`	Configures the policy event with the match-all criteria.
Step 23	**class type control subscriber** *name* **do-all** **Example:** `RP/0/RSP0/CPU0:router(config-pmap)# class type control subscriber pta_class do-all`	Configures the policy event with the match-first criteria.
Step 24	*sequence_number* **activate dynamic-template** *dynamic-template_name* **Example:** `RP/0/RSP0/CPU0:router(config-pmap-c)# 1 activate dynamic-template ppp_pta_template`	Activates actions related to dynamic template.
Step 25	**end-policy-map** **Example:** `RP/0/RSP0/CPU0:router(config-pmap-c)# end-policy-map`	Configures the end policy map.
Step 26	**commit**	

	Command or Action	Purpose
Step 27	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config)# interface BundleEther1.1`	Configures an interface and enters the interface configuration mode.
Step 28	**description** *LINE* **Example:** `RP/0/RSP0/CPU0:router(config-if)# description IPoE`	Sets the description for the above configured interface.
Step 29	**ipv6 enable** **Example:** `RP/0/RSP0/CPU0:router(config-if)# ipv6 enable`	Enables IPv6 on an interface.
Step 30	**service-policy type control subscriber** *name* **Example:** `RP/0/RSP0/CPU0:router(config-if)# service-policy type control subscriber ipoe1`	Associates a subscriber control service policy to the interface.
Step 31	**encapsulation dot1q 801** **Example:** `RP/0/RSP0/CPU0:router(config-if)# encapsulation dot1q 801`	Enables encapsulated 802.1Q VLAN configuration.
Step 32	**ipsubscriber ipv6 l2-connected** **Example:** `RP/0/RSP0/CPU0:router(config-if)# ipsubscriber ipv6 l2-connected`	Enables l2-connected IPv6 subscriber.
Step 33	**initiator dhcp** **Example:** `RP/0/RSP0/CPU0:router(config-if-ipsub-ipv6-l2conn)# initiator dhcp`	Configures IPv6 subscriber initiator.
Step 34	**commit**	

Configuring IPv6 PPPoE Subscriber Interfaces: An example

```
configure
dynamic-template
type ppp PPP_PTA_TEMPLATE
ppp authentication chap
ppp ipcp peer-address pool ADDRESS_POOL
ipv4 unnumbered Loopback0
ipv6 enable
!
type ipsubscriber v6_test1
ipv6 enable
!
```

```
!
class-map type control subscriber match-any PTA_CLASS
match protocol ppp
end-class-map
!
class-map type control subscriber match-all ipoe_test1
match protocol dhcpv6
end-class-map
!
policy-map type control subscriber ipoe1
event session-start match-first
class type control subscriber ipoe_test1 do-all
24 activate dynamic-template v6_test1
!
!
end-policy-map
!
policy-map type control subscriber POLICY1
event session-start match-all
class type control subscriber PTA_CLASS do-all
1 activate dynamic-template PPP_PTA_TEMPLATE
!
!
end-policy-map
!
interface Bundle-Ether2.801
description IPoE
ipv6 enable
service-policy type control subscriber ipoe1
encapsulation dot1q 801
ipsubscriber ipv6 l2-connected
initiator dhcp
```

Ambiguous VLAN Support

An Ambiguous VLAN is configured with a range or group of VLAN IDs. The subscriber sessions created over ambiguous VLANs are identical to subscribers over regular VLANs that support all regular configurations such as policy-map, VRFs, QoS, and ACL. Multiple subscribers can be created on a particular VLAN ID as long as they contain a unique MAC address. Ambiguous VLANs enhance scalability by reducing the need for configuring multiple access interfaces.

To enable DHCPv6 support, ambiguous VLANs are unnumbered on top of the bundle interface.

Note The ambiguous VLANs are named exactly the same way as regular VLANs. The ambiguous VLANs are considered Layer 3 interfaces in contrast to EFP ranges allowed for l2transport interface.

When DHCPv6 Server receives a SOLICIT message on the ambiguous VLAN interface, the VLAN IDs are extracted from the received packet and used for authenticating the subscriber with the client related information.

When an interface configuration is changed from ambiguous to non-ambiguous or vice-versa or Ambiguous VLAN range is changed, then all existing client bindings for the Ambiguous VLAN are cleared.

For more information on configuring ambiguous VLAN, see Configuring Ambiguous VLANs, on page 83.

Configuring Ambiguous VLANs

Perform this task to configure ambiguous vlans.

Note There is no DHCP-specific configuration required for ambiguous VLANs.

SUMMARY STEPS

1. **configure**
2. **interface** *type* *interface-path-id*
3. Use any of these encapsulations to configure encapsulated ambiguous VLANs:
    - **encapsulation ambiguous** { **dot1q** | **dot1ad** } {**any** | *vlan-range* }
    - **encapsulation ambiguous dot1q** *vlan-id* **second-dot1q** { **any** | *vlan-range* }
    - **encapsulation ambiguous dot1q any second-dot1q** { **any** | *vlan-id* }
    - **encapsulation ambiguous dot1ad** *vlan-id* **dot1q** { **any** | *vlan-range* }
    - **encapsulation ambiguous dot1q** *vlan-range* **second-dot1q any**
    - **encapsulation ambiguous dot1ad** *vlan-range* **dot1q any**
4. **ipv4 | ipv6address** *source-ip-address* *destination-ip-address*
5. **service-policy type control subscriber** *policy_name*
6. **ipsubscriber** { **ipv4** | **ipv6** } **l2-connected**
7. **initiator dhcp**
8. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**interface** *type* *interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config)# interface Bundle-Ether100.12`	Configures the interface and enters the interface configuration mode.
Step 3	Use any of these encapsulations to configure encapsulated ambiguous VLANs: • **encapsulation ambiguous** { **dot1q** | **dot1ad** } {**any** | *vlan-range* } • **encapsulation ambiguous dot1q** *vlan-id* **second-dot1q** { **any** | *vlan-range* } • **encapsulation ambiguous dot1q any second-dot1q** { **any** | *vlan-id* } • **encapsulation ambiguous dot1ad** *vlan-id* **dot1q** { **any** | *vlan-range* } • **encapsulation ambiguous dot1q** *vlan-range* **second-dot1q any** • **encapsulation ambiguous dot1ad** *vlan-range* **dot1q any** **Example:**	Configures IEEE 802.1Q VLAN configuration. The *vlan-range* can be given in comma-separated, or hyphen-separated format, or a combination of both, as shown in the examples. **Note** Although **encapsulation ambiguous dot1ad** is supported, it is not commonly used in BNG deployments.

	Command or Action	Purpose

	`RP/0/RSP0/CPU0:router(config-if)# encapsulation ambiguous dot1q any`
	`RP/0/RSP0/CPU0:router(config-if)# encapsulation ambiguous dot1q 14 second-dot1q 100-200`
	`RP/0/RSP0/CPU0:router(config-if)# encapsulation ambiguous dot1q any second-dot1q any`
	`RP/0/RSP0/CPU0:router(config-if)# encapsulation ambiguous dot1ad 14 dot1q 100,200,300-400`
	`RP/0/RSP0/CPU0:router(config-if)# encapsulation ambiguous dot1q 1-1000 second-dot1q any`	

Step 4	**ipv4 | ipv6address** *source-ip-address destination-ip-address*
	Example:
	`RP/0/RSP0/CPU0:router(config-if)# ipv4 address 2.1.12.1 255.255.255.0`
	`RP/0/RSP0/CPU0:router(config-if)# ipv6 address 1:2:3::4 128`
		Configures the IPv4 or IPv6 protocol address.

Step 5	**service-policy type control subscriber** *policy_name* **Example:** `RP/0/RSP0/CPU0:router(config-if)# service-policy type control subscriber PL1`	Applies a policy-map to an access interface where the policy-map was previously defined with the specified PL1 policy_name.

Step 6	**ipsubscriber** { **ipv4** | **ipv6** } **l2-connected**
	Example:
	`RP/0/RSP0/CPU0:router(config-if)# ipsubscriber ipv4 l2-connected`
	`RP/0/RSP0/CPU0:router(config-if)# ipsubscriber ipv6 l2-connected`
		Enables l2-connected IPv4 or IPv6 IP subscriber.

Step 7	**initiator dhcp** **Example:** `RP/0/RSP0/CPU0:router(config-if)# initiator dhcp`	Enables initiator DHCP on the IP subscriber.
Step 8	**commit**	

Configuring Ambiguous VLANs: An example

```
configure
interface Bundle-Ether100.12
encapsulation ambiguous dot1q 14 second-dot1q any
ipv4 address 2.1.12.1 255.255.255.0
service-policy type control subscriber PL1
ipsubscriber ipv4 l2-connected
initiator dhcp
!
!
```

```
end
```

DHCPv6 Address or Prefix Pool

An address or prefix pool represents a pool of available address or prefixes from which a delegating router assigns an address or delegates a prefix to the requesting router. The Distributed Address Pool Service (DAPS) manages and maintains address or prefix pools for DHCPv6.

DHCPv6 Prefix Delegation involves a delegating router selecting a prefix and delegating it on a temporary basis to a requesting router. The delegating router assigns the address or delegates the prefix from the address pool or prefix pool to the requesting router.

For more information about configuring DHCPv6 address or prefix pool, see Configuring IPv6 Address or Prefix Pool Name, on page 86.

Configuring IPv6 Address or Prefix Pool Name

Perform this task to configure IPv6 address or prefix pool name under dynamic template configuration mode.

SUMMARY STEPS

1. **configure**
2. **dynamic-template**
3. **type ipsubscriber** *dynamic-template_name*
4. **dhcpv6 delegated-prefix-pool** *pool-name*
5. **commit**
6. **type ppp** *dynamic-template_name*
7. **dhcpv6 address-pool** *pool-name*
8. **commit**
9. **type ipsubscriber** *dynamic-template_name*
10. **dhcpv6 address-pool** *pool-name*
11. **commit**
12. **ipv6 nd framed-prefix-pool** *pool-name*
13. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**dynamic-template** **Example:** `RP/0/RSP0/CPU0:router(config)# dynamic-template`	Enables dynamic template configuration.
Step 3	**type ipsubscriber** *dynamic-template_name* **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template)# type ipsubscriber ipv6-sub-template`	Configures dynamic template of type ipsubscriber and enters the dynamic-template type configuration mode.

	Command or Action	Purpose
Step 4	**dhcpv6 delegated-prefix-pool** *pool-name* **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template-type)# dhcpv6 delegated-prefix-pool mypool`	Configures IPv6 subscriber dynamic template with prefix-delegation pool.
Step 5	**commit**	
Step 6	**type ppp** *dynamic-template_name* **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template)# type ppp ipv6-sub-template`	Configures dynamic template of type ppp.
Step 7	**dhcpv6 address-pool** *pool-name* **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template-type)# dhcpv6 address-pool my-pppoe-addr-pool`	Configures IPv6 address pool for PPPoE subscribers.
Step 8	**commit**	
Step 9	**type ipsubscriber** *dynamic-template_name* **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template)# type ipsubscriber my-ipv6-template`	Configures dynamic template of type ipsubscriber and enters the dynamic-template type configuration mode.
Step 10	**dhcpv6 address-pool** *pool-name* **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template-type)# dhcpv6 address-pool my-ipsub-addr-pool`	Configures IPv6 address pool for IPoE subscribers.
Step 11	**commit**	
Step 12	**ipv6 nd framed-prefix-pool** *pool-name* **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template-type)# framed-prefix-pool my-slaac-pool`	Configures prefix pool to be used by SLAAC only.
Step 13	**commit**	

Configuring IPv6 Address or Prefix Pool Name: An example

```
configure
dynamic-template
type ipsubscriber ipv6-sub-template
dhcpv6 delegated-prefix-pool mypool
end
dynamic-template
type ppp ipv6-sub-template
dhcpv6 address-pool my-pppoe-addr-pool
!
type ipsubscriber my-ipv6-template
```

```
dhcpv6 address-pool my-ipsub-addr-pool
!!
ipv6 nd framed-prefix-pool my-slaac-pool
end
!!
```

DHCPv6 Dual-Stack Lite Support

Dual-Stack Lite (DS-Lite) is a technique for providing complete support for both IPv4 and IPv6 internet protocols, both in hosts and router. Dual-Stack Lite enables a broadband service provider to share IPv4 addresses among customers by combining two technologies: IP in IP (IPv4- in-IPv6) and Network Address Translation (NAT).

The DS-Lite feature contains two components: Basic Bridging Broad Band (B4) and Address Family Transition Router (AFTR).

The B4 element is a function implemented on a dual-stack-capable node, either a directly connected device or a CPE that creates a tunnel to an Address Family Transition Router (AFTR). On the other hand, an AFTR element is the combination of an IPv4-in-IPv6 tunnel endpoint and an IPv4-IPv4 NAT implemented on the same node. A DS-Lite B4 element uses a DHCPv6 option to discover the IPv6 address of its corresponding AFTR location.

For more information about configuring AFTR for DS-Lite, see Configuring AFTR Fully Qualified Domain Name for DS-Lite, on page 88.

Configuring AFTR Fully Qualified Domain Name for DS-Lite

Perform this task to configure AFTR fully qualified domain name for DS-Lite.

SUMMARY STEPS

1. **configure**
2. **dhcp ipv6**
3. **profile** *server_profile_name* **server**
4. **aftr-name** *aftr_name*
5. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**dhcp ipv6** **Example:** `RP/0/RSP0/CPU0:router(config)# dhcp ipv6`	Configures DHCP for IPv6 and enters the DHCPv6 configuration mode.
Step 3	**profile** *server_profile_name* **server** **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6)# profile my-server-profile server`	Configures DHCPv6 server profile and enters the DHCPv6 server profile sub-configuration mode.

	Command or Action	Purpose
Step 4	**aftr-name** *aftr_name* **Example:** `RP/0/RSP0/CPU0:router(config-dhcpv6-server-profile)# aftr-name aftr-server.example.com`	Configures the AFTR Fully Qualified Domain Name option, in the server profile mode, for the DS-Lite support.
Step 5	**commit**	

Configuring AFTR Fully Qualified Domain Name for DS-Lite: An example

```
configure
dhcp ipv6
profile my-server-profile server
aftr-name aftr-server.example.com
end
!!
```

VRF Awareness in DHCPv6

VRF Awareness is the ability of DHCPv6 Server or Proxy to support multiple clients in different VPNs where the same IP address is assigned to clients on differing VPNs. The IPv6 addresses in a VRF is independent from IPv6 addresses in an another VRF. It is not mandatory to have same prefix/address in multiple VRFs.

For more information about defining VRF in a dynamic template, see Defining VRF in a Dynamic Template, on page 89.

Defining VRF in a Dynamic Template

Perform this task for defining VRF in a dynamic template. The IPv6 addresses in a VRF is independent from IPv6 addresses in an another VRF. It is not mandatory to have same prefix or address in multiple VRFs.

SUMMARY STEPS

1. **configure**
2. **dynamic-template**
3. **type ipsubscriber** *dynamic-template_name*
4. **vrf** *vrf_name*
5. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**dynamic-template** **Example:** `RP/0/RSP0/CPU0:router(config)# dynamic-template`	Enables dynamic template configuration.

	Command or Action	Purpose
Step 3	**type ipsubscriber** *dynamic-template_name* **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template)# type ipsubscriber ipv6-sub-template`	Configures dynamic template of type ipsubscriber and enters the dynamic template type configuration mode.
Step 4	**vrf** *vrf_name* **Example:** `RP/0/RSP0/CPU0:router(config-dynamic-template-type)# vrf vrf1`	Sets the VRF in which the interface operates.
Step 5	**commit**	

Defining VRF in a Dynamic Template: An example

```
configure
dynamic-template
type ipsubscriber ipv6-sub-template
vrf vrf1
end
!!
```

Rapid commit

The **rapid-commit** command aids to enable or disable the rapid commit option of the DHCP server. Enabling it renders the DHCPv6 server to use the two message exchange feature to address/prefix an assignment. Including the rapid commit option in the `SOLICIT` message and enabling the same in the server profile, enables the server to respond with the `REPLY` message. Else, it follows the normal four message exchange procedure to assign address/prefix an assignment.

Note By default, the rapid commit option is disabled.

Example:

```
RP/0/RSP0/CPU0:router(config)# dhcp ipv6
RP/0/RSP0/CPU0:router(config-dhcpv6)# profile my-server-profile server
RP/0/RSP0/CPU0:router(config-dhcpv6-server-profile)# rapid-commit
```

Packet Handling on Subscriber Interfaces

This section describes how subscriber interfaces are supported in certain special cases. These special cases include L3 forwarded interfaces. As a result, this support is applicable only to PPP over Ethernet PPP Termination and Aggregation (PPPoE PTA) and IPoE sessions.

Most subscriber data packets are forwarded directly by the network processing unit (NPU). There are certain special cases where the NPU does not completely handle the data packet. These special cases are handled by the CPU, and go through an internal interface created for this purpose. This internal interface is named the Subscriber Interface or SINT. SINT is an aggregate interface, which is used by all packets punted on subscriber interfaces. There is one SINT for each node. When the BNG package is installed, by default the SINT is created. The SINT interfaces are needed for punt-inject of packets on subscriber interfaces.

These special cases are supported for both IPoE and PPPoE PTA:

Note These special cases do not apply to PPPoE L2TP, because it is an L2 service.

- Ping to and from subscriber

  BNG allows the receiving of a ping request from both IPoE and PPPoE PTA subscriber interfaces; this is consistent with other non-BNG interface types as well. Similarly, BNG also allows the sending of a ping request to both IPoE and PPPoE PTA subscriber interfaces. This includes:

  - various lengths of ping packets including lengths exceeding the subscribers MTU size
  - subscriber in the default and private VRFs
  - various ping options such as type of service, DF set, and verbose

  BNG also supports receiving a ping request from both IPv4 and IPv6 subscribers.

  Note Excessive Punt Flow Trap feature should be disabled when sending a high rate of pings to, or from subscriber interfaces.

- Option Handling

  BNG supports handling IP options; this is consistent with non-BNG interface types. These are punted from the NPU to the CPU. These go through the SINT interface and are handled by the appropriate application.

- Support for traceroute, PMTU discovery, ICMP unreachable

  - BNG supports sending ICMP for packets that are received from or destined to a PPPoE or IP subscriber interface that cannot be forwarded. This functionality is similar to other non-BNG subscriber interfaces.
  - BNG supports PMTU, in which BNG sends ICMPs, when a packet is destined to a subscriber interface, but the packet exceeds the subscriber MTU and the DF bit is set.
  - BNG supports sending ICMPs when packets to (egress ACL) or from (ingress ACL) the subscriber interface are denied due to the ACL. If the ACL is configured do both deny and log, then the packets get dropped, but no ICMP is generated.
  - BNG supports traceroute functionality that enables sending an ICMP when the time to live (TTL) of the packet is exceeded.
  - BNG supports traceroute functionality for both IPv4 and IPv6 subscribers.

- Fragmentation

  BNG does not support fragmentation of packets destined to the PPPoE or IP subscriber interfaces.

> **Caution**
>
> In Cisco IOS XR, fragmentation is handled by linecard (LC) CPU or route processor (RP) CPU. All packets requiring fragmentation are policed by local packet transport service (LPTS), to a maximum of 2500 packets per second (pps) for each network processing unit (NPU).
>
> The fragmentation path is supported only in software, and fragmented packets skip all features, including subscriber features, QoS, ACL and so on. Therefore, irrespective of BNG, it should not be used as a general forwarding path.
>
> BNG over Pseudowire Headend does not support fragmentation.

Restrictions

These restrictions apply to implementing subscriber interfaces:

- During an ACL logging, packets are punted to CPU, and BNG interfaces are directed to the SINT interface. The SINT interface drops these log packets because the system does not support ACL Logging on BNG interfaces.
- IPv6 Ping and traceroute functions should use both the CPE and BNG routers global addresses. IPv6 Ping and traceroute functions using link local address does not work in all cases.
- Logging on subscriber ACLs is not supported.

IPv6 Neighbor Discovery

The IPv6 neighbor discovery process uses Internet Control Message Protocol (ICMP) messages and solicited-node multicast addresses to determine the link-layer address of a neighbor on the same network (local link), verify the reachability of a neighbor, and track neighboring routers.

The IPv6 static cache entry for neighbor discovery feature allows static entries to be made in the IPv6 neighbor cache. Static routing requires an administrator to manually enter IPv6 addresses, subnet masks, gateways, and corresponding Media Access Control (MAC) addresses for each interface of each device into a table. Static routing enables more control but requires more work to maintain the table. The table must be updated each time routes are added or changed.

The different message types in neighbor discovery are:

- IPv6 Neighbor Solicitation Message: A value of 135 in the Type field of the ICMP packet header identifies a neighbor solicitation message. Neighbor solicitation messages are sent on the local link when a node wants to determine the link-layer address of another node on the same local link.
- IPv6 Router Advertisement Message: Router advertisement (RA) messages, which have a value of 134 in the Type field of the ICMP packet header, are periodically sent out of each configured interface of an IPv6 device.

  Ambiguous VLAN does not have association with any particular VLAN, and therefore, a unicast router advertisement message has to be sent out for ambiguous VLAN interfaces. To enable IPv6 unicast router advertisement, you must use the **ipv6 nd ra-unicast** command in the dynamic template configuration mode.

Note From Cisco IOS XR Release 5.1.0 and later, it is mandatory to configure **ipv6 enable** command under the bundle access-interface, in order to send RA messages out of BNG.

- IPv6 Neighbor Redirect Message: A value of 137 in the type field of the ICMP packet header identifies an IPv6 neighbor redirect message. Devices send neighbor redirect messages to inform hosts of better first-hop nodes on the path to a destination.

In BNG, IPv6 neighbor discovery supports both IPoE and PPPoE sessions. IPv6 neighbor discovery provides Stateless Address Auto Configuration (SLAAC), which is used for assigning a prefix to the PPPoE subscriber.

Line Card Subscribers

BNG supports line card (LC) subscribers which are based on physical access interfaces. This support is in addition to supporting route processor (RP) subscribers, which are based on bundle access-interfaces. Apart from route switch processor (RSP), line cards also support session termination and control plane protocols. For LC subscribers, both control and data planes run on the same node and share the same CPU resource. In contrast, for bundle subscribers, the control plane runs completely on RSP, and the data plane runs completely on LC.

The number of LC subscribers sessions scales linearly with the number of line cards in the system. The maximum number of sessions for each LC is 64000. As more line cards are added to the system, the maximum number of sessions in the system reaches a multiple of 64000 subscribers, the multiplier being the number of line cards.

The calls-per-second (CPS) achieved for each chassis scales almost linearly with the number of line cards in the system. Linearity is not achieved for CPS because of the congestion in the communication channel, arising out of the large number of notifications sent out from LC to RSP.

External Interaction for LC Subscribers

As part of LC subscriber support, there are various interactions directly between LC and external servers such as RADIUS and DHCP servers. These interactions change the way how load balancing is done and the way CoA is handled.

Load Balancing

Because each LC control plane functions independently, with LC subscribers, any global configuration of RADIUS and DHCP servers does not result in load-balanced usage. It is possible that all LCs end up using the same RADIUS server. As a result, the user needs to carry out manual load balancing. This is done by creating different AAA groups and method lists using different sets of RADIUS servers, then assigning the AAA groups to different service profiles, and finally assigning these different service profiles to the access interfaces on different LCs. Similarly, for DHCP servers, the access interfaces on different LCs should have different profiles, each pointing to different DHCP servers.

Interaction with RADIUS Server

With the distributed model of interacting with RADIUS, the RADIUS client on BNG can be configured in two different ways. Either the entire BNG router shows up as one BNG to the RADIUS server (**NAS-IP-Address**), or each LC appears as a different router. Currently, the CoAs can be handled only by the iEdge on the RSP. Each LC appearing as its NAS is not supported.

Address Pools

It is preferable to provide different address pools to different LCs so that they work completely independent of each other, without the need to perform significant messaging across nodes.

Benefits and Restrictions of Line Card Subscribers

Benefits of line card subscribers

These are some of the benefits of LC subscribers:

- Subscribers built on bundle interfaces and line card physical interfaces can co-exist on the same router.
- Significant gain in performance because the control plane is distributed to multiple LCs. In aggregate, the entire chassis reaches much higher scale and performance than RSP-based subscribers.
- Higher fault isolation on the router. The control plane runs in a distributed manner and therefore, failure of certain LCs does not affect subscriber sessions on other LCs in the system. In such cases, only the subscriber sessions built on that particular LC is lost.
- Although the CPS achieved on a single LC is lower than the CPS achieved for RSP or Bundle subscribers, LC subscribers overcome the memory usage limit and CPS limit of RSP-based subscribers.
- Provide enhanced multi-service edge (MSE) capability for the ASR9K router, by freeing up the CPU and memory resources on the centralized route processor (RP).

Restrictions of line card subscribers

LC subscriber support in BNG is subjected to these restrictions:

- Bundles are not supported with LC subscribers.
- LC subscribers support features that are available on bundle subscribers, except for a few features such as Parameterized QoS, multicast, and service accounting. If these features are required for specific subscribers, then those subscribers must be built on bundle interfaces.
- Routed subscriber sessions are not supported on LC subscribers.
- Local DHCPv4 Server feature is not supported over LC.

Note From Cisco IOS XR Software Release 5.3.2 and later, features such as Parameterized QoS and service accounting are supported for LC subscribers as well.

High Availability for Line Card Subscribers

The high availability (HA) for line card subscribers is different from that for subscribers built on bundle interfaces because the subscribers are built on LCs. This table details the HA features of LC subscribers and bundle subscribers:

Table 2: High Availability for LC Subscribers and Bundle Subscribers

HA Feature	Plane	Bundle Subscribers	Line Card Subscribers
Process restart	control	Subscriber session state is maintained. New subscriber bring up is delayed by a short time, depending on the component being restarted.	Behavior is the same as for bundle subscribers.
	data	No impact to traffic.	No impact to traffic.
LC online insertion and removal (OIR)	control	No impact with multi-member bundles. Because control packet is not received, control plane cannot function with single member bundles. Session state is not lost because it is stored in RSP.	Control plane is down for new sessions, and all session states are lost for existing sessions. After LC OIR, the LC sessions are restored using DHCP shadow bindings in RP.
	data	No impact with multi-member bundles. Data traffic is lost with single member bundles. Session state is not lost.	All traffic is lost
RP failover	control	Significant quiet time (currently more than 10 minutes) is expected before new sessions can be setup. Existing session state is not lost.	Very small impact (approximately 10 seconds) before new sessions can be setup; the delay is in connecting to RSP based servers, like RIB. Existing session state is not lost.
	data	No impact to traffic.	No impact to traffic.

Static Sessions

BNG supports interface-based static sessions, where all traffic belonging to a particular VLAN sub-interface is treated as a single session. These sessions are created or deleted, based on the configuration of static session on the sub-interface (access-interface). The session establishment is triggered by creating a static subscriber configuration on a sub-interface; the session termination is triggered by removing that configuration.

The number of static sessions that can be created in a router is the same as the number of Bundle VLAN interfaces that can be present in the router.

Static sessions are present only in the control plane, mainly to provide access to AAA, CoA, and dynamic templates. These sessions have the same flexibility as other kinds of sessions (such as DHCP-triggered sessions and packet-triggered sessions) from the perspective of AAA, CoA, and other dynamic configuration changes.

All forwarding and routing features for static sessions are programmed directly on the access-interface. Features such as Access Control List (ACL), Hierarchical Quality of Service (H-QoS), and Session Accounting are allowed to be configured through RADIUS or through dynamic template.

The IP address (and VRF, if used) for a static session is recommended to be configured on the access-interface itself (See the note below for the behavior of feature modification using BNG static sessions). All subnet interface addresses can be assigned to the subscribers in the case of switched Customer Premises Equipment (CPE). The Unicast Reverse Path Forwarding (uRPF) is also configured on the access-interface itself. Because the access-interface is like any other Layer 3 interface, it allows PE-CE routing protocols such as OSPF and BGP.

Note If any feature configured on the access-interface is modified using BNG, the existing configurations get removed from the access-interface, and they do not get restored automatically on removing the static session. For example, if an ACL is already present on the access-interface, and if another ACL is applied by BNG using the static session, the ACL on the access-interface does not get restored when the static session is removed. You must reconfigure the access-interface and add the ACL again, in such scenarios.

Another example of feature modification by BNG is, if a VRF (say, *vrf-blue*) is present on the access-interface, and if another VRF (say, *vrf-green*) is applied on the access-interface by BNG using the static session, *vrf-blue* on the access-interface is not restored when the static session is removed. The interface is set to the default VRF. You must reconfigure the access-interface and add the *vrf-blue* again, in such scenarios.

A static session is similar to a subscriber session, except for these differences:

- The CoA should explicitly have an account session ID because static session does not have MAC address or IP address identity attribute associated with it.
- The statistics of static session is the same as that of the access-interface on which it is configured.

Restrictions for static sessions

The interface-based static session in BNG is subject to these restrictions:

- Because all features are applied on the access-interface itself, all restrictions for feature programming on access-interface applies to static session too.
- The HTTP redirect feature is not supported for static session.
- Service accounting is not supported for static sessions.

Subscriber Session Limit

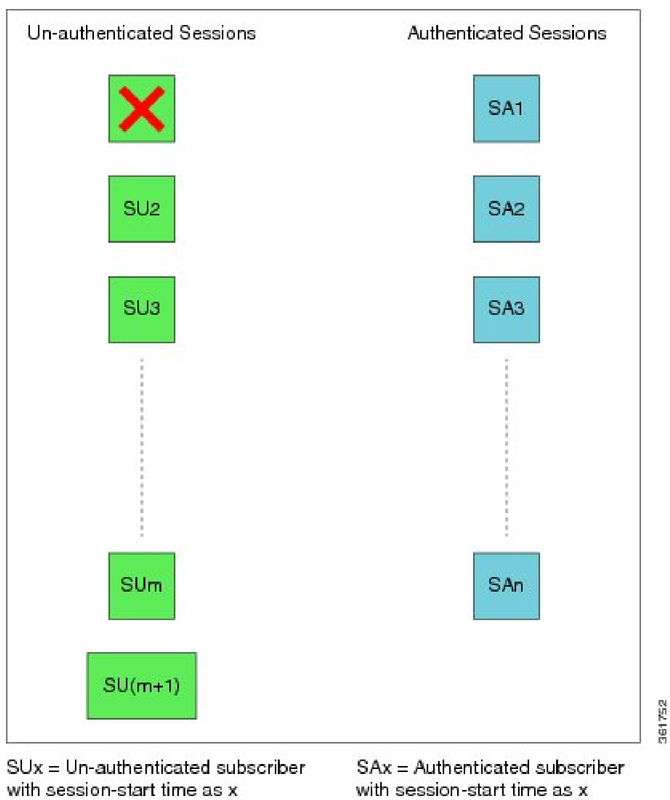
The subscriber session limit feature limits the total number of subscriber sessions in a BNG router. If a new subscriber session comes up after the router reaches the overall session limit, then the earliest un-authenticated session is deleted. If the router reaches the overall subscriber session limit and if all the sessions present in the router are authenticated sessions, then the request for a new session is rejected.

Typically sessions belonging to subscribers who do not have the intent of accessing the network services are typically un-authenticated sessions. Per-subscriber features do not apply to such sessions. Instead, they have the same set of features applied to all users. Generally, if the un-authenticated subscriber sessions do not authenticate themselves within a specific time, they are deleted using the un-auth timer mechanism.

The **subscriber session limit** command is used to apply the overall subscriber session limit in the BNG router.

This figure shows the scenario where a long-lived un-authenticated session is deleted, when a new un-authenticated session (m + 1) comes up after the router reaches the overall session limit. In this example, m+n is the overall session limit, where m is the number of un-authenticated sessions and n is the number of authenticated sessions. The behavior is the same for a new authenticated session (n + 1) too.

Figure 11: Subscriber Session Limit



BNG Subscriber Templates

BNG supports template interface based subscriber provisioning that defines an internal template interface for storing the feature information of each unique subscriber configuration, and reuses that information for feature programming of other subscribers having the same configuration. This reduces the inter-process communications (IPC), memory usage and CPU usage inside the system, thereby providing significant scale and performance improvements in BNG. The free memory available in the system can thus be utilized for enabling more services or for improving existing services on BNG, with full scale stability.

BNG subscriber templates feature is more beneficial in scale scenarios such as Service Provider Wi-Fi (SP Wi-Fi). Template interfaces are not recommended for scenarios where the configuration of template interface based feature is different for each subscriber, or in scenarios where only a few hundreds of subscribers use the similar configuration. Templates must be used or provisioned only if there are a few thousands of subscribers using similar configurations of template interface based features. There is no restriction on individual subscribers having different configurations for non-template interface based features.

Enabling BNG Subscriber Templates

Subscriber templates are enabled per access-interface in BNG. Use this command in interface configuration mode, to enable subscriber templates:

ipsubscriber subscriber-templates *max-templates*

Here, *max-templates* is the maximum number of templates on an access-interface.

This is an example of enabling subscriber templates on an access-interface in BNG:

```
interface Bundle-Ether1.10
 ipsubscriber subscriber-templates 5
!
```

You must clear all subscriber sessions on an access-interface before disabling the subscriber templates or before modifying the number of subscriber templates on that access-interface.

Feature Support for Subscriber Templates

These features are supported with subscriber templates:

- IPv4, IPv4-ACL, IPv6, IPv6-ACL.
- DHCP and packet-triggered sessions.
- RP subscribers.
- LC subscribers.
- High Availability - process restart and route processor fail over (RPFO).
- Scale scenarios.

These features are not supported with subscriber templates:

- PPPoE sessions.
- QoS and PBR.

Restrictions for BNG Subscriber Templates

The support for subscriber templates in BNG is subjected to these restrictions:

- Modifying the number of templates or removing the template configuration is not supported with subscribers provisioned on the access- interface.
- Modifying the encapsulation is not supported on access-interface having subscriber templates configured.
- Each line card (LC) has a micro-interface database (UIDB) limitation of 16 bits (that is, 65535 entries). For an expected scale of 64K subscriber interfaces on an LC, 1535 interfaces are remaining for the access-interfaces and template-interfaces. Provisioning of template-interfaces must be planned within these limits.

Verification of BNG Subscriber Templates

This table lists the verification commands for BNG subscriber templates configuration:

Command	Description
show ipsubscriber interface internal	Displays the internal information such as, *Template ID* (the template interface-handle referred by the subscriber session), of the IP subscriber interfaces.
show ipsubscriber template-interface [**access-interface** *interface-type interface-instance*] [**internal**]	Displays IP subscriber template interface information (brief, detailed or filtered based on the access-interface) such as template subscriber name, template subscriber ifhandle and so on.
show subscriber database session subscriber-label *subscriber-label*	Displays the subscriber database session information that includes the *Template Interface Id* field (this field indicates the subscriber template that is used by the session with the specified subscriber-label).
show subscriber database template [**parent-if-handle** *if-handle* | **parent-if-name** *interface-type interface-instance*]	Displays subscriber database information such as template ifhandle, session count and so on.
show subscriber running-config subscriber-label *label*	Displays the subscriber running configuration in BNG.

Along with these commands, the existing subscriber show commands can also be used to verify the configurations.

eBGP over PPPoE

The eBGP over PPPoE feature provides eiBGP multi-path support over BNG subscriber interfaces. This feature also provides load-balancing and allows service providers to offer L3VPN service with dynamic service provisioning. The label allocation mode used for this feature is **per-prefix**. The feature is supported for IPv4 and IPv6.

Benefits of eBGP over PPPoE

The eBGP over PPPoE feature provides eiBGP multi-path support with **per-prefix** label allocation mode. Currently, Cisco IOS XR supports three label allocation modes - per prefix, per-CE and per-VRF. The per-VRF mode does not provide multi-path support, and it may also cause forwarding loops during local traffic diversion. The per-CE mode does not support eBGP load balancing and BGP PIC functionality. Therefore, the per-prefix mode is chosen for this feature.

For sample topology and sample configurations for eBGP over PPPoE, see Sample Topology for eBGP over PPPoE.

BNG over Pseudowire Headend

BNG provides subscriber support over Pseudowire Headend (PWHE). PWHE provides L3 connectivity to customer edge nodes through a pseudowire connection. PWHE terminates the L2VPN circuits that exists between the access-provide edge (A-PE) nodes, to a virtual interface, and performs routing on the native IP packet. Each virtual interface can use one or more physical interfaces towards the access cloud to reach customer routers through the A-PE nodes. This feature is supported for PPPoE PTA, PPPoE LAC and IPoE subscribers.

For basic PWHE, the access pseudowire (PW) is terminated on an interface in the Services-PE (S-PE) box. The pseudowire in the access network can be of VC type 4 (tagged), type 5 (raw) and type 11 (inter-working). VC type 4 and VC type 5 pseudowires are represented by pw-ether interfaces. VC type 11 pseudowire is represented by a pw-iw interface. The physical interfaces that the pw-ether or pw-iw interface use is decided through a pin-down list, which is also called as generic-interface-list or a Tx-list. The access P nodes must ensure that the psuedowire traffic is sent to the S-PE box, on only one of the interfaces in the pin-down list. If not, the traffic is dropped on S-PE.

For PWHE with BNG, the subscribers are enabled only on VC type 5 pseudowires (that is, only tagged subscriber traffic is supported), and therefore, the access-interface for the subscribers can only be PWHE sub-interfaces. For sample topology, sample configurations and various deployment models for subscribers on PWHE, see Sample Topology for BNG over Pseudowire Headend.

QoS on BNG Pseudowire Headend

Subscriber support over Pseudowire Headend (PWHE) interface was introduced in Cisco IOS XR Software Release 5.2.0. Further support for QoS features for subscribers on PWHE was introduced in Cisco IOS XR Software Release 5.2.2 as follows:

- Support for PPPoE or IPoE subscribers on PWHE sub-interface (with or without SVLAN policy).
- QoS support at different levels:
  - QoS on per-session PPPoE.
  - QoS on multiple PPPoE sessions associated to the same subscriber line, that is shared policy instance (SPI).
  - QoS at pseudowire level.
  - QoS at physical port-level.
- Support for features such as service accounting and pQoS for PWHE subscribers.

- Support for MPLS EXP marking for PWHE subscriber interfaces.

You can configure same SPI instance (with different policy-maps attached) on the sub-interface of PWHE pin-down members as well as on the subscriber interface. In this scenario, the subscriber sessions come up in spite of having the same SPI instance on the pin-down member of PWHE.

For ASR 9000 Enhanced Ethernet Line Card, there are 4 chunks per network processor (NP), and physical interfaces are mapped to a particular NP and chunk. The SE model of this line card (LC) supports 8K subscribers per chunk. To support this, these guidelines must be followed:

- Pin-down members must be distributed so that they are not from the same NP and chunk.
- The **resource-id** option in **service-policy** command must be used to change the chunk mapping of the physical interface.
- The target chunk must not be used by any other interface or sub-interface policy-map.
- The scale is expected to reduce if service accounting is enabled.

Note For BNG PWHE with QoS, an extra 4 bytes per packet get added if service accounting is enabled. This is because of the internal VC label that gets added when the packet enters the ingress LC. This is applicable only for egress direction.

Features Supported for BNG over Pseudowire Headend

These are supported for BNG over PWHE:

- Features such as http-r, Access-Control List (ACL), Accounting, Change of Authorization (CoA) and Lawful-Intercept.
- 64K dual stack and 128K IPv4 subscribers.
- Ambiguous VLANs on PWHE sub-interfaces.
- RFC-3107, for basic PWHE forwarding path from the core to the subscriber direction.
- QoS for the subscribers.
- Other features as applicable for the subscriber.

The supported control protocols for BNG over PWHE are DHCPv4, DHCPv6, IPv6 ND, PPP and PPPoE.

The pw-ether sub-interfaces are also supported in BNG. Ideally, the VC type for the PW can be negotiated as Type 4 or Type 5, for pw-ether interfaces. The pw-ether sub-interfaces are only supported for VC type 5.

These are the supported behavioral models of PWHE for the VC type and the sub-interface:

- According to the standards, the VC type 4 mandates that the SP-VLAN be carried along with the C-VLAN, in the PW. The VC type 5 mandates that the SP-VLAN be removed, and only the C-VLAN be carried in the PW.
- There are implementation differences (mainly in the number of VLANs that are transported in the PW) between Cisco 7600 Series Routers and Cisco ASR 9000 Series Aggregation Services Routers, and Cisco 12000 Series Routers based platforms. However, this does not impact the behavior of A-PE and S-PE.

- Because pw-ether sub-interfaces are supported only for VC type 5, the packet in the PW does not have the SP-VLAN. Therefore, when the subscriber connection enters the S-PE (BNG router), it finds a match with a pw-ether sub-interface VLAN and the C-VLAN in the packet.
- When VC type 4 is configured, it is always matched with the pw-ether main interface. Even if sub-interfaces are configured with VC type 4, they are not used. The system does not restrict the configuration of sub-interfaces.

The hardware support for BNG over PWHE is same as that for the bundle subscriber support. The RSP types supported are RSP-440-SE and RSP-880-SE.

Unsupported Features and Restrictions for BNG over Pseudowire Headend

These are the unsupported features and restrictions for BNG over PW HE feature:

- Subscribers on VC type-4 and VC type-11 pseudowires are not supported (that is, untagged subscribers cannot be terminated on a BNG PWHE interface and they are restricted in CLI on the main pw-ether interface).
- Egress subscriber Lawful-Intercept is not supported.
- Multicast for PPPoE is not supported.
- SPAN is not supported.
- Cluster is not supported.
- IPoE L3 connected subscribers are not supported.
- Because subscribers on PWHE are based out of RP, linecard (LC) subscribers are not supported.
- Because satellite is not supported on PWHE, it is not supported on PWHE over BNG too.
- IPv4 fragmentation is not supported.

The support for QoS on BNG PWHE is subjected to these restrictions:

- PWHE subscribers are supported only in Co-existence disabled mode of line card (LC).
- ATM overhead accounting is not supported.
- Because multicast is not supported on PWHE subscriber, IGMP shaper co-relation is not supported.

PPPoE LAC Subscriber Over PWHE

The PPPoE LAC session over Pseudowire Headend (PWHE) feature enables LAC session to be established on PWHE interface. The PWHE technology allows termination of Access Pseudowire into a Layer 3 (VRF or global) domain or into a Layer 2 domain. PWHE infrastructure enables an easy and scalable mechanism for tunneling or backhauling traffic into a common IP, MPLS, or L2 network.

Supported Features

- Lawful Intercept (LI)
- uRPF

- Subscriber Control Plane Policing (CoPP)
- HTTP-Redirect (HTTPr)

Restrictions

- Routing protocols cannot be run on the subscriber interfaces
- L2TP is not supported for IP subscribers
- L2TP limitations are applicable with respect to sequencing, fragmentation, and checksums as applied to bundle-based LAC sessions
- L2TP imposition is not supported on A9K-SIP-700 Line Cards or Cisco ASR 9000 Series SPA Interface Processor-700
- VC type 4 and 11 are not supported for hosting subscribers
- For ingress L2TP packets, the negotiated UDP destination port is 1701 and the source port is defined by the LNS

Unsupported Features

- Routed subscriber session is not supported
- Multicast is not supported for PPPoE sessions over PWHE
- Cluster, satellite, and geo-redundancy are not supported
- SPAN and egress LI are not supported
- ACL is not applicable on BNG sessions, as the incoming and outgoing traffic flow through MPLS routing
- Quality of Service (QoS)
- Layer 2 Tunnel Protocol Version 3 (L2tpv3)

Additional References

These sections provide references related to implementing PPP, PPPoE, L2TP, and DHCP.

RFCs

Standard/RFC - PPP	Title
RFC-1332	The PPP Internet Protocol Control Protocol (IPCP)
RFC-1570	PPP LCP Extensions
RFC-1661	The Point-to-Point Protocol (PPP)
RFC-1994	PPP Challenge Handshake Authentication Protocol (CHAP)

Standard/RFC - PPPoE	Title
RFC-2516	A Method for Transmitting PPP Over Ethernet (PPPoE)
RFC-4679	DSL Forum Vendor-Specific RADIUS Attributes

Standard/RFC - L2TP	Title
RFC-2661	Layer two tunneling protocol "L2TP"

MIBs

MIBs	MIBs Link
—	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Technical Support website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/cisco/web/support/index.html