EVPN MPLS Multi-Homing

This chapter describes how to configure EVPN MPLS Multi-Homing on EVPN E-LAN and EVPN E-Line services.

EVPN MPLS Multi-Homing

Table 1: Feature History Table

Feature Name	Release Information	Feature Description
EVPN MPLS Multi-Homing on 8212-48FH-M, 8711-32FH-M, 88-LC1-52Y8H-EM, and 88-LC1-12TH24FH-E	Release 24.3.1	The EVPN MPLS multi-homing is now supported on these fixed systems and line cards: • 8212-48FH-M • 8711-32FH-M • 88-LC1-52Y8H-EM • 88-LC1-12TH24FH-E
EVPN MPLS Multi-Homing	Release 24.2.11	EVPN multi-homing enables you to connect a customer edge (CE) device to two or more provider edge (PE) devices to provide redundant connectivity. When the primary link fails, the standby PE device becomes active immediately, ensuring no traffic disruption and providing faster convergence. This feature is supported only on routers with the 88-LC1-36EH line cards.

In EVPN MPLS multi-homing mode, you can connect a customer edge (CE) device to more than one provider edge (PE) device to ensure redundant connectivity. The redundant PE device ensures that there is no traffic disruption when there is a network failure.

The following types of multi-homing are supported:

- Single-Active - In this mode, only a single PE among a group of PEs attached to the particular Ethernet-Segment is allowed to forward traffic to and from that Ethernet Segment.

- All-Active - In this mode, all PEs attached to the particular Ethernet-Segment is allowed to forward traffic to and from that Ethernet Segment.

- Port-Active - In this mode, only the PE which is in the active mode sends and receives the traffic. This mode supports single-active redundancy load balancing at the port-level or the interface-level.

- Single-Flow-Active - In this mode, only the PE that first advertises the host MAC address in a VLAN forwards the traffic in a specific flow.

EVPN E-LAN Single-Active Multi-Homing

In EVPN E-LAN single-active mode, the PE nodes locally connected to an Ethernet Segment load balance traffic to and from the Ethernet Segment based on EVPN service instance (EVI). Within an EVPN service instance, only one PE forwards traffic to and from the Ethernet Segment.

In a ring topology, only one of the PEs, which is the active PE, sends and receives the traffic to prevent a traffic loop. When the link to the active PE fails, the traffic switches over to the standby PE. Traffic switchover takes a while because the standby PE has to learn the MAC addresses of the connected hosts. There is a traffic loss until the traffic switch over happens.

EVPN E-LAN single-active multi-homing enables you to connect a customer edge (CE) device to more than one provider edge (PE) device with redundant connectivity. In single-active mode, only a single PE among a group of PEs attached to the particular Ethernet segment is allowed to forward traffic to and from that Ethernet segment. In this mode, only the PE that first advertises the host MAC address in a VLAN forwards the traffic in a specific flow.

When the primary link fails, the traffic quickly switches to the standby PE that learns the MAC address from the originated path, thereby providing fast convergence. This also enables load balancing of traffic to and from the Ethernet Segment based on EVPN service instance (EVI).

The following image illustrates an EVPN E-LAN single-active multi-homing topology.

Figure 1: EVPN E-LAN Single-Active Multi-Homing
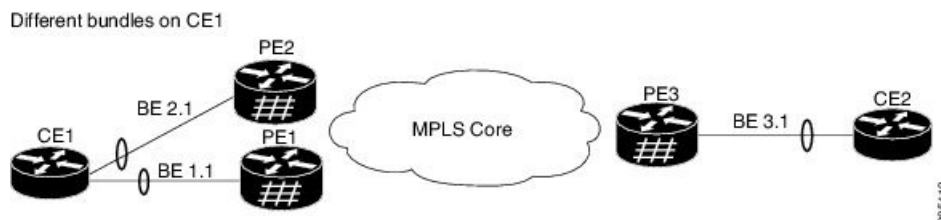
In this topology, CE1 is multi-homed to PE1 and PE2. The PE1 and PE2 are connected to PE3 through MPLS core. CE2 is connected to PE3 through an Ethernet interface bundle. PE1 and PE2 advertise Type 4 routes to elect the designated forwarder (DF). The non-DF blocks the traffic in both the directions in single-active mode. In this example, PE1 is elected as the DF and PE2 is the non-DF.

The traffic flow from CE1 and CE2 happens as follows:

- CE1 sends an address resolution protocol (ARP) broadcast request to both PE1 and PE2.

- As PE1 is the designated forwarder for the EVI, PE1 forwards the ARP request from CE1.

- PE2, the non-DF, drops the traffic from CE1.

- All the traffic is sent through PE1. PE2 remains as a standby device and traffic is not sent through PE2.

- PE1 advertises MAC routes to PE3 and PE3 always sends and receives traffic through PE1.

- PE3 sends the traffic to CE2 over Ethernet interface bundle.

When there is a link failure and the active PE1 goes down, PE2 becomes active to continue with the traffic flow.

Configure EVPN Single-Active Multi-homing

Perform the following configuration on PE1, PE2, and PE3.

1. Configure BGP session and MPLS Label Distribution Protocol (LDP) to enable EVPN.

2. Configure EVPN EVI parameters and advertisement of MAC routes.

3. Enter the bundle interface mode and configure the Ethernet segment identifier (ESI) for the interface.

4. Ensure that you configure the same ESI on all the PEs.

5. Enable single-active mode by using the **load-balancing-mode single-active** command.

Configuration Example

```
/* PE1 Configuration */

/* Configure BGP Session */

Router(config)# router bgp 100
Router(config-bgp)# bgp router-id 54.54.54.54
Router(config-bgp)# address-family l2vpn evpn
Router(config-bgp)# neighbor 51.51.51.51
Router(config-bgp-nbr)# remote-as 100
Router(config-bgp-nbr)# update-source Loopback 0
Router(config-bgp-nbr)# address-family l2vpn evpn
Router(config-bgp)# neighbor 55.55.55.55
Router(config-bgp-nbr)# remote-as 100
Router(config-bgp-nbr)# update-source Loopback 0
Router(config-bgp-nbr)# address-family l2vpn evpn

/* Configure MPLS LDP */
Router(config)# mpls ldp
Router(config-ldp)# router-id 54.54.54.54
Router(config-ldp)# interface FourHundredGigE0/0/0/2

/* PE2 Configuration */

/* Configure BGP Session */

Router(config)# router bgp 100
Router(config-bgp)# bgp router-id 55.55.55.55
Router(config-bgp)# address-family l2vpn evpn
```

```
Router(config-bgp)# neighbor 51.51.51.51
Router(config-bgp-nbr)# remote-as 100
Router(config-bgp-nbr)# update-source Loopback 0
Router(config-bgp-nbr)# address-family l2vpn evpn
Router(config-bgp)# neighbor 54.54.54.54
Router(config-bgp-nbr)# remote-as 100
Router(config-bgp-nbr)# update-source Loopback 0
Router(config-bgp-nbr)# address-family l2vpn evpn

/* Configure MPLS LDP */
Router(config)# mpls ldp
Router(config-ldp)# router-id 55.55.55.55
Router(config-ldp)# interface FourHundredGigE0/0/0/2

/* PE3 Configuration */

/* Configure BGP Session */

Router(config)# router bgp 100
Router(config-bgp)# bgp router-id 51.51.51.51
Router(config-bgp)# address-family l2vpn evpn
Router(config-bgp)# neighbor 54.54.54.54
Router(config-bgp-nbr)# remote-as 100
Router(config-bgp-nbr)# update-source Loopback 0
Router(config-bgp-nbr)# address-family l2vpn evpn
Router(config-bgp)# neighbor 55.55.55.55
Router(config-bgp-nbr)# remote-as 100
Router(config-bgp-nbr)# update-source Loopback 0
Router(config-bgp-nbr)# address-family l2vpn evpn

/* Configure MPLS LDP */
Router(config)# mpls ldp
Router(config-ldp)# router-id 51.51.51.51
Router(config-ldp)# interface FourHundredGigE0/0/0/2

/* Configure Bridge Domain and EVI on PE1, PE2, and PE3 */
Router(config)# l2vpn
Router(config-l2vpn)# bridge group bg1
Router(config-l2vpn-bg)# bridge-domain bd1
Router(config-l2vpn-bg-bd)# interface Bundle-Ether1.1
Router(config-l2vpn-bg-bd-ac)# evi 1
Router(config-l2vpn-bg-bd-ac)# root

Router(config)# l2vpn
Router(config-l2vpn)# bridge group bg2
Router(config-l2vpn-bg)# bridge-domain bd2
Router(config-l2vpn-bg-bd)# interface Bundle-Ether1.2
Router(config-l2vpn-bg-bd-ac)# evi 2

/* Configure EVPN EVI and advertise the MAC routes on PE1, PE2, and PE3 */
Router(config)# evpn
Router(config-evpn)# evi 1
Router(config-evpn-evi)# advertise-mac
Router(config-evpn-evi)# exit
Router(config-evpn)# evi 2
Router(config-evpn-evi)# advertise-mac

/* Configure the same ESI on all the PE Routers */
Router(config)# evpn
Router(config-evpn)# interface Bundle-Ether1
Router(config-evpn-ac)# ethernet-segment
Router(config-evpn-ac-es)# identifier type 0 40.00.00.00.00.00.00.00.01
Router(config-evpn-ac-es)# load-balancing-mode single-active
Router(config-evpn-ac-es)# commit
```

Running Configuration

```
/* PE1 Configuration */
router bgp 100
 bgp router-id 54.54.54.54
 address-family l2vpn evpn
 !
 neighbor 51.51.51.51
  remote-as 100
  update-source Loopback0
  address-family l2vpn evpn
  !
 !
 neighbor 55.55.55.55
  remote-as 100
  update-source Loopback0
  address-family l2vpn evpn
  !
 !
!
mpls ldp
 router-id 54.54.54.54
 interface FourHundredGigE0/0/0/2
 !
!


/* PE2 Configuration */
router bgp 100
 bgp router-id 55.55.55.55
 address-family l2vpn evpn
 !
 neighbor 51.51.51.51
  remote-as 100
  update-source Loopback0
  address-family l2vpn evpn
  !
 !
 neighbor 54.54.54.54
  remote-as 100
  update-source Loopback0
  address-family l2vpn evpn
  !
 !
!
mpls ldp
 router-id 55.55.55.55
 interface FourHundredGigE0/0/0/2
 !
!


/* PE3 Configuration */
router bgp 100
 bgp router-id 51.51.51.51
 address-family l2vpn evpn
 !
 neighbor 54.54.54.54
  remote-as 100
  update-source Loopback0
  address-family l2vpn evpn
  !
 !
 neighbor 55.55.55.55
```

```
    remote-as 100
    update-source Loopback0
    address-family l2vpn evpn
    !
   !
  !
!
mpls ldp
 router-id 51.51.51.51
 interface FourHundredGigE0/0/0/3
 !
!

/* Configuration on all the PEs */
l2vpn
 bridge group bg1
  bridge-domain bd1
   interface Bundle-Ether1.1
   !
   evi 1
   !
  !
 !
 bridge group bg2
  bridge-domain bd2
   interface Bundle-Ether1.2
   !
   evi 2
   !
  !
 !
!
evpn
 evi 1
  advertise-mac
  !
 !
 evi 2
  advertise-mac
  !
 !
 interface Bundle-Ether1
  ethernet-segment
   identifier type 0 40.00.00.00.00.00.00.00.01
   load-balancing-mode single-active
  !
 !
!
```

Verification

The following output shows configuration of single-active mode on PE1:

```
Router#show evpn ethernet-segment interface BE1 carving detail


Ethernet Segment Id      Interface                          Nexthops
------------------------ ---------------------------------- --------------------
0040.0000.0000.0000.0001 BE1                                54.54.54.54
                                                            55.55.55.55
  ES to BGP Gates   : Ready
  ES to L2FIB Gates : Ready
  Main port         :
     Interface name : Bundle-Ether1
```

```
         Interface MAC  : 008d.9c38.7205
         IfHandle       : 0x0f00003c
         State          : Up
         Redundancy     : Not Defined
ESI ID            : 1
ESI type          : 0
    Value         : 0040.0000.0000.0000.0001
ES Import RT      : 4000.0000.0000 (from ESI)
Topology          :
    Operational   : MH, Single-active
    Configured    : Single-active (AApS)
Service Carving   : Auto-selection
    Multicast     : Disabled
Convergence       :
Peering Details   : 2 Nexthops
    54.54.54.54 [MOD:P:00:T]
    55.55.55.55 [MOD:P:00:T]
Service Carving Synchronization:
    Mode          : NONE
    Peer Updates  :
            54.54.54.54 [SCT: N/A]
            55.55.55.55 [SCT: 2024-03-12 10:42:30.1710254]
Service Carving Results:
    Forwarders    : 2
    Elected       : 1
            EVI E  :        2
    Not Elected   : 1
            EVI NE :        1
EVPN-VPWS Service Carving Results:
    Primary       : 0
    Backup        : 0
    Non-DF        : 0
MAC Flush msg     : STP-TCN
Peering timer     : 3 sec [not running]
Recovery timer    : 30 sec [not running]
Carving timer     : 0 sec [not running]
Revert timer      : 0 sec [not running]
HRW Reset timer   : 5 sec [not running]
Local SHG label   : 24004
Remote SHG labels : 1
            24004 : nexthop 55.55.55.55
Access signal mode: Bundle OOS
```
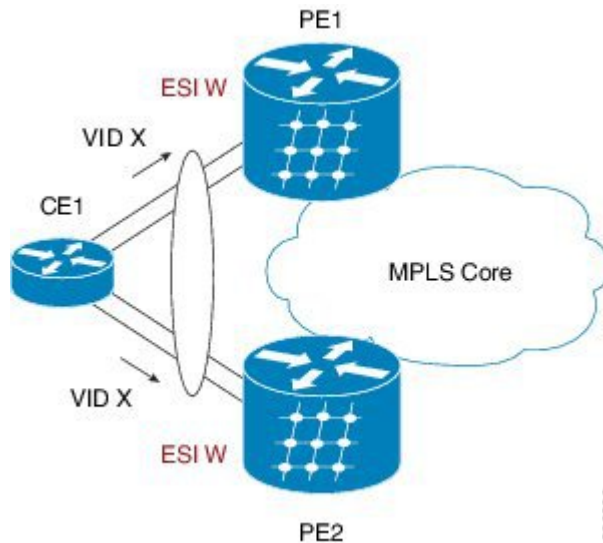
EVPN E-LAN All-Active Multi-Homing

In all-active multi-homing mode, a device is connected to multiple PEs and all the links actively forward the traffic on that Ethernet Segment.

Figure 2: EVPN E-LAN All-Active Multi-homing

All-active load-balancing is known as Active/Active per Flow (AApF). In the above topology, identical Ethernet Segment Identifier is used on both EVPN PEs. PEs are attached to Ethernet Segment using bundle interfaces. In the CE, single bundles are configured towards two EVPN PEs. In this mode, both PE1 and PE2 can forward the traffic within the same EVI.

Configure EVPN E-LAN All-Active Multi-Homing

Perform the following tasks on both PE1 and PE2.

1. Configure BGP session and MPLS Label Distribution Protocol (LDP) to enable EVPN.

2. Configure EVPN EVI parameters and advertisement of MAC routes.

3. Enter the bundle interface mode and configure the Ethernet segment identifier (ESI) for the interface.

4. Ensure that you configure the same ESI on all the PEs.

Configuration Example

```
/* PE1 Configuration */

/* Configure BGP Session */

Router(config)# router bgp 100
Router(config-bgp)# bgp router-id 54.54.54.54
Router(config-bgp)# address-family l2vpn evpn
Router(config-bgp)# neighbor 51.51.51.51
Router(config-bgp-nbr)# remote-as 100
Router(config-bgp-nbr)# update-source Loopback 0
Router(config-bgp-nbr)# address-family l2vpn evpn
Router(config-bgp)# neighbor 55.55.55.55
Router(config-bgp-nbr)# remote-as 100
Router(config-bgp-nbr)# update-source Loopback 0
Router(config-bgp-nbr)# address-family l2vpn evpn
```

```
/* Configure MPLS LDP */
Router(config)# mpls ldp
Router(config-ldp)# router-id 54.54.54.54
Router(config-ldp)# interface FourHundredGigE0/0/0/2

/* PE2 Configuration */

/* Configure BGP Session */

Router(config)# router bgp 100
Router(config-bgp)# bgp router-id 55.55.55.55
Router(config-bgp)# address-family l2vpn evpn
Router(config-bgp)# neighbor 51.51.51.51
Router(config-bgp-nbr)# remote-as 100
Router(config-bgp-nbr)# update-source Loopback 0
Router(config-bgp-nbr)# address-family l2vpn evpn
Router(config-bgp)# neighbor 54.54.54.54
Router(config-bgp-nbr)# remote-as 100
Router(config-bgp-nbr)# update-source Loopback 0
Router(config-bgp-nbr)# address-family l2vpn evpn

/* Configure MPLS LDP */
Router(config)# mpls ldp
Router(config-ldp)# router-id 55.55.55.55
Router(config-ldp)# interface FourHundredGigE0/0/0/2

/* Configure Bridge Domain and EVI on PE1 and PE2 */
Router(config)# l2vpn
Router(config-l2vpn)# bridge group bg1
Router(config-l2vpn-bg)# bridge-domain bd1
Router(config-l2vpn-bg-bd)# interface Bundle-Ether11.1
Router(config-l2vpn-bg-bd-ac)# evi 1
Router(config-l2vpn-bg-bd-ac)# root

Router(config)# l2vpn
Router(config-l2vpn)# bridge group bg2
Router(config-l2vpn-bg)# bridge-domain bd2
Router(config-l2vpn-bg-bd)# interface Bundle-Ether11.2
Router(config-l2vpn-bg-bd-ac)# evi 2

/* Configure EVPN EVI and advertise the MAC routes on PE1 and PE2 */
Router(config)# evpn
Router(config-evpn)# evi 1
Router(config-evpn-evi)# advertise-mac
Router(config-evpn-evi)# exit
Router(config-evpn)# evi 2
Router(config-evpn-evi)# advertise-mac


/* Configure the same ESI on all the PE Routers */
Router(config)# evpn
Router(config-evpn)# interface Bundle-Ether11
Router(config-evpn-ac)# ethernet-segment
Router(config-evpn-ac-es)# identifier type 0 40.00.00.00.00.00.00.00.01
Router(config-evpn-ac-es)# commit
```

Running Configuration

```
/* PE1 Configuration */
router bgp 100
 bgp router-id 54.54.54.54
 address-family l2vpn evpn
 !
 neighbor 51.51.51.51
```

```
   remote-as 100
   update-source Loopback0
   address-family l2vpn evpn
   !
  !
  neighbor 55.55.55.55
   remote-as 100
   update-source Loopback0
   address-family l2vpn evpn
   !
  !
 !
mpls ldp
 router-id 54.54.54.54
 interface FourHundredGigE0/0/0/2
 !
!


/* PE2 Configuration */
router bgp 100
 bgp router-id 55.55.55.55
 address-family l2vpn evpn
 !
 neighbor 51.51.51.51
  remote-as 100
  update-source Loopback0
  address-family l2vpn evpn
  !
 !
 neighbor 54.54.54.54
  remote-as 100
  update-source Loopback0
  address-family l2vpn evpn
  !
 !
!
mpls ldp
 router-id 55.55.55.55
 interface FourHundredGigE0/0/0/2
 !
!

/* Configuration on all the PEs */
l2vpn
 bridge group bg1
  bridge-domain bd1
   interface Bundle-Ether11.1
   !
   evi 1
   !
  !
 !
 bridge group bg2
  bridge-domain bd2
   interface Bundle-Ether11.2
   !
   evi 2
   !
  !
 !
!
evpn
 evi 1
  advertise-mac
```

```
 !
 !
 evi 2
  advertise-mac
  !
 !
 interface Bundle-Ether11
  ethernet-segment
   identifier type 0 40.00.00.00.00.00.00.00.01
  !
 !
!
```

Verification

The following output shows configuration of all-active mode:

```
Router#show evpn ethernet-segment int Bundle-Ether 11 carving detail

Ethernet Segment Id     Interface                        Nexthops
----------------------- -------------------------------- --------------------
0040.0000.0000.0000.0001 BE11                            54.54.54.54
                                                         55.55.55.55
  ES to BGP Gates   : Ready
  ES to L2FIB Gates : Ready
  Main port         :
     Interface name : Bundle-Ether11
     Interface MAC  : 008d.9c38.7205
     IfHandle       : 0x0f00001c
     State          : Up
     Redundancy     : Not Defined
  ESI ID            : 1
  ESI type          : 0
     Value          : 0040.0000.0000.0000.0001
  ES Import RT       : 4000.0000.0000 (from ESI)
  Topology          :
     Operational    : MH, All-active
     Configured     : All-active (AApF) (default)
  Service Carving   : Auto-selection
     Multicast      : Disabled
  Convergence       :
  Peering Details   : 2 Nexthops
     54.54.54.54 [MOD:P:00:T]
     55.55.55.55 [MOD:P:00:T]
  Service Carving Synchronization:
     Mode           : NONE
     Peer Updates   :
           54.54.54.54 [SCT: N/A]
           55.55.55.55 [SCT: N/A]
  Service Carving Results:
     Forwarders     : 2
     Elected        : 1
           EVI E    :         2
     Not Elected    : 1
           EVI NE   :         1
  EVPN-VPWS Service Carving Results:
     Primary        : 0
     Backup         : 0
     Non-DF         : 0
  MAC Flush msg     : STP-TCN
  Peering timer     : 3 sec [not running]
  Recovery timer    : 30 sec [not running]
  Carving timer     : 0 sec [not running]
```

```
Revert timer      : 0 sec [not running]
HRW Reset timer   : 5 sec [not running]
Local SHG label   : 24004
Remote SHG labels : 1
          24004 : nexthop 55.55.55.55
Access signal mode: Bundle OOS
```

EVPN E-LAN Port-Active Multi-Homing

The EVPN E-LAN port-active multi-homing feature supports single-active redundancy load balancing at the port-level or the interface-level. You can use this feature when you want to forward the traffic to a specific interface, rather than have a per-flow load balancing across multiple PE routers. This feature provides a faster convergence during a link failure. This feature enables protocol simplification as only one of the physical ports is active at a given time. You can enable this feature only on bundle interfaces.

EVPN E-LAN port-active provides protocol simplification compared to Inter-Chassis Communication Protocol (ICCP), which runs on top of Label Distribution Protocol (LDP). You can use this feature as an alternative to multi-chassis link aggregation group (MC-LAG) with ICCP.

Also, you can use this feature when you want certain QoS features to work.

This feature allows one of the PEs to be in active mode and another in the standby mode at the port-level. Only the PE which is in the active mode sends and receives the traffic. The other PE remains in the standby mode. The PEs use the Designated Forwarder (DF) election mechanism to determine which PE must be in the active mode and which must be in the standby mode. You can use either modulo or Highest Random Weight (HRW) algorithm for per port DF election. By default, the modulo algorithm is used for per port DF election.

Figure 3: EVPN E-LAN Port-Active Multi-Homing
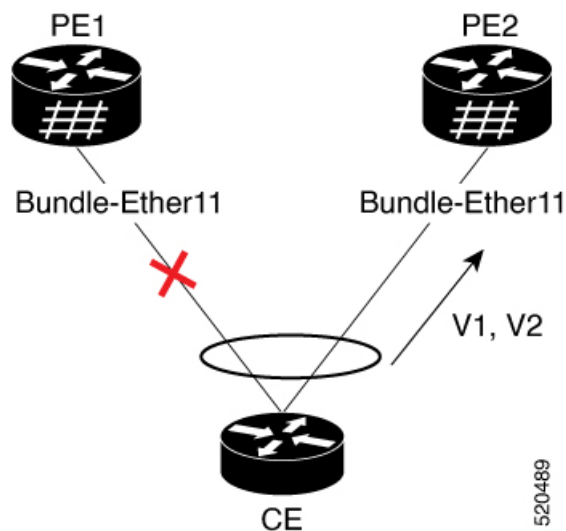
Consider a topology where the customer edge device (CE) is multi-homed to provider edge devices, PE1 and PE2. Use single link aggregation at the CE. Only one of the two interfaces is in the forwarding state, and the other interface is in the standby state. In this topology, PE2 is in the active mode and PE1 is in the standby mode. Hence, PE2 carries traffic from the CE. All services on the PE2 interface operate in the active mode. All services on the PE1 operate in the standby mode.

If you remove the port-active configuration on both PE1 and PE2 and then add back the port-active configuration on both the PEs, PE2 is chosen as an active interface again.

Configure EVPN Port-Active Multi-homing

Perform the following configuration on PE1 and PE2.

1. Configure BGP session and MPLS Label Distribution Protocol (LDP) to enable EVPN.

2. Configure EVPN EVI parameters and advertisement of MAC routes.

3. Enter the bundle interface mode and configure the Ethernet segment identifier (ESI) for the interface.

4. Ensure that you configure the same ESI on all the PEs.

5. Enable single-active mode by using the **load-balancing-mode port-active** command.

Configuration Example

```
/* PE1 Configuration */

/* Configure BGP Session */

Router(config)# router bgp 100
Router(config-bgp)# bgp router-id 55.55.55.55
Router(config-bgp)# address-family l2vpn evpn
Router(config-bgp)# neighbor 51.51.51.51
Router(config-bgp-nbr)# remote-as 100
Router(config-bgp-nbr)# update-source Loopback 0
Router(config-bgp-nbr)# address-family l2vpn evpn
Router(config-bgp)# neighbor 54.54.54.54
Router(config-bgp-nbr)# remote-as 100
Router(config-bgp-nbr)# update-source Loopback 0
Router(config-bgp-nbr)# address-family l2vpn evpn

/* Configure MPLS LDP */
Router(config)# mpls ldp
Router(config-ldp)# router-id 55.55.55.55
Router(config-ldp)# interface FourHundredGigE0/0/0/2

/* PE2 Configuration */

/* Configure BGP Session */

Router(config)# router bgp 100
Router(config-bgp)# bgp router-id 54.54.54.54
Router(config-bgp)# address-family l2vpn evpn
Router(config-bgp)# neighbor 51.51.51.51
Router(config-bgp-nbr)# remote-as 100
Router(config-bgp-nbr)# update-source Loopback 0
Router(config-bgp-nbr)# address-family l2vpn evpn
Router(config-bgp)# neighbor 55.55.55.55
Router(config-bgp-nbr)# remote-as 100
Router(config-bgp-nbr)# update-source Loopback 0
Router(config-bgp-nbr)# address-family l2vpn evpn

/* Configure MPLS LDP */
Router(config)# mpls ldp
Router(config-ldp)# router-id 54.54.54.54
Router(config-ldp)# interface FourHundredGigE0/0/0/2
```

```
/* Configure Bridge Domain and EVI on PE1 and PE2 */
Router(config)# l2vpn
Router(config-l2vpn)# bridge group bg1
Router(config-l2vpn-bg)# bridge-domain bd1
Router(config-l2vpn-bg-bd)# interface Bundle-Ether11.1
Router(config-l2vpn-bg-bd-ac)# evi 1
Router(config-l2vpn-bg-bd-ac)# root

Router(config)# l2vpn
Router(config-l2vpn)# bridge group bg2
Router(config-l2vpn-bg)# bridge-domain bd2
Router(config-l2vpn-bg-bd)# interface Bundle-Ether11.2
Router(config-l2vpn-bg-bd-ac)# evi 2

/* Configure EVPN EVI and advertise the MAC routes on PE1 and PE2 */
Router(config)# evpn
Router(config-evpn)# evi 1
Router(config-evpn-evi)# advertise-mac
Router(config-evpn-evi)# exit
Router(config-evpn)# evi 2
Router(config-evpn-evi)# advertise-mac


/* Configure the same ESI on all the PE Routers */
Router(config)# evpn
Router(config-evpn)# interface Bundle-Ether11
Router(config-evpn-ac)# ethernet-segment
Router(config-evpn-ac-es)# identifier type 0 40.00.00.00.00.00.00.00.01
Router(config-evpn-ac-es)# load-balancing-mode port-active
Router(config-evpn-ac-es)# commit
```

Running Configuration

```
/* PE1 Configuration */
router bgp 100
 bgp router-id 55.55.55.55
 address-family l2vpn evpn
 !
 neighbor 51.51.51.51
  remote-as 100
  update-source Loopback0
  address-family l2vpn evpn
  !
 !
 neighbor 54.54.54.54
  remote-as 100
  update-source Loopback0
  address-family l2vpn evpn
  !
 !
!
mpls ldp
 router-id 55.55.55.55
 interface FourHundredGigE0/0/0/2
 !
!


/* PE2 Configuration */
router bgp 100
 bgp router-id 54.54.54.54
 address-family l2vpn evpn
 !
```

```
 neighbor 51.51.51.51
  remote-as 100
  update-source Loopback0
  address-family l2vpn evpn
  !
 !
 neighbor 55.55.55.55
  remote-as 100
  update-source Loopback0
  address-family l2vpn evpn
  !
 !
!
mpls ldp
 router-id 54.54.54.54
 interface FourHundredGigE0/0/0/2
 !
!

/* Configuration on all the PEs */
l2vpn
 bridge group bg1
  bridge-domain bd1
   interface Bundle-Ether11.1
   !
   evi 1
   !
  !
 !
 bridge group bg2
  bridge-domain bd2
   interface Bundle-Ether11.2
   !
   evi 2
   !
  !
 !
!
evpn
 evi 1
  advertise-mac
  !
 !
 evi 2
  advertise-mac
  !
 !
 interface Bundle-Ether11
  ethernet-segment
   identifier type 0 40.00.00.00.00.00.00.00.01
   load-balancing-mode port-active
  !
 !
!
```

Verification

The following output shows configuration of port-active mode:

```
/* PE2 is in active mode and is Up */
Router# show bundle BE11
Bundle-Ether11
  Status:                               Up
  Local links <active/standby/configured>:   1 / 0 / 1
```

```
Local bandwidth <effective/available>:    400000000 (400000000) kbps
MAC address (source):                     008d.9c38.7205 (Chassis pool)
Inter-chassis link:                       No
Minimum active links / bandwidth:         1 / 1 kbps
Maximum active links:                     64
Wait while timer:                         2000 ms
Load balancing:
  Link order signaling:                   Not configured
  Hash type:                              Default
  Locality threshold:                     None
LACP:                                     Operational
  Flap suppression timer:                 Off
  Cisco extensions:                       Disabled
  Non-revertive:                          Disabled
mLACP:                                    Not configured
IPv4 BFD:                                 Not configured
IPv6 BFD:                                 Not configured

Port                Device          State       Port ID         B/W, kbps
------------------- --------------- ----------- --------------- ----------
FH0/0/0/3           Local           Active      0x8000, 0x0001  400000000
      Link is Active


/* PE1 is in standby mode */

Router#show bundle BE11
Bundle-Ether11
  Status:                                 EVPN Hot-Standby
  Local links <active/standby/configured>: 0 / 1 / 1
  Local bandwidth <effective/available>:  0 (0) kbps
  MAC address (source):                   003f.ee3b.5a05 (Chassis pool)
  Inter-chassis link:                     No
  Minimum active links / bandwidth:       1 / 1 kbps
  Maximum active links:                   64
  Wait while timer:                       2000 ms
  Load balancing:
    Link order signaling:                 Not configured
    Hash type:                            Default
    Locality threshold:                   None
  LACP:                                   Operational
    Flap suppression timer:               Off
    Cisco extensions:                     Disabled
    Non-revertive:                        Disabled
  mLACP:                                  Not configured
  IPv4 BFD:                               Not configured
  IPv6 BFD:                               Not configured

Port                Device          State       Port ID         B/W, kbps
------------------- --------------- ----------- --------------- ----------
FH0/0/0/6           Local           Standby     0x8000, 0x0001  400000000
    Link is in standby due to bundle out of service state




/* The following output shows port-active mode configuration */

Router#show evpn ethernet-segment int Bundle-Ether 11 carving detail

Ethernet Segment Id     Interface                         Nexthops
----------------------- --------------------------------- --------------------
0040.0000.0000.0000.0001 BE11                             54.54.54.54
                                                          55.55.55.55

  ES to BGP Gates   : Ready
```

```
ES to L2FIB Gates : Ready
Main port         :
   Interface name : Bundle-Ether11
   Interface MAC  : 008d.9c38.7205
   IfHandle       : 0x0f00005c
   State          : Up
   Redundancy     : Not Defined
ESI ID            : 1
ESI type          : 0
   Value          : 0040.0000.0000.0000.0001
ES Import RT       : 4000.0000.0000 (from ESI)
Topology          :
   Operational    : MH
   Configured     : Port-Active
Service Carving   : Auto-selection
   Multicast      : Disabled
Convergence       :
Peering Details   : 2 Nexthops
   54.54.54.54 [MOD:P:00:T]
   55.55.55.55 [MOD:P:00:T]
Service Carving Synchronization:
   Mode           : NTP_SCT
   Peer Updates   :
           54.54.54.54 [SCT: 2024-03-12 10:58:28.1710255]
           55.55.55.55 [SCT: 2024-03-12 10:58:47.1710255]
Service Carving Results:
   Forwarders     : 2
   Elected        : 2
           EVI E  :          1,       2
   Not Elected    : 0
EVPN-VPWS Service Carving Results:
   Primary        : 0
   Backup         : 0
   Non-DF         : 0
MAC Flush msg     : STP-TCN
Peering timer     : 3 sec [not running]
Recovery timer    : 30 sec [not running]
Carving timer     : 0 sec [not running]
Revert timer      : 0 sec [not running]
HRW Reset timer   : 5 sec [not running]
Local SHG label   : 24004
Remote SHG labels : 1
           24004 : nexthop 55.55.55.55
Access signal mode: Bundle Hot-Standby
```

EVPN E-LAN Single-Flow-Active Multi-Homing

Table 2: Feature History Table

Feature Name	Release Information	Feature Description
EVPN E-LAN Single-Flow-Active Multi-Homing on 8212-48FH-M, 8711-32FH-M, 88-LC1-52Y8H-EM, and 88-LC1-12TH24FH-E	Release 24.3.1	EVPN E-LAN single-flow-active multi-homing is now supported on these fixed systems and line cards: • 8212-48FH-M • 8711-32FH-M • 88-LC1-52Y8H-EM • 88-LC1-12TH24FH-E
EVPN E-LAN Single-Flow-Active Multi-Homing	Release 24.2.11	This feature introduces EVPN E-LAN single-flow-active multi-homing load balancing mode to connect PE devices in an access network that run Layer 2 access gateway protocols. In this mode, only the PE that first advertises the host MAC address in a VLAN forwards the traffic in a specific flow. When the primary link fails, the traffic quickly switches to the standby PE that learns the MAC address from the originated path, thereby providing fast convergence. The feature introduces the **load-balancing-mode** command with keyword, **single-flow-active**. This feature is supported only on routers with the 88-LC1-36EH line cards.

In a ring topology, only one of the PEs, which is the active PE, sends and receives the traffic to prevent a traffic loop. When the link to the active PE fails, the traffic switches over to the standby PE. Traffic switchover takes a while because the standby PE has to learn the MAC addresses of the connected hosts. There's a traffic loss until the traffic switch over happens.

The EVPN E-LAN single-flow-active multi-homing mode connects PE devices in an access network, and in the event of active link failure the switchover happens immediately and reduces the traffic loss.

Both active and standby PEs learn the MAC addresses of the connected host. The PE that learns the MAC address of the host directly is called the Primary (active) PE. The primary PE advertises the learnt MAC addresses to the peer PE, which is referred as standby PE. As the standby PE learns the MAC address of the host through the active PE, this learnt path is referred to as the reoriginated path.

When the primary link fails, the convergence happens fast and the traffic is sent through the standby PE (reoriginated path).

Let us understand how EVPN E-LAN single flow-active mode helps in fast convergence:

- In this topology, the access network devices are connected through a ring topology. The access network uses Layer-2 gateway protocols such as G.8032, MPLS-TP, REP-AG or MSTP-AG to prevent traffic loop due to continuous flooding.
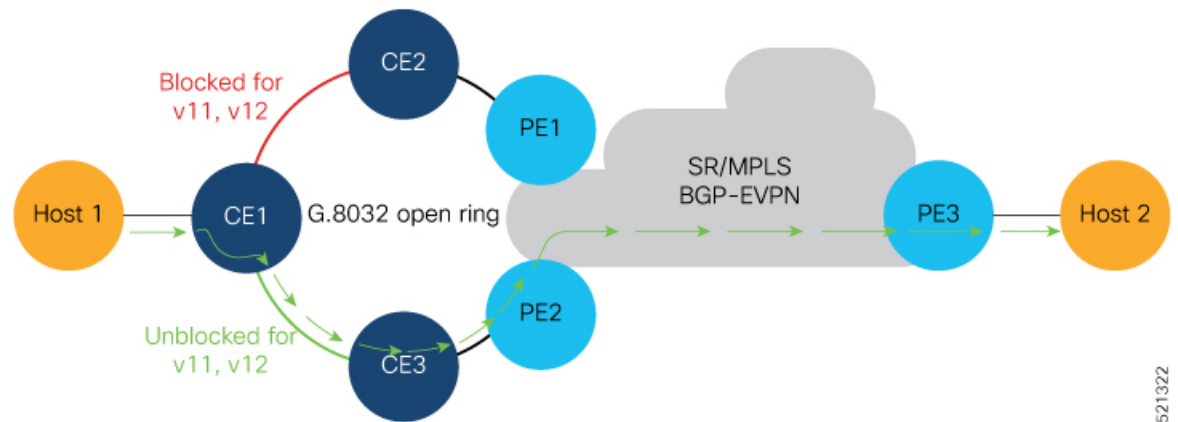

- Host 1 is connected to CE1.

- CE1 is connected to both PE1 and PE2, thus is multihomed.

- PE1 and PE2 are Multihoming devices.

- Both PE1 and PE2 is configured with the same non-zero Ethernet Segment ID (ESI) number `0 36.37.00.00.00.00.00.11.00` for the bundle interface to enable multihoming of the host (CE1).

- PE1 and PE2 belongs to te same VLAN and hence configured with the same EVPN instance (EVI) 100.

Traffic Flow

- Consider a traffic flow from Host 1 to Host 2. The traffic is sent from Host 1 to CE1.

- In this ring topology, the link between CE1 to CE2 is in the blocked state; the link between CE1 to CE3 is in the forwarding state. Hence, CE1 sends the traffic to PE2 through CE3.

- PE2 first learns the MAC address of Host1 through CE1. PE2 advertises the learnt MAC address to the peering PE1.

- As PE2 has learnt the MAC address directly from Host 1, and acts as an active PE.

- The PE which originates the MAC route due to access learning sets the default BGP local preference attribute value to 100.

- PE1 learns the MAC address from PE2 and acts as a stand-by PE. As PE1 gets the reoriginated MAC route from PE2, PE1 sets the BGP local preference attribute value to 80.

- The PE that has the higher local preference always sends and receives the traffic. Thus PE1 sends the traffic to PE3. PE3 sends the traffic to Host 2.

Failure Scenario

When the link between CE1 and CE3 is down or when the link between CE3 and PE2 is down, traffic is sent through PE1.
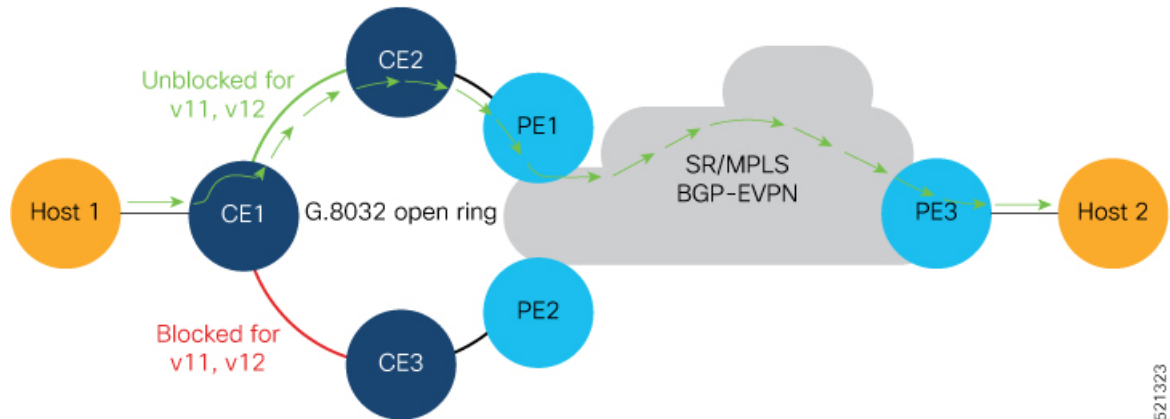
- When the link fails, the link CE1-CE2 changes to the forwarding state.

- PE1 learns the MAC address of Host 1 directly and advertises the learnt MAC address to PE2.

- PE1 sends the traffic to Host 2 through the remote PE3 with a BGP local preference value of 100.

- PE3 sends and receives the traffic from PE1 until the access link between CE1 and CE2 changes to the blocked state.

Limitations and Restrictions for EVPN E-LAN Single-Flow-Active Multi-Homing

- The EVPN E-LAN single-flow active multi-homing is not supported for EVPN VPWS.

- The EVPN E-LAN single-flow-active multi-homing is not supported on the Q100 and Q200 based systems.

- Starting from Release 24.1.1, only the G.8032 is supported for EVPN E-LAN single-flow-active multi-homing.

Configure EVPN E-LAN Single-Flow-Active Multi-Homing

Perform the following tasks on both PE1 and PE2.

1. Configure both PE1 and PE2 with the same EVI of 100.

2. Configure both PE1 and PE2 with the same ESI 0 36.37.00.00.00.00.00.11.01.

3. Verify the following ethernet segment status:

   a. Ensure that you configure the same ESI on both PE1 and PE2.

   b. Verify that the Single-flow-active mode is enabled in the Topology section.

Configuration Example

Configure both PE1 and PE2 with the same EVI of 100 and same ESI 0 36.37.00.00.00.00.00.11.01.

```
/* Configure advertisement of MAC routes */
Router# configure
Router(config)# evpn
Router(config-evpn)# evi 100
Router(config-evpn-instance)# advertise-mac
Router(config-evpn-instance-mac)# root

/* Configure single-flow-active load-balancing mode */
Router(config)# evpn
Router(config-evpn)# interface bundle-ether 1
Router(config-evpn-ac)# ethernet-segment
Router(config-evpn-ac-es)# identifier type 0 36.37.00.00.00.00.00.11.01
Router(config-evpn-ac-es)# load-balancing-mode single-flow-active

Router(config-evpn-ac-es)# root

/* Configure bridge domain and associating the evi to the bridge domain */
Router(config)# l2vpn
Router(config-l2vpn)# bridge group 100
Router(config-l2vpn-bg)# bridge-domain 100
Router(config-l2vpn-bg-bd)# interface Bundle-Ether1.2
Router(config-l2vpn-bg-bd-ac)#exit
Router(config-l2vpn-bg-bd)# evi 100
Router(config-l2vpn-bg-bd-evi)# root
Router(config)# interface Bundle-Ether1.2 l2transport
Router(config-l2vpn-subif)#encapsulation dot1q 2
Router(config-l2vpn-subif)#commit
```

Running Configuration

```
evpn
 evi 100
  advertise-mac
  !
 !
 interface Bundle-Ether1
  ethernet-segment
   identifier type 0 36.37.00.00.00.00.00.11.01
   load-balancing-mode single-flow-active
  convergence
     mac-mobility
   !
  !
 !
!
l2vpn
  bridge group 100
   bridge-domain 100
    interface Bundle-Ether1
   !
   evi 100
   !
  !
 !
 interface Bundle-Ether1.2 l2transport
  encapsulation dot1q 2
```

```
!
!
```

Verification

Verify the ethernet segment status:

```
Router#show  evpn  ethernet-segment  interface  be 1 detail
Legend:
B   - No Forwarders EVPN-enabled,
C   - MAC missing (Backbone S-MAC PBB-EVPN / Grouping ES-MAC vES),
RT  - ES-Import Route Target missing,
E   - ESI missing,
H   - Interface handle missing,
I   - Name (Interface or Virtual Access) missing,
M   - Interface in Down state,
O   - BGP End of Download missing,
P   - Interface already Access Protected,
Pf  - Interface forced single-homed,
R   - BGP RID not received,
S   - Interface in redundancy standby state,
X   - ESI-extracted MAC Conflict
SHG - No local split-horizon-group label allocated
Hp  - Interface blocked on peering complete during HA event
Rc  - Recovery timer running during peering sequence


Ethernet Segment Id          Interface                    Nexthops
0 36.37.00.00.00.00.00.11.01  BE1                         172.16.0.4
                                                          172.16.0.5

ES to BGP Gates   : Ready
ES to L2FIB Gates : P
Main port        :
Interface name   : Bundle-Ether1
Interface MAC    : b0a6.51e5.00dd
IfHandle         : 0x2000802c
State            : Up
Redundancy       : Not Defined
ESI type         : 0
Value            : 07.0807.0807.0807.0800
ES Import RT      : 0708.0708.0708 (from ESI)
Source MAC       : 0000.0000.0000 (N/A)
Topology         :
Operational      : MH, Single-flow-active
Configured       : Single-flow-active
Service Carving   : Auto-selection
Multicast        : Disabled
Convergence      : MAC-Mobility
Mobility-Flush   : Debounce 1 sec, Count 0, Skip 0
                 : Last n/a
Peering Details   : 2 Nexthops
172.16.0.4 [MOD:P:00:T]
172.16.0.5 [MOD:P:00:T]
Service Carving Synchronization:
Mode             : NONE
Peer Updates     :
172.16.0.4 [SCT: N/A]
172.16.0.5 [SCT: N/A]
Service Carving Results:
Forwarders    : 1
Elected       : 0
Not Elected   : 0
EVPN-VPWS Service Carving Results:
Primary          : 0
Backup           : 0
```

```
Non-DF              : 0
MAC Flushing mode: STP-TCN
Peering timer     : 3 sec [not running]
Recovery timer    : 30 sec [not running]
Carving timer     : 0 sec [not running]
HRW Reset timer   : 5 sec [not running]
Local SHG label   : 24007
Remote SHG labels: 1
24010             : nexthop 172.16.0.5
Access signal mode: Bundle OOS (Default)

Router#show l2vpn protection main-interface
Main Interface ID           # of subIntf Protected  Protect Type
Bundle-Ether1               2            Yes        ERP

Instance : 1
State    : FORWARDING

Sub-Intf # : 2

Flush    # : 6
```

EVPN E-Line Multi-Homed

The EVPN E-Line feature supports multi-homing capability that enables you to connect a customer edge device to two or more provider edge (PE) devices to provide load balancing and redundant connectivity. The load balancing is done using equal-cost multipath (ECMP).

Topology

Figure 4: EVPN E-Line Multi-Homed
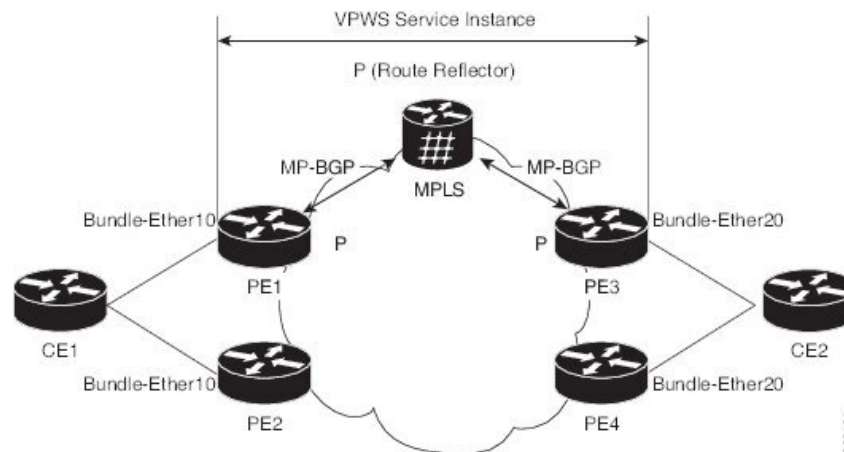
In this topology, the CEs and PEs are connected as follows:

• CE1 is multi-homed to PE1 and PE2.

• CE2 is multi-homed to PE3 and PE4.

• PE1 and PE2 advertise an EAD per EVI route per AC to remote PEs which is PE3 and PE4, with the associated MPLS label. The ES-EAD route is advertised per ES (main interface), and it will not have a label.

- PE3 and PE4 advertise an EAD per EVI route per AC to remote PEs, which is PE1 and PE2, with the associated MPLS label.

Consider a traffic flow from CE1 to CE2:

- The selection of path is dependent on the CE implementation for forwarding over a LAG.

- Traffic is encapsulated at each PE and forwarded to the remote PEs (PE 3 and PE4) through MPLS core.

- Selection of the destination PE is established by flow-based load balancing.

- PE3 and PE4 send the traffic to CE2. The selection of path from PE3 or PE4 to CE2 is established by flow-based load balancing.

If there is a failure and when the link from CE1 to PE1 goes down, the PE1 withdraws the ES-EAD route; sends a signal to the remote PEs to switch all the E-Line service instances associated with this multi-homed ES to the backup PE, which is PE2.

Configure EVPN E-Line Single-Active Multi-Homed

This section describes how to configure single-active multi-homed EVPN E-Line.

- Configure cross-connect group.

- Configure point-to-point (p2p) cross-connect and assign an interface to the cross-connect.

- Enable EVPN E-Line endpoint on the p2p cross-connect.

- Configure Ethernet segment identifier (ESI) for the interface.

- Enable the single-active mode by using the **load-balancing-mode single-active** command.

```
/* PE1 Configuration */
Router# configure
Router(config)# l2vpn
Router(config-l2vpn)# xconnect group xg1
Router(config-l2vpn-xc)# p2p e1_5-6
Router(config-l2vpn-xc-p2p)# interface Bundle-Ether10.2
Router(config-l2vpn-xc-p2p)# neighbor evpn evi 1 target 5 source 6
Router(config-l2vpn-xc-p2p)#  root
Router(config)# evpn
Router(config-evpn)# interface Bundle-Ether10
Router(config-evpn-ac)#  ethernet-segment
Router(config-evpn-ac-es)# identifier type 0 00.01.00.ac.ce.55.00.0a.00
Router(config-evpn-ac-es)# load-balancing-mode single-active
Router(config-evpn-ac-es)# commit


/* PE2 Configuration */
Router# configure
Router(config)# l2vpn
Router(config-l2vpn)# xconnect group xg1
Router(config-l2vpn-xc)# p2p e1_5-6
Router(config-l2vpn-xc-p2p)# interface Bundle-Ether10.2
Router(config-l2vpn-xc-p2p)# neighbor evpn evi 1 target 5 source 6
Router(config-l2vpn-xc-p2p)#  root
Router(config)# evpn
Router(config-evpn)# interface Bundle-Ether10
Router(config-evpn-ac)#  ethernet-segment
```

```
Router(config-evpn-ac-es)# identifier type 0 00.01.00.ac.ce.55.00.0a.00
Router(config-evpn-ac-es)# load-balancing-mode single-active
Router(config-evpn-ac-es)# commit


/* PE3 Configuration */
Router# configure
Router(config)# l2vpn
Router(config-l2vpn)#  xconnect group xg1
Router(config-l2vpn-xc)#  p2p e1_5-6
Router(config-l2vpn-xc-p2p)# interface Bundle-Ether20.1
Router(config-l2vpn-xc-p2p)# neighbor evpn evi 1 target 6 source 5
Router(config-l2vpn-xc)# root
Router(config)# evpn
Router(config-evpn)# interface Bundle-Ether20
Router(config-evpn-ac)#  ethernet-segment
Router(config-evpn-ac-es)# identifier type 0 00.01.00.ac.ce.55.00.14.00
Router(config-evpn-ac-es)# load-balancing-mode single-active
Router(config-evpn-ac-es)# commit


/* PE4 Configuration */
Router# configure
Router(config)# l2vpn
Router(config-l2vpn)#  xconnect group xg1
Router(config-l2vpn-xc)#  p2p e1_5-6
Router(config-l2vpn-xc-p2p)# interface Bundle-Ether20.1
Router(config-l2vpn-xc-p2p)# neighbor evpn evi 1 target 6 source 5
Router(config-l2vpn-xc)# root
Router(config)# evpn
Router(config-evpn)# interface Bundle-Ether20
Router(config-evpn-ac)#  ethernet-segment
Router(config-evpn-ac-es)# identifier type 0 00.01.00.ac.ce.55.00.14.00
Router(config-evpn-ac-es)# load-balancing-mode single-active
Router(config-evpn-ac-es)# commit
```

Running Configuration

```
/* On PE1 */
!
l2vpn xconnect group xg1
 p2p e1_5-6
  interface Bundle-Ether10.2
  neighbor evpn evi 1 target 5 source 6
!
evpn
interface Bundle-Ether10
  ethernet-segment
    identifier type 0 00.01.00.ac.ce.55.00.0a.00
    load-balancing-mode single-active
!


/* On PE2 */
!
l2vpn xconnect group xg1
 p2p e1_5-6
  interface Bundle-Ether10.2
  neighbor evpn evi 1 target 5 source 6
!
evpn
interface Bundle-Ether10
  ethernet-segment
```

```
      identifier type 0 00.01.00.ac.ce.55.00.0a.00
      load-balancing-mode single-active
!

/* On PE3 */
!
l2vpn xconnect group xg1
 p2p e1_5-6
   interface Bundle-Ether20.1
   neighbor evpn evi 1 target 6 source 5
!
evpn
interface Bundle-Ether20
   ethernet-segment
   identifier type 0 00.01.00.ac.ce.55.00.14.00
   load-balancing-mode single-active
!

/* On PE4 */
!
l2vpn xconnect group xg1
 p2p e1_5-6
   interface Bundle-Ether20.1
   neighbor evpn evi 1 target 6 source 5
!
evpn
interface Bundle-Ether20
   ethernet-segment
   identifier type 0 00.01.00.ac.ce.55.00.14.00
   load-balancing-mode single-active
!
```

Configure EVPN E-Line All-Active Multi-Homed

This section describes how to configure all-active multi-homed EVPN E-Line.

- Configure cross-connect group.

- Configure point-to-point (p2p) cross-connect and assign an interface to the cross-connect.

- Enable EVPN E-Line endpoint on the p2p cross-connect.

- Configure Ethernet segment identifier (ESI) for the interface.

```
/* PE1 Configuration */
Router# configure
Router(config)# l2vpn
Router(config-l2vpn)# xconnect group xg1
Router(config-l2vpn-xc)# p2p e1_5-6
Router(config-l2vpn-xc-p2p)# interface Bundle-Ether10.2
Router(config-l2vpn-xc-p2p)# neighbor evpn evi 1 target 5 source 6
Router(config-l2vpn-xc-p2p)#  root
Router(config)# evpn
Router(config-evpn)# interface Bundle-Ether10
Router(config-evpn-ac)#  ethernet-segment
Router(config-evpn-ac-es)# identifier type 0 00.01.00.ac.ce.55.00.0a.00
Router(config-evpn-ac-es)# commit

/* PE2 Configuration */
Router# configure
```

```
Router(config)# l2vpn
Router(config-l2vpn)# xconnect group xg1
Router(config-l2vpn-xc)# p2p e1_5-6
Router(config-l2vpn-xc-p2p)# interface Bundle-Ether10.2
Router(config-l2vpn-xc-p2p)# neighbor evpn evi 1 target 5 source 6
Router(config-l2vpn-xc-p2p)#  root
Router(config)# evpn
Router(config-evpn)# interface Bundle-Ether10
Router(config-evpn-ac)#  ethernet-segment
Router(config-evpn-ac-es)# identifier type 0 00.01.00.ac.ce.55.00.0a.00
Router(config-evpn-ac-es)# commit


/* PE3 Configuration */
Router# configure
Router(config)# l2vpn
Router(config-l2vpn)#  xconnect group xg1
Router(config-l2vpn-xc)#  p2p e1_5-6
Router(config-l2vpn-xc-p2p)# interface Bundle-Ether20.1
Router(config-l2vpn-xc-p2p)# neighbor evpn evi 1 target 6 source 5
Router(config-l2vpn-xc)# root
Router(config)# evpn
Router(config-evpn)# interface Bundle-Ether20
Router(config-evpn-ac)#  ethernet-segment
Router(config-evpn-ac-es)# identifier type 0 00.01.00.ac.ce.55.00.14.00
Router(config-evpn-ac-es)# commit


/* PE4 Configuration */
Router# configure
Router(config)# l2vpn
Router(config-l2vpn)#  xconnect group xg1
Router(config-l2vpn-xc)#  p2p e1_5-6
Router(config-l2vpn-xc-p2p)# interface Bundle-Ether20.1
Router(config-l2vpn-xc-p2p)# neighbor evpn evi 1 target 6 source 5
Router(config-l2vpn-xc)# root
Router(config)# evpn
Router(config-evpn)# interface Bundle-Ether20
Router(config-evpn-ac)#  ethernet-segment
Router(config-evpn-ac-es)# identifier type 0 00.01.00.ac.ce.55.00.14.00
Router(config-evpn-ac-es)# commit
```

Running Configuration

```
/* On PE1 */
!
configure
l2vpn xconnect group xg1
 p2p e1_5-6
  interface Bundle-Ether10.2
  neighbor evpn evi 1 target 5 source 6
!
evpn
interface Bundle-Ether10
  ethernet-segment
    identifier type 0 00.01.00.ac.ce.55.00.0a.00


!


/* On PE2 */
!
configure
```

```
l2vpn xconnect group xg1
 p2p e1_5-6
  interface Bundle-Ether10.2
  neighbor evpn evi 1 target 5 source 6
!
evpn
interface Bundle-Ether10
  ethernet-segment
   identifier type 0 00.01.00.ac.ce.55.00.0a.00

!

/* On PE3 */
!
configure
l2vpn xconnect group xg1
 p2p e1_5-6
  interface Bundle-Ether20.1
  neighbor evpn evi 1 target 6 source 5
!
evpn
interface Bundle-Ether20
  ethernet-segment
      identifier type 0 00.01.00.ac.ce.55.00.14.00

!

/* On PE4 */
!
configure
l2vpn xconnect group xg1
 p2p e1_5-6
  interface Bundle-Ether20.1
  neighbor evpn evi 1 target 6 source 5
!
evpn
interface Bundle-Ether20
  ethernet-segment
      identifier type 0 00.01.00.ac.ce.55.00.14.00

!
```

Configure EVPN E-Line Port-Active Multi-Homed

This section describes how to configure port-active multi-homed EVPN E-Line.

- Configure cross-connect group.

- Configure point-to-point (p2p) cross-connect and assign an interface to the cross-connect.

- Enable EVPN E-Line endpoint on the p2p cross-connect.

- Configure Ethernet segment identifier (ESI) for the interface.

- Enable the port-active mode by using the **load-balancing-mode port-active** command.

```
/* PE1 Configuration */
Router# configure
Router(config)# l2vpn
Router(config-l2vpn)# xconnect group xg1
Router(config-l2vpn-xc)# p2p e1_5-6
```

```
Router(config-l2vpn-xc-p2p)# interface Bundle-Ether10.2
Router(config-l2vpn-xc-p2p)# neighbor evpn evi 1 target 5 source 6
Router(config-l2vpn-xc-p2p)#  root
Router(config)# evpn
Router(config-evpn)# interface Bundle-Ether10
Router(config-evpn-ac)#  ethernet-segment
Router(config-evpn-ac-es)# identifier type 0 00.01.00.ac.ce.55.00.0a.00
Router(config-evpn-ac-es)# load-balancing-mode port-active
Router(config-evpn-ac-es)# commit


/* PE2 Configuration */
Router# configure
Router(config)# l2vpn
Router(config-l2vpn)# xconnect group xg1
Router(config-l2vpn-xc)# p2p e1_5-6
Router(config-l2vpn-xc-p2p)# interface Bundle-Ether10.2
Router(config-l2vpn-xc-p2p)# neighbor evpn evi 1 target 5 source 6
Router(config-l2vpn-xc-p2p)#  root
Router(config)# evpn
Router(config-evpn)# interface Bundle-Ether10
Router(config-evpn-ac)#  ethernet-segment
Router(config-evpn-ac-es)# identifier type 0 00.01.00.ac.ce.55.00.0a.00
Router(config-evpn-ac-es)# load-balancing-mode port-active
Router(config-evpn-ac-es)# commit


/* PE3 Configuration */
Router# configure
Router(config)# l2vpn
Router(config-l2vpn)#  xconnect group xg1
Router(config-l2vpn-xc)#  p2p e1_5-6
Router(config-l2vpn-xc-p2p)# interface Bundle-Ether20.1
Router(config-l2vpn-xc-p2p)# neighbor evpn evi 1 target 6 source 5
Router(config-l2vpn-xc)# root
Router(config)# evpn
Router(config-evpn)# interface Bundle-Ether20
Router(config-evpn-ac)#  ethernet-segment
Router(config-evpn-ac-es)# identifier type 0 00.01.00.ac.ce.55.00.14.00
Router(config-evpn-ac-es)# load-balancing-mode port-active
Router(config-evpn-ac-es)# commit


/* PE4 Configuration */
Router# configure
Router(config)# l2vpn
Router(config-l2vpn)#  xconnect group xg1
Router(config-l2vpn-xc)#  p2p e1_5-6
Router(config-l2vpn-xc-p2p)# interface Bundle-Ether20.1
Router(config-l2vpn-xc-p2p)# neighbor evpn evi 1 target 6 source 5
Router(config-l2vpn-xc)# root
Router(config)# evpn
Router(config-evpn)# interface Bundle-Ether20
Router(config-evpn-ac)#  ethernet-segment
Router(config-evpn-ac-es)# identifier type 0 00.01.00.ac.ce.55.00.14.00
Router(config-evpn-ac-es)# load-balancing-mode port-active
Router(config-evpn-ac-es)# commit
```

Running Configuration

```
/* On PE1 */
!
l2vpn xconnect group xg1
```

```
 p2p e1_5-6
  interface Bundle-Ether10.2
  neighbor evpn evi 1 target 5 source 6
!
evpn
interface Bundle-Ether10
  ethernet-segment
    identifier type 0 00.01.00.ac.ce.55.00.0a.00
    load-balancing-mode port-active
!


/* On PE2 */
!
l2vpn xconnect group xg1
 p2p e1_5-6
  interface Bundle-Ether10.2
  neighbor evpn evi 1 target 5 source 6
!
evpn
interface Bundle-Ether10
  ethernet-segment
    identifier type 0 00.01.00.ac.ce.55.00.0a.00
    load-balancing-mode port-active
!

/* On PE3 */
!
l2vpn xconnect group xg1
 p2p e1_5-6
  interface Bundle-Ether20.1
  neighbor evpn evi 1 target 6 source 5
!
evpn
interface Bundle-Ether20
  ethernet-segment
    identifier type 0 00.01.00.ac.ce.55.00.14.00
    load-balancing-mode port-active
!

/* On PE4 */
!
l2vpn xconnect group xg1
 p2p e1_5-6
  interface Bundle-Ether20.1
  neighbor evpn evi 1 target 6 source 5
!
evpn
interface Bundle-Ether20
  ethernet-segment
    identifier type 0 00.01.00.ac.ce.55.00.14.00
    load-balancing-mode port-active
!
```

EVPN Designated Forwarder Election

Table 3: Feature History Table

Feature Name	Release Information	Feature Description

EVPN Designated Forwarder Election on 8212-48FH-M, 8711-32FH-M, 88-LC1-52Y8H-EM, and 88-LC1-12TH24FH-E	Release 24.3.1	The EVPN Designated Forwarder election is now supported on these fixed systems and line cards: • 8212-48FH-M • 8711-32FH-M • 88-LC1-52Y8H-EM • 88-LC1-12TH24FH-E
EVPN Designated Forwarder Election	Release 24.2.11	Designated Forwarder (DF) election enables the access network to control EVPN PE devices by defining the backup path much before the event of a link failure. During the link failure, the PE node is aware of the next PE that will take over the active role and this reduces the traffic loss. DF election supports preference-based and access-driven mechanism. This feature is supported only on routers with the 88-LC1-36EH line cards.

Designated Forwarder (DF) election enables the access network to control EVPN PE devices by defining the backup path much before the event of a link failure. During the link failure, the PE node is aware of the next PE that will take over the active role and this reduces the traffic loss.

You can configure the DF election as preference-based or access driven.

In a preference-based DF election mechanism, the weight decides which PE is the DF at any given time. You can use this method for topologies where interface failures are revertive. However, for topologies where an access-PE is directly connected to the core PE, use the access-driven DF election mechanism.

When access PEs are configured in a non-revertive mode, the access-driven DF election mechanism allows the access-PE to choose which PE is the DF.

Consider an interface in an access network that connects PE nodes with the EVPN PE in the core network. When this interface fails, there may be a traffic loss for a longer duration. The delay in convergence is because the backup PE is not chosen before failure occurs.

The EVPN DF Election feature allows the EVPN PE to preprogram a backup PE even before the failure of the interface. In the event of failure, the PE node will be aware of the next PE that will take over, thereby reducing the convergence time. Use the *preference df weight* option for an Ethernet segment identifier (ESI) to set the backup path. By configuring the weight for a PE, you can control the DF election, thus define the backup path.
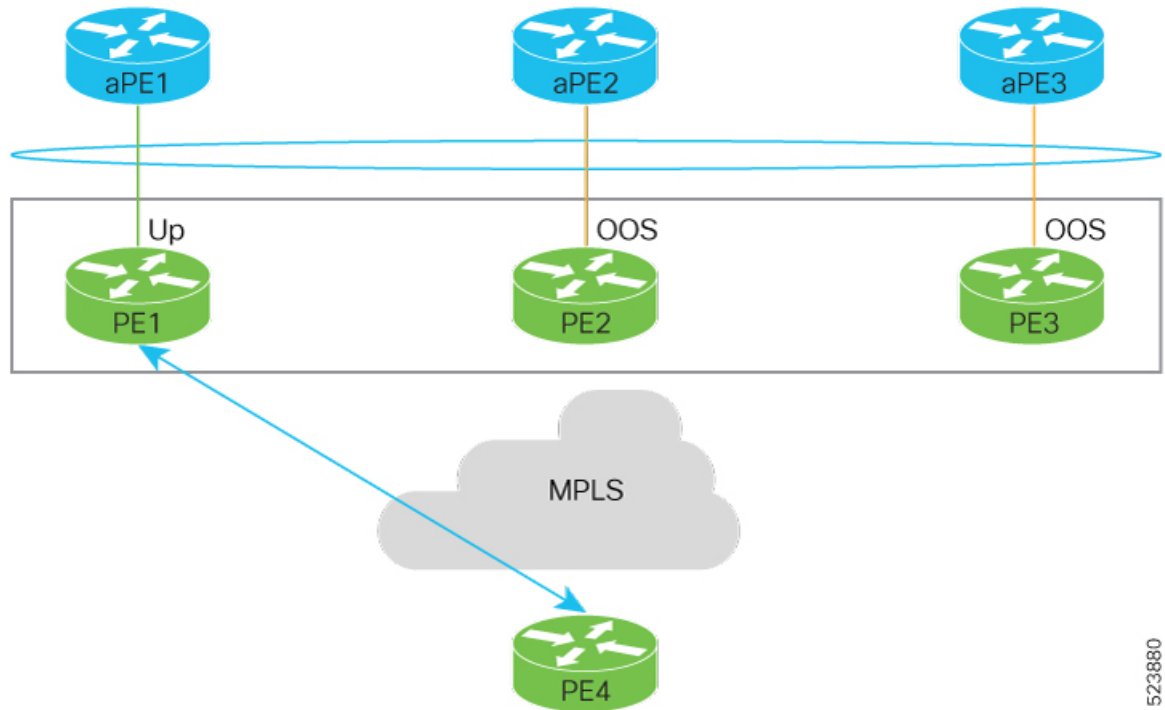
Restrictions

- The feature is supported only on EVPN PEs in the port-active mode.

- The bundle attached to the ethernet segment must be configured with the **lacp mode active** command.

  The **LACP mode on** command is not supported.

Topology

Let's understand the feature on how the backup path is precomputed with the following topology.

Figure 5: EVPN DF Election


- PE1, PE2, and PE3 are PEs for the EVPN core network.

- aPE1, aPE2, and aPE3 are their access PE counterparts and configured in a multichassis link aggregation group (MCLAG) redundancy group. Only one link among the three is active at any given time. aPE1, aPE2, and aPE3 are in a non-revertive mode.

- PE1 is directly connected to aPE1, PE2 to aPE2, and PE3 to aPE3. EVPN VPWS is configured on the PE devices in the core.

- All PE devices are attached to the same bundle and shares the same ethernet segment identifier.

- PE1, PE2, and PE3 are configured with a weight of 100, 10, and 1 respectively.

Traffic Flow

In this example, consider a traffic flow from a host connected to PE4 to the host connected to the access PE.

Figure 6: Traffic
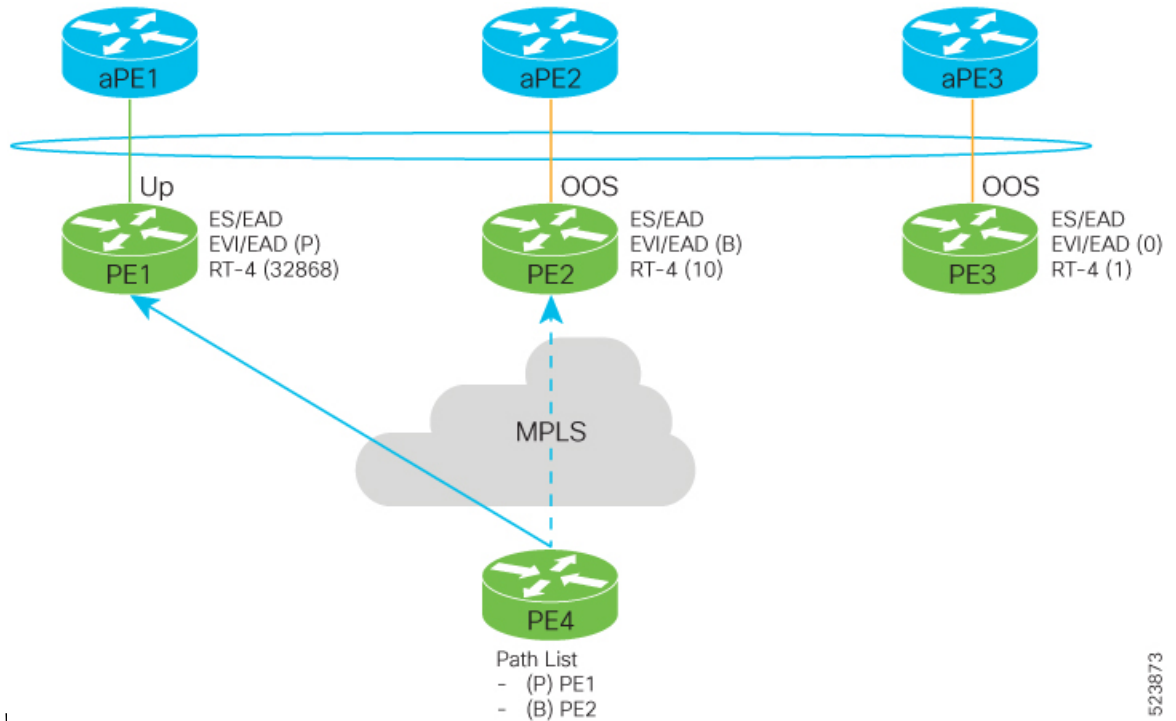
- aPE1-PE1 interface state is up. The aPE2-PE2 and aPE3-PE3 remains in OOS state.

- The traffic is sent from PE4 to aPE1 through PE1 as the PE1 is configured with the highest weight of 100.

- The highest weight is modified by adding 32768 to the configured weight. For example, the weight of PE1 is 100, 32768 is added to this weight. Hence, 32868 is advertised to the peer PEs.

- The highest weight is advertised as P-bit, which is primary. The next highest weight is advertised as B-bit, which is secondary. The lowest weight as non-DF (NDF).

- When the EVPN PE devices are of same weight, the traffic is sent based on the IP address. Lowest IP address takes the precedence.

- Only one PE indicates that the state of the bundle for the Ethernet Segment is up. For all other PEs, the Ethernet Segment is standby and the bundle is in OOS state.

- All PE devices are aware of the associated next hop and weights of their peers.

Failure and Recovery Scenarios

The weights configured on the EVPN PE devices cascade in the same order as the protection mechanism on the access side PEs:

- During the network failure, the redundancy ordering for the access PEs is aPE1, aPE2, aPE3.

- The weights of PE1 through PE3 are weight of PE1 > weight of PE2 > weight of PE3.

- If this ordering is not satisfied, the network will eventually converge, but it will not be as efficient as if the weights are ordered correctly.
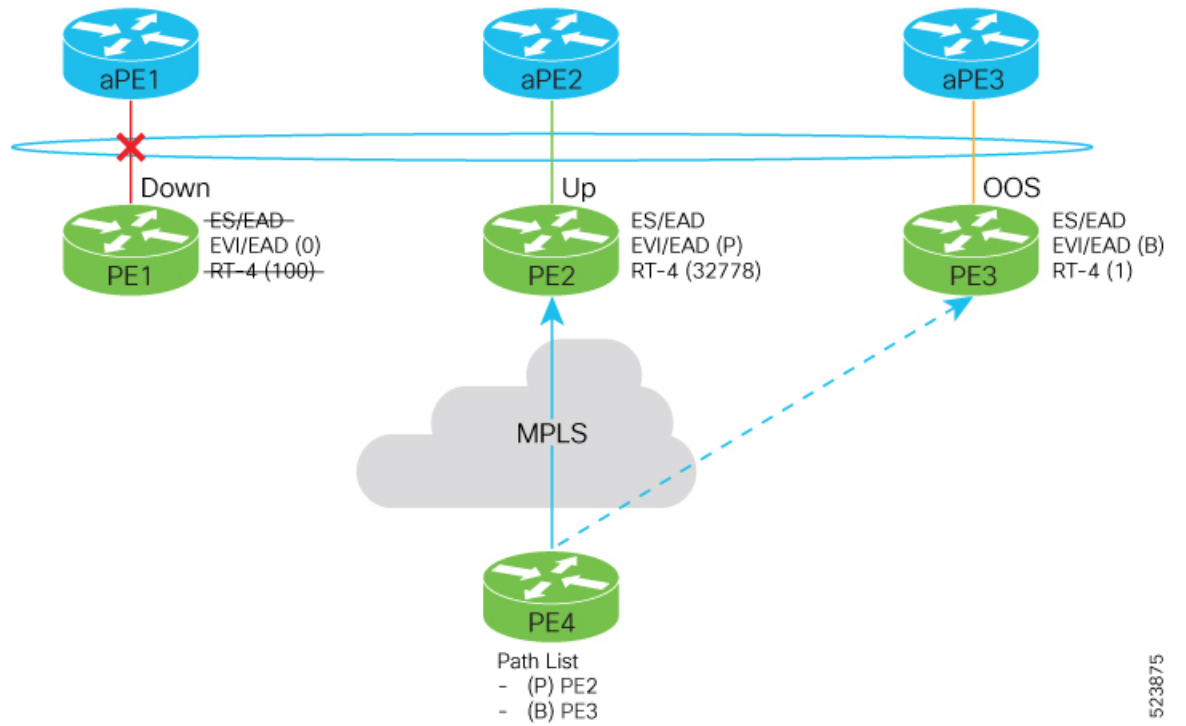
Scenario - 1

Consider a scenario where the aPE1-PE1 interface is down.
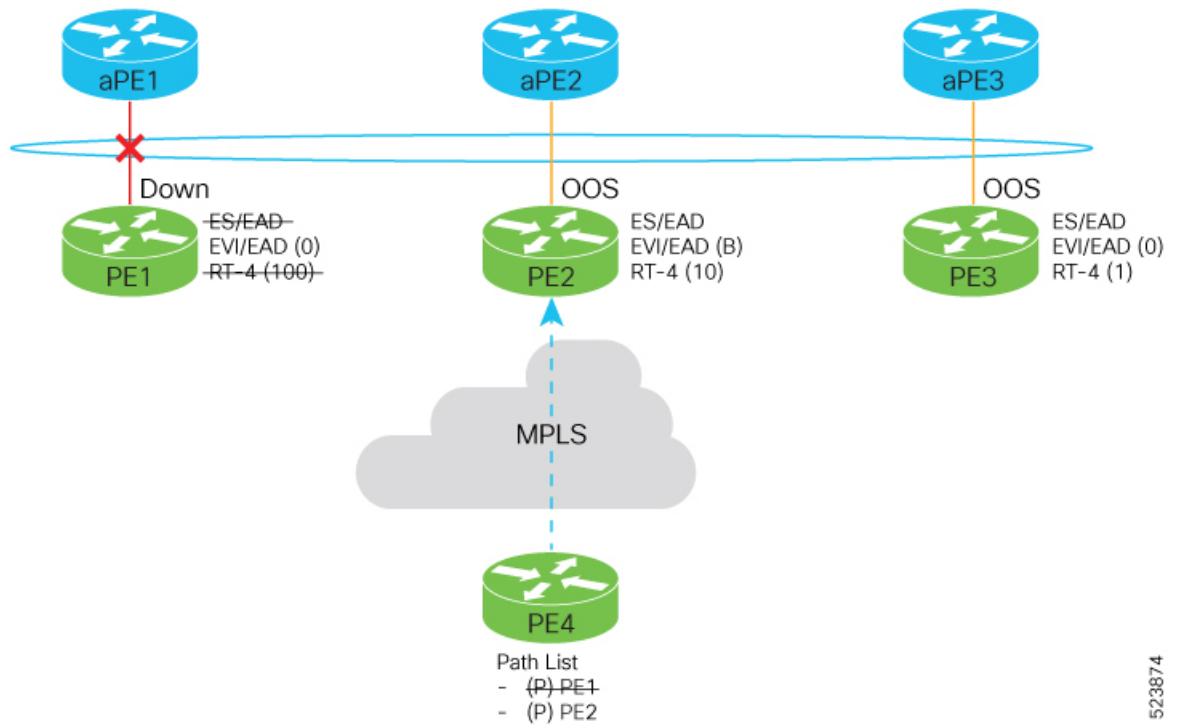
When aPE1-PE1 interface is down, the PE1 withdraws the EAD/ES route, and the traffic is sent through the backup path, which is PE2.
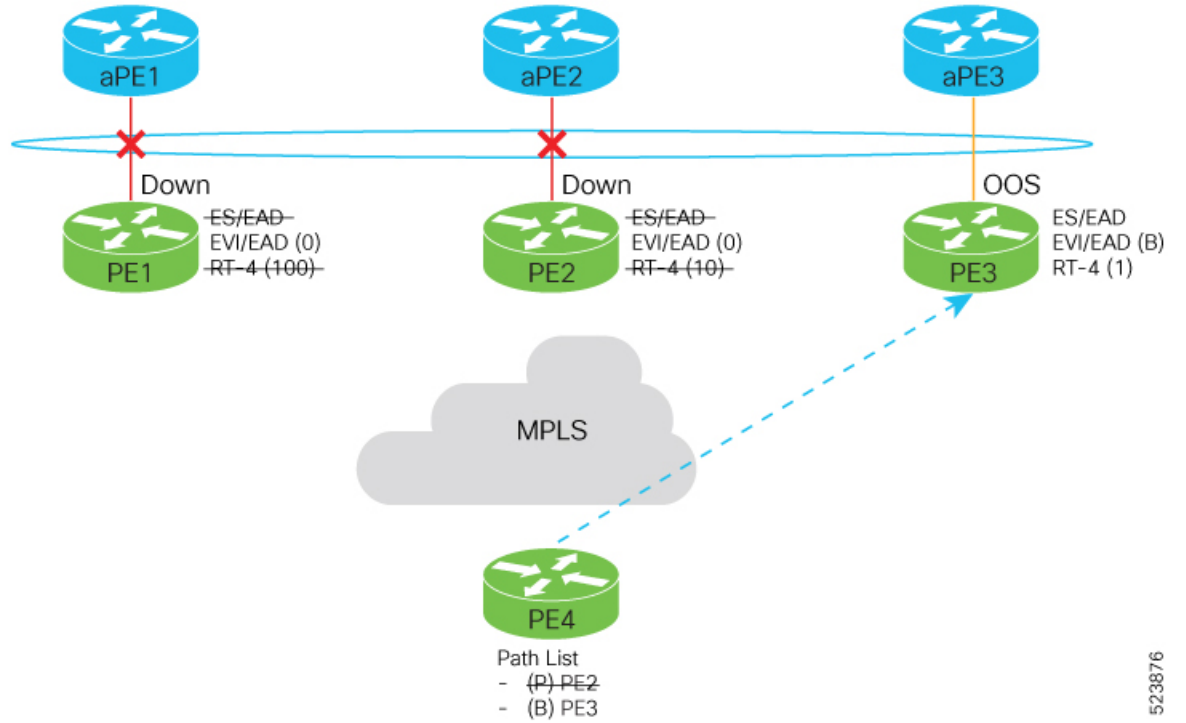
The aPE2-PE2 becomes the primary with a weight of 32778, and aPE3-PE3 becomes the backup. The aPE2-PE2 advertises P-bit to PE4. aPE3-PE3 advertises the B-bit to PE4.
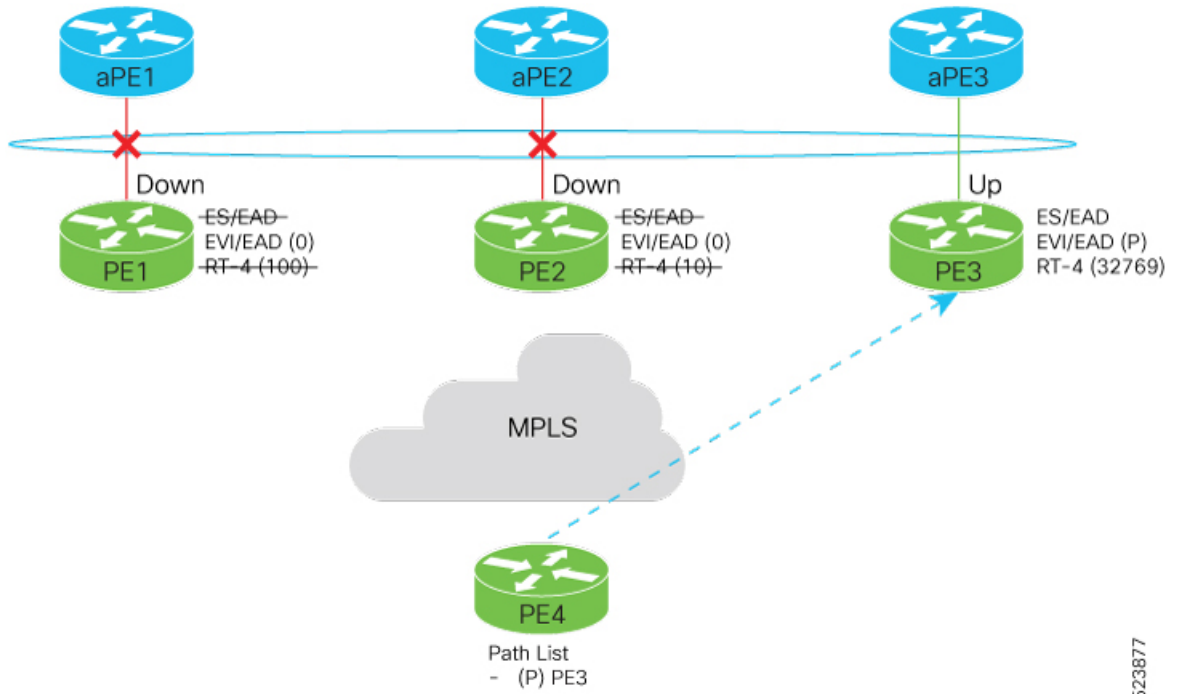
Scenario - 2
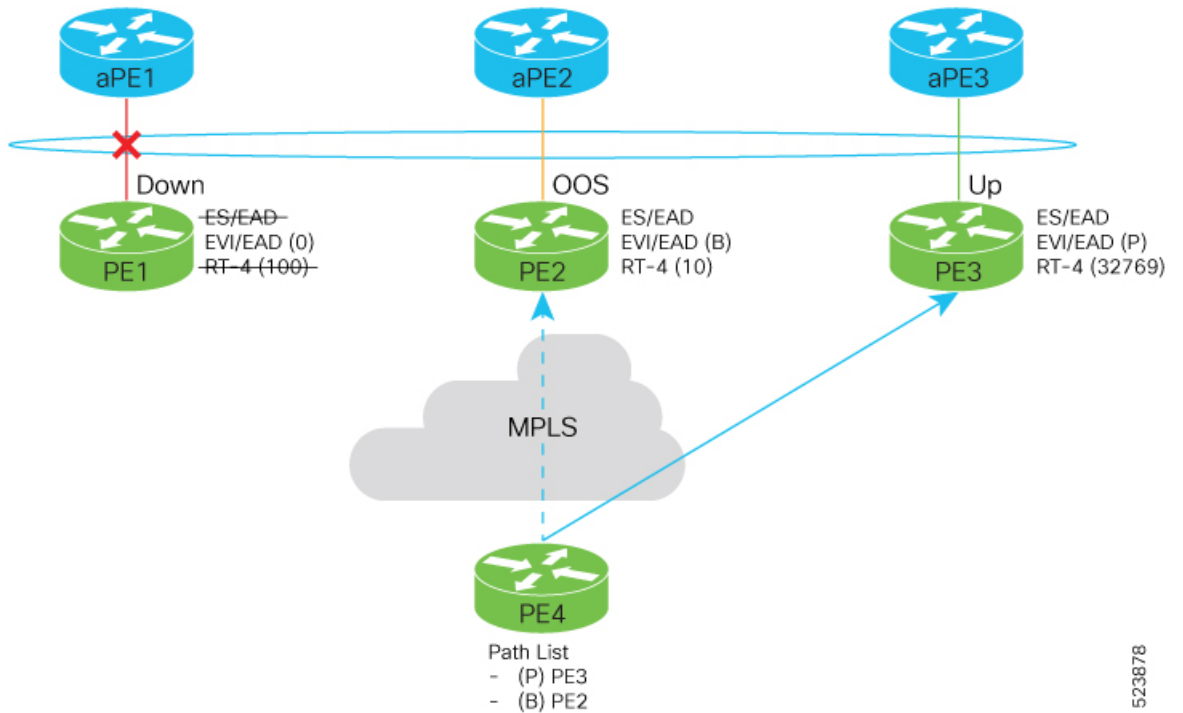
Consider a scenario where aPE2-PE2 interface is also down.

When the aPE2-PE2 interface is also down, the traffic is sent through aPE3-PE3 link. aPE3-PE3 becomes the primary path with a weight of 32769.


Scenario - 3

When the aPE2-PE2 interface comes up, the aPE3-PE3 link still remains the primary path. aPE2-PE2 interface becomes the backup path with a weight of 10.

Scenario - 4

When the aPE1-PE1 interface comes up, the aPE3-PE3 link remains the primary path with a weight of 32769. aPE1-PE1 interface becomes the backup path with a weight of 100. The aPE2-PE2 interface becomes NDF with a weight of 10.
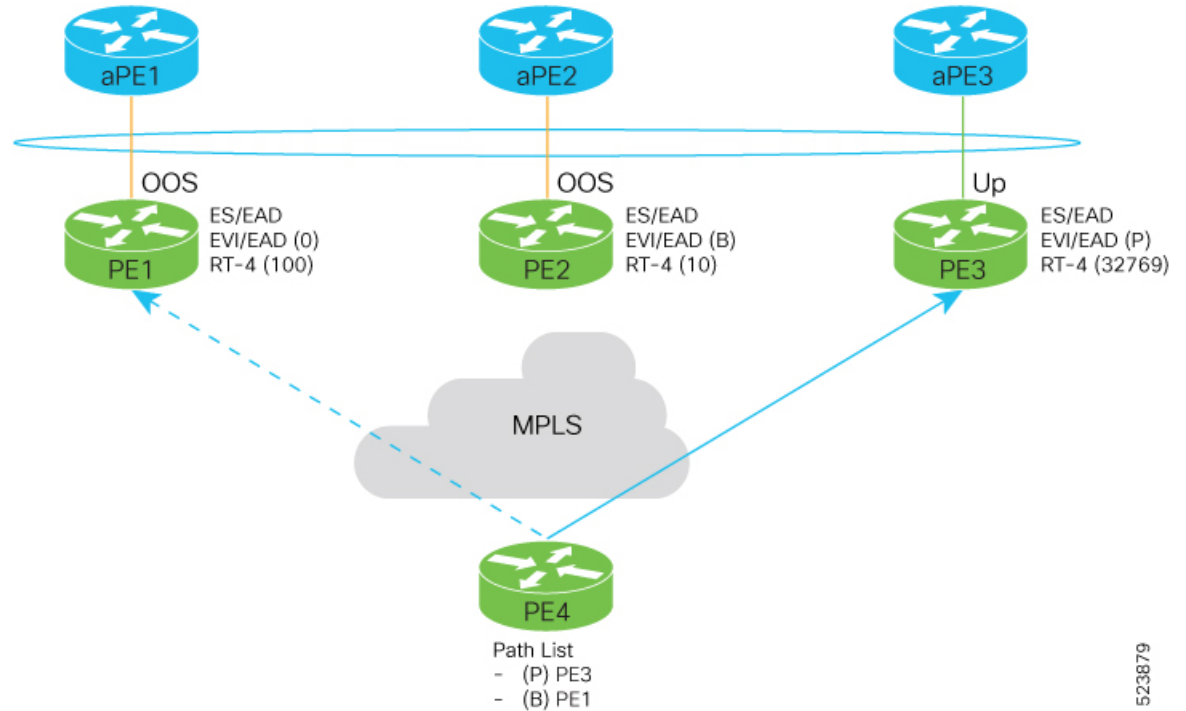
Configure EVPN DF Election

Perform the following tasks to configure access-driven and preference based EVPN DF Election:

- Configure EVPN DF election on PE1, PE2, and PE3, with the service carving mode as preference-based and access-driven.

- Configure LACP on aPE1, aPE2, and aPE3

Configuration Example

- All PE devices are configured with different weights. PE1, PE2, and PE3 are configured with a weight of 100, 10, and 1 respectively.

- The bundle attached to the ethernet segment is configured with **lacp mode active**.

```
/* Configure EVPN DF election on PE1, PE2, and PE3 */

/*  PE1 Configuration */
Router#configure
Router(config)#evpn
Router(config-evpn)#interface Bundle-Ether1
Router(config-evpn-ac)#ethernet-segment
Router(config-evpn-ac-es)#identifier type 0 01.11.00.00.00.00.00.00.01
Router(config-evpn-ac-es)#load-balancing-mode port-active
```

```
Router(config-evpn-ac-es)#service-carving preference-based
Router(config-evpn-ac-es-sc-pref)#weight 100
Router(config-evpn-ac-es-sc-pref)#access-driven
Router(config-evpn-ac-es-sc-pref)#commit

/* PE2 Configuration */
Router#configure
Router(config)#evpn
Router(config-evpn)#interface Bundle-Ether1
Router(config-evpn-ac)#ethernet-segment
Router(config-evpn-ac-es)#identifier type 0 01.11.00.00.00.00.00.00.01
Router(config-evpn-ac-es)#load-balancing-mode port-active
Router(config-evpn-ac-es)#service-carving preference-based
Router(config-evpn-ac-es-sc-pref)#weight 10
Router(config-evpn-ac-es-sc-pref)#access-driven
Router(config-evpn-ac-es-sc-pref)#commit

/* PE3 Configuration */
Router#configure
Router(config)#evpn
Router(config-evpn)#interface Bundle-Ether1
Router(config-evpn-ac)#ethernet-segment
Router(config-evpn-ac-es)#identifier type 0 01.11.00.00.00.00.00.00.01
Router(config-evpn-ac-es)#load-balancing-mode port-active
Router(config-evpn-ac-es)#service-carving preference-based
Router(config-evpn-ac-es-sc-pref)#weight 1
Router(config-evpn-ac-es-sc-pref)#access-driven
Router(config-evpn-ac-es-sc-pref)#commit
```

Configure LACP on aPE1, aPE2, and aPE3

```
/* aPE1 Configuration */
Router#configure
Router(config)#interface Bundle-Ether 1
Router(config-if)#lacp non-revertive
Router(config-if)#bundle maximum-active links 1 hot-standby
Router(config-if)#exit
Router(config-if)#interface GigabitEthernet0/0/0/40
Router(config-if)bundle id 10 mode active
Router(config-if)bundle port-priority 10000
Router(config-if)description Connection to PE1
Router(config-if)commit

/* aPE2 Configuration */
Router#configure
Router(config)#interface Bundle-Ether 1
Router(config-if)#lacp non-revertive
Router(config-if)#bundle maximum-active links 1 hot-standby
Router(config-if)#exit
Router(config-if)#interface GigabitEthernet0/0/0/39
Router(config-if)bundle id 10 mode active
Router(config-if)bundle port-priority 20000
Router(config-if)description Connection to PE2
Router(config-if)commit

/* aPE3 Configuration */
Router#configure
Router(config)#interface Bundle-Ether 1
Router(config-if)#lacp non-revertive
Router(config-if)#bundle maximum-active links 1 hot-standby
Router(config-if)#exit
```

```
Router(config-if)#interface GigabitEthernet0/0/0/38
Router(config-if)bundle id 10 mode active
Router(config-if)bundle port-priority 30000
Router(config-if)description Connection to PE3
Router(config-if)commit
```

Running Configuration

```
/* PE1 Configuration */
evpn
 interface Bundle-Ether 1
  ethernet-segment
   identifier type 0 01.11.00.00.00.00.00.00.01
    load-balancing-mode port-active
    service-carving preference-based
    weight 100
    access-driven
   !
 !

/* PE2 Configuration */
evpn
 interface Bundle-Ether 1
  ethernet-segment
   identifier type 0 01.11.00.00.00.00.00.00.01
    load-balancing-mode port-active
    service-carving preference-based
    weight 10
    access-driven
   !
 !

/* PE3 Configuration */
evpn
 interface Bundle-Ether 1
  ethernet-segment
   identifier type 0 01.11.00.00.00.00.00.00.01
    load-balancing-mode port-active
    service-carving preference-based
    weight 1
    access-driven
   !
 !

/* aPE1 Configuration */

interface Bundle-Ether 1
 lacp non-revertive
  bundle maximum-active links 1 hot-standby
interface GigabitEthernet0/0/0/40
 bundle id 10 mode active
 bundle port-priority 10000
 description Connection to PE1
!

/* aPE2 Configuration */

interface Bundle-Ether 1
 lacp non-revertive
  bundle maximum-active links 1 hot-standby
interface GigabitEthernet0/0/0/39
 bundle id 10 mode active
 bundle port-priority 20000
```

```
 description Connection to PE2
!

/* aPE3 Configuration */

interface Bundle-Ether 1
 lacp non-revertive
  bundle maximum-active links 1 hot-standby
interface GigabitEthernet0/0/0/40
 bundle id 10 mode active
 bundle port-priority 30000
 description Connection to PE3
!
```

Verification

The following output shows configuration of the EVPN DF Election.

```
Router#show evpn ethernet-segment detail
Ethernet Segment Id     Interface                        Nexthops
----------------------- -------------------------------- --------------------
0001.0001.0001.1b01.001b BE1                             192.168.0.1
                                                         192.168.0.3
  ES to BGP Gates   : Ready
  ES to L2FIB Gates : Ready
  Main port         :
    Interface name : Bundle-Ether1
    Interface MAC  : 02ef.af8d.8008
    IfHandle       : 0x00004190
    State          : Up
    Redundancy     : Active
  ESI type         : 0
    Value          : 01.0001.0001.1b01.001b
  ES Import RT      : 0100.0100.011b (from ESI)
  Source MAC        : 0000.0000.0000 (N/A)
  Topology         :
    Operational    : MH
    Configured     : Port-Active
  Service Carving   : Preferential
    Multicast      : Disabled
  Convergence      :
  Peering Details   : 2 Nexthops
    192.168.0.1 [PREF:P:d6ce:T] >> Weight in hexadecimal
    192.168.0.3 [PREF:P:457]
  Service Carving Synchronization:
    Mode           : NONE
    Peer Updates   :
  Service Carving Results:
    Forwarders     : 3
    Elected        : 3
    Not Elected    : 0
  EVPN-VPWS Service Carving Results:
    Primary        : 1
    Backup         : 0
    Non-DF         : 0
  MAC Flushing mode : STP-TCN
  Peering timer     : 3 sec [not running]
  Recovery timer    : 30 sec [not running]
  Carving timer     : 0 sec [not running]
  Local SHG label   : 28384
  Remote SHG labels : 0
  Access signal mode: Bundle OOS (Default)
```

Highest Random Weight Mode for EVPN DF Election

The Highest Random Weight (HRW) Mode for EVPN DF Election feature provides optimal load distribution of Designated Forwarder (DF) election, redundancy, and fast access. It ensures a nondisruptive service for an ES irrespective of the state of a peer DF.

The DF election is calculated based on the weight. The highest weight becomes the DF and the subsequent weight becomes a backup DF (BDF). The weight is determined by the mathematical function of EVI, ESI, and the IP address of the server.

DF weight calculation is based on the weight vector:

```
Wrand(v, Si) = (1103515245((1103515245.Si+12345)XOR
       D(v))+12345)(mod 2^31)
                    where:
           Si: IP Address of the server i
           v: EVI
           D(v): 31 bit digest [CRC-32 of v]
```

The existing DF election algorithm is based on ordinal value of a modulus calculation, and it comprises of number of peers and EVI. The DF is determined by the mathematical function of ESI and EVI, which is called "service carving". This mode of DF election is described in RFC 7432.

In modulus calculation mode, the algorithm does not perform well when the Ethernet tags are all even or all odd. When the Ethernet Segment (ES) is multihomed to two PEs, all the VLANs pick only one of the PEs as the DF; one of the PEs does not get elected at all as the DF. The DF election is not optimal in this mode of operation.

The HRW mode of DF election has the following advantages over modulus mode of DF election:

- The DF election for the respective VLANs is equally distributed among the PEs.

- When a PE which is neither a DF nor a BDF hosts some VLANs on a given ES, and if the PE goes down, or its connection to the ES goes down, it does not result in a DF and BDF reassignment to the other PEs. This eliminates computation during the connection flaps.

- It avoids the service disruption that are inherent in the existing modulus based algorithm.

- The BDF provides redundant connectivity. The BDF ensures that there is no traffic disruption when a DF fails. When a DF fails, the BDF becomes the DF.

Configure Highest Random Weight Mode for EVPN DF Election

Perform this task to configure Highest Random Weight Mode for EVPN DF Election feature.

Configuration Example

```
Router# configure
Router(config)#evpn
Router(config-evpn)#interface Bundle-Ether 23
Router(config-evpn-ac)#ethernet-segment
Router(config-evpn-ac-es)#service-carving hrw
Router(config-evpn-ac-es)#commit
```

Running Configuration

```
configure
 evpn
  interface Bundle-Ether 23
   ethernet-segment
    service-carving hrw
   !
  !
 !
```

Verification

Verify that you have configured HRW mode of DF election.

```
Router#show evpn ethernet-segment interface bundleEther 23 carving detail
Ethernet Segment Id     Interface                          Nexthops
----------------------- ---------------------------------- --------------------
0011.1111.1111.1111.1111 Gi0/2/0/0                         192.168.0.2
                                                           192.168.0.3
  ES to BGP Gates   : Ready
  ES to L2FIB Gates : Ready
  Main port         :
     Interface name : GigabitEthernet0/2/0/0
     Interface MAC  : 02db.c740.ca4e
     IfHandle       : 0x01000060
     State          : Up
     Redundancy     : Not Defined
  ESI type          : 0
     Value          : 11.1111.1111.1111.1111
  ES Import RT       : 0011.0011.0011 (Local)
  Source MAC         : 0000.0000.0000 (N/A)
  Topology           :
     Operational    : MH, Single-active
     Configured     : Single-active (AApS) (default)
  Service Carving    : HRW     -> Operation mode of carving
  Peering Details    : 192.168.0.2[HRW:P:00] 192.168.0.3[HRW:P:00] -> Carving capability as
 advertised by peers
  Service Carving Results:
     Forwarders     : 1
     Permanent      : 0
     Elected        : 0
     Not Elected    : 1
  MAC Flushing mode : STP-TCN
  Peering timer     : 3 sec [not running]
  Recovery timer    : 30 sec [not running]
  Carving timer     : 0 sec [not running]
  Local SHG label   : 28109
  Remote SHG labels : 1
            24016 : nexthop 192.168.0.3
```
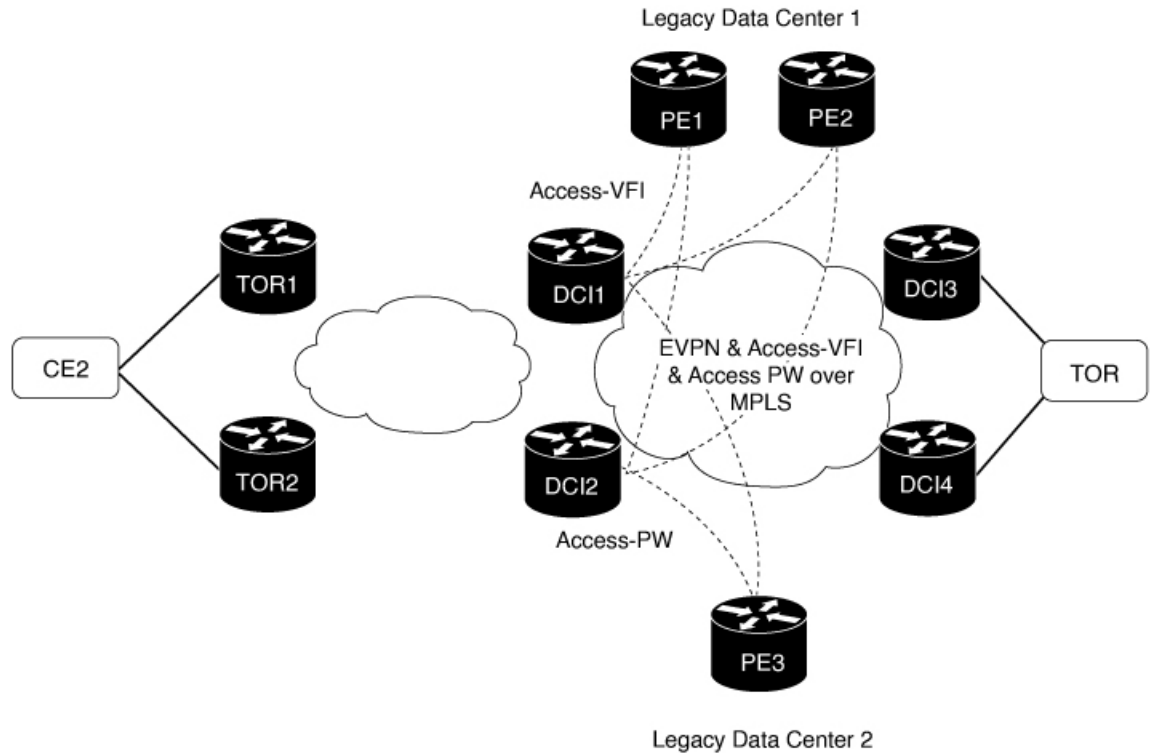
Virtual Ethernet Segment

Table 4: Feature History Table

Feature Name	Release Information	Feature Description

Virtual Ethernet Segment on 8212-48FH-M, 8711-32FH-M, 88-LC1-52Y8H-EM, and 88-LC1-12TH24FH-E	Release 24.3.1	The Virtual Ethernet Segment is now supported on these fixed systems and line cards: • 8212-48FH-M • 8711-32FH-M • 88-LC1-52Y8H-EM • 88-LC1-12TH24FH-E
Virtual Ethernet Segment	Release 24.2.11	A Virtual Ethernet Segment (VES) allows a Customer Edge (CE) device to connect to an EVPN service over an MPLS network, which can be used for redundancy and load balancing. This feature is supported only on routers with the 88-LC1-36EH line cards.

Traditionally, multi-homing access to EVPN bridge is through bundle Ethernet connection or a physical Ethernet connection. A customer edge (CE) is connected to multiple provider edges (PEs) and each CE-PE pair is an Ethernet segment (ES). When multiple Ethernet segments are made to appear as one common Ethernet segment to the CE device, it is a Virtual Ethernet Segment (VES). The VES allows a CE to access EVPN bridge through MPLS network. The logical connection between CE and PE is a pseudowire (PW). You can use VES to access PW and AC sub-interface, which is used for redundancy and load balancing.

Figure 7: Virtual Ethernet Segment (VES)

Consider the topology where EVPN data centers, DCI1 and DCI2 are connected to legacy data centers through access PW on a single Ethernet segment, which is VES. In the topology, the traffic flow from CE2 reaches the legacy data centers through EVPN data centers using VES.

Consider a traffic flow from CE2 to PE3, the Legacy Data Center 2.

- CE2 sends the traffic to DCI1 or DCI2 through EVPN.

- DCI1 and DCI2 are connected to PE3 through access PW on a single Ethernet segment.

- DCI1 and DCI2 advertise Type 4 routes, and then perform designated forwarder (DF) election after they discover each other. One of them becomes a DF and other a non-DF.

- The traffic is forwarded through the DF. The non-DF path is in standby mode. DCI1 or DCI2, whichever is the DF, sends the traffic to PE3.

Consider a traffic flow from CE2 to PE1 and PE2, the Legacy Data Center 1.

- CE2 sends the traffic to DCI1 or DCI2 through EVPN.

- DCI1 or DCI2 sends the traffic to PE1 and PE2.

- DCI1 and DCI2 advertise Type 4 routes, and then perform DF election after they discover each other. One of them becomes a DF and other a non-DF.

- One of them becomes a DF and other a non-DF.

- The traffic is forwarded through the DF. The non-DF path is in standby mode. DCI1 or DCI2, whichever is the DF, sends the traffic to PE1 and PE2.

Configure Virtual Ethernet Segment

The following section describes how to configure access PW that acts as VES.

1. Configure DCI1 and DCI2 with bridge domain and assign EVI to the bridge domain.

2. Configure EVPN with virtual ethernet segment on both DCI1 and DCI2.

3. Configure PE3 with bridge domain and assign the virtual ethernet segments of DC1 and DCI2 as neighbors to the bridge domain.

```
/* Configure DCI1 */
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group bg1
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain bd1
RP/0/RSP0/CPU0:router(config-bg-bd)# neighbor 70.70.70.70 pw-id 17300001
RP/0/RSP0/CPU0:router(config-bg-bd-pw)# evi 1
RP/0/RSP0/CPU0:router(config-bg-bd-pw-evi)# member vni 10001

/* Configure EVPN */
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# evpn
RP/0/RSP0/CPU0:router(config-evpn)# virtual neighbor 70.70.70.70 pw-id 17300001
RP/0/RSP0/CPU0:router(config-evpn-ac-pw)# ethernet-segment
RP/0/RSP0/CPU0:router(config-evpn-ac-pw-es)# identifier type 0 12.12.00.00.00.01.00.00.03
RP/0/RSP0/CPU0:router(config-evpn-ac-pw-es)# bgp route-target 1212.8888.0003
RP/0/RSP0/CPU0:router(config-evpn-ac-pw-es)# exit
RP/0/RSP0/CPU0:router(config-evpn-ac-pw)# timers peering 15
RP/0/RSP0/CPU0:router(config-evpn-ac-pw-timers)# commit

/* Configure DCI2 */
RP/0/RSP0/CPU0:router# configure
```

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group bg1
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain bd1
RP/0/RSP0/CPU0:router(config-bg-bd)# neighbor 70.70.70.70 pw-id 27300001
RP/0/RSP0/CPU0:router(config-bg-bd-pw)# evi 1
RP/0/RSP0/CPU0:router(config-bg-bd-pw-evi)# member vni 10001

/* Configure EVPN */
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# evpn
RP/0/RSP0/CPU0:router(config-evpn)# virtual neighbor 70.70.70.70 pw-id 27300001
RP/0/RSP0/CPU0:router(config-evpn-ac-pw)# ethernet-segment
RP/0/RSP0/CPU0:router(config-evpn-ac-pw-es)# identifier type 0 12.12.00.00.00.01.00.00.03
RP/0/RSP0/CPU0:router(config-evpn-ac-pw-es)# bgp route-target 1212.8888.0003
RP/0/RSP0/CPU0:router(config-evpn-ac-pw-es)# exit
RP/0/RSP0/CPU0:router(config-evpn-ac-pw)# timers peering 15
RP/0/RSP0/CPU0:router(config-evpn-ac-pw-timers)# commit

/* Configure PE3 */
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group 73
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain 73-1
RP/0/RSP0/CPU0:router(config-bg-bd)# neighbor 10.10.10.10 pw-id 17300001
RP/0/RSP0/CPU0:router(config-bg-bd-pw)# exit
RP/0/RSP0/CPU0:router(config-bg-bd)# neighbor 20.20.20.20 pw-id 27300001
RP/0/RSP0/CPU0:router(config-bg-bd)# commit
```

Running Configuration

This section shows access PW running configuration.

```
/* On DCI1 */

l2vpn
 bridge group bg1
  bridge-domain bd1
   neighbor 70.70.70.70 pw-id 17300001
    evi 1
     member vni 10001
!

evpn
  virtual neighbor 70.70.70.70 pw-id 17300001
   ethernet-segment
    identifier type 0 12.12.00.00.00.01.00.00.03
    bgp route-target 1212.8888.0003
    !
  timers peering 15
!

/* On DCI2 */

l2vpn
 bridge group bg1
  bridge-domain bd1
   neighbor 70.70.70.70 pw-id 27300001
    evi 1
     member vni 10001
!

evpn
  virtual neighbor 70.70.70.70 pw-id 27300001
```

```
    ethernet-segment
     identifier type 0 12.12.00.00.00.01.00.00.03
     bgp route-target 1212.8888.0003
     !
  timers peering 15
!

/* On PE3 */
!
l2vpn
 bridge group bg73
  bridge-domain bd73-1
    neighbor 10.10.10.10 pw-id 17300001
    !
    neighbor 20.20.20.20 pw-id 27300001

!
```

Verification

The following output shows the virtual access PW configuration.

```
Router# show evpn ethernet-segment
Thu Mar  7 10:56:37.662 UTC

Ethernet Segment Id      Interface                        Nexthops
----------------------- -------------------------------- --------------------
0012.1200.0000.0100.0003 PW:70.70.70.70,17300001           N/A
RP/0/RP0/CPU0:ios#show evpn ethernet-segment  detail
Thu Mar  7 10:56:53.806 UTC
Legend:
  B  - No Forwarders EVPN-enabled,
  C  - MAC missing (Backbone S-MAC PBB-EVPN / Grouping ES-MAC vES),
  RT - ES-Import Route Target missing,
  E  - ESI missing,
  H  - Interface handle missing,
  I  - Name (Interface or Virtual Access) missing,
  M  - Interface in Down state,
  O  - BGP End of Download missing,
  P  - Interface already Access Protected,
  Pf - Interface forced single-homed,
  R  - BGP RID not received,
  S  - Interface in redundancy standby state,
  X  - ESI-extracted MAC Conflict
  SHG - No local split-horizon-group label allocated
  Hp - Interface blocked on peering complete during HA event
  Rc - Recovery timer running during peering sequence

Ethernet Segment Id      Interface                        Nexthops
----------------------- -------------------------------- --------------------
0012.1200.0000.0100.0003 PW:70.70.70.70,17300001           N/A
  ES to BGP Gates   : R
  ES to L2FIB Gates : Ready
  Virtual Access    :
    Name            : PW_70.70.70.70_17300001
    State           : Peering
    Num PW Up       : 0
  ESI ID            : 1
  ESI type          : 0
    Value           : 0012.1200.0000.0100.0003
  ES Import RT       : 1212.8888.0003 (Local)
  Source MAC        : 0000.0000.0000 (N/A)
  Topology          :
    Operational     : SH
```

```
     Configured      : Single-active (AApS) (default)
```

EVPN Cost-Out

Table 5: Feature History Table

Feature Name	Release Information	Feature Description
EVPN Cost-Out on 8212-48FH-M, 8711-32FH-M, 88-LC1-52Y8H-EM, and 88-LC1-12TH24FH-E	Release 24.3.1	The EVPN Cost-Out is now supported on these fixed systems and line cards: • 8212-48FH-M • 8711-32FH-M • 88-LC1-52Y8H-EM • 88-LC1-12TH24FH-E
EVPN Cost-Out	Release 24.2.11	The cost-out node brings down the bundle interfaces on the PE to prepare the node for reload or software upgrade. By costing out a node, the traffic is steered away from the PE without any traffic disruption. This allows you to manage the network traffic effectively while reloading or upgrading a node. This feature is supported only on routers with the 88-LC1-36EH line cards.

EVPN cost-out enables you to control the state of bundle interfaces that are part of an Ethernet segment that have Link Aggregation Control protocol (LACP) configured. This feature enables you to put a node out of service (OOS) without having to manually shutdown all the bundles on their provider edge (PE) and prepare the node for reload or software upgrade.
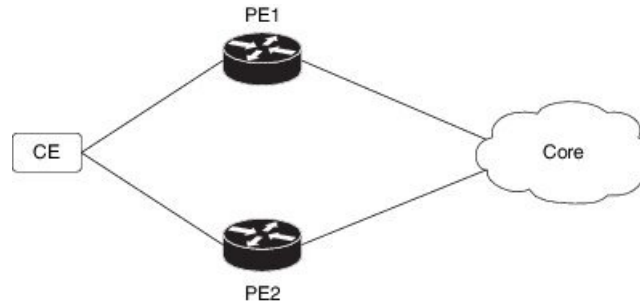
Use the **cost-out** command to bring down all the bundle interfaces belonging to an Ethernet VPN (EVPN) Ethernet segment on a node. The Ethernet A-D Ethernet Segment (ES-EAD) routes are withdrawn before shutting down the bundles. The PE signals to the connected customer edge (CE) device to bring down the corresponding bundle member. This steers away traffic from this PE node without traffic disruption. The traffic that is bound for the Ethernet segment from the CE is directed to the peer PE in a multi-homing environment.

Note EVPN cost-out is supported only on manually configured ESIs.

In the following topology, the CE is connected to PE1 and PE2. When you configure the **cost-out** command on PE1, all the bundle interfaces on the Ethernet segment are brought down. In addition, the corresponding bundle member is brought down on the CE. Hence, the traffic for this Ethernet segment is now sent to PE2 from the CE.

Figure 8: EVPN Cost-Out

To bring up the node into service, use the **no cost-out** command. This brings up all the bundle interfaces belonging to EVPN Ethernet segment on the PE and the corresponding bundle members on the CE.

When the node is in cost-out state, adding a new bundle Ethernet segment brings that bundle down. Similarly, removing the bundle Ethernet segment brings that bundle up.

Use the **startup-cost-in** command to bring up the node into service after the specified time on reload. The node will cost-out when EVPN is initialized and remain cost-out until the set time. If you execute the **no startup-cost-in** command while the timer is running, the timer stops and the node is cost-in.

The 'cost-out' configuration always takes precedence over the 'startup-cost-in' timer. So, if you reload with both the configurations, cost-out state is controlled by the 'cost-out' configuration and the timer is not relevant. Similarly, if you reload with the startup timer, and configure 'cost-out' while the timer is running, the timer is stopped and OOS state is controlled only by the 'cost-out' configuration.

If you do a process restart while the startup-cost-in timer is running, the node remains in cost-out state and the timer restarts.

Configure EVPN Cost-Out

The following examples show configuration of cost-out and startup cost-in timer.

```
/* Configuring cost-out to bring down the node on a PE */

Router# configure
Router(config)# evpn
Router(config-evpn)# cost-out
Router(config-evpn)commit

/* Bringing up the node into service */

Router# configure
Router(config)# evpn
Router(config-evpn)# no cost-out
Router(config-evpn)commit

/* Configuring the timer to bring up the node into service after the specified time on
reload */

Router# configure
Router(config)# evpn
Router(config-evpn)# startup-cost-in 6000
Router(config-evpn)commit
```

Running Configuration

```
configure
evpn
 cost-out
!

configure
evpn
 startup-cost-in 6000
!
```

Verification

The following examples show outputs to verify the cost-out and startup cost-in timer configurations.

```
/* Verify the node cost-out configuration */

Router# show evpn summary
Fri Apr  7 07:45:22.311 IST
Global Information
----------------------------
Number of EVIs             : 2
Number of Local EAD Entries  : 0
Number of Remote EAD Entries : 0
Number of Local MAC Routes   : 0
Number of Local MAC Routes   : 5
        MAC                : 5
        MAC-IPv4           : 0
        MAC-IPv6           : 0
Number of Local ES:Global MAC : 12
Number of Remote MAC Routes   : 7
        MAC                : 7
        MAC-IPv4           : 0
        MAC-IPv6           : 0
Number of Local IMCAST Routes : 56
Number of Remote IMCAST Routes: 56
Number of Internal Labels    : 5
Number of ES Entries         : 9
Number of Neighbor Entries   : 1
EVPN Router ID             : 192.168.0.1
BGP Router ID              : ::
BGP ASN                    : 100
PBB BSA MAC address        : 0207.1fee.be00
Global peering timer       :     3 seconds
Global recovery timer      :    30 seconds
EVPN cost-out              : TRUE
      startup-cost-in timer  : Not configured


/* Verify the no cost-out configuration */

Router# show evpn summary
Fri Apr  7 07:45:22.311 IST
Global Information
----------------------------
Number of EVIs             : 2
Number of Local EAD Entries  : 0
Number of Remote EAD Entries : 0
Number of Local MAC Routes   : 0
Number of Local MAC Routes   : 5
        MAC                : 5
```

```
              MAC-IPv4             : 0
              MAC-IPv6             : 0
Number of Local ES:Global MAC : 12
Number of Remote MAC Routes  : 7
              MAC                  : 7
              MAC-IPv4             : 0
              MAC-IPv6             : 0
Number of Local IMCAST Routes : 56
Number of Remote IMCAST Routes: 56
Number of Internal Labels    : 5
Number of ES Entries         : 9
Number of Neighbor Entries   : 1
EVPN Router ID               : 192.168.0.1
BGP Router ID                : ::
BGP ASN                      : 100
PBB BSA MAC address          : 0207.1fee.be00
Global peering timer         :     3 seconds
Global recovery timer        :    30 seconds
EVPN cost-out                : FALSE
     startup-cost-in timer   : Not configured


/* Verify the startup-cost-in timer configuration */

Router# show evpn summary
Fri Apr  7 07:45:22.311 IST
Global Information
---------------------------
Number of EVIs               : 2
Number of Local EAD Entries  : 0
Number of Remote EAD Entries : 0
Number of Local MAC Routes   : 0
Number of Local MAC Routes   : 5
              MAC                  : 5
              MAC-IPv4             : 0
              MAC-IPv6             : 0
Number of Local ES:Global MAC : 12
Number of Remote MAC Routes  : 7
              MAC                  : 7
              MAC-IPv4             : 0
              MAC-IPv6             : 0
Number of Local IMCAST Routes : 56
Number of Remote IMCAST Routes: 56
Number of Internal Labels    : 5
Number of ES Entries         : 9
Number of Neighbor Entries   : 1
EVPN Router ID               : 192.168.0.1
BGP Router ID                : ::
BGP ASN                      : 100
PBB BSA MAC address          : 0207.1fee.be00
Global peering timer         :     3 seconds
Global recovery timer        :    30 seconds
EVPN node cost-out           : TRUE
     startup-cost-in timer : 6000
```