Spoke Termination for IPv6-6VPE

In This Chapter

This section provides information about spoke termination for IPv6-6VPE.

Topics in this section include:

- Applicability on page 868
- Overview on page 869
- Configuration on page 872
- Conclusion on page 897

Applicability

Spoke termination for IPv6 is applicable to all of the 7750 SR family, plus 7450 ESS in mixed-mode. Chassis modes B (with mixed mode enabled), C or D need to be enabled to support IPv6 and VPNv6 address families. Spoke termination for IPv6 is supported for both IES and 6VPE services and has been tested for this note on 6VPE on 7750 SR-OS R9.0.

Overview

RFC 4659, *BGP-MPLS IP Virtual Private Network (VPN) Extension for IPv6 VPN*, standardized the use of an IPv6 over IPv4 tunneling scheme. The 7750 SR supports the standardized IPv6 over IPv4 tunneling scheme for VPRN services using Multi-Protocol Border Gateway Protocol (MP-BGP), also known as 6VPE. The 7750 SR also supports pseudowire termination by a VPRN from an Epipe Virtual Leased Line (VLL) or VPLS spoke SDP where the pseudowire can be given IPv6 addresses and run IPV6 protocols. In the example used in this section, any advertisements across the Multi-Protocol Labeled Service (MPLS) network between Virtual Private Routed Network (VPRN) Provider Edge (PE) devices will use 6VPE. The goal of this section is to list configuration guidelines for IPv6 spoke termination to a VPRN over an Epipe VLL and transporting IPv6 packets over 6VPE tunnels between PE devices.

This solution is to be used where a service provider is providing VPRN services built on a transport network whose Interior Gateway Protocol (IGP) is using IPv4 addressing on the network interfaces. The customer's CE and the service provider's PE must support IPv6 pseudowires, IPv6 interfaces and in addition, the service provider also be able to support the advertisements of IPv6 prefixes between CE-PE peerings and between the transport PE routers using MP-BGP. The advertisement of IPv6 prefixes across the MPLS network and the transport of IPv6 traffic is tunneled using 6VPE.

The VPRN PE has the ability to support spoke termination of Epipe VLL services on access with IPv6 addressing between the CE and VPRN PE. The functions of IPv6 spoke termination on VPRN services have the same functionality as VPRN IPv4 spoke termination prior to R8.0.

The example in Figure 120 illustrates a CE device that connects to a VPRN PE on an IPv6 interface addressing using spoke termination.
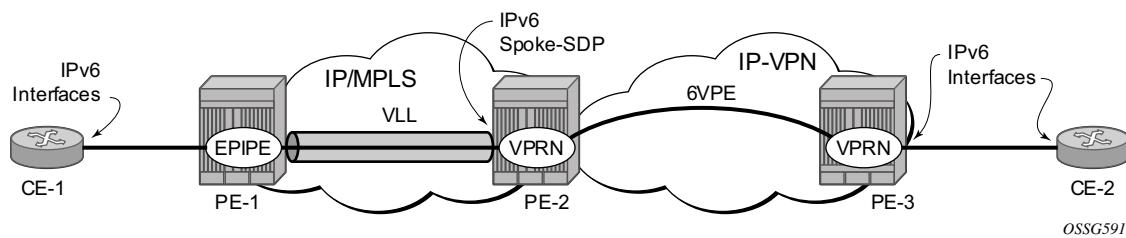
Figure 120: Spoke Termination for IPv6

CE-1 is connected to the VPRN service on PE-2, using IPv6 interfaces. CE-1 reaches PE-2 by connecting to PE-1. PE-1 uses an Epipe VLL for transport to the VPRN on the PE-2. The connectivity between PE-1's VLL service and PE-2's VPRN service is using spoke termination with IPv6 addressing on the PE-2's spoke-service distribution point (spoke SDP) interface.
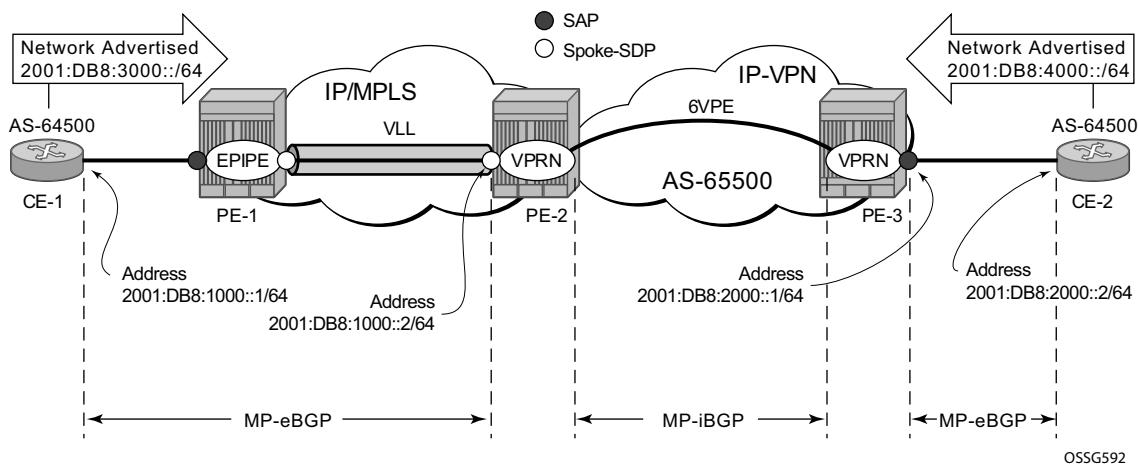

Figure 121: IPv6 Addressing and IPv6 Prefixes

Figure 121 shows the overall IPv6 addressing from interfaces to prefixes advertised from CE-1 and CE-2 across the VPRN network.

- Link between CE-1 and PE-2: 2001:DB8:1000::/64
- Link between CE-2 and PE-3: 2001:DB8:2000::/64
- Advertised Prefix from CE-1: 2001:DB8:3000::/64
- Advertised Prefix from CE-2: 2001:DB8:4000::/64

PE-2 has an MP-eBGP session with CE-1 to receive and advertise IPv6 routes. PE-2 also has an MP-iBGP peering session with PE-3 to use 6VPE to tunnel IPv6 routes and traffic to and from PE-3. PE-3 has an IPv6 SAP interface to CE-2 and uses MP-eBGP to advertise and receive routes to/from CE-2 (no spoke-termination). PE-3's configuration will also be included to provide examples of the end-to-end VPRN service using a 6VPE model.

This network topology will illustrate the use of spoke termination using IPv6 interfaces and the tunneling of IPv6 traffic over 6VPE MPLS network.

Configuration

First is to configure and establish an MPLS network where the VPRN service can use 6VPE to tunnel traffic across the IPv4 IGP.
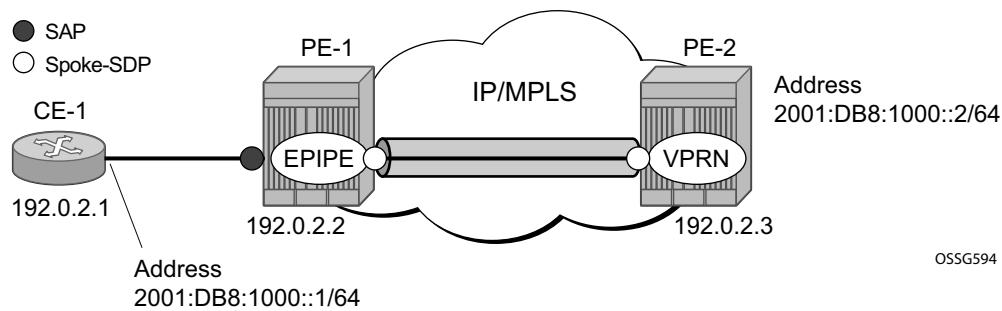
Figure 122: MP-BGP VPNv6

PE-2 and PE-3 in Figure 122 are edge routers running VPRN Services on access with IPv6 Interfaces. The MPLS network is configured using IPv4 link addressing. Interior Border Gateway Protocol (iBGP) peerings need to be established with MP-BGP for VPN-IPv6 address families between PE-2 and PE-3.

```
A:PE-2>config>router>bgp# info
        hold-time 10
        router-id 192.0.2.3
        group "iBGP_AS65500"
            description "iBGP_peerings_AS65500"
            family vpn-ipv6
            peer-as 65500
            local-address 192.0.2.3
            neighbor 192.0.2.4
                description "PE-3"
            exit
        exit


A:PE-3>config>router>bgp# info
        hold-time 10
        router-id 192.0.2.4
        group "iBGP_AS65500"
            description "iBGP_peerings_AS65500"
            family vpn-ipv6
            peer-as 65500
```

```
                    local-address 192.0.2.4
                    neighbor 192.0.2.3
                        description "PE-2"
                    exit
                exit
```

Configuring family vpn-ipv6 between VPRN PE edge routers in BGP turns on the functionality of MP-BGP for the Layer 3 VPNs supporting the customer's IPv6 Addressing (6VPE).

Verify BGP sessions for VPN-IPv6 address families between the PE-2 and PE-3.

```
A:PE-2# show router bgp neighbor 192.0.2.4

BGP Neighbor

Peer  : 192.0.2.4
Group : iBGP_AS65500

Peer AS             : 65500          Peer Port          : 49521
Peer Address        : 192.0.2.4
Local AS            : 65500          Local Port         : 179
Local Address       : 192.0.2.3
Peer Type           : Internal
State               : Established    Last State         : Established
Last Event          : recvKeepAlive
Last Error          : Cease
Local Family        : VPN-Ipv6
Remote Family       : VPN-Ipv6


A:PE-3# show router bgp neighbor 192.0.2.3

BGP Neighbor

Peer  : 192.0.2.3
Group : iBGP_AS65500

Peer AS             : 65500          Peer Port          : 179
Peer Address        : 192.0.2.3
Local AS            : 65500          Local Port         : 49521
Local Address       : 192.0.2.4
Peer Type           : Internal
State               : Established    Last State         : Active
Last Event          : recvKeepAlive
Last Error          : Cease
Local Family        : VPN-Ipv6
Remote Family       : VPN-Ipv6
```

Now that you have established MP-BGP sessions for VPN-IPv6 address-family, 6VPE tunnel support is provided between PE-2 and PE-3.
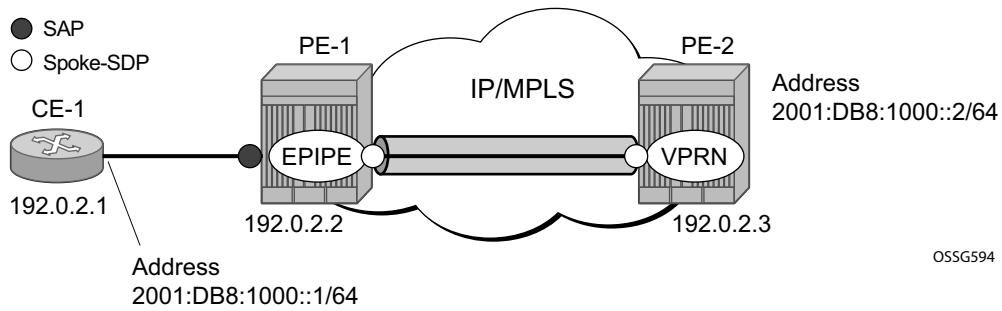
Figure 123: Spoke Termination for IPv6 Addressing

Figure 123 illustrates the model for spoke termination for IPv6 using VPRN services. CE-1 is configured with IPv6 addressing on the access interface facing the VPRN service. CE-1's access is backhauled to the VPRN service on PE-2 using Epipe VLL with spoke termination. Only Epipe VLL is supported for IPv6 spoke termination within the VPRN in R8.0. The configuration of the Epipe VLL on PE-1 is shown below:

```
A:PE-1>config>service# info
        customer 1 create
            description "Default customer"
        exit
        sdp 40 mpls create
            far-end 192.0.2.3
            ldp
            keep-alive
                shutdown
            exit
            no shutdown
        exit
        epipe 1 customer 1 create
            sap 1/1/4 create
            exit
            spoke-sdp 40:1 create
            exit
            no shutdown
        exit
```

The example above is taken from PE-1 which has been configured using the Epipe VLL service with a SAP interface facing the customer and a spoke SDP facing PE-2. The spoke SDP is terminated into the customer's VPRN service on PE-2.

PE-2 is now ready to be configured for the IPv6 spoke SDP. Review the possible IPv6 options for spoke SDP interfaces on the CLI for VPRN Services (compliant to RFC 4213, *Basic Transition Mechanisms for IPv6 Hosts and Routers <draft-ietf-v6ops-mech-v2-07.txt>)*:

- Interface spoke SDP (IPv6 options only)

```
A:PE-2>config>service>vprn$ interface <interface> create
A:PE-2>config>service>vprn>if$
 [no] ipv6           + Enables/Configures IPv6 for a VPRN interface
A:PE-2>config>service>vprn>if$ ipv6
 [no] address
 [no] dhcp6-relay
 [no] dhcp6-server
      icmp6
 [no] link-local-address
 [no] local-proxy-nd
 [no] neighbor
 [no] proxy-nd-policy
 [no] vrrp
```

- IPv6 address

```
A:PE-2>config>service>vprn>if>ipv6# address
 - address <ipv6-address/prefix-length> [eui-64] [preferred]
 - no address <ipv6-address/prefix-length>

<ipv6-address/pref*> : ipv6-address  x:x:x:x:x:x:x:x  (eight 16-bit pieces)
                                     x:x:x:x:x:x:d.d.d.d
                                     x [0..FFFF]H
                                     d [0..255]D
                       prefix-length [1..128]
<eui-64>             : keyword
<preferred>          : keyword
```

- DHCPv6 relay parameters for the VPRN service

```
A:PE-2>config>service>vprn>if>ipv6>dhcp6-relay# info detail
                    shutdown
                    no description
                    no lease-populate
                    no neighbor-resolution
                    option
                        no interface-id
                        no remote-id
                    exit
                    no source-address
                    no server
```

- DHCPv6 server parameters for the VPRN service

```
A:PE-2>config>service>vprn>if>ipv6>dhcp6-server# info detail
                    prefix-delegation
                        shutdown
                    exit
                    max-nbr-of-leases 8000
```

- ICMPv6

```
A:PE-2>config>service>vprn>if>ipv6>icmp6# info detail
packet-too-big 100 10
param-problem 100 10
redirects 100 10
time-exceeded 100 10
unreachables 100 10
```

- Link-local-addressing, for the VPRN interface. Link-local addressing by default is assigned dynamically. Use this command if you would like to add a static link-local-address.

```
A:PE-2>config>service>vprn>if>ipv6# link-local-address
 - link-local-address <ipv6-address> [preferred]
 - no link-local-address

<ipv6-address>      : ipv6-address   - x:x:x:x:x:x:x:x
                                       x:x:x:x:x:x:d.d.d.d
                                       x [0..FFFF]H
                                       d [0..255]D
<preferred>         : keyword
```

- Neighbor

* IPv6 to MAC address mapping on the VRPN Interface

```
A:PE-2>config>service>vprn>if>ipv6# neighbor
 - neighbor <ipv6-address> <mac-address>
 - no neighbor <ipv6-address>

<ipv6-address>      : x:x:x:x:x:x:x:x   (eight 16-bit pieces)
                                x:x:x:x:x:x:d.d.d.d
                                x [0..FFFF]H
                                d [0..255]D
                      prefix-length [1..128]
<mac-address>       : xx:xx:xx:xx:xx:xx or xx-xx-xx-xx-xx-xx
```

- Enabling Local Proxy Neighbor Discovery

```
A:PE-2>config>service>vprn>if>ipv6# local-proxy-nd
 - local-proxy-nd
 - no local-proxy-nd
```

- VRRP

```
A:PE-2>config>service>vprn>if>ipv6# vrrp <virtual-router-id> [owner]
                    priority 100
                    no policy
                    preempt
                    master-int-inherit
                    no ping-reply
                    no telnet-reply
                    no traceroute-reply
                    no standby-forwarding
                    no mac
                    no init-delay
```

```
                      message-interval 1
                      no shutdown
```

PE-2 configuration for the VPRN service with IPv6 interface (spoke SDP) in reference to

```
*A:PE-2>config>service>vprn# info
            router-id 192.0.2.6
            autonomous-system 65500
            route-distinguisher 65500:1
            auto-bind ldp
            vrf-target target:65500:1
            interface "loopback" create
                address 192.0.2.6/32
                loopback
            exit
            interface "Spoke_to_PE-1" create
                ipv6
                    address 2001:DB8:1000::2/64
                exit
                spoke-sdp 40:1 create
                exit
            exit
            bgp
                router-id 192.0.2.6
                group "CE-1-PE-2-spoke"
                    family ipv6
                    local-as 65500
                    peer-as 64500
                    local-address 2001:DB8:1000::2
                    neighbor 2001:DB8:1000::1
                        as-override
                        type external
                        export "PE-2-BGP-CE-1"
                    exit
                exit
            exit
            no shutdown

*A:PE-2>config>router>policy-options# info
             policy-options
                 begin
                prefix-list "PE-2-CE-1"
                    prefix 2001:DB8:4000::/64 exact
                exit
                policy-statement "PE-2-BGP-CE-1"
                    entry 10
                        from
                            prefix-list "PE-2-CE-1"
                        exit
                        action accept
                        exit
                    exit
                exit

                commit
            exit
```

In the prior configuration example, PE-2 has been configured with an IPv6 spoke SDP (spoke termination) with interface spoke_to_PE-1. The VPRN configuration has also been set up for MP-eBGP peering to CE-1 through the IPv6 spoke interface. The MP-eBGP peering will be receiving and advertising IPv6 prefixes from/to CE-1. Route policy configuration has been included to show how IPv6 routes are advertised to CE-1 from PE-2 (policy-statement PE-2-BGP-CE-1).

On PE-1, verification that the Epipe VLL is established with the SAP facing CE-1 and spoke SDP facing VPRN on PE-2 can be seen as follows:

```
A:PE-1# show service id 1 all

Service Detailed Information

Service Id        : 1                    Vpn Id          : 0
Service Type      : Epipe
Name              : (Not Specified)
Description       : (Not Specified)
Customer Id       : 1
Last Status Change: 05/17/2010 21:45:56
Last Mgmt Change  : 05/17/2010 21:38:10
Admin State       : Up                   Oper State      : Up
MTU               : 1514
Vc Switching      : False
SAP Count         : 1                    SDP Bind Count  : 1
Per Svc Hashing   : Disabled
Force Qtag Fwd    : Disabled

Service Destination Points(SDPs)

 Sdp Id 40:1  -(192.0.2.3)

Description    : (Not Specified)
SDP Id            : 40:1                 Type            : Spoke
Spoke Descr    : (Not Specified)
VC Type           : Ether                VC Tag          : n/a
Admin Path MTU    : 1514                 Oper Path MTU   : 1514
Far End           : 192.0.2.3            Delivery        : LDP
Hash Label        : Disabled

Admin State       : Up                   Oper State      : Up
Acct. Pol         : None                 Collect Stats   : Disabled
Ingress Label     : 131069               Egress Label    : 131069
Ingr Mac Fltr-Id  : n/a                  Egr Mac Fltr-Id : n/a
Ingr IP Fltr-Id   : n/a                  Egr IP Fltr-Id  : n/a
Ingr Ipv6 Fltr-Id : n/a                  Egr Ipv6 Fltr-Id : n/a
Admin ControlWord : Not Preferred        Oper ControlWord : False
Admin BW(Kbps)    : 0                    Oper BW(Kbps)   : 0
Last Status Change : 05/17/2010 21:45:56 Signaling       : TLDP
Last Mgmt Change   : 05/17/2010 21:38:10 Force Vlan-Vc   : Disabled
Endpoint          : N/A                  Precedence      : 4
Class Fwding State : Down
Flags             : None
Peer Pw Bits      : None
Peer Fault Ip     : None
Peer Vccv CV Bits : lspPing
Peer Vccv CC Bits : mplsRouterAlertLabel
Application Profile: None
```

```
KeepAlive Information :
Admin State        : Disabled           Oper State        : Disabled
Hello Time         : 10                 Hello Msg Len     : 0
Max Drop Count     : 3                  Hold Down Time    : 10

Statistics         :
I. Fwd. Pkts.      : 231915             I. Dro. Pkts.     : 0
I. Fwd. Octs.      : 21994828           I. Dro. Octs.     : 0
E. Fwd. Pkts.      : 231914             E. Fwd. Octets    : 21992191
.
...
.
SAP 1/1/4

Service Id         : 1
SAP                : 1/1/4              Encap             : null
Description        : (Not Specified)
Admin State        : Up                 Oper State        : Up
Flags              : None
Multi Svc Site     : None
Last Status Change : 05/17/2010 21:37:57
Last Mgmt Change   : 05/17/2010 21:07:20
Sub Type           : regular
Dot1Q Ethertype    : 0x8100             QinQ Ethertype    : 0x8100
Split Horizon Group: (Not Specified)

LLF Admin State    : Down               LLF Oper State    : Clear
Admin MTU          : 9212               Oper MTU          : 9212
Ingr IP Fltr-Id    : n/a                Egr IP Fltr-Id    : n/a
Ingr Mac Fltr-Id   : n/a                Egr Mac Fltr-Id   : n/a
Ingr Ipv6 Fltr-Id  : n/a                Egr Ipv6 Fltr-Id  : n/a
tod-suite          : None               qinq-pbit-marking : both
Ing Agg Rate Limit : max                Egr Agg Rate Limit: max
Endpoint           : N/A
Q Frame-Based Acct : Disabled
Vlan-translation   : None

Acct. Pol          : None               Collect Stats     : Disabled
Application Profile: None

Sap Statistics

Last Cleared Time     : N/A

                        Packets               Octets
Forwarding Engine Stats
Dropped              : 0                      0
Off. HiPrio          : 0                      0
Off. LowPrio         : 231919                 22920335
Off. Uncolor         : 0                      0

Queueing Stats(Ingress QoS Policy 1)
Dro. HiPrio          : 0                      0
Dro. LowPrio         : 0                      0
For. InProf          : 0                      0
For. OutProf         : 231919                 22920335

Queueing Stats(Egress QoS Policy 1)
```

```
Dro. InProf          : 0                      0
Dro. OutProf         : 0                      0
For. InProf          : 231920                 22922995
For. OutProf         : 0                      0
```

Now, proceed to verify that the spoke termination on PE-2 in the VPRN using IPv6 addressing is established in an up/up state:

```
A:PE-2# show service id 1 all
Service Detailed Information

Service Id        : 1                 Vpn Id            : 0
Service Type      : VPRN
Name              : (Not Specified)
Description       : (Not Specified)
Customer Id       : 1
Last Status Change: 05/17/2010 21:42:52
Last Mgmt Change  : 05/17/2010 21:45:59
Admin State       : Up                Oper State        : Up

Route Dist.       : 65500:1           VPRN Type         : regular
AS Number         : 65500             Router Id         : 192.0.2.6
ECMP              : Enabled           ECMP Max Routes   : 1
Max Ipv4 Routes   : No Limit          Auto Bind         : LDP
Max Ipv6 Routes   : No Limit
Ignore NH Metric  : Disabled
Hash Label        : Disabled
Vrf Target        : target:65500:1
Vrf Import        : None
Vrf Export        : None
MVPN Vrf Target   : None
MVPN Vrf Import   : None
MVPN Vrf Export   : None

SAP Count         : 0                 SDP Bind Count    : 1

Service Destination Points(SDPs)

 Sdp Id 40:1  -(192.0.2.2)

Description     : (Not Specified)
SDP Id            : 40:1              Type              : Spoke
Spoke Descr     : (Not Specified)
VC Type           : n/a               VC Tag            : n/a
Admin Path MTU    : 1514              Oper Path MTU     : 1514
Far End           : 192.0.2.2         Delivery          : LDP

Admin State       : Up                Oper State        : Up
Acct. Pol         : None              Collect Stats     : Disabled
Ingress Label     : 131069            Egress Label      : 131069
Ingr Mac Fltr-Id  : n/a               Egr Mac Fltr-Id   : n/a
Ingr IP Fltr-Id   : n/a               Egr IP Fltr-Id    : n/a
Ingr Ipv6 Fltr-Id : n/a               Egr Ipv6 Fltr-Id  : n/a
Admin ControlWord : Not Preferred     Oper ControlWord  : False
Last Status Change : 05/17/2010 21:45:59    Signaling         : n/a
Last Mgmt Change  : 05/17/2010 21:45:59
```

```
Class Fwding State : Down
Flags               : None
Peer Pw Bits        : None
Peer Fault Ip       : None
Peer Vccv CV Bits   : lspPing
Peer Vccv CC Bits   : mplsRouterAlertLabel
Application Profile: None

KeepAlive Information :
Admin State         : Disabled           Oper State          : Disabled
Hello Time          : 10                 Hello Msg Len       : 0
Max Drop Count      : 3                  Hold Down Time      : 10

Statistics          :
I. Fwd. Pkts.       : 0                  I. Dro. Pkts.       : 0
I. Fwd. Octs.       : 0                  I. Dro. Octs.       : 0
E. Fwd. Pkts.       : 232421             E. Fwd. Octets      : 22042904

Number of SDPs : 1

Service Access Points

No Sap Associations

Service Interfaces

Interface

If Name             : loopback
Admin State         : Up                 Oper (v4/v6)        : Up/Down
Protocols           : None
IP Addr/mask        : 192.0.2.6/32       Address Type        : Primary
IGP Inhibit         : Disabled           Broadcast Address : Host-ones
Description         : N/A

Details

Description         : (Not Specified)
If Index            : 2                  Virt. If Index      : 2
Last Oper Chg       : 05/17/2010 21:48:08 Global If Index    : 384
Port Id             : loopback
TOS Marking         : Trusted            If Type             : VPRN
SNTP B.Cast         : False
MAC Address         : 68:64:ff:00:00:00  Arp Timeout         : 14400
IP Oper MTU         : 1500               ICMP Mask Reply   : True
Arp Populate        : Disabled           Host Conn Verify  : Disabled
Cflowd              : None
LdpSyncTimer        : None
LSR Load Balance    : system
uRPF Chk            : disabled
uRPF Fail Bytes     : 0                  uRPF Chk Fail Pkts: 0

Proxy ARP Details
Rem Proxy ARP       : Disabled           Local Proxy ARP   : Disabled
Policies            : none

Proxy Neighbor Discovery Details
Local Pxy ND        : Disabled
Policies            : none
```

7750 SR Advanced Configuration Guide   **Page 881**

```
DHCP no local server

DHCP Details
Description  : (Not Specified)
Admin State      : Down            Lease Populate   : 0
Gi-Addr          : 192.0.2.6*      Gi-Addr as Src Ip : Disabled
* = inferred gi-address from interface IP address


Action           : Keep           Trusted          : Disabled

DHCP Proxy Details
Admin State      : Down
Lease Time       : N/A
Emul. Server     : Not configured

Subscriber Authentication Details
Auth Policy      : None

DHCP6 Relay Details
Description      : (Not Specified)
Admin State      : Down            Lease Populate   : 0
Oper State       : Down            Nbr Resolution   : Disabled
If-Id Option     : None            Remote Id        : Disabled
Src Addr         : Not configured

DHCP6 Server Details
Admin State      : Down            Max. Lease States : 8000

ICMP Details
Redirects   : Number - 100               Time (seconds)   - 10
Unreachables : Number - 100              Time (seconds)   - 10
TTL Expired : Number - 100               Time (seconds)   - 10

IPCP Address Extension Details
Peer IP Addr      : Not configured
Peer Pri DNS Addr : Not configured
Peer Sec DNS Addr : Not configured

Interface

If Name           : Spoke_to_PE-1
Admin State       : Up              Oper (v4/v6)     : Down/Up
Protocols         : None
Ipv6 Addr    : 2001:DB8:1000::2/64                        PREFERRED
Ipv6 Addr    : FE80::6A64:FFFF:FE00:0/64                  PREFERRED
Description       : N/A

Details

Description       : (Not Specified)
If Index          : 3               Virt. If Index   : 3
Last Oper Chg     : 05/17/2010 21:42:42 Global If Index  : 383
SDP Id            : spoke-40:1

Spoke-SDP Details
Admin State       : Up              Oper State       : Up
Hash Label        : Disabled
Peer Fault Ip     : None
```

```
Peer Pw Bits      : None
Peer Vccv CV Bits : lspPing
Peer Vccv CC Bits : mplsRouterAlertLabel
Flags             : None


TOS Marking       : Trusted           If Type           : VPRN
SNTP B.Cast       : False
MAC Address       : 68:64:ff:00:00:00 Arp Timeout       : 14400
IP Oper MTU       : 1500              ICMP Mask Reply   : True
Arp Populate      : Disabled          Host Conn Verify  : Disabled
Cflowd            : None
LdpSyncTimer      : None
LSR Load Balance  : system
uRPF Chk          : disabled
uRPF Fail Bytes   : 0                 uRPF Chk Fail Pkts: 0

Proxy ARP Details
Rem Proxy ARP     : Disabled          Local Proxy ARP   : Disabled
Policies          : none

Proxy Neighbor Discovery Details
Local Pxy ND      : Disabled
Policies          : none

DHCP no local server

DHCP Details
Description  : (Not Specified)
Admin State       : Down              Lease Populate    : 0
Gi-Addr           : Not configured    Gi-Addr as Src Ip : Disabled
Action            : Keep              Trusted           : Disabled

DHCP Proxy Details
Admin State       : Down
Lease Time        : N/A
Emul. Server      : Not configured

Subscriber Authentication Details
Auth Policy       : None

DHCP6 Relay Details
Description       : (Not Specified)
Admin State       : Down              Lease Populate    : 0
Oper State        : Down              Nbr Resolution    : Disabled
If-Id Option      : None              Remote Id         : Disabled
Src Addr          : Not configured

DHCP6 Server Details
Admin State       : Down              Max. Lease States : 8000

ICMP Details
Redirects   : Number - 100                Time (seconds)   - 10
Unreachables : Number -100                Time (seconds)   - 10
TTL Expired : Number -100                 Time (seconds)   - 10

IPCP Address Extension Details
Peer IP Addr      : Not configured
Peer Pri DNS Addr : Not configured
Peer Sec DNS Addr : Not configured
```

```
      VPLS Sites

      Site              Site-Id   Dest              Mesh-SDP   Admin   Oper   Fwdr

      No Matching Entries
```

It is important to note the following from PE-2 **show service** output above:

- VPRN service is in an admin/oper up/up state
- Spoke SDP is established to PE-1 (192.0.2.2) admin/oper up/up (IPv6) state.
    - → IPv6 interface is established and its IPv6 address is preferred (2001:DB8:1000::2/64)
    - → IPv6 link local address has been dynamically assigned and preferred (FE80::6A64:FFFF:FE00:0/64).
    - → This output also lists other IPv6 fields that can be checked if configured: DHCP6-relay, DHCP6 server, etc.

After verification of the services (Epipe, VPRN), verify MP-eBGP peering connectivity (through IPv6 interfaces) on the VPRN between PE-2 and CE-1.

```
A:PE-2# show router 1 bgp neighbor

BGP Neighbor

Peer  : 2001:DB8:1000::1
Group : CE-1-PE-2-spoke

Peer AS            : 64500           Peer Port          : 179
Peer Address       : 2001:DB8:1000::1
Local AS           : 65500           Local Port         : 49723
Local Address      : 2001:DB8:1000::2
Peer Type          : External
State              : Established     Last State         : Active
Last Event         : recvKeepAlive
Last Error         : Unrecognized Error
Local Family       : Ipv6
Remote Family      : Ipv6
Hold Time          : 90              Keep Alive         : 30
Active Hold Time   : 10              Active Keep Alive  : 3
Cluster Id         : None
Preference         : 170             Num of Update Flaps : 0
Recd. Paths        : 1
Ipv4 Recd. Prefixes  : 0             Ipv4 Active Prefixes : 0
Ipv4 Suppressed Pfxs : 0             VPN-Ipv4 Suppr. Pfxs : 0
VPN-Ipv4 Recd. Pfxs  : 0             VPN-Ipv4 Active Pfxs : 0
Mc Ipv4 Recd. Pfxs.  : 0             Mc Ipv4 Active Pfxs. : 0
Mc Ipv4 Suppr. Pfxs  : 0             Ipv6 Suppressed Pfxs : 0
Ipv6 Recd. Prefixes  : 1             Ipv6 Active Prefixes : 1
VPN-Ipv6 Recd. Pfxs  : 0             VPN-Ipv6 Active Pfxs : 0
VPN-Ipv6 Suppr. Pfxs : 0             L2-VPN Suppr. Pfxs   : 0
L2-VPN Recd. Pfxs    : 0             L2-VPN Active Pfxs   : 0
MVPN-Ipv4 Suppr. Pfxs: 0             MVPN-Ipv4 Recd. Pfxs : 0
```
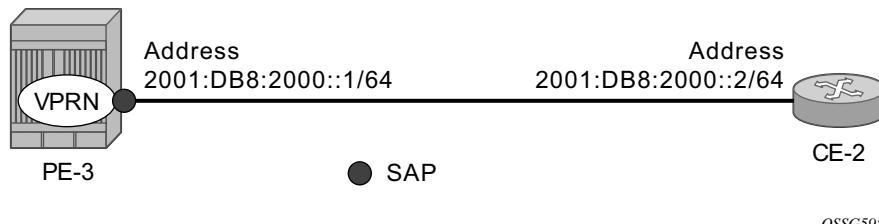
```
MVPN-Ipv4 Active Pfxs: 0              MDT-SAFI Suppr. Pfxs : 0
MDT-SAFI Recd. Pfxs  : 0              MDT-SAFI Active Pfxs : 0
Input Queue          : 0             Output Queue         : 0
i/p Messages         : 109157        o/p Messages         : 109704
i/p Octets           : 2074060       o/p Octets           : 2084468
i/p Updates          : 1             o/p Updates          : 1
TTL Security         : Disabled      Min TTL Value        : n/a
Graceful Restart     : Disabled      Stale Routes Time    : n/a
Advertise Inactive   : Disabled      Peer Tracking        : Disabled
Advertise Label      : None
Auth key chain       : n/a
Bfd Enabled          : Disabled
Local Capability     : RtRefresh MPBGP 4byte ASN
Remote Capability    : RtRefresh MPBGP 4byte ASN
Import Policy        : None Specified / Inherited
Export Policy        : PE-2-BGP-CE-1

Neighbors : 1
```

It is important to note that not only is the MP-eBGP session on the VPRN established but that the MP-BGP capabilities are supported (locally and remotely).

Finally, the following configuration is an example of the VPRN service on PE-3 with SAP interfaces to CE-2, with MP-eBGP peering configured.


Figure 124: PE-3 VPRN with SAP to CE-2

```
A:PE-3>config>service>vprn# info
        router-id 192.0.2.7
        autonomous-system 65500
        route-distinguisher 65500:1
        auto-bind ldp
        vrf-target target:65500:1
        interface "loopback" create
            address 192.0.2.7/32
            loopback
        exit
        interface "int-PE-3-CE-2" create
            ipv6
                address 2001:DB8:2000::1/64
            exit
            sap 1/1/2 create
            exit
        exit
        bgp
            router-id 192.0.2.7
            group "CE-2-PE-3"
                family ipv6
                local-as 65500
                peer-as 64500
                local-address 2001:DB8:2000::1
                neighbor 2001:DB8:2000::2
                    as-override
                    type external
                    export "PE-3-BGP-CE-2"
                exit
            exit
        exit
        no shutdown

A:PE3>config>router>policy-options# info
    policy-options
        begin
        prefix-list "PE-3-CE-2"
            prefix 2001:DB8:3000::/64 exact
        exit
        policy-statement "PE-3-BGP-CE-2"
            entry 10
                from
                    prefix-list "PE-3-CE-2"
                exit
                action accept
                exit
            exit
        exit
        commit
    exit
```

The IPv6 configuration options for the SAP interface (int-PE-3-CE-2) are similar to those in the above example for the spoke SDP on PE-2. PE-3 BGP export policy (PE-3-BGP-CE-2) is also similar to the example for PE-2 in advertising the learned IPv6 route to CE-2.

Verification of the configuration of the VPRN service and MP-eBGP peering connectivity to CE-2 is shown below:

```
A:PE-3# show service id 1 all

Service Detailed Information

Service Id        : 1                    Vpn Id            : 0
Service Type      : VPRN
Name              : (Not Specified)
Description       : (Not Specified)
Customer Id       : 1
Last Status Change: 05/19/2010 14:10:48
Last Mgmt Change  : 05/19/2010 14:10:48
Admin State       : Up                   Oper State        : Up

Route Dist.       : 65500:1              VPRN Type         : regular
AS Number         : 65500                Router Id         : 192.0.2.7
ECMP              : Enabled              ECMP Max Routes   : 1
Max Ipv4 Routes   : No Limit             Auto Bind         : LDP
Max Ipv6 Routes   : No Limit
Ignore NH Metric  : Disabled
Hash Label        : Disabled
Vrf Target        : target:65500:1
Vrf Import        : None
Vrf Export        : None
MVPN Vrf Target   : None
MVPN Vrf Import   : None
MVPN Vrf Export   : None

SAP Count         : 1                    SDP Bind Count    : 0

Service Destination Points(SDPs)

No Matching Entries

Service Access Points

SAP 1/1/2

Service Id          : 1
SAP                 : 1/1/2              Encap             : null
Description         : (Not Specified)
Admin State         : Up                 Oper State        : Up
Flags               : None
Multi Svc Site      : None
Last Status Change  : 05/19/2010 11:20:22
Last Mgmt Change    : 05/19/2010 14:16:54
Sub Type            : regular
Dot1Q Ethertype     : 0x8100             QinQ Ethertype    : 0x8100
Split Horizon Group : (Not Specified)

Admin MTU           : 9212               Oper MTU          : 9212
Ingr IP Fltr-Id     : n/a                Egr IP Fltr-Id    : n/a
Ingr Mac Fltr-Id    : n/a                Egr Mac Fltr-Id   : n/a
Ingr Ipv6 Fltr-Id   : n/a                Egr Ipv6 Fltr-Id  : n/a
tod-suite           : None               qinq-pbit-marking : both
Ing Agg Rate Limit  : max                Egr Agg Rate Limit: max
```

```
             Q Frame-Based Acct : Disabled

             Acct. Pol        : None                  Collect Stats    : Disabled

             Anti Spoofing     : None                  Avl Static Hosts : 0
                                                       Tot Static Hosts : 0
             Calling-Station-Id : n/a
             Application Profile: None

             Sap Statistics

             Last Cleared Time    : N/A


                               Packets                 Octets
             Forwarding Engine Stats
             Dropped           : 0                      0
             Off. HiPrio       : 0                      0
             Off. LowPrio      : 0                      0
             Off. Uncolor      : 0                      0

             Queueing Stats(Ingress QoS Policy 1)
             Dro. HiPrio       : 0                      0
             Dro. LowPrio      : 0                      0
             For. InProf       : 0                      0
             For. OutProf      : 0                      0

             Queueing Stats(Egress QoS Policy 1)
             Dro. InProf       : 0                      0
             Dro. OutProf      : 0                      0
             For. InProf       : 141983                 14042605
             For. OutProf      : 0                      0

             Service Interfaces

             Interface

             If Name          : loopback
             Admin State      : Up                 Oper (v4/v6)      : Up/Down
             Protocols        : None
             IP Addr/mask     : 192.0.2.7/32       Address Type      : Primary
             IGP Inhibit      : Disabled           Broadcast Address : Host-ones
             Description      : N/A

             Details

             Description      : (Not Specified)
             If Index         : 2                  Virt. If Index    : 2
             Last Oper Chg    : 05/19/2010 14:12:24 Global If Index   : 384
             Port Id          : loopback
             TOS Marking      : Trusted            If Type           : VPRN
             SNTP B.Cast      : False
             MAC Address      : 68:67:ff:00:00:00  Arp Timeout       : 14400
             IP Oper MTU      : 1500               ICMP Mask Reply   : True
             Arp Populate     : Disabled           Host Conn Verify  : Disabled
             Cflowd           : None
             LdpSyncTimer     : None
             LSR Load Balance : system
             uRPF Chk         : disabled
             uRPF Fail Bytes  : 0                  uRPF Chk Fail Pkts: 0
```

```
Proxy ARP Details
Rem Proxy ARP    : Disabled          Local Proxy ARP  : Disabled
Policies         : none

Proxy Neighbor Discovery Details
Local Pxy ND     : Disabled
Policies         : none

DHCP no local server

DHCP Details
Description  : (Not Specified)
Admin State      : Down              Lease Populate   : 0
Gi-Addr          : 192.0.2.7*        Gi-Addr as Src Ip : Disabled
* = inferred gi-address from interface IP address

Action           : Keep             Trusted          : Disabled

DHCP Proxy Details
Admin State      : Down
Lease Time       : N/A
Emul. Server     : Not configured

Subscriber Authentication Details
Auth Policy      : None

DHCP6 Relay Details
Description      : (Not Specified)
Admin State      : Down              Lease Populate   : 0
Oper State       : Down              Nbr Resolution   : Disabled
If-Id Option     : None              Remote Id        : Disabled
Src Addr         : Not configured

DHCP6 Server Details
Admin State      : Down              Max. Lease States : 8000

ICMP Details
Redirects    : Number -100                Time (seconds)   - 10
Unreachables : Number -100                Time (seconds)   - 10
TTL Expired  : Number -100                Time (seconds)   - 10

IPCP Address Extension Details
Peer IP Addr     : Not configured
Peer Pri DNS Addr : Not configured
Peer Sec DNS Addr : Not configured

Interface

If Name          : int-PE-3-CE-2
Admin State      : Up                Oper (v4/v6)     : Down/Up
Protocols        : None
Ipv6 Addr   : 2001:DB8:2000::1/64                         PREFERRED
Ipv6 Addr   : FE80::6A67:FFFF:FE00:0/64                   PREFERRED
Description      : N/A

Details

Description      : (Not Specified)
```

```
If Index         : 3                 Virt. If Index   : 3
Last Oper Chg    : 05/19/2010 14:13:01 Global If Index  : 383
SAP Id           : 1/1/2
TOS Marking      : Trusted           If Type          : VPRN
SNTP B.Cast      : False
MAC Address      : 68:67:01:01:00:02 Arp Timeout      : 14400
IP Oper MTU      : 9198              ICMP Mask Reply  : True
Arp Populate     : Disabled          Host Conn Verify : Disabled
Cflowd           : None
LdpSyncTimer     : None
LSR Load Balance : system
uRPF Chk         : disabled
uRPF Fail Bytes  : 0                 uRPF Chk Fail Pkts: 0

Proxy ARP Details
Rem Proxy ARP    : Disabled          Local Proxy ARP  : Disabled
Policies         : none

Proxy Neighbor Discovery Details
Local Pxy ND     : Disabled
Policies         : none

DHCP no local server

DHCP Details
Description  : (Not Specified)
Admin State      : Down              Lease Populate   : 0
Gi-Addr          : Not configured    Gi-Addr as Src Ip : Disabled
Action           : Keep              Trusted          : Disabled

DHCP Proxy Details
Admin State      : Down
Lease Time       : N/A
Emul. Server     : Not configured

Subscriber Authentication Details
Auth Policy      : None

DHCP6 Relay Details
Description      : (Not Specified)
Admin State      : Down              Lease Populate   : 0
Oper State       : Down              Nbr Resolution   : Disabled
If-Id Option     : None              Remote Id        : Disabled
Src Addr         : Not configured

DHCP6 Server Details
Admin State      : Down              Max. Lease States : 8000

ICMP Details
Redirects   : Number -100                    Time (seconds)  - 10
Unreachables : Number -100                    Time (seconds)  - 10
TTL Expired : Number -100                    Time (seconds)  - 10

IPCP Address Extension Details
Peer IP Addr     : Not configured
Peer Pri DNS Addr : Not configured
Peer Sec DNS Addr : Not configured
```

At this point, VPRN access using spoke termination for IPv6 with MP-eBGP peering on PE-2, towards CE-1, has been established. VPRN access using a SAP with MP-eBGP peering on PE-3, towards CE-1, has also been established. MP-iBGP, providing 6VPE, has been configured and built between PE-2 and PE-3 across the MPLS Network. Now, propagate the advertisements of the IPv6 prefixes learned on PE-2 from CE-1 (2001:DB8:3000::/64) and on PE-3 from CE-2 (2001:DB8:4000::/64) across the MPLS network using MP-iBGP (6VPE).

Perform verification on PE-2 of routes learned and advertised to CE-1.

```
A:PE-2# show router bgp summary
BGP Router ID:192.0.2.3      AS:65500      Local AS:65500

BGP Admin State         : Up           BGP Oper State            : Up
Total Peer Groups       : 1            Total Peers               : 1
Total BGP Paths         : 6            Total Path Memory         : 752
Total Ipv4 Remote Rts   : 0            Total Ipv4 Rem. Active Rts : 0
Total Ipv6 Remote Rts   : 0            Total Ipv6 Rem. Active Rts : 0
Total Supressed Rts     : 0            Total Hist. Rts           : 0
Total Decay Rts         : 0

Total VPN Peer Groups   : 1            Total VPN Peers           : 1
Total VPN Local Rts     : 1
Total VPN-Ipv4 Rem. Rts : 0            Total VPN-Ipv4 Rem. Act. Rts: 0
Total VPN-Ipv6 Rem. Rts : 1            Total VPN-Ipv6 Rem. Act. Rts: 1
Total L2-VPN Rem. Rts   : 0            Total L2VPN Rem. Act. Rts : 0
Total VPN Supp. Rts     : 0            Total VPN Hist. Rts       : 0
Total VPN Decay Rts     : 0
Total MVPN-Ipv4 Rem Rts : 0            Total MVPN-Ipv4 Rem Act Rts : 0
Total MDT-SAFI Rem Rts  : 0            Total MDT-SAFI Rem Act Rts : 0

BGP Summary

Neighbor
                AS PktRcvd InQ  Up/Down   State|Rcv/Act/Sent (Addr Family)
                   PktSent OutQ

192.0.2.4
            65500   72529    0 01d23h54m 1/1/1 (VpnIPv6)
                    72550    0
```

The above output shows the BGP Neighbor of CE-1 (192.0.2.4) and that PE-2 has received and learned an IPv6 prefix.

```
A:PE-2# show router 1 bgp routes ipv6
 BGP Router ID:192.0.2.6        AS:65500        Local AS:65500

 Legend
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : I - IGP, e - EGP, ? - incomplete, > - best

BGP Ipv6 Routes

Flag  Network                                        LocalPref   MED
      Nexthop                                                    VPNLabel
```

```
        As-Path

u*>?  2001:DB8:3000::/64                                  None        None
        2001:DB8:1000::1                                               -
        64500

Routes : 1
```

The output above of the VPRN's BGP route-table for the IPv6 address-family lists the valid and best route for 2001:DB8:3000::/64 with a BGP next hop of 2001:DB8:1000::1 (CE-1).

```
A:PE-2# show router 1 bgp neighbor 2001:DB8:1000::1 advertised-routes ipv6

 BGP Router ID:192.0.2.6        AS:65500        Local AS:65500

 Legend
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : I - IGP, e - EGP, ? - incomplete, > - best

BGP Ipv6 Routes

Flag  Network                                        LocalPref   MED
      Nexthop                                                    VPNLabel
      As-Path

?     2001:DB8:4000::/64                             n/a         None
      2001:DB8:1000::2                                           -
      65500 65500

Routes : 1
```

The above output taken from PE-2 shows the advertised IPv6 prefix of 2001:DB8:4000::/64, originated and advertised from CE-2 to PE-3.

```
A:PE-2# show router bgp routes vpn-ipv6
 BGP Router ID:192.0.2.3        AS:65500        Local AS:65500

 Legend
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : I - IGP, e - EGP, ? - incomplete, > - best

BGP VPN-Ipv6 Routes

Flag  Network                                        LocalPref   MED
      Nexthop                                                    VPNLabel
      As-Path

u*>?  65500:1:2001:DB8:4000::/64                      100         None
      ::FFFF:C000:204                                             131068
      64500

Routes : 1
```

PE-2 in the previous output has learned of prefix 2001:DB8:4000::/64 as an MP-BGP VPN-IPv6 route, with the VRF route-target of 65500:1 from PE-3.

In the output below PE-2 is advertising the VPN-IPv6 route of 2001:DB8:3000::/64 that was learned from CE-1 across the MP-iBGP Session to PE-3.

```
A:PE-2# show router bgp neighbor 192.0.2.4 advertised-routes vpn-ipv6
BGP Router ID:192.0.2.3        AS:65500       Local AS:65500

Legend
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : I - IGP, e - EGP, ? - incomplete, > - best

BGP VPN-Ipv6 Routes

Flag   Network                                          LocalPref   MED
       Nexthop                                                      VPNLabel
       As-Path

?      65500:1:2001:DB8:3000::/64                        100        None
       ::FFFF:C000:203                                              131068
       64500

Routes : 1
```

Verify VPN-IPv6 routes on PE-3.

```
A:PE-3# show router bgp routes vpn-ipv6
BGP Router ID:192.0.2.4        AS:65500        Local AS:65500

Legend
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : I - IGP, e - EGP, ? - incomplete, > - best

BGP VPN-Ipv6 Routes

Flag  Network                                         LocalPref   MED
      Nexthop                                                     VPNLabel
      As-Path

u*>?  65500:1:2001:DB8:3000::/64                      100         None
      ::FFFF:C000:203                                             131068
      64500

Routes : 1
```

The output above, taken from PE-3, lists the VPN-IPv6 route that is being learned from PE-2, namely 2001:DB8:3000::/64.

The output show below lists the advertised VPN-IPv6 route of 2001:DB8:4000::/64 from PE-3 to PE-2.

```
A:PE-3# show router bgp neighbor 192.0.2.3 advertised-routes vpn-ipv6
 BGP Router ID:192.0.2.4        AS:65500        Local AS:65500
Legend
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : I - IGP, e - EGP, ? - incomplete, > - best

BGP VPN-Ipv6 Routes

Flag  Network                                         LocalPref   MED
      Nexthop                                                     VPNLabel
      As-Path

?     65500:1:2001:DB8:4000::/64                      100         None
      ::FFFF:C000:204                                             131068
      64500

Routes : 1
```

Verify IPv6 prefixes learned and advertised between PE-3 and CE-2.

```
A:PE-3# show router 1 bgp routes ipv6
 BGP Router ID:192.0.2.7        AS:65500        Local AS:65500

Legend
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : I - IGP, e - EGP, ? - incomplete, > - best
```

```
BGP Ipv6 Routes

Flag  Network                                         LocalPref   MED
      Nexthop                                                     VPNLabel
      As-Path

u*> 2001:DB8:4000::/64                                None        None
      2001:DB8:2000::2                                            -
      64500

Routes : 1
```

From the PE-3 output above shows the IPv6 prefix of 2001:DB8:4000::/64 learned from CE-2.

The output below verifies the advertisement of IPv6 prefix 2001:DB8:3000::/64 to CE-2.

```
A:PE-3# show router 1 bgp neighbor 2001:DB8:2000::2 advertised-routes ipv6
 BGP Router ID:192.0.2.7      AS:65500      Local AS:65500

Legend
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : I - IGP, e - EGP, ? - incomplete, > - best

BGP Ipv6 Routes

Flag  Network                                         LocalPref   MED
      Nexthop                                                     VPNLabel
      As-Path

?     2001:DB8:3000::/64                              n/a         None
      2001:DB8:2000::1                                            -
      65500 65500

Routes : 1
```

Perform the final verification of CE-1 and CE-2 showing that IPv6 routes for AS-64500 have been received and are valid across the VPRN service.

```
A:CE-1# show router bgp routes ipv6
 BGP Router ID:192.0.2.1      AS:64500      Local AS:64500

Legend
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : I - IGP, e - EGP, ? - incomplete, > - best

BGP Ipv6 Routes

Flag  Network                                         LocalPref   MED
      Nexthop                                                     VPNLabel
      As-Path

u*>? 2001:DB8:4000::/64                               None        None
      2001:DB8:1000::2                                            -
      65500 65500
```

```
        Routes : 1


        A:CE-2# show router bgp routes ipv6
        BGP Router ID:192.0.2.5        AS:64500        Local AS:64500

         Legend
         Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
         Origin codes  : I - IGP, e - EGP, ? - incomplete, > - best

        BGP Ipv6 Routes

        Flag  Network                                        LocalPref  MED
              Nexthop                                                   VPNLabel
              As-Path

        u*>?  2001:DB8:3000::/64                             None       None
              2001:DB8:2000::1                                          -
              65500 65500

        Routes : 1
```

Conclusion

Spoke termination for IPv6-6VPE extends the use of spoke terminated interfaces from an EPIPE VLL into a VPRN service using IPv6 interfaces on the access. Supporting the requirement of IPv6 interfaces, routing of IPv6 prefixes and the use of 6VPE for IPv6 tunnelling over an IPv4 network allows the 7750 SR to provide capabilities to support the growth of IPv6 architectures. This chapter provides examples of this feature with **show** commands for guidance.