ESMv6: PPPoE Dual Stack Hosts

In This Chapter

This section describes ESMv6 PPPoE dual stack host configurations.

Topics in this section include:

Applicability

This section is applicable to all of the 7750 SR series (SR-7, SR-12, SR-c4 and SR-c12) as well as 7450 ESS (ESS-7 and ESS-12) series in mixed mode. It was tested on release 8.0R4.

Pre-requisites:

- IOM3-XP or IMM required for subscriber and network interfaces
- Chassis-mode C
- Routed CO (IES/VPRN service) with Enhanced Subscriber Management (ESM)
- Bridged or routed home gateway

Note: The focus of this section is on PPPoE IPv6. IPv4 configuration is shown for completeness.

Overview

PPPoE Dual Stack

A PPPoE dual stack subscriber may support both IPv4 and IPv6 simultaneously. The dual stack hosts share a common subscriber identification policy and have a common sla-profile and subscriber-profile and are linked together through one PPPoE session.

For PPPoE dual stack hosts, one subscriber host entry is created for the IPv4 and one for the IPv6 address family.
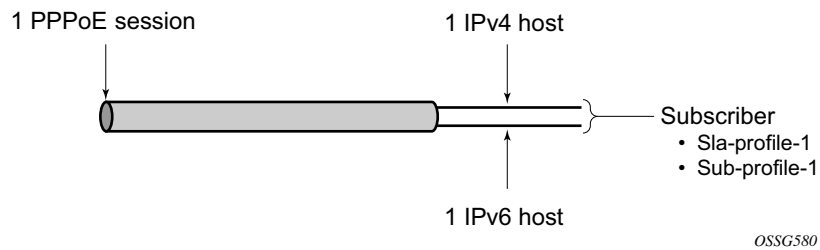

Figure 363: PPPoE Dual Stack Hosts

ESM for IPv6 is supported with RADIUS as backend authentication, address assignment and authorization.

PPPoE dual stack subscriber-hosts are supported through bridged or routed home gateways. It is mandatory to retrieve IPv6 address information in both models from RADIUS, whereas the IPv4 address information can be retrieved by DHCPv4 or RADIUS.

Dual Stack PPPoE Bridged Gateway Service

In the dual stack PPPoE host service, the PPPoE session is initiated directly from a dual stack host device or PC within the home network. PPPoE is used to carry IPv6 and (optionally) IPv4 traffic from the device to the Broadband Remote Access Server (BRAS), also called Broadband Network Gateway (BNG).

Unlike the Routed Gateway application examples (see later), no IPv6 prefix delegation occurs in the bridged gateway service, instead, a global unicast address prefix (/64) is advertised using Router Advertisements (RAs) directly to the PPPoE interface on the host.

The device addresses are self-assigned through Stateless Auto Configuration (SLAAC). where SLAAC makes use of ICMPv6 router-advertisements to announce these IPv6 prefixes. The SLAAC prefixes have a mandatory length of /64.

Because of limited device support for DHCPv6, only SLAAC is used for address assignment in this model.

This application is targeted at operators who currently use a bridging modem in the customer premise and who want to incrementally add IPv6 capability without a change of the modem on the customer site.
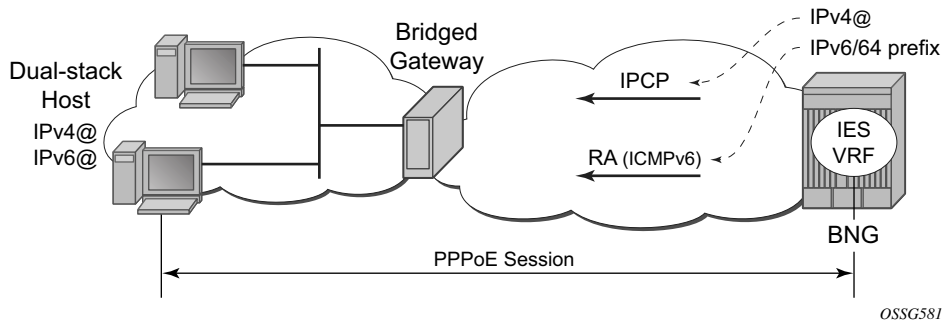
Figure 364: Dual Stack PPPoE Bridged Gateway Service Example

Dual Stack PPPoE Routed Gateway Service

The dual stack PPPoE Routed Gateway (RG) service runs over a dual stack PPPoE session between a dual stack router and BNG. It allows operators of existing PPPoE networks (with either PPPoE to the RG or PPPoA with translation to PPPoE in the DSLAM) to deploy IPv6 services in conjunction with an existing IPv4 service.

As a RG is provided, a unique subscriber IPv6 prefix is delegated to the dual stack router for use within the home network. DHCPv6 is used to provide prefix delegation (PD). No RG WAN IPv6 address assignment is supported in this model. The dual stack router does not perform any NAT for IPv6 traffic.
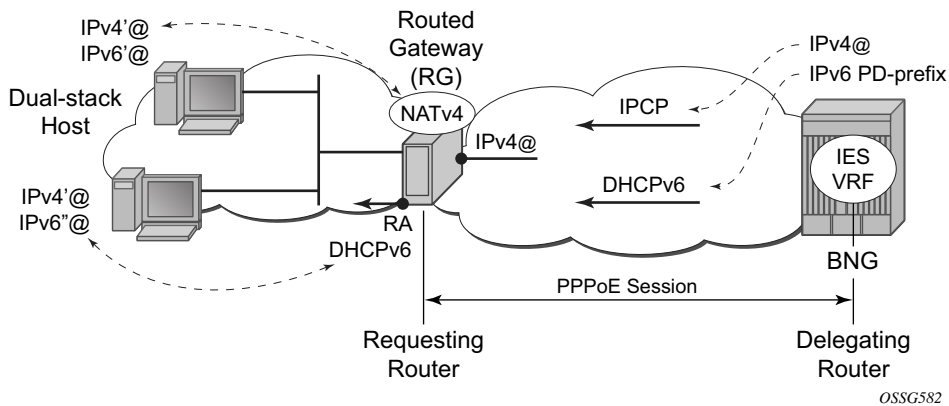

Figure 365: Dual Stack PPPoE Routed Gateway Service Example

SLAAC

The IPv6 stateless auto configuration (SLAAC) mechanism requires no manual configuration of hosts, minimal configuration of routers, and no additional servers (such as DHCP). The stateless mechanism allows a host to generate its own addresses using a combination of locally available information and information advertised by routers. Routers advertise /64 prefixes, by an ICMPv6 router advertisement, that identify the subnet(s) associated with a link, while hosts generate a 64-bit "interface identifier" that uniquely identifies an interface on a subnet. An address is formed by combining the two.

DHCPv6

The Dynamic Host Configuration Protocol for IPv6 (DHCPv6) is defined in RFC 3315. The protocol enables DHCPv6 servers to pass configuration parameters such as IPv6 network addresses or DNSv6 addresses to IPv6 nodes.

For further information on DHCPv6, refer to ESMv6: IPoE Dual Stack Hosts on page 2263,

Prefix Delegation

Prefix Delegation (PD) is a mechanism for automated delegation of IPv6 prefixes using DHCPv6. A delegating router delegates a long-lived IPv6 prefix to a requesting router. The delegating router does not require knowledge about the topology of the links in the network to which the prefixes will be assigned

For further information on Prefix Delegation, refer to ESMv6: IPoE Dual Stack Hosts on page 2263.

Configuration

ESMv6 for PPPoE is applicable in a Routed CO environment. Details of non-specific dual stack configurations like authentication-policies, sla-profile, subscriber-profile, accounting-policies and QoS policies are out of scope for this section.

The minimal RADIUS authentication configuration and ESM string configuration is just added for completeness.

```
A:BNG-1#
      configure subscriber-mgmt
          authentication-policy "radius-1"
              description "Radius authentication policy"
              password ALU
              radius-authentication-server
                  router "Base"
                  server 1 address 172.16.1.1 secret ALU
              exit
              PPPoE-access-method pap-chap
          exit


A:BNG-1#
      configure subscriber-mgmt
          sla-profile "sla-profile-1"
          exit
          sub-profile "sub-profile-1"
          exit
          sub-ident-policy "sub-ident-1"
              sub-profile-map
                  use-direct-map-as-default
              exit
              sla-profile-map
                  use-direct-map-as-default
              exit
          exit
```

Service

Dual Stack PPPoE for Bridged Gateway

Figure 366 shows the message flow for a dual stack PPPoE host behind a bridged gateway corresponding with the configured service.

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Figure 366: Message Flow for a Dual Stack PPPoE Host
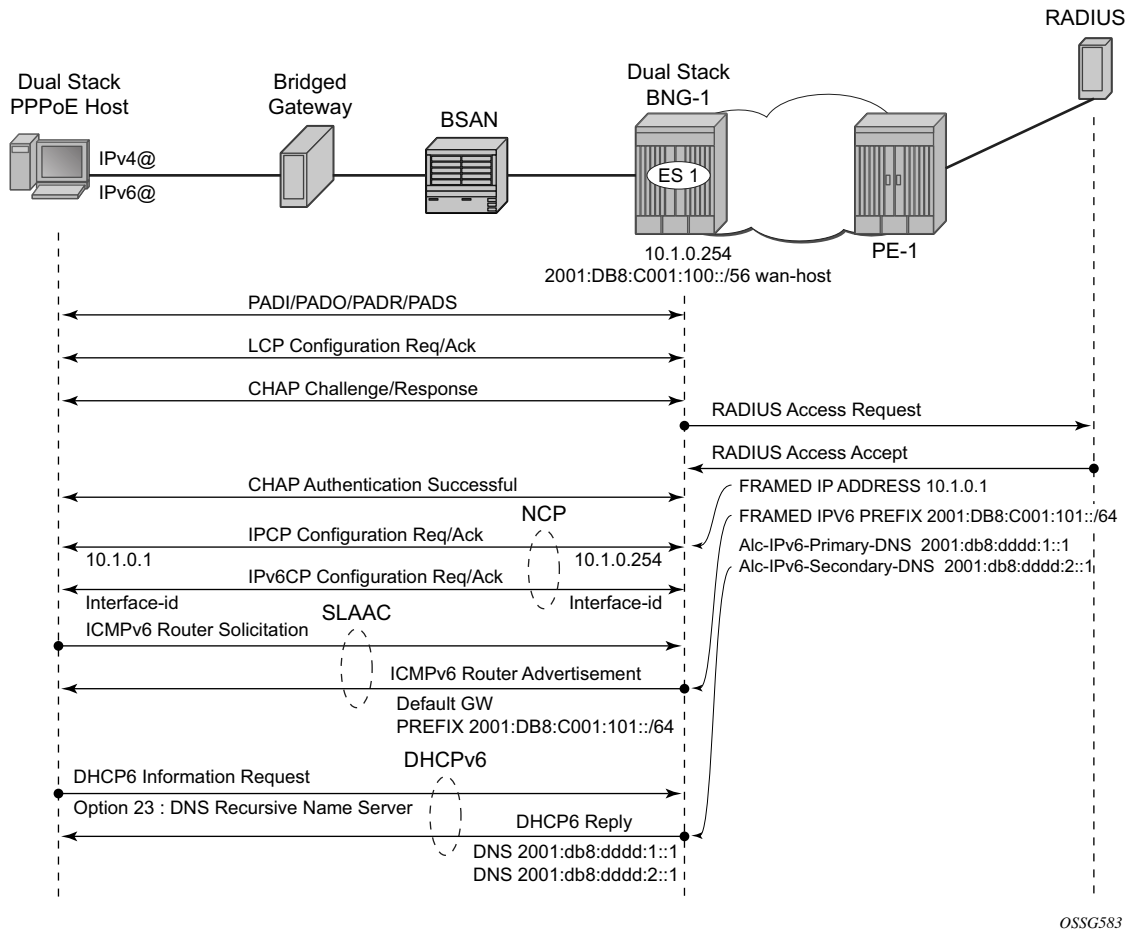
For dual stack PPPoE, the BNG initiates the IPv6CP protocol to the client during the session setup phase if the appropriate attributes have been returned by the RADIUS server on authentication. The RADIUS attribute that indicates the setup of a dual stack PPPoE host in bridged mode is framed-ipv6-prefix which should contain a /64 prefix for the client. When a PPPoE host has

successfully completed the IPv6CP negotiation, the BNG will transmit an RA to the PPPoE host containing the prefix and any other option that is configured. The host can request optional IPv6 DNS server information from the BNG by sending a DHCPv6 information-request.

The following example shows a minimal configuration to enable dual stack subscribers in an IES service context with the ESM IPv6-specific parts in bold and is discussed in Dual Stack PPPoE Routed Gateway Service on page 2311.

```
A:BNG-1#
     configure service ies 1
         subscriber-interface "sub-int-1"
             address 10.1.0.254/16
             group-interface "group-int-1"
                 ipv6
                     router-advertisements
                         prefix-options
                             autonomous
                         exit
                         no shutdown
                     exit
                     dhcp6
                         proxy-server
                             client-applications pppoe
                             no shutdown
                         exit
                     exit
                 exit
                 authentication-policy "radius-1"
                 sap 1/1/4:301
                     sub-sla-mgmt
                         sub-ident-policy "sub-ident-1"
                         multi-sub-sap 10
                         no shutdown
                     exit
                 exit
                 PPPoE
                     no shutdown
                 exit
             exit
             ipv6
                 subscriber-prefixes
                     prefix 2001:DB8:C001:100::/40 wan-host   ### length [/32../63]
                 exit
             exit
         exit
         no shutdown
     exit
```

IPv6 subscriber prefixes must be defined at the **subscriber-interface** *<sub-int-name>* **ipv6** *subscriber-prefixes* context.

Three types of prefixes can be configured where **wan-host** is required for this bridged gateway scenario and **pd** is used for dual stack PPPoE routed gateways.

- wan-host — Prefix from which the IPv6 addresses are assigned (by DHCPv6 IA_NA) for the IPoEv6 routed gateway WAN interface (network facing) or a prefix from which /64 prefixes are assigned for the PPPoE (by RA SLAAC) hosts in the bridged gateway model.

- pd — Prefix from which the IPv6 prefix delegation prefixes are assigned that are to be used by the IPoEv6 or PPPoEv6 routed gateway for allocation in the home network (LAN interfaces).

- pd wan-host (both) — Prefix from which both IPv6 addresses (wan-host) and IPv6 prefix delegation prefixes (pd) can be assigned. This requires that the delegated prefix length is set to 64 bits.

Table 36 and Table 37 provide an overview of the subscriber-prefix parameters that apply and an example of subscriber prefix subnetting for SLAAC.

Table 36: Subscriber Prefix Parameters

Subscriber Prefix Type	Prefix Length	DHCPv6 Option	SLAAC	RADIUS AVP	Must be sub netted as
wan-host	/32..63	N/A	yes	[97]Framed-IPv6-Prefix	/64

Table 37: Subscriber Prefix Subnetting for SLAAC

Subscriber prefix	Framed-IPv6-Prefix	Hosts
2001:db8:c001:100::/56	2001:db8:c001:101::/64	pppoev6-host-1
	2001:db8:c001:102::/64	pppoev6-host-2
	2001:db8:c001:103::/64	pppoev6-host-3
	\<snip>	\<snip>
	2001:db8:c001:1FF::/64	pppoev6-host-256
2001:db8:c001:200::/56	2001:db8:c001:201::/64	PPPoEv6-host-257
	2001:db8:c001:202::/64	PPPoEv6-host-258
	2001:db8:c001:203::/64	PPPoEv6-host-259
	\<snip>	\<snip>
	2001:db8:c001:2FF::/64	PPPoEv6-host-512

Dual Stack PPPoE for Routed Gateway

Figure 367 shows the message flow for a dual stack PPPoE host behind a routed gateway corresponding with the configured service.

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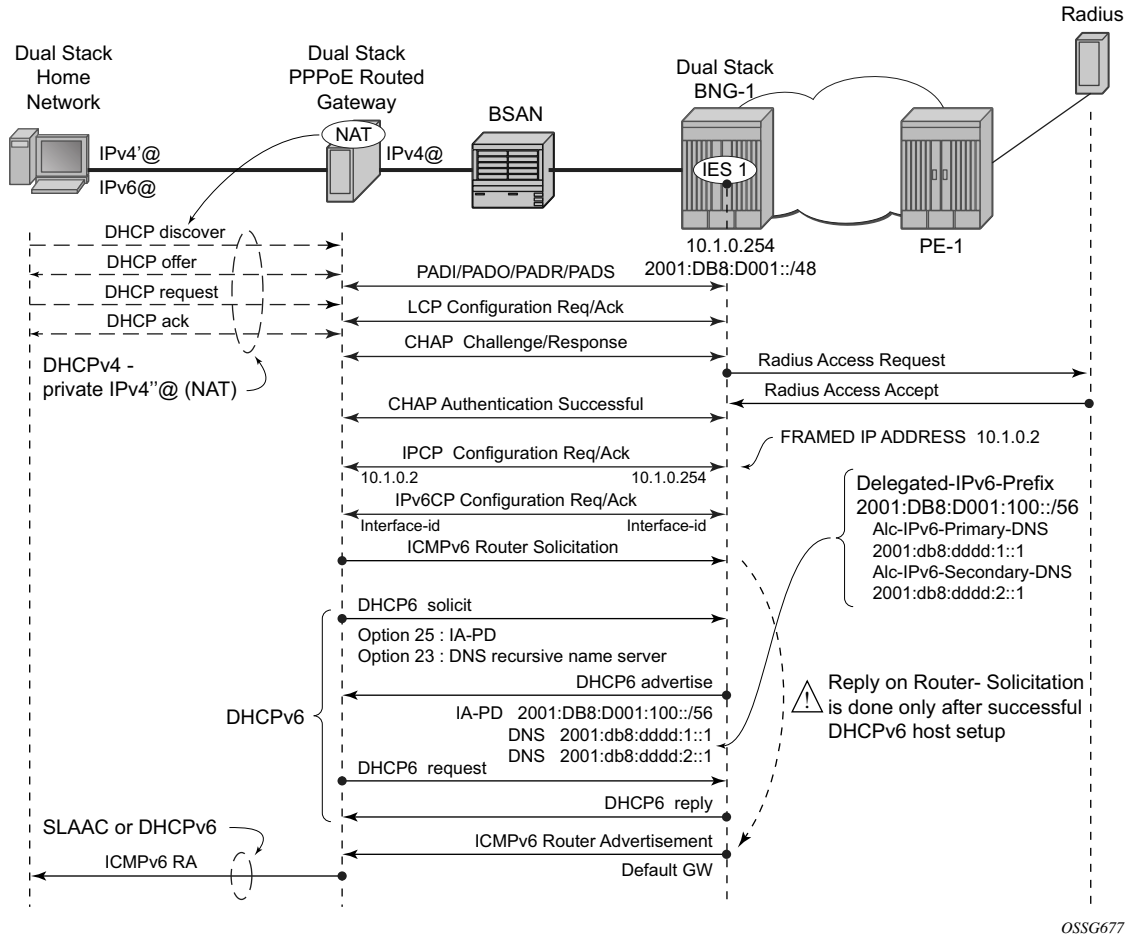
Figure 367: Dual Stack PPPoE for Routed Gateway

Initially, a PPPoE routed gateway follows the same procedure as a dual stack PPPoE host. The BNG receives a prefix from RADIUS (in this case through a delegated-ipv6-prefix attribute), which is used as a trigger to initiate the IPv6CP protocol to the client. The prefix that is offered to the client should have the same prefix length as configured under the subscriber interface ipv6 node (delegated-prefix length).This length should be between 48 and 64 bits, inclusive.

After the IPv6CP protocol has completed the client must run the DHCPv6 protocol over its PPPoE tunnel to receive a delegated prefix (IA_PD) and optionally IPv6 DNS server information.

This delegated prefix can then be subdivided by the client and distributed over its downstream interfaces. During DHCPv6, no extra RADIUS request will be made; the information is stored during the initial PPPoE authentication until the client starts DHCPv6. Only after DHCPv6 has completed will the IPv6 subscriber host be instantiated and the BNG will start sending RAs if configured. (It is a mandatory requirement for the BNG to send RAs which makes the enabling of router-advertisements under the group-level a mandatory parameter). The router advertisements do not contain any prefix information, which has already been provided by DHCPv6, but it is used as an indication to the client that its default gateway should be the BNG sourcing this RA.

```
A:BNG-1#
     configure service ies 1
         subscriber-interface "sub-int-1"
             address 10.1.0.254/16
             group-interface "group-int-1"
                 ipv6
                     router-advertisements
                         no shutdown
                     exit
                     dhcp6
                         proxy-server
                             client-applications pppoe
                             no shutdown
                         exit
                     exit
                 exit
                 authentication-policy "radius-1"
                 sap 1/1/4:301
                     sub-sla-mgmt
                         sub-ident-policy "sub-ident-1"
                         multi-sub-sap 10
                         no shutdown
                     exit
                 exit
                 PPPoE
                     no shutdown
                 exit
             exit
             ipv6
                 delegated-prefix-len 56
                 subscriber-prefixes
                     prefix 2001:DB8:D001::/48 pd
                 exit
             exit
         exit
         no shutdown
```

IPv6 subscriber prefixes must be defined at the **subscriber-interface** *<sub-int-name>* **ipv6** *subscriber-prefixes* context.

Refer to Dual Stack PPPoE Bridged Gateway Service on page 2310.

Subscriber prefixes are subnetted in fixed length subnets that are assigned to subscriber hosts:

- /delegated-prefix-len (/48..64) for p subscriber prefixes

The delegated prefix length is configured in the **subscriber-interface** *<sub-int-name>* **ipv6** context. The recommended value is /56 (default = /64). The configured length applies to all pd subscriber prefixes on a subscriber-interface.

Table 38 and Table 39 provide an overview of the subscriber-prefix parameters that apply and an example of prefix subnetting for delegated-prefix-length /56.

Table 38: Subscriber-Prefix Parameters

Subscriber Prefix Type	Prefix Length	DHCPv6 Option	SLAAC	RADIUS AVP	Must be sub netted as
pd	/48..64 *	IA-PD	N/A	[123] Delegated-IPv6-Prefix	/delegated-prefix-len

*Must be smaller than configured delegated prefix length.

Table 39: Prefix Subnetting for delegated-prefix-length /56

Subscriber Prefix and /56 delegated-prefix-len	Framed-IPv6-Prefix	Hosts
2001:db8:d001::/48	2001:db8:d001:100::/56	Responsibility Home Gateway (HGW)
		Responsibility HGW
		Responsibility HGW
	2001:db8:d001:200::/56	Responsibility HGW
		Responsibility HGW
		Responsibility HGW
	<snip>	--
	2001:db8:d001:FF00::/56	Responsibility HGW
		Responsibility HGW
		Responsibility HGW

Table 39: Prefix Subnetting for delegated-prefix-length /56 (Continued)

Subscriber Prefix and /56 delegated-prefix-len	Framed-IPv6-Prefix	Hosts
<snip>	--	--
2001:db8:d002::/48	2001:db8:d002:100::/56	Responsibility HGW
		Responsibility HGW
		Responsibility HGW
	2001:db8:d002:200::/56	Responsibility HGW
		Responsibility HGW
		Responsibility HGW
	<snip>	--
	2001:db8:d002:FF00::/56	Responsibility HGW
		Responsibility HGW
		Responsibility HGW

RADIUS

The DHCPv6 proxy server mandates the use of RADIUS for PPPoE IPv6 subscriber host authentication and authorization. The configuration is no different from an IPv4 subscriber host:

```
A:BNG-1#
      configure subscriber-mgmt
         authentication-policy "radius-1"
            description "Radius authentication policy"
            password <hashed password> hash2
            radius-authentication-server
                router "Base"
                server 1 address 172.16.1.1 secret ALU
            exit
         exit

A:BNG-1#
      configure service ies 1 customer 1
         subscriber-interface "sub-int-1"
            group-interface "group-int-1"
                authentication-policy "radius-1"
```

Notice that for dual stack subscribers, it is mandatory to retrieve the IPv6 configuration information through RADIUS. IPv4 configuration information can come from RADIUS or from a different source (like the local user database or DHCPv4 server).

Additional RADIUS Attribute Value pairs (AVPs) that are applicable for PPPoE IPv6 subscriber hosts are listed in the following section.

Table 40: RADIUS AVPs

RADIUS AVP	Type	Purpose
Framed-IPv6-Prefix [97]	ipv6prefix	Maps to SLAAC (RFC 4862) /64 Prefix-information in ICMPv6 RA.
Delegated-IPv6-Prefix [123]	ipv6prefix	Maps to IA_PD for prefix delegation (RFC 3633) in DHCPv6
Alc-Ipv6-Primary-Dns [26-6527-105]	ipv6addr	Maps to DNS recursive name server option (RFC 3646) in DHCPv6
Alc-Ipv6-Secondary-Dns [26-6527-106]	ipv6addr	Maps to DNS recursive name server option (RFC 3646) in DHCPv6

Dual Stack PPPoE for Bridged Gateway

The following shows a sample of a FreeRADIUS user record to authenticate a dual stack PPPoE subscriber for a bridged gateway:

```
"pppoev6-host1@isp1.com" Cleartext-Password := "ALU"
                Framed-IP-Address = 10.1.0.1,
                Framed-IP-Netmask = 255.255.255.0,
                Alc-Subsc-ID-Str  = "%{User-name}",
                Alc-Subsc-Prof-Str = "sub-profile-1",
                Alc-SLA-Prof-Str = "sla-profile-1",
                Framed-IPv6-Prefix = "2001:db8:c001:0101::/64",
                Alc-IPv6-Primary-DNS = "2001:db8:dddd:1::1",
                Alc-IPv6-Secondary-DNS = "2001:db8:dddd:2::1"
```

Dual Stack PPPoE for Routed Gateway

The following shows a sample of a FreeRADIUS user record to authenticate a dual stack PPPoE subscriber for a routed gateway:

```
"PPPoEv6-gw1@isp1.com"  Cleartext-Password := "ALU"
                Framed-IP-Address = 10.1.0.2,
                Framed-IP-Netmask = 255.255.255.0,
                Alc-Subsc-ID-Str = "%{User-name}",
                Alc-Subsc-Prof-Str = "sub-profile-1",
                Alc-SLA-Prof-Str = "sla-profile-1",
                Delegated-IPv6-Prefix = "2001:db8:d001:0100::/56",
                Alc-IPv6-Primary-DNS = "2001:db8:dddd:1::1",
                Alc-IPv6-Secondary-DNS = "2001:db8:dddd:2::1"
```

A RADIUS user's configuration with multiple delegated-ipv6-prefixes for the same dual stack PPPoE host will result in a single DHCPv6 advertise message sent by the BNG with a single IA_PD option and single IA-Prefix. The other RADIUS configured delegated-IPv6-prefixes are silently dropped by the BNG.

Router Advertisements

ICMPv6 router advertisements have two major functions.

- Default router function for hosts (applicable for IPoEv6 and PPPoEv6)
- Address auto-configuration for hosts aka SLAAC (applicable for PPPoEv6 only)

Unsolicited RA must explicitly be enabled on a group interface (default shutdown) and are refreshed with a pseudo random timer. The boundaries of this random timer are configurable with the min-advertisement parameter (minimum with default set to 900s) and max-advertisement (maximum with default set to 1800s).

```
A:BNG-1#
     configure service ies 1 customer 1
         subscriber-interface "sub-int-1"
            group-interface "group-int-1"
               ipv6
                  router-advertisements
                     max-advertisement 1800      # Default 30 min
                     min-advertisement 900      # Default 15 min
                  no shutdown
                  exit
```

The **router-advertisements router-lifetime** parameter (default 4500 sec) specifies how long the host is allowed to use the originator of the RA as default gateway. This timer is configurable between 2700 and 9000 seconds.

Configuring a **smaller router-advertisements router-life** timer than the **router-advertisements min-advertisement** timer results in a dual stack PPPoE host without a default gateway.

```
A:BNG-1#
     configure service ies 1 customer 1
         subscriber-interface "sub-int-1"
            group-interface "group-int-1"
               ipv6
                  router-advertisements
                     router-lifetime 4500          # Default 1h 15min
                  no shutdown
                  exit
```

The **prefix-options autonomous** parameter below specifies whether or not offered RADIUS IPv6 prefix can be used for stateless address configuration (SLAAC). The **prefix-options lifetime** parameter defines how long the host is allowed to use this prefix. Configuring a smaller **prefix-option valid-lifetime** than the **router-advertisements min-advertisement** timer results in host traffic being sourced with the link-local address instead of global unique IPv6 address.

```
A:BNG-1#
     configure service ies 1 customer 1
          subscriber-interface "sub-int-1"
               group-interface "group-int-1"
                    ipv6
                         router-advertisements
                              prefix-options
                                   autonomous                  # Required for SLAAC
                                   preferred-lifetime 3600     # Default 1 hour
                                   valid-lifetime 86400        # Default 24 hour
                                   exit
                              no shutdown
                              exit
```

The following is a snapshot from an ICMPv6 RA message with default timer settings with a focus on the SLAAC function.

```
Internet Control Message Protocol v6
    Type: 134 (Router advertisement)

    <snip>

    ICMPv6 Option (Prefix information)
        Type: Prefix information (3)
        Length: 32
        Prefix length: 64
        Flags: 0x40
            1... .... = on link
            .1.. .... = Auto                   # Auto-Configuration flag
            ..0. .... = Not router address
            ...0 .... = Not site prefix
        Valid lifetime: 86400                  # Default value 24 hour
        Preferred lifetime: 3600               # Default value  1 hour
        Prefix: 2001:DB8:C001:101::            # SLAAC prefix
```

SLAAC-related parameters are listed in Table 41:

Table 41: SLAAC-Related Parameters

Parameter	Description (RFC-4861)	Value Range (Default)
prefix-options: autonomous	Autonomous address-configuration flag. When set indicates that this prefix can be used for stateless address auto configuration (SLAAC)	(no)
prefix-options: preferred-lifetime	The length of time in seconds that the addresses generated from the prefix through stateless address auto configuration (SLAAC) remains preferred.	0..4294967295 s (3600s) 1hour
prefix-options: valid-lifetime	The length of time in seconds that the prefix is valid for the purpose of on-link determination.	0..4294967295 s (86400s) 24hours

Note that additional router advertisements parameters common to PPPoEv6 and IPoEv6 are listed and explained in ESMv6: IPoE Dual Stack Hosts on page 2263.

For dual stack PPPoE hosts the default values, as shown in the following output, can be used. Timer values equal to zero (reachable-time and retransmit-time) causes the host to use its own timers for that function. The reachable-time is used by the host for Neighbor_Unreachable_Detection (NUD) whereas the retransmit-time is used by the host for Duplicate_Address_Detection (DAD). DAD is normally only performed by dual stack IPoE hosts and not by dual stack PPPoE hosts.

```
A:BNG-1#
    configure service ies 1 customer 1
        subscriber-interface "sub-int-1"
            group-interface "group-int-1"
                ipv6
                    router-advertisements
                        current-hop-limit 64             # default value
                        no managed-configuration         # default value
                        no mtu                           # default value
                        no other-stateful-configuration  # default value
                        reachable-time 0                 # default value
                        retransmit-time 0                # default value
                exit
```

DHCPv6 Proxy Server

Dual Stack PPPoE for Bridged Gateway

This dual stack PPPoE host uses SLAAC for address assignment and does not require DHCPv6 for this assignment. The 7750 SR however does not support DNSv6 information through the RA DNS Option (RFC 5006, *IPv6 Router Advertisement Option for DNS Configuration*) which forces the use of DHCPv6 information requests and replies to retrieve the DNSv6 information. The DHCPv6 proxy server must be enabled (the default is **shutdown**) and PPPoE defined as client-application (default=dhcp only). No lease state is kept for this DNSv6 information and therefore it is known as Stateless DHCPv6.

```
A:BNG-1#
        configure service ies 1 customer 1
            subscriber-interface "sub-int-1"
                group-interface "group-int-1"
                    ipv6
                        dhcp6
                            proxy-server
                                client-applications PPPoE
                                no shutdown
```

Dual Stack PPPoE for Routed Gateway

An IPv6 PPPoE routed gateway initiates, after successful IPv6CP negotiation, a DHCPv6 session to request its configuration data (IPv6 PD prefixes, DNS servers). A DHCPv6 proxy server in the BNG maintains the DHCPv6 session with the IPv6 PPPoE subscriber host. The DHCPv6 proxy server must be enabled (the default is **shutdown**) and PPPoE defined as client-application (default=dhcp only).

```
A:BNG-1#
        configure service ies 1 customer 1
            subscriber-interface "sub-int-1"
                group-interface "group-int-1"
                    ipv6
                        dhcp6
                            proxy-server
                                renew-timer 1800           # default
                                rebind-timer 2880          # default
                                valid-lifetime 86400       # default
                                preferred-lifetime 3600    # default
                                client-applications pppoe
                                no shutdown
                            exit
```

Note that a number of timers associated with IPv6 addresses and IPv6 prefixes within DHCPv6 identity associations can be configured in the DHCPv6 proxy server. These timers are valid for IPoEv6 and PPPoEv6 sessions and are listed and further explained in ESMv6: IPoE Dual Stack Hosts on page 2263.

There is never RADIUS re-authentication for dual stack PPPoE routed gateways on DHCPv6 renewals as indicated in Figure 368.

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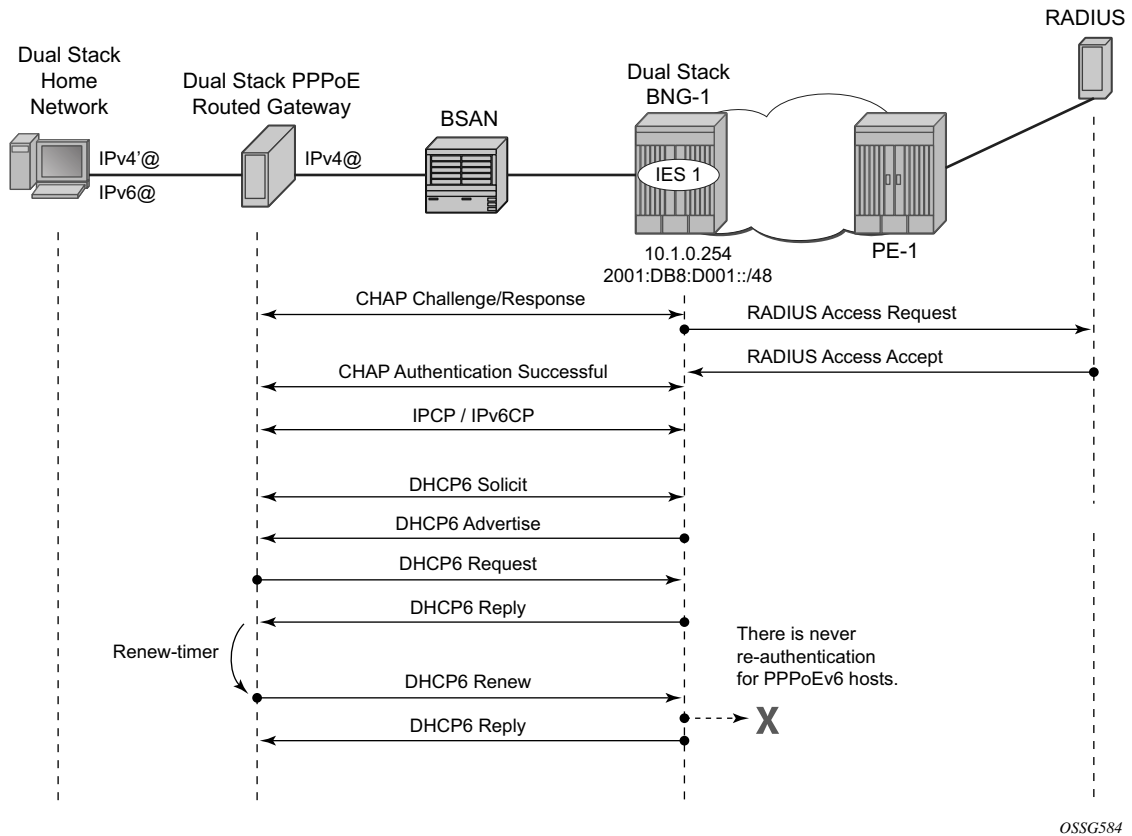
Figure 368: DHCPv6 Renewals

DHCPv6 Lease State

The DHCPv6 lease state is an internal database structure that keeps track of the DHCPv6 host states. The DHCP lease information for a specific host is extracted from the DHCPv6 reply message in case of DHCPv6. Stateful (with lease state) DHCPv6 is applicable for dual stack PPPoE on routed gateway where Stateless (without lease state) DHCPv6 is optional and applicable for dual stack PPPoE on bridged gateways.

For more information on DHCPV6 lease states, see .

Operation

Dual Stack PPPoE for Bridged Gateway

A PPPoEv6 dual stack subscriber scenario for a bridged home gateway consumes two subscriber host entries sharing a common subscriber.

- IPv4 host-addressing by IPCP
- IPv6 wan-host addressing by SLAAC

```
A:BNG-1# show service active-subscribers subscriber "pppoev6-host1@isp1.com"
===========================================================
Active Subscribers
===========================================================
-----------------------------------------------------------
Subscriber pppoev6-host1@isp1.com (sub-profile-1)
-----------------------------------------------------------
(1) SLA Profile Instance sap:1/1/4:301 - sla:sla-profile-1
-----------------------------------------------------------
IP Address
               MAC Address        PPPoE-SID   Origin
-------------------------------------------------------
10.1.0.1
               00:0c:29:54:30:bf   1           IPCP
2001:DB8:C001:101::/64
               00:0c:29:54:30:bf   1           PPP-SLAAC
-------------------------------------------------------
Number of active subscribers: 1
```

The **hierarchy** parameter for active-subscribers gives a top level down overview for this subscriber.

```
A:BNG-1# show service active-subscribers hierarchy subscriber "pppoev6-host1@isp1.com"
============================================================================
Active Subscriber hierarchy
============================================================================
-- pppoev6-host1@isp1.com (sub-profile-1)
   |
   |-- sap:1/1/4:301 - sla:sla-profile-1
   |   |
   |   |-- 10.1.0.1
   |   |    00:0c:29:54:30:bf - 1 (IPCP)
   |   |
   |   |-- 2001:DB8:C001:101::/64
   |   |    00:0c:29:54:30:bf - 1 (PPP-SLAAC)
   |   |
============================================================================
A:BNG-1#
```

IPCP and IPv6CP are in an opened state for the dual stack PPPoE session and it is mandatory that their origin is RADIUS, as shown below.

```
A:BNG-1# show service id 1 PPPoE session ip-address 10.1.0.1 detail
===============================================================
PPPoE sessions for svc-id 1
===============================================================
Sap Id            Mac Address       Sid    Up Time        Type
    IP/L2TP-Id/Interface-Id
---------------------------------------------------------------
1/1/4:301            00:0c:29:54:30:bf 1      0d 00:04:03    Local
    10.1.0.1
    81:35:1D:7C:1F:3F:8B:41

LCP State           : Opened
IPCP State          : Opened
IPv6CP State        : Opened
PPP MTU             : 1492
PPP Auth-Protocol   : CHAP
PPP User-Name       : pppoev6-host1@isp1.com

Subscriber-interface : sub-int-1
Group-interface     : group-int-1

Subscriber Origin   : Radius
Strings Origin      : Radius
IPCP Info Origin    : Radius
IPv6CP Info Origin   : Radius

Subscriber          : "pppoev6-host1@isp1.com"
Sub-Profile-String  : "sub-profile-1"
SLA-Profile-String  : "sla-profile-1"

<snip>

IPv6 Prefix         : 2001:DB8:C001:101::/64           #SLAAC
IPv6 Del.Pfx.       : N/A
Primary IPv6 DNS    : 2001:DB8:DDDD:1::1
Secondary IPv6 DNS  : 2001:DB8:DDDD:2::1

<snip>
-------------------------------------------------------
Number of sessions  : 1
```

The IPv6 routing table for dual stack hosts is displayed using the **protocol** keyword **sub-mgmt**.

```
A:BNG-1# show router route-table ipv6 protocol sub-mgmt
===============================================================================
IPv6 Route Table (Router: Base)
===============================================================================
Dest Prefix                              Type    Proto   Age         Pref
      Next Hop[Interface Name]                                       Metric
-------------------------------------------------------------------------------
2001:DB8:C001:101::/64                   Remote  Sub Mgmt 00h20m01s   0
      [group-int-1]                                                  0
```

DNSv6

DNSv6 information, in a dual stack PPPoE bridged gateway model, is optionally retrieved through stateless DHCPv6 information requests. Debugging is done through debug commands or/and observation by statistics counters.

Request and Reply:

```
00 2010/07/23 14:16:40.01 IST MINOR: DEBUG #2001 Base TIP
"TIP: DHCP6_PKT
   Incoming DHCP6 Msg : INFO_REQUEST (11)
   on itf group-int-1
     Trans Id : 0xcef3f0
     Option : CLIENTID (1), Length : 14
       LLT : HwTyp=0001,T=322878930,LL=000c29c851ca
       00010001133ebdd2000c29c851ca
     Option : ELAPSED_TIME (8), Length : 2
       Time : 100 seconds
     Option : ORO (6), Length : 4
       Requested Option : DNS_NAME_SRVR (23)


101 2010/07/23 14:16:40.02 IST MINOR: DEBUG #2001 Base TIP
"TIP: DHCP6_PKT
   Outgoing DHCP6 Msg : REPLY (7)
   to itf group-int-1
     Trans Id : 0xcef3f0
     Option : SERVERID (2), Length : 10
       LL  : HwTyp=0001,LL=24b1ff000000
       0003000124b1ff000000
     Option : CLIENTID (1), Length : 14
       LLT : HwTyp=0001,T=322878930,LL=000c29c851ca
       00010001133ebdd2000c29c851ca
     Option : DNS_NAME_SRVR (23), Length : 32
       Server : 2001:DB8:DDDD:1::1               # retrieved from radius
       Server : 2001:DB8:DDDD:2::1               # retrieved from RADIUS
```

DHCPv6 statistics

```
A:BNG-1# clear router dhcp6 statistics
A:BNG-1# show router dhcp6 statistics
===============================================================================
DHCP6 statistics (Router: Base)
===============================================================================
Msg-type                        Rx              Tx              Dropped
-------------------------------------------------------------------------------
1 SOLICIT                       0               0               0
2 ADVERTISE                     0               0               0
3 REQUEST                       0               0               0
4 CONFIRM                       0               0               0
5 RENEW                         0               0               0
6 REBIND                        0               0               0
7 REPLY                         0               1               0
8 RELEASE                       0               0               0
9 DECLINE                       0               0               0
10 RECONFIGURE                  0               0               0
11 INFO_REQUEST                 1               0               0
12 RELAY_FORW                   0               0               0
13 RELAY_REPLY                  0               0               0
```

Entries, for dual stack PPPoE subscribers, in the IPv4 ARP and/or IPv6 neighbor cache table are counted as internal entries and are shown from the **summary** parameter.

```
A:BNG-1# show router arp summary
====================================
ARP Table Summary (Router: Base)
====================================
Local ARP Entries    : 0
Static ARP Entries   : 0
Dynamic ARP Entries  : 0
Managed ARP Entries  : 0
Internal ARP Entries : 1
------------------------------------
No. of ARP Entries   : 1

 A:BNG-1# show router neighbor summary
====================================
Neighbor Table Summary (Router: Base)
====================================
Static Nbr Entries    : 0
Dynamic Nbr Entries   : 0
Managed Nbr Entries   : 0
Internal Nbr Entries  : 1
------------------------------------
No. of Neighbor Entries : 1
```

Dual Stack PPPoE for Routed Gateway

A PPPoEv6 dual stack subscriber scenario for a routed CPE consumes two subscriber host entries sharing a common subscriber.

- IPv4 host addressing through IPCP
- IPv6 pd addressing through DHCPv6

```
A:BNG-1#
show service active-subscribers subscriber "PPPoEv6-rgw1@isp1.com"
===============================================================================
Active Subscribers
===============================================================================
-------------------------------------------------------------------------------
Subscriber PPPoEv6-rgw1@isp1.com (sub-profile-1)
-------------------------------------------------------------------------------
(1) SLA Profile Instance sap:1/1/4:301 - sla:sla-profile-1
-------------------------------------------------------------------------------
IP Address
              MAC Address        PPPoE-SID Origin
-----------------------------------------------------------
10.1.0.2
              00:0c:29:54:30:bf 1         IPCP
2001:DB8:D001:100::/56
              00:0c:29:54:30:bf 1         PPP-DHCP6
-----------------------------------------------------------
Number of active subscribers: 1
```

The hierarchy parameter for active-subscribers gives a top level down overview for this subscriber.

```
A:BNG-1#
show service active-subscribers hierarchy subscriber "PPPoEv6-rgw1@isp1.com"
===============================================================================
Active Subscriber hierarchy
===============================================================================
-- PPPoEv6-rgw1@isp1.com (sub-profile-1)
   |
   |-- sap:1/1/4:301 - sla:sla-profile-1
   |   |
   |   |-- 10.1.0.2
   |   |   00:0c:29:54:30:bf - 1 (IPCP)
   |   |
   |   |-- 2001:DB8:D001:100::/56
   |   |   00:0c:29:54:30:bf - 1 (PPP-DHCP6)
===============================================================================
```

IPCP and IPv6CP are in an opened state for the dual stack PPPoE session and it is mandatory that their origin is RADIUS, as shown below.

```
A:BNG-1# show service id 1 PPPoE session ip-address 10.1.0.2 detail
===============================================================
PPPoE sessions for svc-id 1
===============================================================
Sap Id            Mac Address       Sid   Up Time        Type
   IP/L2TP-Id/Interface-Id
---------------------------------------------------------------
1/1/4:301         00:0c:29:54:30:bf 1     0d 00:05:23    Local
   10.1.0.2
   B5:4B:0D:D7:69:9E:CD:7F

LCP State          : Opened
IPCP State         : Opened
IPv6CP State       : Opened
PPP MTU            : 1492
PPP Auth-Protocol  : CHAP
PPP User-Name      : PPPoEv6-rgw1@isp1.com

Subscriber-interface : sub-int-1
Group-interface      : group-int-1

Subscriber Origin  : Radius
Strings Origin     : Radius
IPCP Info Origin   : Radius
IPv6CP Info Origin : Radius

Subscriber         : "PPPoEv6-rgw1@isp1.com"
Sub-Profile-String : "sub-profile-1"
SLA-Profile-String : "sla-profile-1"

<snip>

IPv6 Prefix        : N/A
IPv6 Del.Pfx.      : 2001:DB8:D001:100::/56          #IA-PD
Primary IPv6 DNS   : 2001:DB8:DDDD:1::1
Secondary IPv6 DNS : 2001:DB8:DDDD:2::1
<snip>
----------------------------------------------------------
Number of sessions : 1
```

The IPv6 routing table for dual stack hosts is displayed using the **protocol** keyword **sub-mgmt**.

```
A:BNG-1# show router route-table ipv6 protocol sub-mgmt
===============================================================================
IPv6 Route Table (Router: Base)
===============================================================================
Dest Prefix                             Type    Proto    Age        Pref
     Next Hop[Interface Name]                                       Metric
-------------------------------------------------------------------------------
2001:DB8:D001:100::/56                   Remote  Sub Mgmt 00h06m45s   0
     [group-int-1]
```

DNSv6

DNSv6 information, in a dual stack PPPoE routed gateway model, is optionally retrieved by stateful DHCPv6 information requests. Debugging is done through debug commands or/and observation by statistics counters.

Solicit and Advertise

```
171 2010/07/23 15:01:18.24 IST MINOR: DEBUG #2001 Base TIP
"TIP: DHCP6_PKT
  Incoming DHCP6 Msg : SOLICIT (1)
  on itf group-int-1
    Trans Id : 0xb6f6f1
    Option : CLIENTID (1), Length : 14
      LLT : HwTyp=0001,T=322878930,LL=000c29c851ca
      00010001133ebdd2000c29c851ca
    Option : IA_PD (25), Length : 12
      IAID : 1
      Time1: 4294967295 seconds
      Time2: 4294967295 seconds
    Option : ELAPSED_TIME (8), Length : 2
      Time : 100 seconds
    Option : ORO (6), Length : 4
      Requested Option : DNS_NAME_SRVR (23)

172 2010/07/23 15:01:18.23 IST MINOR: DEBUG #2001 Base TIP
"TIP: DHCP6_PKT
  Outgoing DHCP6 Msg : ADVERTISE (2)
  to itf group-int-1
    Trans Id : 0xb6f6f1
    Option : SERVERID (2), Length : 10
      LL  : HwTyp=0001,LL=24b1ff000000
      0003000124b1ff000000
    Option : CLIENTID (1), Length : 14
      LLT : HwTyp=0001,T=322878930,LL=000c29c851ca
      00010001133ebdd2000c29c851ca
    Option : DNS_NAME_SRVR (23), Length : 32
      Server : 2001:DB8:DDDD:1::1
      Server : 2001:DB8:DDDD:2::1
    Option : IA_PD (25), Length : 41
      IAID : 1
      Time1: 1800 seconds
      Time2: 2880 seconds
      Option : IAPREFIX (26), Length : 25
        Prefix : 2001:DB8:D001:100::/56
        Preferred Lifetime : 3600 seconds
        Valid Lifetime     : 86400 seconds
```

Request and Reply

```
3 2010/07/23 15:01:20.24 IST MINOR: DEBUG #2001 Base TIP
"TIP: DHCP6_PKT
   Incoming DHCP6 Msg : REQUEST (3)
   on itf group-int-1
     Trans Id : 0x1c52e7
     Option : CLIENTID (1), Length : 14
       LLT : HwTyp=0001,T=322878930,LL=000c29c851ca
       00010001133ebdd2000c29c851ca
     Option : IA_PD (25), Length : 12
       IAID : 1
       Time1: 4294967295 seconds
       Time2: 4294967295 seconds
     Option : ELAPSED_TIME (8), Length : 2
       Time : 300 seconds
     Option : ORO (6), Length : 4
       Requested Option : DNS_NAME_SRVR (23)
     Option : SERVERID (2), Length : 10
       LL  : HwTyp=0001,LL=24b1ff000000
       0003000124b1ff000000

176 2010/07/23 15:01:20.25 IST MINOR: DEBUG #2001 Base TIP
"TIP: DHCP6_PKT
   Outgoing DHCP6 Msg : REPLY (7)
   to itf group-int-1
     Trans Id : 0x1c52e7
     Option : SERVERID (2), Length : 10
       LL  : HwTyp=0001,LL=24b1ff000000
       0003000124b1ff000000
     Option : CLIENTID (1), Length : 14
       LLT : HwTyp=0001,T=322878930,LL=000c29c851ca
       00010001133ebdd2000c29c851ca
     Option : DNS_NAME_SRVR (23), Length : 32
       Server : 2001:DB8:DDDD:1::1
       Server : 2001:DB8:DDDD:2::1
     Option : IA_PD (25), Length : 41
       IAID : 1
       Time1: 1800 seconds
       Time2: 2880 seconds
       Option : IAPREFIX (26), Length : 25
         Prefix : 2001:DB8:D001:100::/56
         Preferred Lifetime : 3600 seconds
         Valid Lifetime     : 86400 seconds
```

DHCPv6 statistics:

```
A:BNG-1# clear router dhcp6 statistics
A:BNG-1# show router dhcp6 statistics
===============================================================================
DHCP6 statistics (Router: Base)
===============================================================================
Msg-type                     Rx              Tx              Dropped
-------------------------------------------------------------------------------
1 SOLICIT                    1               0               0
2 ADVERTISE                  0               1               0
3 REQUEST                    1               0               0
4 CONFIRM                    0               0               0
5 RENEW                      0               0               0
6 REBIND                     0               0               0
7 REPLY                      0               1               0
8 RELEASE                    0               0               0
9 DECLINE                    0               0               0
10 RECONFIGURE               0               0               0
11 INFO_REQUEST              0               0               0
12 RELAY_FORW                0               0               0
13 RELAY_REPLY               0               0               0
```

Debugging

To troubleshoot a PPPoE dual stack host session, use:

- Log-id 99: Default system log and use appropriate filtering to reduce the output if needed.

```
A:BNG-1# show log log-id 99
```

- Debug PPPoE

```
A:BNG-1# show debug
 debug
    service
        id 1
            PPPoE
                packet
                    mode egr-ingr-and-dropped
                    detail-level high
                    discovery
                    ppp
                    dhcp-client
                exit
            exit
        exit
    exit
```

- Debug radius

```
A:BNG-1# show debug
  debug
    radius detail
  exit
```

- Debug dhcpv6

```
A:BNG-1# show debug
  debug
    router "Base"
        ip
            dhcp6
                mode egr-ingr-and-dropped
                detail-level high
            exit
        exit
     exit
exit
```

- DHCPv6 and PPPoE protocol statistics:

```
A:BNG-1# show router dhcp6 statistics
A:BNG-1# show service id 1 PPPoE session statistics
```

Advanced Topics

RADIUS COA

For dual stack PPPoE subscriber hosts, RADIUS-triggered mid-session change or/and session terminations identify the subscriber host to be changed by the same prefix that was originally returned from RADIUS or by the host-session-id (If RADIUS accounting host-accounting is enabled and the accounting session-id format equals number. Changing either the IPv4 or IPv6 information will result in both the v4 and v6 subscriber hosts being modified. Further elaboration on accounting is out of scope in this document.

IPv6CP Interface ID

IPv6CP negotiates, unlike ipv4-addresses in IPv4CP, only interface-ids (interface-id: The last 64 bits of an IPv6 address is the interface identifier that is unique to the 64-bit prefix of the IPv6 address and is usually derived from the link-layer or MAC address).

Dual stack PPPoE subscribers and the BNG exchange their interface-ids during this NCP phase. For ESM subscriber-interfaces on the BNG the interface-id is derived from the chassis-mac address.

- The BNG will nack the PPPoE host's IPv6CP configuration request if the dual stack PPPoE host negotiates an interface-id equal zero or an interface-id equal to the BNG interface ID. In that scenario the BNG offers in the IPv6CP nack message a suitable interface ID with following format:

Table 42: IPv6CP Nack Message Format

1	2	3	4	5	6	7	8
SAP ID				Last 2 bytes MAC host		Session ID	

- The BNG terminates the session if the dual stack PPPoE hosts nacks its IPv6CP configuration request and offers something else to the BNG.

Conclusion

This note provides configuration and troubleshooting commands for dual stack PPPoE subscribers on bridged or routed gateways. SLAAC is used as IPv6 address assignment for bridged gateways and stateful DHCPv6 prefix-delegation is used for address assignment for on routed gateways. No RG WAN IPv6 address assignment is supported in this latter model.

DNSv6 addressing on a bridged gateway is retrieved by stateless DHCPv6 (information request and reply) and it is mandatory that all IPv6 address information is retrieved through RADIUS.