Source Redundancy in a Multicast VPN

In This Chapter

This section provides information about MVPN source redundancy.

Topics in this section include:

Applicability

This example is applicable to the 7750 SR-7/12, 7750 SR-c4/c12 and 7950 XRS. It can be configured on any supported IOM (IOM2 or IOM3-XP) or IMM type. It is also applicable to the 7450 ESS-7/12 with IOM3-XP or IMM. Chassis mode C or D is required for MPLS provider tunnels using multicast LDP or point to multi-point RSVP-TE Label Switched Paths.

The configuration was tested on release 12.0.R1, using multicast LDP as the provider tunnel signaling mechanism, for IPv4 multi-casting. The customer multicast signaling protocol within the VPN must be BGP.

Summary

Multicast source redundancy allows operators to provide multiple geo-redundant sources for the same multicast group in a multicast Virtual Private Network (MVPN). For instance, in an IPTV environment where a TV channel maps to a multicast group, the same TV channel can be provided from sources in a geographically diverse manner where a national broadcaster can have multiple sources from two or more regional distribution centers.

Knowledge of Multi-Protocol BGP (MP-BGP) and RFC 4364, *BGP/MPLS IP Virtual Private Networks (VPNs)*, is assumed throughout this example, as well as Protocol Independent Multicast (PIM), RFC 6513, *Multicast in MPLS/BGP IP VPNs*, and RFC 6514, *BGP Encodings and Procedures for Multicast in MPLS/BGP IP VPNs*.

Overview

Hosts connected to receiver PEs can receive TV channels from a specific source, with a regional backup source available in case of a failure.
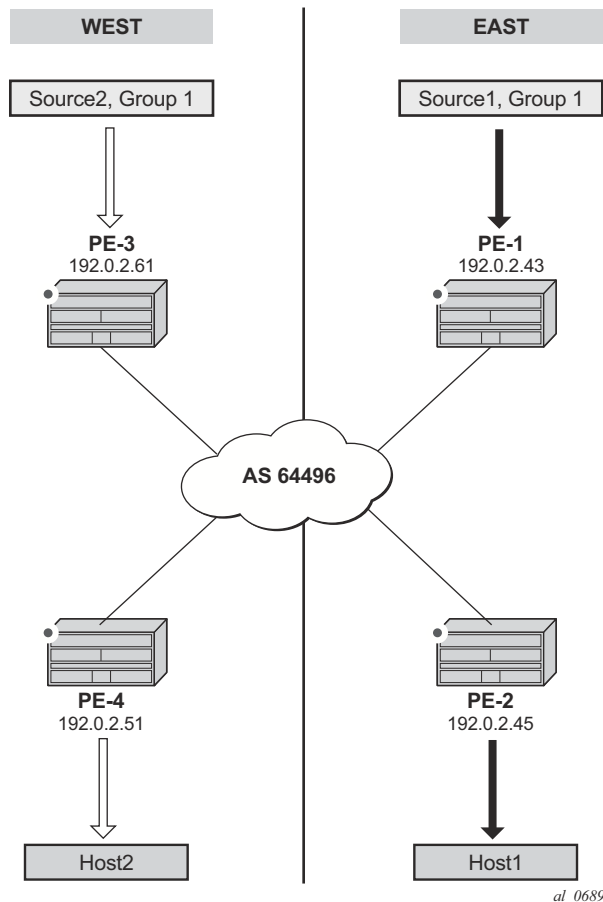
Figure 118: Source Redundancy Example.

Figure 118 shows the concept of source redundancy. PE-1 and PE-3 have directly connected multicast sources. For clarity, consider a single multicast group with two separate sources connected at different sites. The content of each group is identical at a given time (allowing for transmission delay), as is expected for an IPTV channel. PE-1 and PE-3 are referred to as sender PEs as they are closer to the source; PE2 and PE4 are referred to as receiver PEs as they are closer to hosts 1 and 2.

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A multicast group, group 1 (G1) has two sources: Source 1 (S1) in the east region and Source (S2) in the west region which are connected to PE-1 and PE-3 respectively. Receivers connected to PE-2 in the east region will join group (S1,G1) and receivers connected to PE-4 in the west region will join group (S2,G1). The presence of each source is declared within the multicast VPN by the sender PE. When a multicast group becomes active, a BGP Source Active auto-discovery (SA) route is advertised to all PEs within the multicast VPN. This must occur even if no receiver indicates that it wishes to become a member of this group. In other words, the SA must be persistently present in the receiver PEs when the source is available.

Should either source fail or become unavailable, then the sender PE will notify the receiver PEs by sending an NLRI unreachable BGP SA Route that declares the absence of the source. All hosts that are members of this group will then switch to receive traffic from the remaining active source. Note that only customer multicast joins received as IGMP (*,G) queries or PIM (*,G) joins at the receiver PE are valid, as the source address is not specified.

Source redundancy is achieved by:

- Configuring a list of redundant sources within each receiver PE.
- Configuring the sender PEs to originate a BGP Source Active Auto Discovery for each detected active multicast source, regardless of whether a receiver is joined to the multicast group or not. As a result, a Source Active route is originated on a per (S,G) basis.

   For multiple SAs to be persistently present in the receiver PEs, one of the following two conditions must be configured within the sender PEs:

   ç Either disable inter-site shared trees on the sender PEs, such that there is no c-tree with root at the RP. Any active source will announce its presence using a BGP SA to all receiver PEs so no shared joins are sent by receiver PEs to RP, or

   ç Leave inter-site shared trees as enabled, but configured so that the SA AD route for each multicast group is persistently present in the receiver PEs, even in the absence of requesting hosts for each group. Shared and Source Joins are sent by the receiver PEs.

   Both of the above options are supported. The default behavior has inter-site shared trees enabled without persistency.In this example, inter-site shared trees at the sender PEs are enabled with Source Active routes set to be persistent.

- Ensuring that the preferred source is IP reachable within the VPRN from the receiver PE. This must be a remote source advertised from a remote PE within the VPRN.

- Receiver PEs will accept the Source Active route(s) into the appropriate Multicast VRF.

- Ensuring the preferred active source should have a higher BGP Local Preference. This is achieved using a route policy. Any other sources from the redundant list should exist as suppressed standby sources, but the (S,G) state should exist if the source is active – when a valid BGP MVPN Source Active route for that source has been received.

All of these conditions are achieved by configuration.

In order to allow each receiver PE to choose a preferred source, each SA route advertised by the sender PE will be tagged with a community value. Each receiver PE can then use the community value contained within each SA route update received to set the Local Preference BGP attribute to a value such that the receiver PE can choose the most preferred active source.

The objectives are:

- To configure multicast in a VPRN on PE-1 to PE-4 with inter-site-shared trees enabled on the receiver PEs and Source Active routes persistently present, for reasons previously described.
- To connect redundant sources to the sender PE-1 and PE-3, with each multicast source having the same group address. For ease of configuration a single redundant source is used.
- To advertise each source to the receiver PEs (PE-2 and PE-4), using appropriate route policies for adding community strings to the BGP Source Active Auto-Discovery routes.
- To configure appropriate route policies that allow each BGP SA route to have the correct Local Preference set, based on the community strings present.
- To allow receivers to connect to the appropriate source, using (*,G) joins.

The following configuration tasks should be completed as a pre-requisite:

- Full mesh ISIS or OSPF between each of the PE routers and the route reflector.
- Link-layer LDP between all PEs. (RSVP could also be used)
- Multicast LDP is used as the provider tunnel signaling protocol. This is enabled by default when link layer LDP is enabled.

For completeness, the command for all routers is as follows:

```
configure
    router ldp
        interface-parameters
            interface int-PE-1-P-1
                multicast-traffic enable
            exit
        exit
    exit
```

Note that RSVP and PIM SSM are also supported as provider tunnel signaling mechanisms and could be used.

Configuration

The test topology is shown in Figure 119, containing the four PEs plus the route reflector at P-1.
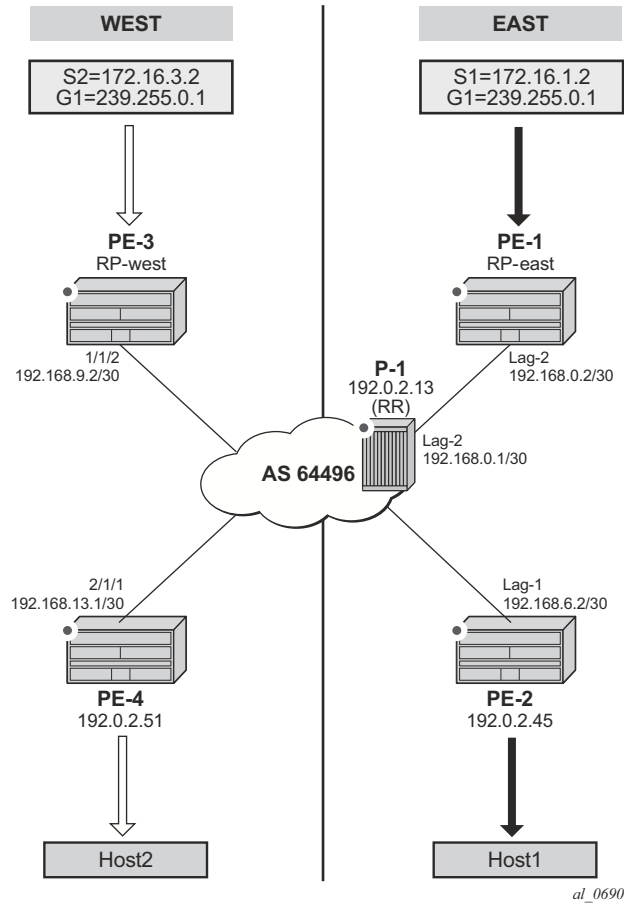
Figure 119: Schematic Topology

Global BGP Configuration

The first step is to configure an iBGP session between each of the PEs and the Route Reflector (RR) seen in Figure 119. The address families negotiated between the iBGP peers are vpn-ipv4 (unicast routing) and mvpn-ipv4 (multicast routing).

The configuration for PE1 is:

```
configure router bgp
    group internal
        family vpn-ipv4 mvpn-ipv4
        type internal
        neighbor 192.0.2.13
        exit
    exit
exit
```

The configuration for the other PE nodes is the same, apart from the IP addresses. The IP addresses can be derived from Figure 119.

The configuration for the Route Reflector at P-1 is:

```
configure router bgp
    cluster 0.0.0.1
    group rr_clients
            type internal
            family vpn-ipv4 mvpn-ipv4
            neighbor 192.0.2.51
            exit
            neighbor 192.0.2.61
            exit
            neighbor 192.0.2.43
            exit
            neighbor 192.0.2.45
            exit
        exit
exit all
```

On PE-1, verify that the BGP session with RR at P-1 is established with address families "vpn-ipv4" and "mvpn-ipv4" capabilities negotiated:

```
*B:PE-1>config>router>bgp>group# show router bgp summary
===============================================================================
 BGP Router ID:192.0.2.43      AS:64496      Local AS:64496
===============================================================================
BGP Admin State         : Up          BGP Oper State              : Up
Total Peer Groups       : 1           Total Peers                 : 1
Total BGP Paths         : 32          Total Path Memory           : 7864
Total IPv4 Remote Rts   : 0           Total IPv4 Rem. Active Rts  : 0
Total McIPv4 Remote Rts : 0           Total McIPv4 Rem. Active Rts: 0
Total McIPv6 Remote Rts : 0           Total McIPv6 Rem. Active Rts: 0
Total IPv6 Remote Rts   : 0           Total IPv6 Rem. Active Rts  : 0
```

```
Total IPv4 Backup Rts    : 0          Total IPv6 Backup Rts       : 0

Total Supressed Rts      : 0          Total Hist. Rts             : 0
Total Decay Rts          : 0

Total VPN Peer Groups    : 0          Total VPN Peers             : 0
Total VPN Local Rts      : 10
Total VPN-IPv4 Rem. Rts : 0           Total VPN-IPv4 Rem. Act. Rts: 0
Total VPN-IPv6 Rem. Rts : 0           Total VPN-IPv6 Rem. Act. Rts: 0
Total VPN-IPv4 Bkup Rts : 0           Total VPN-IPv6 Bkup Rts     : 0

Total VPN Supp. Rts      : 0          Total VPN Hist. Rts         : 0
Total VPN Decay Rts      : 0

Total L2-VPN Rem. Rts    : 0          Total L2VPN Rem. Act. 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
Total MSPW Rem Rts       : 0          Total MSPW Rem Act Rts      : 0
Total RouteTgt Rem Rts  : 0           Total RouteTgt Rem Act Rts  : 0
Total McVpnIPv4 Rem Rts : 0           Total McVpnIPv4 Rem Act Rts : 0
Total MVPN-IPv6 Rem Rts : 0           Total MVPN-IPv6 Rem Act Rts : 0
Total EVPN Rem Rts       : 0          Total EVPN Rem Act Rts      : 0
Total FlowIpv4 Rem Rts  : 0           Total FlowIpv4 Rem Act Rts  : 0
Total FlowIpv6 Rem Rts  : 0           Total FlowIpv6 Rem Act Rts  : 0
===============================================================================
BGP Summary
===============================================================================
Neighbor
                AS PktRcvd InQ  Up/Down   State|Rcv/Act/Sent (Addr Family)
                   PktSent OutQ
-------------------------------------------------------------------------------
192.0.2.13
            64496     616    0 00h00m05s 0/0/0 (VpnIPv4)
                       12    0           0/0/0 (MvpnIPv4)
-------------------------------------------------------------------------------
```

The same command can be used on the other PEs to verify their BGP sessions to the RR.

Configuring VPRN on PEs

The following outputs show the VPRN configurations for each PE. The specific MVPN configuration is shown later.

PE-1

The VPRN configuration for PE-1 is as follows:

```
B:PE-1# configure service vprn 10
B:PE-1>config>service>vprn# info
---------------------------------------------
            route-distinguisher 64496:10
            auto-bind ldp
            vrf-target target:64496:10
            interface "int-PE-1-CE-1" create
                address 172.16.1.1/24
                sap 2/2/3:10.0 create
                exit
            exit
            interface "rp" create
                address 10.10.10.10/32
                loopback
            exit
            pim
                apply-to all
                rp
                    static
                        address 10.10.10.10
                            group-prefix 239.255.0.0/8
                        exit
                    exit
                    bsr-candidate
                        shutdown
                    exit
                    rp-candidate
                        shutdown
                    exit
                exit
                no shutdown
            exit
            mvpn
                auto-discovery default
                c-mcast-signaling bgp
                provider-tunnel
                    inclusive
                        mldp
                            no shutdown
                        exit
                    exit
                exit
            exit
            no shutdown
```

There is a single interface towards CE-1 from which the multicast group is generated.

If the customer signaling uses PIM ASM then the customer Rendezvous Point (RP) must be positioned on the sender PE as registration of the source with the RP causes the SA to be sent to the remote source PEs.

A loopback interface called **rp** acts as the RP for all group prefixes in the 239.255.0.0/16 range. This will be the RP for the East groups.

MVPN configuration enables BGP as both auto-discovery mechanism and the customer multicast signaling protocol across the VPRN. The provider tunnel between PEs within the MVPN is signaled using Multicast LDP.

PE-2

PE-2 contains an attached receiver so a single interface is configured to accommodate this. The RP configured is that of the East region and has a configuration as follows:

```
B:PE-2# configure service vprn 10
B:PE-2>config>service>vprn# info
--------------------------------------------
            route-distinguisher 64496:10
            auto-bind ldp
            vrf-target target:64496:10
            interface "int-PE-2-CE-2" create
                address 172.16.2.1/24
                sap 1/1/2:10.0 create
                exit
            exit
            igmp
                interface "int-PE-2-CE-2"
                    no shutdown
                exit
                no shutdown
            exit
            pim
                rp
                    static
                        address 10.10.10.10
                            group-prefix 239.255.0.0/8
                        exit
                    exit
                    no shutdown
                exit
                no shutdown
```

PE-3

PE-3 acts as the RP for the West region and uses a different IP address for the Rendezvous Point interface.

```
*B:PE-3# configure service vprn 10
*B:PE-3>config>service>vprn# info
---------------------------------------------
        route-distinguisher 64496:10
        auto-bind ldp
        vrf-target target:64496:10
        interface "rp" create
            address 10.10.10.11/32
            loopback
        exit
        interface "int-PE3-CE-3" create
            address 172.16.3.1/24
            sap 2/1/3:10 create
            exit
        exit
        pim
            apply-to all
            rp
                static
                    address 10.10.10.11
                        group-prefix 239.255.0.0/8
                    exit
                exit
            exit
            no shutdown
        exit
        no shutdown
---------------------------------------------
```

PE-4

PE-4 also contains a receiver, and uses the West Sender PE (PE-3) as the Rendezvous Point.

```
*B:PE-4>config>service>vprn# info
---------------------------------------------
            route-distinguisher 64496:10
            auto-bind ldp
            vrf-target target:64496:10
            interface "int-PE-4-CE-4" create
                address 172.16.4.1/24
                sap 2/2/2:10 create
                exit
            exit
            igmp
                interface "int-PE-4-CE-4"
                    no shutdown
                exit
                no shutdown
            exit
            pim
                rp
                    static
                        address 10.10.10.11
                            group-prefix 239.255.0.0/8
                        exit
                    exit
                exit
                no shutdown
            exit
            no shutdown
---------------------------------------------
```

MVPN Configuration for Source PEs

At the PEs closest to the sources (PE-1 and PE-3) Source Active auto-discovery BGP routes are generated when the source is active.

This applies for PIM-ASM (*,G) joins only, or IGMP (*,G) membership queries received by the provider domain. These are received by all PEs.

Inter-site trees must be disabled for this to occur. Alternatively, inter-site trees can be enabled such that when a source is discovered, a Source Active is advertised to each other PE in the MVPN. This occurs regardless of whether any receivers wish to become members of the multicast groups.

As previously stated, the presence of the SA in the receiver PEs means that no shared joins routes are generated towards the C-RPs.

The MVPN configuration for each PE should be as follows:

```
B:PE-1>config>service>vprn# info
---------------------------------------------
        mvpn
            auto-discovery default
            c-mcast-signaling bgp
            provider-tunnel
                inclusive
                    mldp
                        no shutdown
                    exit
                exit
            exit
        exit
```

The VPRN MVPN configuration for PEs 2, 3 and 4 is identical.

Sender PE Route Policies

The choice of active and standby sources by the receiver PEs is determined by the "best route" policy. PE-1 and PE-3 advertises BGP Source Active Auto Discovery routes when a source is active. This is received by all PEs within the MVPN. As two different sources advertise the same group, it is necessary to differentiate between them.

Assuming that PE-2 receiver prefers the source from PE-1, and PE-4 prefers the source active on PE-3, then the export policy for MVPN routes on PE-1 requires the following steps:

1. Set a community value at PE-1 for the (S,G) multicast group – call this "blue" with value 64496:452.

2. Set the route target community for the VPRN – 64496:10.

3. Create a policy statement that becomes the export policy for MVPN routes within PE-1.

4. Create a policy statement entry (entry 10) that adds the community value "blue" along with the route target for Source Active AD BGP routes. Source Active AD routes are MVPN type 5 routes.

5. Create a policy statement entry default-action that adds the route target for all other MVPN AD BGP routes (e.g. Intra-AD (type 1)) that are exported to the MVPN PEs.

```
B:PE-1# configure router policy-options
    begin
        community "blue" members "64496:452"
        community "mvpn_10_rt" members "target:64496:10"

        policy-statement "mvpn_10"
            entry 10
            description "match mvpn routes - type 5 Source AD - add RT and 'blue'
                        community"
                from
                    mvpn-type 5
                    family mvpn-ipv4
                exit
                action accept
                    community add "blue" "mvpn_10_rt"
                exit
            exit
            default-action accept
                community add "mvpn_10_rt"
            exit
        exit
```

6. Apply as an export policy within the MVPN context.

The import policy requires that all imported MVPN BGP routes have the correct route target extended community value, specifically 64496:10.

1. Create a policy statement that becomes the import policy for PE-1.

2. Create a policy statement entry (entry 10) that matches the community of the route target extended community for all MVPN BGP routes. These include the Intra-AD and Source-Join routes.

```
B:PE-1# configure router policy-options
    begin
        community "blue" members "64496:452"
        community "mvpn_10_rt" members "target:64496:10"
        policy-statement "mvpn_10_import"
            entry 10
                from
                    community "mvpn_10_rt"
                exit
                action accept
                exit
            exit
        exit
```

Enable the inter-site-shared type 5 advertisement persistency so that source ADs are advertised when multicast sources are active. Note that alternatively, inter-site shared trees can be disabled using the **no intersite shared** command. In this example only inter-site shared MVPN type 5 persistency is shown.

The MVPN configuration for PE-1 now looks as follows:

```
*B:PE-1>config>service>vprn>mvpn# info
--------------------------------------------
            auto-discovery default
            c-mcast-signaling bgp
            intersite-shared persistent-type5-adv
            provider-tunnel
                inclusive
                    mldp
                        no shutdown
                    exit
                exit
            exit
            vrf-import "mvpn_10_import"
            vrf-export "mvpn_10_export"
```

For PE-3 (the other sender PE), similar import and export policies are required. In this case, the community will be called "red" and is added to the Source Active AD route generated when the source is active.

The requirements for the export policy for PE-3 are as follows:

```
B:PE-3# configure router policy-options
    begin
       community "red" members "64496:332"
          community "mvpn_10_rt" members "target:64496:10"
          policy-statement "mvpn_10_export"
             entry 10
                from
                    mvpn-type 5
                    family mvpn-ipv4
                exit
                action accept
                    community add "red" "mvpn_10_rt"
                exit
             exit
             default-action accept
                community add "mvpn_10_rt"
             exit
          exit
```

The import policy is:

```
           policy-statement "mvpn_10_import"
             entry 10
                from
                    community "mvpn_10_rt"
                exit
                action accept
                exit
             exit
           exit
```

Apply the import and export policies to the MVPN context of the sender PE (PE-3).

```
*B:PE-3>config>service>vprn>mvpn# info
---------------------------------------------
            auto-discovery default
            c-mcast-signaling bgp
            intersite-shared persistent-type5-adv
            provider-tunnel
                inclusive
                    mldp
                        no shutdown
                    exit
                exit
            exit
            vrf-import "mvpn_10_import"
            vrf-export "mvpn_10_export"
```

Receiver PE Configuration

PE-2 and PE-4 are the receiver PEs. These will receive the Source Active AD routes and initiate Joins towards the preferred source.

When a Source-Active AD route is received, the community value is examined and the Local Preference value of the route is set using a Route Policy. The preferred source is determined by the SA AD route with the highest Local Preference value.

In the case of PE-2, the preferred source is that advertised by PE-1, the "blue" source as previously referenced. PE-2 sets the Local Preference to 200. The SA AD tagged with the "red" community has the Local Preference set to 50.

For PE-4, the reverse applies: SA AD routes tagged with the "red" community have the Local Preference set to 200, and "blue" SA AD routes have the Local Preference set to 50.

Once again, assuming that the PE-2 receiver prefers the source from PE-1 and PE-4 prefers the source active on PE-3, the import policy for MVPN routes on PE-2 requires the following steps:

1. Set a community value at PE-2 for the (S,G), call this "blue" with value 64496:452.

2. Set the route target community for the VPRN to 64496:10.

3. Create a prefix list that matches the multicast group address, in this case 239.255.0.0/24.

4. Create a policy statement that becomes the import policy for MVPN routes within PE-1.

5. Create a policy statement entry (entry 10) that matches the following attributes:

   • Source Active AD BGP routes type. Source Active AD routes are classed as MVPN type 5 routes, and

   • Community value "blue" AND Route Target extended community, and

   • Group address prefix 239.255.0.0/24

   If the BGP route matches all three conditions then set the Local Preference to 200.

6. Create a policy statement default-action that accepts all other MVPN BGP routes, including SA routes tagged with the "red" community value.

The import policy statement looks like:

```
*B:PE-2>config>router>policy-options# info
--------------------------------------------
            community "red" members "64496:332"
            community "blue" members "64496:452"
            community "mvpn_10_rt" members "target:64496:10"
            policy-statement "mvpn_10_import"
                entry 10
                    description "allow mvpn source-ad for 'red' group - set local-pref to
                                200"
                    from
```

```
                              community expression "[blue] AND [mvpn_10_rt]"
                              mvpn-type 5
                      exit
                      action accept
                          local-preference 200
                      exit
              exit
              entry 20
                      from
                          community expression "[red] AND [mvpn_10_rt]"
                          mvpn-type 5
                      exit
                      action accept
                          local-preference 50
                      exit
              exit
          default-action accept
          exit
      exit
```

The export policy for PE-2 MVPN routes requires each MVPN route to be tagged with the route target extended community for VPRN 10. The following policy statement is created:

```
*B:PE-2>config>router>policy-options# info
-------------------------------------------
          begin
          prefix-list "group_239.255.x.x"
              prefix 239.255.0.0/16 longer
          exit
          community "red" members "64496:332"
          community "blue" members "64496:452"
          community "mvpn_10_rt" members "target:64496:10"
          policy-statement "mvpn_10_export"
              entry 10
                  from
                      family mvpn-ipv4
                  exit
                  action accept
                      community add "mvpn_10_rt"
                  exit
              exit
          exit
          commit
```

7. Create a list of redundant sources. This is a list of prefixes that match the source addresses of redundant multicast groups. This is an important parameter as the receiver PEs only creates active and standby (S,G) states for groups with source address prefixes that are contained in this list.

8. Before any hosts attempt to join the multicast groups, the decision must be made to enable or disable inter-site shared trees at the receiver PEs. In this example, only the Inter-site shared trees disabled option will be considered. In order to make this change in configuration, it is necessary to shut the PIM protocol down before and re-enable when completed.

The MVPN configuration for PE-2 is shown in the following output. Note the redundant source prefix list is included, and inter-site shared trees are disabled:

```
B:PE-2# configure service vprn 10
B:PE-2>config>service>vprn# info
----------------------------------------------
            route-distinguisher 64496:10
            auto-bind ldp
            vrf-target target:64496:10
            mvpn
                auto-discovery default
                c-mcast-signaling bgp
                no intersite-shared
                red-source-list
                    src-prefix 172.16.1.0/24
                    src-prefix 172.16.3.0/24
                exit
                provider-tunnel
                    inclusive
                        mldp
                            no shutdown
                        exit
                    exit
                exit
                vrf-import "mvpn_10_import"
                vrf-export "mvpn_10_export"
            exit
            no shutdown
```

PE-4 requires a similar set of import and export policies. In this case, the "red" sources have the highest Local Preference value, based on the community string added by the export policy of PE-3.

```
B:PE-4>config>router>policy-options# info
----------------------------------------------
    begin
    community "red" members "64496:332"
    community "mvpn_10_rt" members "target:64496:10"
    policy-statement "mvpn_10_import"
        entry 10
            description "Match Source AD from 'red' group - set local preference to 200"
                from
                    community expression "[red] AND [mvpn_10_rt]"
                    mvpn-type 5
                exit
                action accept
                    local-preference 200
                exit
        exit
        entry 20
            description "Match Source AD from 'blue' group - set local preference to 50"
                from
                    community expression "[blue] AND [mvpn_10_rt]"
                    mvpn-type 5
                exit
                action accept
```

```
                    local-preference 50
                exit
            exit
            default-action accept
            exit
    exit
    commit
```

The export policy for MVPN routes adds the route target extended community, as follows:

```
B:PE-4>config>router>policy-options# info
----------------------------------------------
        begin
        community "mvpn_10_rt" members "target:64496:10"
        policy-statement "mvpn_10_export"
            description "export policy for mvpn routes"
            entry 10
                description "add RT for mvpn routes"
                from
                    family mvpn-ipv4
                exit
                action accept
                    community add "mvpn_10"
                exit
            exit
        exit
        commit
```

The MVPN configuration for VPRN 10 on PE-4 is now:

```
B:PE-4# configure service vprn 10
B:PE-4>config>service>vprn# info
----------------------------------------------
        mvpn
            auto-discovery default
            c-mcast-signaling bgp
            no intersite-shared
            red-source-list
                src-prefix 172.16.1.0/24
                src-prefix 172.16.3.0/24
            exit
            provider-tunnel
                inclusive
                    mldp
                        no shutdown
                    exit
                exit
            exit
            vrf-import "mvpn_10_import"
            vrf-export "mvpn_10_export"
        exit
        no shutdown
```

Each PE within the MVPN originates an Intra-AD BGP route. This notifies the other PEs within the VPRN. This is used to create a set of Inclusive Provider Multicast Service Interfaces (I-PMSI) between each PE. In this case, I-PMSIs are signaled using mLDP.

Using PE-1 as an example, the set of Intra-AD routes can be seen using the following command:

```
*B:PE-1# show router bgp routes mvpn-ipv4
===============================================================================
 BGP Router ID:192.0.2.43       AS:64496       Local AS:64496
===============================================================================
 Legend -
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : i - IGP, e - EGP, ? - incomplete, > - best, b - backup
===============================================================================
BGP MVPN-IPv4 Routes
===============================================================================
Flag  RouteType                 OriginatorIP        LocalPref  MED
      RD                        SourceAS                       Label
      Nexthop                   SourceIP
      As-Path                   GroupIP
-------------------------------------------------------------------------------
i     Intra-Ad                  192.0.2.43          100        0
      64496:10                  -                              -
      192.0.2.43                -
      No As-Path                -
u*>i  Intra-Ad                  192.0.2.45          100        0
      64496:10                  -                              -
      192.0.2.45                -
      No As-Path                -
u*>i  Intra-Ad                  192.0.2.51          100        0
      64496:10                  -                              -
      192.0.2.51                -
      No As-Path                -
u*>i  Intra-Ad                  192.0.2.61          100        0
      64496:10                  -                              -
      192.0.2.61                -
      No As-Path                -
-------------------------------------------------------------------------------
Routes : 4
===============================================================================
```

At this moment, there are no connected sources detected and no receivers wishing to join any multicast sources.

Each I-PMSI is seen as a PIM tunnel interface. As there are four routers in the MVPN, there are four I-PMSIs.

```
*B:PE-1# show router 10 pim tunnel-interface
===============================================================================
PIM Interfaces ipv4
===============================================================================
Interface               Adm  Opr  DR Prty      Hello Intvl  Mcast Send
  DR
-------------------------------------------------------------------------------
mpls-if-73734           Up   Up   N/A          N/A          N/A
```

```
   192.0.2.43
mpls-if-73735               Up   Up   N/A         N/A        N/A
   192.0.2.51
mpls-if-73736               Up   Up   N/A         N/A        N/A
   192.0.2.45
mpls-if-73737               Up   Up   N/A         N/A        N/A
   192.0.2.61
-------------------------------------------------------------------------------
Interfaces : 4
===============================================================================
```

In order to be able to reach the source, a route for each source is included in the VRF for VPRN 10.

For PE-2, this looks as follows:

```
*B:PE-2# show router 10 route-table
===============================================================================
Route Table (Service: 10)
===============================================================================
Dest Prefix[Flags]                         Type    Proto    Age       Pref
     Next Hop[Interface Name]                                Metric
-------------------------------------------------------------------------------
10.10.10.10/32                             Remote  BGP VPN  03h30m32s 170
     192.0.2.61 (tunneled)                                  0
10.10.10.11/32                             Remote  BGP VPN  02h25m19s 170
     192.0.2.43 (tunneled)                                  0
172.16.1.0/24                              Remote  BGP VPN  02h25m19s 170
     192.0.2.43 (tunneled)                                  0
172.16.2.0/24                              Local   Local    02d02h51m 0
     int-PE-2-CE-2                                          0
172.16.3.0/24                              Remote  BGP VPN  03h30m32s 170
     192.0.2.61 (tunneled)                                  0
172.16.4.0/24                              Remote  BGP VPN  03h18m27s 170
     192.0.2.51 (tunneled)                                  0
-------------------------------------------------------------------------------
No. of Routes: 6
Flags: n = Number of times nexthop is repeated
       B = BGP backup route available
       L = LFA nexthop available
===============================================================================
```

The sources at 172.16.1.0/24 and 172.16.3.0/24 are learned as BGP VPN routes.

Examining the BGP routes for these prefixes. For 172.16.1.0/24 on PE-2:

```
*B:PE-2# show router bgp routes vpn-ipv4 172.16.1.0/24 hunt
===============================================================================
 BGP Router ID:192.0.2.45      AS:64496       Local AS:64496
===============================================================================
 Legend -
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : i - IGP, e - EGP, ? - incomplete, > - best, b - backup
===============================================================================
BGP VPN-IPv4 Routes
```

```
===============================================================================
-------------------------------------------------------------------------------
RIB In Entries
-------------------------------------------------------------------------------
Network        : 172.16.1.0/24
Nexthop        : 192.0.2.43
Route Dist.    : 64496:10              VPN Label     : 262072
Path Id        : None
From           : 192.0.2.13
Res. Nexthop   : n/a
Local Pref.    : 100                   Interface Name : int-PE-2-P-3
Aggregator AS  : None                  Aggregator    : None
Atomic Aggr.   : Not Atomic            MED           : None
AIGP Metric    : None
Connector      : None
Community      : target:64496:10 l2-vpn/vrf-imp:192.0.2.43:2
                 source-as:64496:0
Cluster        : 192.0.2.13
Originator Id  : 192.0.2.43            Peer Router Id : 192.0.2.13
Fwd Class      : None                  Priority      : None
Flags          : Used  Valid  Best  IGP
Route Source   : Internal
AS-Path        : No As-Path
Neighbor-AS    : N/A
VPRN Imported  :  10
-------------------------------------------------------------------------------
RIB Out Entries
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
Routes : 1
===============================================================================
*B:PE-2#
```

Note that this prefix is advertised with three communities:

- A Route Target extended community
- An l2-vpn/vrf-import extended community.
- A source-AS extended community (not used in Intra-AS context).

The l2-vpn/vrf-import extended community is significant as it is a unique value. It represents a specific MVPN on a specific PE and is comprised of a 32 bit value that identifies the PE plus an index identifying the VRF. The 32 bit value is the system address. The index (2) can be derived from the command:

```
*B:PE-1# admin display-config index | match vprn10
        virtual-router "vprn10" 2 0
```

Hence, the l2-vpn/vrf-import community for VPRN 10 on PE-1 is 192.0.2.43:2

This community attribute is included within the source-join BGP route that is sent in a BGP Update by a receiver PE as it tries to join a multicast group with a source address that matches the 172.16.1.0/24 prefix. This ensures that the source-join route is only accepted as a valid route and imported by the PE that originated the source address prefix. This is explained below.

Enable Redundant Sources

The redundant sources are now enabled so that multicast traffic flows into both PE-1 and PE-3, using groups (S1,G1) and (S2,G1), respectively.

On each of these PEs a source active AD route is generated. By examining each receiver PE, these can be clearly seen.

For PE-2, the source active AD routes can be seen using the following command.

```
*B:PE-2# show router bgp routes mvpn-ipv4 type source-ad
===============================================================================
 BGP Router ID:192.0.2.45        AS:64496        Local AS:64496
===============================================================================
 Legend -
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : i - IGP, e - EGP, ? - incomplete, > - best, b - backup
===============================================================================
BGP MVPN-IPv4 Routes
===============================================================================
Flag  RouteType              OriginatorIP         LocalPref   MED
      RD                     SourceAS                         Label
      Nexthop                SourceIP
      As-Path                GroupIP
-------------------------------------------------------------------------------
u*>i  Source-Ad              -                    200         0
      64496:10               -                                -
      192.0.2.43             172.16.1.2
      No As-Path             239.255.0.1
u*>i  Source-Ad              -                    100         0
      64496:10               -                                -
      192.0.2.61             172.16.3.2
      No As-Path             239.255.0.1
-------------------------------------------------------------------------------
Routes : 2
===============================================================================
```

Note that there are two routes present, one from each source for the same group from PE-1 and PE-3.

The PIM groups can now be seen on PE-1 as follows:

```
B:PE-1# show router 10 pim group
===============================================================================
Legend:  A = Active   S = Standby
===============================================================================
PIM Groups ipv4
===============================================================================
Group Address            Type           Spt Bit  Inc Intf      No.Oifs
   Source Address          RP            State    Inc Intf(S)
-------------------------------------------------------------------------------
239.255.0.1              (S,G)                    int-PE-1-CE-1  0
   172.16.1.2              10.10.10.11
239.255.0.1              (S,G)                    mpls-if-73833  0
```

```
     172.16.3.2                    10.10.10.11
--------------------------------------------------------------------------------
Groups : 2
================================================================================
```

There are two groups at PE-1. In addition to its locally connected source, PE-1 has also received a source active from PE-3 which has an incoming interface of the I-PMSI towards PE-3. Note that the outgoing interface list is empty as there is no host wishing to become a group member.

Similarly, on the other sender, PE-3.

```
*B:PE-3# show router 10 pim group
================================================================================
Legend:  A = Active   S = Standby
================================================================================
PIM Groups ipv4
================================================================================
Group Address           Type            Spt Bit  Inc Intf       No.Oifs
   Source Address          RP              State    Inc Intf(S)
--------------------------------------------------------------------------------
239.255.0.1             (S,G)                    mpls-if-73820  0
   172.16.1.2              10.10.10.10
239.255.0.1             (S,G)                    int-PE3-CE-3   0
   172.16.3.2              10.10.10.10
--------------------------------------------------------------------------------
Groups : 2
================================================================================
```

By examining the receiver PE-2, it can be seen that the Source AD route for (S,G) (172.16.1.2, 239.255.0.1) from PE-1 has a higher local preference so it is chosen as the preferred (active) source. Examining these routes in more detail shows that each route is tagged with two communities: the route target extended community and the "red" or "blue" community, as seen in the following output.

```
*B:PE-2# show router bgp routes mvpn-ipv4 type source-ad hunt
===============================================================================
 BGP Router ID:192.0.2.45        AS:64496        Local AS:64496
===============================================================================
 Legend -
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : i - IGP, e - EGP, ? - incomplete, > - best, b - backup
===============================================================================
BGP MVPN-IPv4 Routes
===============================================================================
-------------------------------------------------------------------------------
RIB In Entries
-------------------------------------------------------------------------------
Route Type    : Source-Ad
Route Dist.   : 64496:10
Source IP     : 172.16.1.2
Group IP      : 239.255.0.1
Nexthop       : 192.0.2.43
From          : 192.0.2.13
Res. Nexthop  : 0.0.0.0
```

```
Local Pref.    : 200                  Interface Name : NotAvailable
Aggregator AS  : None                 Aggregator     : None
Atomic Aggr.   : Not Atomic           MED            : 0
AIGP Metric    : None
Connector      : None
Community      : 64496:452 target:64496:10
Cluster        : 192.0.2.13
Originator Id  : 192.0.2.43           Peer Router Id : 192.0.2.13
Flags          : Used  Valid  Best  IGP
Route Source   : Internal
AS-Path        : No As-Path
Neighbor-AS    : N/A
VPRN Imported  :  10

Route Type     : Source-Ad
Route Dist.    : 64496:10
Source IP      : 172.16.3.2
Group IP       : 239.255.0.1
Nexthop        : 192.0.2.61
From           : 192.0.2.13
Res. Nexthop   : 0.0.0.0
Local Pref.    : 100                  Interface Name : NotAvailable
Aggregator AS  : None                 Aggregator     : None
Atomic Aggr.   : Not Atomic           MED            : 0
AIGP Metric    : None
Connector      : None
Community      : 64496:332 target:64496:10
Cluster        : 192.0.2.13
Originator Id  : 192.0.2.61           Peer Router Id : 192.0.2.13
Flags          : Used  Valid  Best  IGP
Route Source   : Internal
AS-Path        : No As-Path
Neighbor-AS    : N/A
VPRN Imported  :  10
-------------------------------------------------------------------------------
RIB Out Entries
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
Routes : 2
===============================================================================
```

The Local Preference is set based on these community values.

A debug of the received BGP Source AD routes is shown below for PE-2:

```
B:PE-2# 1 2014/03/05 13:51:51.31 GMT MINOR: DEBUG #2001 Base Peer 1: 192.0.2.13
"Peer 1: 192.0.2.13: UPDATE
Peer 1: 192.0.2.13 - Received BGP UPDATE:
    Withdrawn Length = 0
    Total Path Attr Length = 86
    Flag: 0x90 Type: 14 Len: 29 Multiprotocol Reachable NLRI:
        Address Family MVPN_IPV4
        NextHop len 4 NextHop 192.0.2.43
        Type: Source-AD Len: 18 RD: 64496:10 Src: 172.16.1.2 Grp: 239.255.0.1
    Flag: 0x40 Type: 1 Len: 1 Origin: 0
    Flag: 0x40 Type: 2 Len: 0 AS Path:
    Flag: 0x80 Type: 4 Len: 4 MED: 0
```

```
       Flag: 0x40 Type: 5 Len: 4 Local Preference: 100
       Flag: 0xc0 Type: 8 Len: 4 Community:
           64496:452
       Flag: 0x80 Type: 9 Len: 4 Originator ID: 192.0.2.43
       Flag: 0x80 Type: 10 Len: 4 Cluster ID:
           192.0.2.13
       Flag: 0xc0 Type: 16 Len: 8 Extended Community:
           target:64496:10
"

2 2014/03/05 13:51:51.31 GMT MINOR: DEBUG #2001 Base Peer 1: 192.0.2.13
"Peer 1: 192.0.2.13: UPDATE
Peer 1: 192.0.2.13 - Received BGP UPDATE:
    Withdrawn Length = 0
    Total Path Attr Length = 86
    Flag: 0x90 Type: 14 Len: 29 Multiprotocol Reachable NLRI:
       Address Family MVPN_IPV4
       NextHop len 4 NextHop 192.0.2.61
       Type: Source-AD Len: 18 RD: 64496:10 Src: 172.16.3.2 Grp: 239.255.0.1
    Flag: 0x40 Type: 1 Len: 1 Origin: 0
    Flag: 0x40 Type: 2 Len: 0 AS Path:
    Flag: 0x80 Type: 4 Len: 4 MED: 0
    Flag: 0x40 Type: 5 Len: 4 Local Preference: 100
    Flag: 0xc0 Type: 8 Len: 4 Community:
       64496:332
    Flag: 0x80 Type: 9 Len: 4 Originator ID: 192.0.2.61
    Flag: 0x80 Type: 10 Len: 4 Cluster ID:
       192.0.2.13
    Flag: 0xc0 Type: 16 Len: 8 Extended Community:
       target:64496:10
"
```

Similarly, the Source Active routes on receiver PE-4 show that the highest local preference value of 200 is set for the SA route received from PE-3 with an originator ID of 192.0.2.61, as shown below:

```
B:PE-4# show router bgp routes mvpn-ipv4 type source-ad hunt
===============================================================================
 BGP Router ID:192.0.2.51       AS:64496       Local AS:64496
===============================================================================
 Legend -
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : i - IGP, e - EGP, ? - incomplete, > - best, b - backup
===============================================================================
BGP MVPN-IPv4 Routes
===============================================================================
-------------------------------------------------------------------------------
RIB In Entries
-------------------------------------------------------------------------------
Route Type    : Source-Ad
Route Dist.   : 64496:10
Source IP     : 172.16.1.2
Group IP      : 239.255.0.1
Nexthop       : 192.0.2.43
From          : 192.0.2.13
Res. Nexthop  : 0.0.0.0
Local Pref.   : 100                    Interface Name : NotAvailable
```

```
Aggregator AS  : None                     Aggregator     : None
Atomic Aggr.   : Not Atomic               MED            : 0
AIGP Metric    : None
Connector      : None
Community      : 64496:452 target:64496:10
Cluster        : 192.0.2.13
Originator Id  : 192.0.2.43               Peer Router Id : 192.0.2.13
Flags          : Used  Valid  Best  IGP
Route Source   : Internal
AS-Path        : No As-Path
Neighbor-AS    : N/A
VPRN Imported  :  10

Route Type     : Source-Ad
Route Dist.    : 64496:10
Source IP      : 172.16.3.2
Group IP       : 239.255.0.1
Nexthop        : 192.0.2.61
From           : 192.0.2.13
Res. Nexthop   : 0.0.0.0
Local Pref.    : 200                      Interface Name : NotAvailable
Aggregator AS  : None                     Aggregator     : None
Atomic Aggr.   : Not Atomic               MED            : 0
AIGP Metric    : None
Connector      : None
Community      : 64496:332 target:64496:10
Cluster        : 192.0.2.13
Originator Id  : 192.0.2.61               Peer Router Id : 192.0.2.13
Flags          : Used  Valid  Best  IGP
Route Source   : Internal
AS-Path        : No As-Path
Neighbor-AS    : N/A
VPRN Imported  :  10
-------------------------------------------------------------------------------
RIB Out Entries
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
Routes : 2
===============================================================================
*B:PE-4#
```

Host Group Membership

If the hosts then send a (*,G) request to join the group, a source-join route is originated at each receiver PE towards the preferred source from the redundant list.

The following output shows a join originated by PE-2:

```
*B:PE-2# show debug
debug
    router "Base"
        bgp
            update neighbor 192.0.2.13
        exit
    exit
exit

*B:PE-2#
1 103 2014/05/27 11:15:19.29 BST MINOR: DEBUG #2001 Base Peer 1: 192.0.2.13
"Peer 1: 192.0.2.13: UPDATE
Peer 1: 192.0.2.13 - Send BGP UPDATE:
    Withdrawn Length = 0
    Total Path Attr Length = 101
    Flag: 0x90 Type: 14 Len: 57 Multiprotocol Reachable NLRI:
        Address Family MVPN_IPV4
        NextHop len 4 NextHop 192.0.2.45
        Type: Shared-Join Len:22 RD: 64496:101 SrcAS: 64496 Src: 10.10.10.11 Grp
: 239.255.0.1
        Type: Source-Join Len:22 RD: 64496:101 SrcAS: 64496 Src: 172.16.1.2 Grp:
 239.255.0.1
    Flag: 0x40 Type: 1 Len: 1 Origin: 0
    Flag: 0x40 Type: 2 Len: 0 AS Path:
    Flag: 0x80 Type: 4 Len: 4 MED: 0
    Flag: 0x40 Type: 5 Len: 4 Local Preference: 100
    Flag: 0xc0 Type: 16 Len: 16 Extended Community:
        target:64496:10
        target:192.0.2.43:2
"
```

Note that there is both a source-join and a shared join for the same group address (239.255.0.1).

The shared-join is sent to the Rendezvous Point 10.10.10.11 and the source-join is trying to become a member of group 239.255.0.1 with a source address of 172.16.1.2. As this is sent as a BGP routing update, this must be accepted by the MVPN VRF at the PE that originated the unicast route that represents the c-multicast source. As previously mentioned, there are two extended community values. The second of these is the l2-vpn/vrf-import route target for 192.0.2.43 (PE-1), so only PE-1 will accept this route.

Examining the PIM state table for PE-2 shows the presence of a group with multiple sources.

```
*B:PE-2# show router 10 pim group
===============================================================================
Legend:  A = Active   S = Standby
===============================================================================
PIM Groups ipv4
===============================================================================
Group Address            Type             Spt Bit  Inc Intf      No.Oifs
   Source Address           RP                State   Inc Intf(S)
-------------------------------------------------------------------------------
239.255.0.1              (*,G)                              mpls-if-73881  1
   *                        10.10.10.11
239.255.0.1              (S,G)             spt     mpls-if-73881  1
   172.16.1.2               10.10.10.11        A
239.255.0.1              (S,G)                              mpls-if-73882  1
   172.16.3.2               10.10.10.11        S
-------------------------------------------------------------------------------
Groups :3
===============================================================================
```

Note that each (S,G) has a state of either Active (A) or Standby (S), and the active group is chosen based on the Source Active AD with the highest Local Preference.

As a direct comparison, PE-4 also has the same two (S,G) states, but has a reversed active and standby source.

```
B:PE-4# show router 10 pim group
===============================================================================
Legend:  A = Active   S = Standby
===============================================================================
PIM Groups ipv4
===============================================================================
Group Address            Type             Spt Bit  Inc Intf      No.Oifs
   Source Address           RP                State   Inc Intf(S)
-------------------------------------------------------------------------------
239.255.0.1              (*,G)                              mpls-if-73889  1
   *                        10.10.10.10
239.255.0.1              (S,G)                              mpls-if-73888  1
   172.16.1.2               10.10.10.10        S
239.255.0.1              (S,G)             spt     mpls-if-73889  1
   172.16.3.2               10.10.10.10        A
-------------------------------------------------------------------------------
Groups : 3
===============================================================================
```

The Source Active ADs received on PE-4 have their Local Preference values based on the community string value.

```
B:PE-4# show router bgp routes mvpn-ipv4 type source-ad hunt
===============================================================================
 BGP Router ID:192.0.2.51        AS:64496        Local AS:64496
===============================================================================
 Legend -
 Status codes : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes : i - IGP, e - EGP, ? - incomplete, > - best, b - backup
===============================================================================
BGP MVPN-IPv4 Routes
===============================================================================
-------------------------------------------------------------------------------
RIB In Entries
-------------------------------------------------------------------------------
Route Type    : Source-Ad
Route Dist.   : 64496:10
Source IP     : 172.16.1.2
Group IP      : 239.255.0.1
Nexthop       : 192.0.2.43
From          : 192.0.2.13
Res. Nexthop  : 0.0.0.0
Local Pref.   : 100                 Interface Name : NotAvailable
Aggregator AS : None                Aggregator     : None
Atomic Aggr.  : Not Atomic          MED            : 0
AIGP Metric   : None
Connector     : None
Community     : 64496:452 target:64496:10
Cluster       : 192.0.2.13
Originator Id : 192.0.2.43          Peer Router Id : 192.0.2.13
Flags         : Used  Valid  Best  IGP
Route Source  : Internal
AS-Path       : No As-Path
Neighbor-AS   : N/A
VPRN Imported :  10

Route Type    : Source-Ad
Route Dist.   : 64496:10
Source IP     : 172.16.3.2
Group IP      : 239.255.0.1
Nexthop       : 192.0.2.61
From          : 192.0.2.13
Res. Nexthop  : 0.0.0.0
Local Pref.   : 200                 Interface Name : NotAvailable
Aggregator AS : None                Aggregator     : None
Atomic Aggr.  : Not Atomic          MED            : 0
AIGP Metric   : None
Connector     : None
Community     : 64496:332 target:64496:10
Cluster       : 192.0.2.13
Originator Id : 192.0.2.61          Peer Router Id : 192.0.2.13
Flags         : Used  Valid  Best  IGP
Route Source  : Internal
AS-Path       : No As-Path
Neighbor-AS   : N/A
VPRN Imported :  10
```

```
-------------------------------------------------------------------------------
RIB Out Entries
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
Routes : 2
===============================================================================
```

Sender PE MVPN status

The MVPN status of the PE-1 sender PE is as follows:

```
*B:PE-1# show router 10 mvpn
===============================================================================
MVPN 10 configuration data
===============================================================================
signaling        : Bgp                 auto-discovery    : Default
UMH Selection    : Highest-Ip
intersite-shared : Disabled            Persist SA        : Disabled
vrf-import       : mvpn_10_import
vrf-export       : mvpn_10_export
vrf-target       : N/A
C-Mcast Import RT : target:192.0.2.43:2

ipmsi            : ldp
i-pmsi P2MP AdmSt : Up
i-pmsi Tunnel Name : mpls-if-73829
Mdt-type         : sender-receiver

s-pmsi           : none
data-delay-interval: 3 seconds
enable-asm-mdt   : N/A
===============================================================================
```

Note that the C-Mcast Import RT is set to <system-address>:<VPRN index>.

The VPRN index is derived from the command:

```
*B:PE-1# admin display-config index | match vprn10
        virtual-router "vprn10" 2 0
```

Any Source Join received must include this attribute along with the route target extended community. As previously stated, this is advertised within the VPN-IPV4 routes as a BGP attribute.

A source join is shown below, received from PE-2, to join (S,G) (172.16.1.2, 239.255.0.1).

```
*B:PE-1# show router bgp routes mvpn-ipv4 type source-join hunt
===============================================================================
 BGP Router ID:192.0.2.43      AS:64496        Local AS:64496
===============================================================================
 Legend -
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : i - IGP, e - EGP, ? - incomplete, > - best, b - backup
===============================================================================
BGP MVPN-IPv4 Routes
===============================================================================
-------------------------------------------------------------------------------
RIB In Entries
-------------------------------------------------------------------------------
```

```
Route Type      : Source-Join
Route Dist.     : 64496:10
Source AS       : 64496
Source IP       : 172.16.1.2
Group IP        : 239.255.0.1
Nexthop         : 192.0.2.45
From            : 192.0.2.13
Res. Nexthop    : 0.0.0.0
Local Pref.     : 100                   Interface Name : NotAvailable
Aggregator AS   : None                  Aggregator     : None
Atomic Aggr.    : Not Atomic            MED            : 0
AIGP Metric     : None
Connector       : None
Community       : target:64496:10 target:192.0.2.43:2
Cluster         : 192.0.2.13
Originator Id   : 192.0.2.45            Peer Router Id : 192.0.2.13
Flags           : Used  Valid  Best  IGP
Route Source    : Internal
AS-Path         : No As-Path
Neighbor-AS     : N/A
VPRN Imported   :  10
-------------------------------------------------------------------------------
RIB Out Entries
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
Routes : 1
===============================================================================
```

The PIM status for this group on sender PE-1 is shown below:

```
*B:PE-1# show router 10 pim group 239.255.0.1 source 172.16.1.2 detail
===============================================================================
PIM Source Group ipv4
===============================================================================
Group Address      : 239.255.0.1
Source Address     : 172.16.1.2
RP Address         : 10.10.10.11
Advt Router        : 192.0.2.43
Flags              : spt              Type               : (S,G)
MRIB Next Hop      : 172.16.1.2
MRIB Src Flags     : direct
Keepalive Timer Exp: 0d 00:00:20
Up Time            : 0d 03:47:22      Resolved By        : rtable-u

Up JP State        : Joined           Up JP Expiry       : 0d 00:00:00
Up JP Rpt          : Not Joined StarG  Up JP Rpt Override : 0d 00:00:00

Register State     : Pruned           Register Stop Exp  : 0d 00:00:12
Reg From Anycast RP: No

Rpf Neighbor       : 172.16.1.2
Incoming Intf      : int-PE-1-CE-1
Outgoing Intf List : mpls-if-73829

Curr Fwding Rate   : 21504.0 kbps
Forwarded Packets  : 26603799         Discarded Packets  : 0
Forwarded Octets   : 35755505856      RPF Mismatches     : 0
Spt threshold      : 0 kbps           ECMP opt threshold : 7
```

```
Admin bandwidth   : 1 kbps
--------------------------------------------------------------------------------
Groups : 1
================================================================================
```

The outgoing interface list is the I-PMSI, and traffic is seen to be flowing as the current forwarding rate is non-zero.

Similarly for sender PE-3, the MVPN status is:

```
*B:PE-3# show router 10 mvpn
================================================================================
MVPN 10 configuration data
================================================================================
signaling          : Bgp                  auto-discovery     : Default
UMH Selection      : Highest-Ip
intersite-shared   : Enabled              Persist SA         : Enabled
vrf-import         : mvpn_10_import
vrf-export         : mvpn_10_export
vrf-target         : N/A
C-Mcast Import RT  : target:192.0.2.61:3

ipmsi              : ldp
i-pmsi P2MP AdmSt  : Up
i-pmsi Tunnel Name : mpls-if-73819
Mdt-type           : sender-receiver

s-pmsi             : none
data-delay-interval: 3 seconds
enable-asm-mdt     : N/A


================================================================================
```

The Source-Join route on PE-3 for this multicast group is:

```
*B:PE-3# show router bgp routes mvpn-ipv4 type source-ad detail
================================================================================
 BGP Router ID:192.0.2.61      AS:64496        Local AS:64496
================================================================================
 Legend -
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : i - IGP, e - EGP, ? - incomplete, > - best, b - backup
================================================================================
BGP MVPN-IPv4 Routes
================================================================================
Route Type     : Source-Ad
Route Dist.    : 64496:10
Source IP      : 172.16.1.2
Group IP       : 239.255.0.1
Nexthop        : 192.0.2.43
From           : 192.0.2.13
Res. Nexthop   : 0.0.0.0
Local Pref.    : 100                   Interface Name : NotAvailable
Aggregator AS  : None                  Aggregator     : None
Atomic Aggr.   : Not Atomic            MED            : 0
```

```
AIGP Metric    : None
Connector      : None
Community      : 64496:452 target:64496:10
Cluster        : 192.0.2.13
Originator Id  : 192.0.2.43            Peer Router Id : 192.0.2.13
Flags          : Used  Valid  Best  IGP
Route Source   : Internal
AS-Path        : No As-Path
Neighbor-AS    : N/A
VPRN Imported  :  10


-------------------------------------------------------------------------------
Routes : 1
===============================================================================
```

The PIM state for this group is seen below:

```
*B:PE-3# show router 10 pim group 239.255.0.1 source 172.16.3.2 detail
===============================================================================
PIM Source Group ipv4
===============================================================================
Group Address     : 239.255.0.1
Source Address    : 172.16.3.2
RP Address        : 10.10.10.10
Advt Router       : 192.0.2.61
Flags             : spt            Type             : (S,G)
MRIB Next Hop     : 172.16.3.2
MRIB Src Flags    : direct
Keepalive Timer Exp: 0d 00:00:13
Up Time           : 0d 03:50:59    Resolved By      : rtable-u

Up JP State       : Joined         Up JP Expiry     : 0d 00:00:00
Up JP Rpt         : Not Joined StarG  Up JP Rpt Override : 0d 00:00:00

Register State    : Pruned         Register Stop Exp : 0d 00:00:29
Reg From Anycast RP: No

Rpf Neighbor      : 172.16.3.2
Incoming Intf     : int-PE3-CE-3
Outgoing Intf List : mpls-if-73819

Curr Fwding Rate  : 10703.9 kbps
Forwarded Packets : 13518483       Discarded Packets : 0
Forwarded Octets  : 18168841152    RPF Mismatches    : 0
Spt threshold     : 0 kbps         ECMP opt threshold : 7
Admin bandwidth   : 1 kbps
-------------------------------------------------------------------------------
Groups : 1
===============================================================================
```

Note that the preferred source remains active unless:

- The multicast source ceases to exist, the source PE withdraws the Source Active AD route
- Or a Source Active AD is received with a higher local preference.

Conclusion

MVPN Source Redundancy provides an optimal solution for multicast routing in a VPRN. This protocol provides simple configuration, operation and guaranteed fast protection time. It could be utilized in a regionalized IPTV solution where multiple sources for the same TV channel are used.