



Configure EVPN IRB

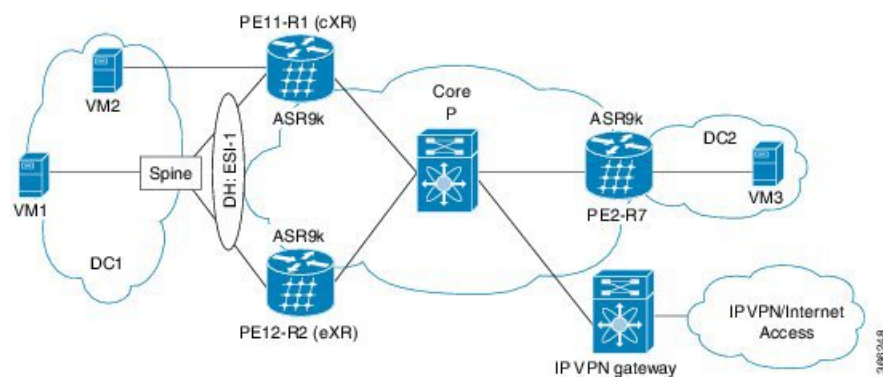
This chapter introduces you to Ethernet VPN (EVPN) Integrated Routing and Bridging (IRB) feature and describe how you can configure the EVPN IRB feature.

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EVPN IRB

Ethernet VPN (EVPN) provides an extensible and flexible multi-homing VPN solution for Layer 2 connectivity among hosts over an MPLS core/IP network. EVPN Integrated Routing and Bridging (IRB) feature enables Layer 3 forwarding among hosts across different IP subnets, while maintaining the multi-homing capabilities of EVPN. Also, EVPN IRB feature enables EVPN hosts or subnets to communicate with IP VPNs.

Figure 1: EVPN IRB



The above figure illustrates a scenario where EVPN IRB is deployed using three EVPN PE routers that provide single-homing or multi-homing Active-Active access. The PE routers exchange EVPN and IP VPN BGP address-families information. In Cisco ASR 9000 Series Aggregation Services Router, the centralized EVPN gateway with both EVPN and VPN address-families are enabled, so EVPN route stitching and re-origination does not occur. The single IP VPN gateway provides access to other IP VPNs or the Internet. The IP VPN gateway exchanges VPNv4 or VPNv6 address families with the EVPN PE routers but EVPN address family is not available.

In the above figure, the host sends an IP packet whose frame contain its MAC and IP address. The frame of the packet also includes the destination MAC address of the BVI interface of the local PE device and the IP address of the destination host. When the host is required to send packets for routing to other subnets and IP VPN or the Internet, the host uses the MAC address of the local BVI interface as destination MAC address. The IRB interface receives the packet in whose frame the interface's MAC address is set as the destination. The IRB interface routes the packet to the destination after looking up the VRF table. The PE device chooses an intra-subnet route registered earlier in the VRF table. The MAC address that matches the destination IP, in the earlier route, becomes the new MAC address which replaces the existing MAC address in the packet. The packet reaches the destination remote PE device, to which the destination host is connected, which does an inter-subnet looks up in the VRF table for the MAC address of the destination host. Then, through the IRB interface, the remote PE device forwards the packet to the destination host.

EVPN Single-Homing Access EVPN Gateway

The EVPN provider edge (PE) devices learn the MAC address and IP address from the ARP traffic that they receives from the customer edge (CE) devices. The PEs create the MAC+IP routes. The PEs advertise the MAC+IP routes to MPLS core. They inject the host IP routes to IP-VPN gateway. All the PE nodes add the host routes in the IP-VRF table. The EVPN PE nodes add MAC route to the MAC-VRF table. The IP-VPN PE advertise the subnet routes to the provider edge devices who add the subnet routes to IP-VRF table. On the PE devices, IRB IP addresses and MAC addresses are not advertised through BGP. The IRB IP addresses or MAC addresses are used to send ARP requests towards the datacenter CEs.

EVPN Multi-Homing Active-Active

EVPN Multi-homing access gateway enables redundant network connectivity by allowing a CE device to connect to more than one PE devices. Disruptions to the network connectivity are prevented by allowing a CE device to be connected to a PE device or several PE devices through multi-homing. Ethernet segment is the bunch of Ethernet links through which a CE device is connected to more than one PE devices. The Multi-chassis Link Aggregation Group (MC-LAG) bundle operates as an Ethernet segment. In Release 6.2.1, only MC bundles crossing two chassis are supported.

In EVPN IRB, both EVPN and IP VPN (both VPNv4 and VPNv6) address families are enabled between ASR 9000 Data Center Interconnect (DCI) gateways. When Layer 2 (L2) stretch is not available in multiple datacenters (DC), routing is established through VPNv4 or VPNv6 routes. When Layer 2 stretch is available, host routing is applied where IP-MAC routes are learnt by ARP/IPv6 ND and are distributed to EVPN/BGP. In remote peer gateway, these IP-MAC EVPN routes are imported into IP VPN routing table from EVPN route-type 2 routes with secondary label and Layer 3 VRF route-target.

EVPN IRB Support

EVPN IRB supports the following scenarios:

- In single-homing scenario, only physical, VLAN, .1q, .1ad, or QinQ access methods are supported.
- In dual-homing scenario, only active-active mode is supported.
- In dual-homing scenario, only two PE gateways in a redundancy group are supported.
- Both IPv4 and IPv6 are supported.

Distributed Anycast Gateway

EVPN IRB for the given subnet is configured on all the EVPN PEs that are hosted on this subnet. To facilitate optimal routing while supporting transparent virtual machine mobility, hosts are configured with a single default gateway address for their local subnet. That single (anycast) gateway address is configured with a single (anycast) MAC address on all EVPN PE nodes locally supporting that subnet. This process is repeated for each locally defined subnet requires Anycast Gateway support.

The host-to-host Layer 3 traffic, similar to Layer 3 VPN PE-PE forwarding, is routed on the source EVPN PE to the destination EVPN PE next-hop over an IP or MPLS tunnel, where it is routed again to the directly connected host. Such forwarding is also known as Symmetric IRB because the Layer 3 flows are routed at both the source and destination EVPN PEs.

The following solutions are part of the Distributed Anycast Gateway feature:

EVPN IRB with Active-Active Multi-Homing with Subnet Stretch or Host-Routing across the Fabric

For a bridge domain or subnet that is stretched across remote EVPN PEs, both /32 host routes and MAC routes are distributed in a EVPN overlay control plane to enable Layer 2 and Layer 2 traffic to the end points in a stretched subnet.

This type of multi-homing has the following characteristics:

- All-active MC-LAG on access
- Layer 2 or Layer 3 ECMP for the fabric for dual-homed hosts based on Route Type 1 and Route Type 2
- Layer 3 unipath over the Fabric for single-homed hosts based on Route Type 2
- Layer 2 subnet stretch over the fabric
- Layer 2 stretch within redundancy group of leafs with orphan ports

MAC and IP Unicast Control Plane

This use case has following types:

Prefix Routing or No Subnet Stretch

IP reachability across the fabric is established using subnet prefix routes that are advertised using EVPN Route Type 5 with the VPN label and VRF RTs. Host ARP and MAC sync are established across multi-homing EVPN PEs using MAC+IP Route Type 2 based on a shared ESI to enable local switching through both the multi-homing EVPN PEs.

Host Routing or Stretched Subnet

When a host is discovered through ARP, the MAC and IP Route Type 2 is advertised with both MAC VRF and IP VRF router targets, and with VPN labels for both MAC-VRF and IP-VRF. Particularly, the VRF route targets and Layer 3 VPN label are associated with Route Type 2 to achieve PE-PE IP routing identical to traditional L3VPNs. A remote EVPN PE installs IP/32 entries directly in Layer 3 VRF table through the advertising EVPN PE next-hop with the Layer 3 VPN label encapsulation, much like a Layer 3 VPN imposition PE. This approach avoids the need to install separate adjacency rewrites for each remote host in a stretched subnet. Instead, it inherits a key Layer 3 VPN scale benefit of being able to share a common forwarding rewrite or load-balance resource across all IP host entries reachable through a set of EVPN PEs.

ARP and MAC sync

For hosts that are connected through LAG to more than one EVPN PE, the local host ARP and MAC entries are learnt in data plane on either or both of the multihoming EVPN PEs. Local ARP and MAC entries are synced across the two multihoming EVPN PEs using MAC and IP Route Type 2 based on a shared ESI to enable local switching through both the multihoming EVPN PEs. Essentially, a MAC and IP Route Type 2 that is received with a local ESI causes the installation of a synced MAC entry that points to the local AC port, and a synced ARP entry that is installed on the local BVI interface.



Note Only one Ethernet Flow Point (EFP) is supported per non-Zero ESI per bridge domain or EVI. This is a limitation of EVPN.

MAC and IP Route Re-origination

MAC and IP Route Type 2 received with a local ESI, which is used to sync MAC and ARP entries, is also re-originated from the router that installs a SYNC entry, if the host is not locally learnt and advertised based on local learning. This route re-origination is required to establish overlay IP ECMP paths on remote EVPN PEs, and to minimize traffic hit on local AC link failures, that can result in MAC and IP route withdraw in the overlay.

Intra-subnet Unicast Data Plane

The Layer 2 traffic is bridged on the source EVPN PE using ECMP paths to remote EVPN PEs, established through MAC+IP RT2, for every ES and for every EVI, ES and EAD Route Type 2 routes that are advertised from the local EVPN PEs.

Inter-subnet Unicast Data Plane

Inter-subnet traffic is routed on the source EVPN PEs through overlay ECMP to the destination EVPN PEs next-hops. Data packets are encapsulated with the VPN label advertised from the EVPN PE and tunnel label for the BGP next-hop towards the spine. It is then routed again on the destination EVPN PE using a local ARP adjacency towards the host. IP ECMP on the remote EVPN PEs is established through local and re-originated routes advertised from the local EVPN PEs.

VM Mobility Support

VM mobility is the ability of virtual machines to migrate between one server and another while retaining their existing MAC and IP addresses.

The following are the two key components in EVPN Route Type 2 that enable VM Mobility:

- Host MAC advertisement component that is imported into local bridge MAC table, and Layer 2 bridged traffic across the network overlay.
- Host IP advertisement component that is imported into the IP routing table in a symmetric IRB design, enables routed traffic across the network overlay.

The above-mentioned components are advertised together in a single MAC + IP host route advertisement. An additional MAC-only route could also be advertised.

The following behaviors of VM are supported. The VM can:

- retain existing MAC and acquire a new IP address
- retain existing IP address and acquire a new MAC
- retain both existing MAC and IP address



Note IRB solution supports VM mobility with IP+MAC pair. VM mobility move, with new IP to MAC, or new MAC to IP, is not supported.

Configuring EVPN IRB

```
/* Configure CEF to prefer RIB prefixes over adjacency prefixes.*/
```

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# interface Bundle-Ether 3
RP/0/RSP0/CPU0:router(config-if)# lacp system mac 1.1.1
RP/0/RSP0/CPU0:router(config-if)# exit
RP/0/RSP0/CPU0:router(config)# cef adjacency route override rib
```

```
/* Configure EVPN L3VRF per DC tenant. */
```

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# vrf irb1
RP/0/RSP0/CPU0:router(config-vrf)# address-family ipv4 unicast
RP/0/RSP0/CPU0:router(config-vrf-af)# import route-target 1000:1
RP/0/RSP0/CPU0:router(config-vrf-af)# export route-target 1000:1
RP/0/RSP0/CPU0:router(config-vrf-af)# exit
```

```
/* Configure Layer 2 attachment circuit (AC) from multichassis (MC) bundle interface, and
bridge-group virtual interface (BVI) per bridge domain. */
/* Note: When a VM migrates from one subnet to another (subnet stretching), apply the
following IRB configuration to both the EVPN PEs. */
```

```

RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# interface bvi 1001
RP/0/RSP0/CPU0:router(config-if)# host-routing
RP/0/RSP0/CPU0:router(config-if)# ipv4 address 10.10.0.4 255.255.255.0
RP/0/RSP0/CPU0:router(config-if)# ipv4 address 172.16.0.1 secondary
RP/0/RSP0/CPU0:router(config-if)# mac-address 2001:DB8::1

/* Configure EVPN Layer 2 bridging service. Note: This configuration is performed in Layer
 2 gateway or bridging scenario. */

Router# configure
Router(config)# l2vpn
Router(config-l2vpn)# bridge group 1
Router(config-l2vpn-bg)# bridge-domain 1-1
Router(config-l2vpn-bg-bd)# interface GigabitEthernet 0/0/0/1.1
Router(config-l2vpn-bg-bd-ac)# evi 1
Router(config-l2vpn-bg-bd-ac-evi)# commit
Router(config-l2vpnbg-bd-ac-evi)# exit

/* Configure BGP. */

RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# router bgp 3107
RP/0/RSP0/CPU0:router(config-bgp)# vrf irb1
RP/0/RSP0/CPU0:router(config-bgp-vrf)# rd auto
RP/0/RSP0/CPU0:router(config-bgp-vrf)# address-family ipv4 unicast
RP/0/RSP0/CPU0:router(config-bgp-vrf-af)# redistribute connected
RP/0/RSP0/CPU0:router(config-bgp-vrf-af)# redistribute static
RP/0/RSP0/CPU0:router(config-bgp-vrf-af)# exit
RP/0/RSP0/CPU0:router(config-bgp-vrf-af)# redistribute connected
RP/0/RSP0/CPU0:router(config-bgp-vrf-af)# redistribute static

/* Configure EVPN, and configure main bundle ethernet segment parameters in EVPN. */

RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# evpn
RP/0/RSP0/CPU0:router(config-evpn)# evi 2001
RP/0/RSP0/CPU0:router(config-evpn-evi)# bgp
RP/0/RSP0/CPU0:router(config-evpn-evi-bgp)# route-target import 1000:1
RP/0/RSP0/CPU0:router(config-evpn-evi-bgp)# route-target export 1000:1
RP/0/RSP0/CPU0:router(config-evpn-evi-bgp)# exit
RP/0/RSP0/CPU0:router(config-evpn-evi)# advertise-mac
RP/0/RSP0/CPU0:router(config-evpn-evi)# unknown-unicast-suppression

/* Configure Layer 2 VPN. */

RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group irb
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain irb1
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# interface bundle-Ether3.1001
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)# routed interface BVI100
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-bvi)# split-horizon group core
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-bvi)# evi 10001

```

Running Configuration for EVPN IRB

```
/* Configure LACP */

interface Bundle-Ether3
  lacp system mac 1.1.1
!

/* Configure CEF adjacency overwrite. */

cef adjacency route override rib

/* Configure EVPN Layer 3 VRF per DC tenant. */

vrf irbl
address-family ipv4 unicast
  import route-target
    1000:1
  !
  export route-target
    1000:1
  !
!
!

/* Configure Layer 2 attachment circuit (AC) from multichassis (MC) bundle interface, and
bridge-group virtual interface (BVI) per bridge domain.*/

interface Bundle-Ether3.1001 l2transport
  encapsulation dot1q 1001
  rewrite ingress tag pop 1 symmetric
!
interface BVI1001
  host-routing
  vrf irbl
  ipv4 address 10.0.1.1 255.255.255.0
  mac-address 0000.3030.1
!

/* Configure BGP. */

router bgp 3107
  vrf irbl
  rd auto
  address-family ipv4 unicast
  redistribute connected
  redistribute static
!
!

/* Configure EVPN. */

evpn
evi 10001
  bgp
  route-target import 1000:1
  route-target export 1000:1
  !
  advertise-mac
  unknown-unicast-suppression
!

/* Configure Layer2 VPN. */
```

```

l2vpn
bridge group irb
  bridge-domain irb1
  interface Bundle-Ether3.1001
  !
  routed interface BVI1001
  split-horizon group core
  !
  evi 10001
  !
  !

```

Verify EVPN IRB

Verify the Address Resolution Protocol (ARP) protocol entries, and synced entries in multi-homing scenarios; only multi-homing active-active mode is supported for EVPN IRB.

```
RP/0/RSP0/CPU0:router# show arp vrf evpn1
```

```

-----
0/1/CPU0
-----
Address      Age           Hardware Addr  State   Type   Interface
-----
10.1.1.1     -            0010.0001.0001 Interface ARPA   BVI1
10.1.1.11   02:23:46    1000.0001.0001 Dynamic  ARPA   BVI1
10.1.1.93    -            0000.f65a.357c EVPN_SYNC ARPA   BVI1
10.1.2.1     -            0011.0112.0001 Interface ARPA   BVI2
10.1.2.91   02:24:14    0000.f65a.3570 Dynamic  ARPA   BVI2
10.1.2.93   02:21:52    0000.f65a.357d Dynamic  ARPA   BVI2
-----
0/0/CPU0
-----
Address      Age           Hardware Addr  State   Type   Interface
-----
10.1.1.1     -            0010.0001.0001 Interface ARPA   BVI1
10.1.1.11   02:23:46    1000.0001.0001 Dynamic  ARPA   BVI1
10.1.1.93    -            0000.f65a.357c EVPN_SYNC ARPA   BVI1
10.1.2.1     -            0011.0112.0001 Interface ARPA   BVI2
10.1.2.91   02:24:14    0000.f65a.3570 Dynamic  ARPA   BVI2
10.1.2.93   02:21:52    0000.f65a.357d Dynamic  ARPA   BVI2

```

Verify the adjacency entries, particularly verify newly added information for synced IPv4 and IP ARP entries.

```
RP/0/RSP0/CPU0:router# show adjacency ipv4 BVI 1 internal detail location 0/0/CPU0
```

```

BVI1, 10.1.1.93 (ipv4)
Version: 1169, references: 2, transient lock: 0
Encapsulation information (14 bytes) 0000f65a357c0000f65a357c0800 MTU: 1500
Adjacency pointer is: 0x770a9278
Platform adjacency pointer is: 0x7d7bc380
Last updated: Feb 28 15:58:21.998
Adjacency producer: arp (prod_id: 10)
Flags: incomplete adj,
Additional Adjacency Information (4 bytes long),
Upto first 4 bytes (in hex): 01000000
Netio idb pointer not cached Cached interface type: 78

```



```

Adjacency references:
bfd_agent (JID 150, PID 3637), 0 reference
l2fib_mgr (JID 185, PID 4003), 0 reference
fib_mgr (JID 294, PID 3605), 1 reference
aib (JID 314, PID 3590), 1 reference

BVI1, 10.1.1.11 (ipv4) Version: 1493,
references: 3, transient lock: 0
Encapsulation information (14 bytes) 1000000100010010000100010800
MTU: 1500
Adjacency pointer is: 0x770ab778
Platform adjacency pointer is: 0x7d7bcb10
Last updated: Mar 2 17:22:00.544
Adjacency producer: arp (prod_id: 10)
Flags: incomplete adj,
Netio idb pointer not cached Cached interface type: 78
Adjacency references:
bfd_agent (JID 150, PID 3637), 0 reference
l2fib_mgr (JID 185, PID 4003), 1 reference
fib_mgr (JID 294, PID 3605), 1 reference
aib (JID 314, PID 3590), 1 reference
    
```

Verify the entries to obtain details learnt in L2FIB line cards. In multi-homing active-active scenario, the link-local addresses are also updated and distributed to EVPN peer gateways.

```
RP/0/RSP0/CPU0:router# show l2vpn mac-learning mac-ipv4 all location 0/0/cPU0
```

Topo ID	Producer	Next Hop(s)	Mac Address	IP Address
6	0/0/CPU0	BV1	1000.0001.0001	10.1.1.11
7	0/0/CPU0	BV2	0000.f65a.3570	10.1.2.91
7	0/0/CPU0	BV2	0000.f65a.357d	10.1.2.93

```
RP/0/RSP0/CPU0:router# show l2vpn mac-learning mac-ipv4 all location 0/0/cPU0
```

Topo ID	Producer	Next Hop(s)	Mac Address	IP Address
6	0/0/CPU0	BV1	0000.f65a.357c	fe80::200:f6ff:fe5a:357c
7	0/0/CPU0	BV2	0000.f65a.3570	10:1:2::91
7	0/0/CPU0	BV2	0000.f65a.357d	10:1:2::93
7	0/0/CPU0	BV2	0000.f65a.3570	fe80::200:f6ff:fe5a:3570

Verify sequence ID for VM mobility.

```
RP/0/RSP0/CPU0:router# show l2route evpn mac-ip all detail
```

```

Sun Apr 30 18:09:19.368 PDT
Flags: (Stt)=Static; (L)=Local; (R)=Remote; (F)=Flood;
(N)=No Redistribution; (Rtr)=Router MAC; (B)=Best Route;
(P)=Probe; (S)=Peer Sync; (F)=Flush;
(D)=Duplicate MAC; (Z)=Frozen MAC;

Topo ID      Mac Address      IP Address      Prod   Next Hop(s)      Seq No  Flags
Opaque Data Type  Opaque Data Len Opaque Data Value
-----
-----
-----
33          0022.6730.0001  10.130.0.2     L2VPN Bundle-Ether6.1300  0       SB 0 12
0x06000000          0x22000080     0x00000000
    
```

Last Update: Sun Apr 30 15:00:01.911 PDT

```
33          0022.6730.0002 10.130.0.3 LOCAL Bundle-Ether6.1300 0      B      N/A
           N/A                N/A
```

Verify the entries to obtain details learnt in L2FIB RP when it is an aggregator. Route processor (RP) entries are aggregated entries obtained from the line cards. In some cases of MAC move, there could be different states for the same MAC. This is displayed in RP aggregated entries. RP determines the update to be sent to L2RIB according to MAC-Learning algorithms.

RP/0/RSP0/CPU0:router# **show l2vpn mac-learning mac-ipv4 all location 0/RSP0/CPU0**

Topo ID	Producer	Next Hop(s)	Mac Address	IP Address
6	0/0/CPU0	BV1	1000.0001.0001	10.1.1.11
7	0/0/CPU0	BV2	0000.f65a.3570	10.1.2.91
7	0/0/CPU0	BV2	0000.f65a.357d	10.1.2.93

Verify the entries in L2RIB that are updated by RP L2FIB. Note the following when you verify the entries:

- The entries with producer as L2VPN and NH as remote IP are learnt from the remote peer gateways, which are learnt from BGP, updated to EVPN, and then updated to L2RIB. So these entries are not from local IP-MAC learning.
- The entries with producer as L2VPN and NH as local bundle interfaces are synced entries from MH-AA peer gateway.
- The entries with producer as LOCAL and NH as local bundle interfaces are dynamically learnt local entries.

RP/0/RSP0/CPU0:router# **show l2route evpn mac-ip evi 6**

Topo ID	Mac Address	IP Address	Prod	Next Hop(s)
6	0000.f65a.3569	10.1.1.101	L2VPN	172.16.0.2/24014/ME
6	0000.f65a.3575	10.1.1.97	L2VPN	172.16.0.7/24025/ME
6	0000.f65a.3575	10:1:1::97	L2VPN	172.16.0.7/24025/ME
6	0000.f65a.3575	fe80::200:f6ff:fe5a:3575	L2VPN	172.16.0.7/24025/ME
6	0000.f65a.357c	10.1.1.93	L2VPN	Bundle-Ether1.11
6	0000.f65a.357c	10:1:1::93	L2VPN	Bundle-Ether1.11
6	0000.f65a.357c	fe80::200:f6ff:fe5a:357c	LOCAL	Bundle-Ether1.11
6	0010.0001.0012	10.1.1.12	L2VPN	172.16.0.7/24025/ME
6	1000.0001.0001	10.1.1.11	LOCAL	Bundle-Ether1.11
6	90e2.ba8e.c0c9	10.1.1.102	L2VPN	172.16.0.2/24014/ME

Verify entries to obtain details of EVPN.

RP/0/RSP0/CPU0:router# **show evpn evi vpn-id 1 mac ipv4 10.1.1.93 detail**

EVI	MAC address	IP address	Nexthop	Label
-----	-------------	------------	---------	-------

```

-----
1          0000.f65a.357c      10.1.1.93          172.16.0.2          24014

```

```

Ethernet Tag : 0
Multi-paths Resolved : True
Static : No
Local Ethernet Segment : N/A
Remote Ethernet Segment : 0100.6cbc.a77c.c180.0000
Local Sequence Number : N/A
Remote Sequence Number : 0
Local Encapsulation : N/A
Remote Encapsulation : MPLS

```

Verify local BGP entries with appropriate second label and second IP VRF route-target.

```

RP/0/RSP0/CPU0:router# show bgp l2vpn evpn rd 172.16.0.1:1
[2] [0] [48] [0000.f65a.357c] [32] [10.1.1.93]/136

```

```

BGP routing table entry for [2] [0] [48] [0000.f65a.357c] [32] [10.1.1.93]/136, Route
Distinguisher: 172.16.0.1:1
Versions:

```

```

Process bRIB/RIB SendTblVer
Speaker 3772 3772
Local Label: 24013
Last Modified: Feb 28 16:06:37.073 for 2d19h
Paths: (2 available, best #1)
Advertised to peers (in unique update groups):
172.16.0.9
Path #1: Received by speaker 0
Advertised to peers (in unique update groups):
172.16.0.9
Local
0.0.0.0 from 0.0.0.0 (172.16.0.1)
Second Label 24027 >>>> Second label when IRB host-routing
is enabled.
Origin IGP, localpref 100, valid, redistributed, best, group-best, import-candidate,
rib-install
Received Path ID 0, Local Path ID 0, version 3772
Extended community: SoO:172.16.0.2:1 RT:100:100
EVPN ESI: 0100.6cbc.a77c.c180.0000
Path #2: Received by speaker 0
Not advertised to any peer
Local
172.16.0.2 (metric 101) from 172.16.0.9 (172.16.0.2)
Received Label 24014, Second Label 24031
Origin IGP, localpref 100, valid, internal, add-path, import-candidate, imported, rib-install
Received Path ID 0, Local Path ID 2, version 3769
Extended community: SoO:172.16.0.2:1 RT:200:1 RT:700:100 >>> Second RT is IP VRF RT for
remote to import into IP VRF routing table.
Originator: 172.16.0.2, Cluster list: 172.16.0.9
EVPN ESI: 0100.6cbc.a77c.c180.0000
Source AFI: L2VPN EVPN, Source VRF: default, Source Route Distinguisher: 172.16.0.2:1

```

```

RP/0/RSP0/CPU0:router# show bgp l2vpn evpn rd 172.16.0.1:1
[2] [0] [48] [0000.f65a.357c] [128] [10:1:1::93]/232

```

```

[2] [0] [48] [0000.f65a.357c] [128] [10:1:1::93]/232
BGP routing table entry for [2] [0] [48] [0000.f65a.357c] [128] [10:1:1::93]/232, Route

```

```

Distinguisher: 172.16.0.1:1
Versions:
Process bRIB/RIB SendTblVer
Speaker 3172 3172
Local Label: 24013
Last Modified: Feb 28 11:34:33.073 for 3d00h
Paths: (2 available, best #1)
Advertised to peers (in unique update groups):
172.16.0.9
Path #1: Received by speaker 0
Advertised to peers (in unique update groups):
172.16.0.9
Local
0.0.0.0 from 0.0.0.0 (172.16.0.1)
Second Label 24029
Origin IGP, localpref 100, valid, redistributed, best, group-best, import-candidate,
rib-install
Received Path ID 0, Local Path ID 0, version 3172
Extended community: SoO:172.16.0.2:1 RT:100:100
EVPN ESI: 0100.6cbc.a77c.c180.0000
Path #2: Received by speaker 0
Not advertised to any peer
Local
172.16.0.2 (metric 101) from 172.16.0.9 (172.16.0.2)
Received Label 24014, Second Label 24033
Origin IGP, localpref 100, valid, internal, add-path, import-candidate, imported, rib-install
Received Path ID 0, Local Path ID 2, version 3167
Extended community: SoO:172.16.0.2:1 RT:200:1 RT:700:100
Originator: 172.16.0.2, Cluster list: 172.16.0.9
EVPN ESI: 0100.6cbc.a77c.c180.0000
Source AFI: L2VPN EVPN, Source VRF: default, Source Route Distinguisher: 172.16.0.2:1

```

Verify the remote peer gateway BGP entries with correct label and route-target. Particularly verify the local auto-generated RD on a remote EVPN gateway. EVPN type-2 routes are imported into EVPN. The host routes of IPv4 /32 addresses are imported only into IP VRF route-table in the remote EVPN gateway, but not in the local EVPN gateway where local BVI adjacency is used to overwrite RIB entries.

```

RP/0/RSP0/CPU0:router# show bgp l2vpn evpn rd 172.16.0.7:1
[2][0][48][0000.f65a.357c][32][10.1.1.93]/136
BGP routing table entry for [2][0][48][0000.f65a.357c][32][10.1.1.93]/136, Route
Distinguisher: 172.16.0.7:1
Versions:
Process bRIB/RIB SendTblVer
Speaker 16712 16712
Last Modified: Feb 28 16:06:36.448 for 2d19h
Paths: (2 available, best #1)
Not advertised to any peer
Path #1: Received by speaker 0
Not advertised to any peer
Local
172.16.0.1 from 172.16.0.9 (172.16.0.1)
Received Label 24013, Second Label 24027 >>>> First label for L2 MAC unicast bridging;
second label for EVPN IRB host-routing
Origin IGP, localpref 100, valid, internal, best, group-best, import-candidate, imported,
rib-install
Received Path ID 0, Local Path ID 0, version 16712
Extended community: SoO:172.16.0.2:1 RT:100:1 RT:100:100
Originator: 172.16.0.1, Cluster list: 172.16.0.9
EVPN ESI: 0100.6cbc.a77c.c180.0000

```

```

Source AFI: L2VPN EVPN, Source VRF: default, Source Route Distinguisher: 172.16.0.1:1
Path #2: Received by speaker 0
Not advertised to any peer
Local
172.16.0.2 from 172.16.0.9 (172.16.0.2)
Received Label 24014, Second Label 24031
Origin IGP, localpref 100, valid, internal, backup, add-path, import-candidate, imported,
rib-install
Received Path ID 0, Local Path ID 1, version 16706
Extended community: SoO:172.16.0.2:1 RT:200:1 RT:700:100
Originator: 172.16.0.2, Cluster list: 172.16.0.9
EVPN ESI: 0100.6cbc.a77c.c180.0000
Source AFI: L2VPN EVPN, Source VRF: default, Source Route Distinguisher: 172.16.0.2:1

```

```

RP/0/RSP0/CPU0:router# show bgp l2vpn evpn rd 172.16.0.7:1
[2][0][48][0000.f65a.357c][128][10:1:1::93]/232

```

```

BGP routing table entry for [2][0][48][0000.f65a.357c][128][10:1:1::93]/232, Route
Distinguisher: 172.16.0.7:1
Versions:
Process bRIB/RIB SendTblVer
Speaker 6059 6059
Last Modified: Feb 28 12:03:22.448 for 2d23h
Paths: (2 available, best #1)
Not advertised to any peer
Path #1: Received by speaker 0
Not advertised to any peer
Local
172.16.0.1 from 172.16.0.9 (172.16.0.1)
Received Label 24013, Second Label 24029
Origin IGP, localpref 100, valid, internal, best, group-best, import-candidate, imported,
rib-install
Received Path ID 0, Local Path ID 0, version 6043
Extended community: SoO:172.16.0.2:1 RT:100:1 RT:100:100
Originator: 172.16.0.1, Cluster list: 172.16.0.9
EVPN ESI: 0100.6cbc.a77c.c180.0000
Source AFI: L2VPN EVPN, Source VRF: default, Source Route Distinguisher: 172.16.0.1:1
Path #2: Received by speaker 0
Not advertised to any peer
Local
172.16.0.2 from 172.16.0.9 (172.16.0.2)
Received Label 24014, Second Label 24033
Origin IGP, localpref 100, valid, internal, backup, add-path, import-candidate, imported,
rib-install
Received Path ID 0, Local Path ID 1, version 6059
Extended community: SoO:172.16.0.2:1 RT:200:1 RT:700:100
Originator: 172.16.0.2, Cluster list: 172.16.0.9
EVPN ESI: 0100.6cbc.a77c.c180.0000
Source AFI: L2VPN EVPN, Source VRF: default, Source Route Distinguisher: 172.16.0.2:1

```

Verify the remote peer gateway with host routes of IPv4 /32 addresses imported into the IP VRF routing table.

```

RP/0/RSP0/CPU0:router# show bgp vpnv4 unicast vrf evpn1 10.1.1.93/32

```

```

BGP routing table entry for 10.1.1.93/32, Route Distinguisher: 172.16.0.7:11
Versions:

```

```

Process bRIB/RIB SendTblVer
Speaker 22202 22202
Last Modified: Feb 28 16:06:36.447 for 2d19h
Paths: (2 available, best #1)
Not advertised to any peer
Path #1: Received by speaker 0
Not advertised to any peer
Local
172.16.0.1 from 172.16.0.9 (172.16.0.1)
Received Label 24027
Origin IGP, localpref 100, valid, internal, best, group-best, import-candidate, imported
Received Path ID 0, Local Path ID 0, version 22202
Extended community: SoO:172.16.0.2:1 RT:100:1 RT:100:100
Originator: 172.16.0.1, Cluster list: 172.16.0.9
Source AFI: L2VPN EVPN, Source VRF: default, Source Route Distinguisher: 172.16.0.1:1 >>>>
The source from

>>>> L2VPN and from

>>>> synced ARP entry.
Path #2: Received by speaker 0
Not advertised to any peer
Local
172.16.0.2 from 172.16.0.9 (172.16.0.2)
Received Label 24031
Origin IGP, localpref 100, valid, internal, backup, add-path, import-candidate, imported
Received Path ID 0, Local Path ID 1, version 22201
Extended community: SoO:172.16.0.2:1 RT:200:1 RT:700:100
Originator: 172.16.0.2, Cluster list: 17.0.0.9
Source AFI: L2VPN EVPN, Source VRF: default, Source Route Distinguisher: 172.16.0.2:1 >>>>
The source from

>>>> L2VPN and

>>>> from dynamic

>>>> ARP entry.

```

```
RP/0/RSP0/CPU0:router# show bgp vpnv6 unicast vrf evpn1 10:1:1::93/128
```

```

BGP routing table entry for 10:1:1::93/128, Route Distinguisher: 172.16.0.7:11
Versions:
Process bRIB/RIB SendTblVer
Speaker 22163 22163
Last Modified: Feb 28 12:09:30.447 for 2d23h
Paths: (2 available, best #1)
Not advertised to any peer
Path #1: Received by speaker 0
Not advertised to any peer
Local
172.16.0.1 from 172.16.0.9 (172.16.0.1)
Received Label 24029
Origin IGP, localpref 100, valid, internal, best, group-best, import-candidate, imported
Received Path ID 0, Local Path ID 0, version 22163
Extended community: SoO:172.16.0.2:1 RT:100:1 RT:100:100
Originator: 172.16.0.1, Cluster list: 172.16.0.9
Source AFI: L2VPN EVPN, Source VRF: default, Source Route Distinguisher: 172.16.0.1:1 >>>>
Source from

>>>> L2VPN and from

```

```

>>>> synced ARP entry.
Path #2: Received by speaker 0
Not advertised to any peer
Local
172.16.0.2 from 172.16.0.9 (172.16.0.2)
Received Label 24033
Origin IGP, localpref 100, valid, internal, backup, add-path, import-candidate, imported
Received Path ID 0, Local Path ID 1, version 22163
Extended community: SoO:172.16.0.2:1 RT:200:1 RT:700:100
Originator: 172.16.0.2, Cluster list: 172.16.0.9
Source AFI: L2VPN EVPN, Source VRF: default, Source Route Distinguisher: 172.16.0.2:1 >>>>
Source from

>>>> L2VPN and from

>>>> dynamic ARP entry.

```

```

RP/0/RSP0/CPU0:router# show bgp vpnv6 unicast vrf evpn1 10:1:1::93/128

BGP routing table entry for 10:1:1::93/128, Route Distinguisher: 172.16.0.7:11
Versions:
Process bRIB/RIB SendTblVer
Speaker 22163 22163
Last Modified: Feb 28 12:09:30.447 for 2d23h
Paths: (2 available, best #1)
Not advertised to any peer
Path #1: Received by speaker 0
Not advertised to any peer
Local
172.16.0.1 from 172.16.0.9 (172.16.0.1)
Received Label 24029
Origin IGP, localpref 100, valid, internal, best, group-best, import-candidate, imported
Received Path ID 0, Local Path ID 0, version 22163
Extended community: SoO:172.16.0.2:1 RT:100:1 RT:100:100
Originator: 172.16.0.1, Cluster list: 172.16.0.9
Source AFI: L2VPN EVPN, Source VRF: default, Source Route Distinguisher: 172.16.0.1:1
Path #2: Received by speaker 0
Not advertised to any peer
Local
172.16.0.2 from 172.16.0.9 (172.16.0.2)
Received Label 24033
Origin IGP, localpref 100, valid, internal, backup, add-path, import-candidate, imported
Received Path ID 0, Local Path ID 1, version 22163
Extended community: SoO:172.16.0.2:1 RT:200:1 RT:700:100
Originator: 172.16.0.2, Cluster list: 172.16.0.9
Source AFI: L2VPN EVPN, Source VRF: default, Source Route Distinguisher: 172.16.0.2:1

```

Verify local forwarding with local adjacency which overwrite the RIB entries, and remote peer that use the IP VRF host route entries for IP VPN forwarding.

```

RP/0/RSP0/CPU0:router# show bgp vpnv4 unicast vrf evpn1 10.1.1.93/32

-- For local routing and forwarding
RP/0/RSP0/CPU0:PE11-R1#show route vrf evpn1 10.1.1.93
Routing entry for 10.1.1.93/32
Known via "bgp 3107", distance 200, metric 0, type internal
Installed Feb 28 15:57:28.154 for 2d20h

```

```

Routing Descriptor Blocks
172.16.0.2, from 172.16.0.9    >>> From MH-AA peer.
Nexthop in Vrf: "default", Table: "default", IPv4 Unicast, Table Id: 0xe0000000
Route metric is 0
No advertising protos.

RP/0/RSP0/CPU0:PE11-R1# show cef vrf evpn1 10.1.1.93 location 0/0/CPU0
10.1.1.93/32, version 0, internal 0x1120001 0x0 (ptr 0x7b40052c) [1], 0x0 (0x7b286010), 0x0
(0x0)
Updated Feb 28 15:58:22.688
local adjacency 10.1.1.93
Prefix Len 32, traffic index 0, Adjacency-prefix, precedence n/a, priority 15
via 10.1.1.93/32, BVI1, 2 dependencies, weight 0, class 0 [flags 0x0]
path-idx 0 NHID 0x0 [0x7f531f88 0x0]
next hop
Local adjacency                >>> Forwarding with local synced ARP adjacency entries.

```

For remote routing and forwarding:

```

RP/0/RSP0/CPU0:router# show route vrf evpn1 10.1.1.93

Routing entry for 10.1.1.93/32
Known via "bgp 3107", distance 200, metric 0
Number of pic paths 1 , type internal
Installed Feb 28 16:06:36.431 for 2d20h
Routing Descriptor Blocks
172.16.0.1, from 172.16.0.9
Nexthop in Vrf: "default", Table: "default", IPv4 Unicast, Table Id: 0xe0000000
Route metric is 0
172.16.0.2, from 172.16.0.9, BGP backup path
Nexthop in Vrf: "default", Table: "default", IPv4 Unicast, Table Id: 0xe0000000
Route metric is 0
No advertising protos.

RP/0/RSP0/CPU0:router# show cef vrf evpn1 10.1.1.93 location 0/0/CPU0

10.1.1.93/32, version 86, internal 0x5000001 0x0 (ptr 0x99fac884) [1], 0x0 (0x0), 0x208
(0x96c58494)
Updated Feb 28 16:06:39.285
Prefix Len 32, traffic index 0, precedence n/a, priority 3
via 172.16.0.1/32, 15 dependencies, recursive [flags 0x6000]
path-idx 0 NHID 0x0 [0x97955380 0x0]
recursion-via-/32
next hop VRF - 'default', table - 0xe0000000
next hop 172.16.0.1/32 via 34034/0/21
next hop 100.0.57.5/32 Te0/0/0/3 labels imposed {ImplNull 24011 24027}
next hop 100.0.67.6/32 Te0/0/0/1 labels imposed {ImplNull 24009 24027}
via 172.16.0.2/32, 11 dependencies, recursive, backup [flags 0x6100]
path-idx 1 NHID 0x0 [0x979554a0 0x0]
recursion-via-/32
next hop VRF - 'default', table - 0xe0000000
next hop 172.16.0.2/32 via 34035/0/21
next hop 100.0.57.5/32 Te0/0/0/3 labels imposed {ImplNull 24012 24031}
next hop 100.0.67.6/32 Te0/0/0/1 labels imposed {ImplNull 24010 24031}

```

The following sections describe how to verify the subnet stretching.

Verify the VRF.

```

RP/0/RP0/CPU0:leafW# show run vrf cust130

```



```
vrf cust130
address-family ipv4 unicast
  import route-target
    130:130
  !
  export route-target
    130:130
  !
!
!
```

Verify the BGP configuration.

```
RP/0/RP0/CPU0:leafW# show run router bgp | begin vrf cust130
```

```
vrf cust130
  rd auto
  address-family ipv4 unicast
    label mode per-vrf
    maximum-paths ibgp 10
    redistribute connected
  !
!
```

Verify the L2VPN.

```
RP/0/RP0/CPU0:leafW# show run l2vpn bridge group bg130
```

```
l2vpn
bridge group bg130
  bridge-domain bd130
    interface Bundle-Ether1.1300
    !
    interface Bundle-Ether5.1300
    !
    routed interface BVI130
    evi 130
    !
  !
!
!
```

EVPN IPv6 Hosts with Mobility

EVPN IPv6 Hosts with Mobility feature enables you to provide EVPN IPv6 service over IPv4-MPLS core network. This feature supports all-active multihoming and virtual machine (VM) or host move.

Service Providers (SPs) use a stable and established core with IPv4-MPLS backbone for providing IPv4 VPN services. The IPv6 VPN Provider Edge Transport over MPLS (IPv6 on Provider Edge Routers [6PE] and IPv6 on VPN Provider Edge Routers [6VPE]) facilitates SPs to offer IPv6 VPN services over IPv4 backbone without an IPv6 core. The provide edge (PE) routers run MP-iBGP to advertise IPv6 reachability and IPv6 label distribution. For 6PE, the labels are allocated per IPv6 prefix learnt from connected customer edge (CE) routers and for 6VPE, the PE router can be configured to allocate labels on a per-prefix or per-CE and per-VRF level.

Mobility Support

In global VRF, mobility is not supported. However, you can move a host from one ES to another ES within the same bridge domain. The host gets a new MAC address and IP address. The host can have multiple IP addresses for the same MAC address.

In non-default VRF, mobility is supported with the following conditions:

- Basic MAC move: The IP address and MAC address remains the same. You can move a host from one ES to another ES with the same IP address and MAC address.
- Same MAC address but with a different IP address: The host gets a new IP address
- Same IP address but with a different MAC address: The host gets a new MAC address but retains the same IP address
- Multiple IP addresses with the same MAC address: Many VMs are involved in the same the MAC move

Restrictions

- In customer VRFs, when host routing is not configured, MAC-IP advertisement is different between zero ESI and non-zero ESI. When host routing is not configured, MAC-IP with non-zero ESI is advertised without L3 RT (VRF RT). MAC-IP with zero ESI is not advertised. The following table lists the behavior of MAC-IP advertisement with respect to ESI and host routing.

ESI Type	With host routing	Without host routing
MAC-IP with non-zero ESI	Advertised with L3 VRF RT	Advertised without L3 VRF RT
MAC-IP with zero ESI	Advertised with L3 VRF RT	Not advertised

- In global VRF, Layer 2 stretch is not supported.
- MAC move in global VRF is only supported if the host is within the same bridge domain. You can move a host from one ES to another ES within the same bridge domain.
- Duplication of IP address detection is not supported.
- Maximum number of leafs allowed per ESI is two.

Configure EVPN IPv6 Hosts with Mobility

Perform the following tasks to configure EVPN IPv6 Hosts with Mobility feature:

- Configure VRF
- Configure ISIS
- Configure BGP
- Configure AC interface
- Configure BVI interface
- Configure EVPN
- Configure L2VPN

**Note**

- You cannot configure the EVPN remote peer using the VPNv4 unicast if you have configured the **advertise vpnv4 unicast re-originated** command under the L2VPN EVPN address-family. You can either configure the VPNv4 unicast or the advertise vpnv4 unicast re-originated under L2VPN EVPN address-family.
- You cannot configure the EVPN remote peer using the VPNv6 unicast if you have configured the **advertise vpnv6 unicast re-originated** command under the L2VPN EVPN address-family. You can either configure the VPNv6 unicast or the advertise vpnv6 unicast re-originated under L2VPN EVPN address-family.

```

/* Configure VRF */

Router# configure
Router(config)# vrf cust102
Router(config-vrf)# address-family ipv4 unicast
Router(config-vrf-af)# import route-target 160102:16102
Router(config-vrf-af)# export route-target 160102:16102
Router(config-vrf-af)# exit
!
Router(config-vrf)# address-family ipv6 unicast
Router(config-vrf-af)# import route-target 6160102:16102
Router(config-vrf-af)# export route-target 6160102:16102
Router(config-vrf-af)# commit
!

/* Configure ISIS */

Router# configure
Route(config)# router isis v6
Route(config-isis)# 49.0001.0000.0160.0005.00
Route(config-isis)# nsr
Route(config-isis)# log adjacency changes
Route(config-isis)# lsp-gen-interval maximum-wait 5000 initial-wait 1 secondary-wait
20
Route(config-isis)# lsp-mtu 1468
Route(config-isis)# lsp-refresh-interval 65000
Route(config-isis)# max-lsp-lifetime 65535
Route(config-isis)# address-family ipv4 unicast
Route(config-isis-af)# metric-style wide
Route(config-isis-af)# microloop avoidance protected
Route(config-isis-af)# spf-interval maximum-wait 5000 initial-wait 1 secondary-wait 20
Route(config-isis-af)# segment-routing mpls sr-prefer
Route(config-isis-af)# segment-routing prefix-sid-map advertise-local
Route(config-isis-af)# exit
!
Route(config-isis)# interface Bundle-Ether10
Route(config-isis-if)# point-to-point
Route(config-isis-if)# address-family ipv4 unicast
Route(config-isis-af)# fast-reroute per-prefix
Route(config-isis-af)# fast-reroute per-prefix ti-lfa
Route(config-isis-af)# metric 10
Route(config-isis-af)# exit
!
Route(config-isis)# interface Bundle-Ether20

```

```

Route(config-isis-if) # point-to-point
Route(config-isis-if) # address-family ipv4 unicast
Route(config-isis-af) # fast-reroute per-prefix
Route(config-isis-af) # fast-reroute per-prefix ti-lfa
Route(config-isis-af) # metric 10
Route(config-isis-af) # exit
!
Route(config-isis) # interface loopback0
Route(config-isis-if) # passive
Route(config-isis-if) # address-family ipv4 unicast
Route(config-isis-af) # exit
!
Route(config-isis) # interface loopback10
Route(config-isis-if) # passive
Route(config-isis-if) # address-family ipv4 unicast
Route(config-isis-af) # prefix-sid index 1605
Route(config-isis-af) # commit
Route(config-isis-af) # exit
!

/* Configure Segment Routing */

Router# configure
Router(config) # segment-routing
Router(config-sr) # global-block 16000 23999
Router(config-sr) # commit

/* Configure BGP */

Router(config) # router bgp 100
Router(config-bgp) # bfd minimum-interval 50
Router(config-bgp) # bfd multiplier 3
Router(config-bgp) # bgp router-id 160.0.0.5
Router(config-bgp) # address-family ipv4 unicast      ---> To support V4 Global VRF
Router(config-bgp-af) # maximum-paths ibgp 10 unequal-cost ---> ECMP
Router(config-bgp-af) # redistribute connected      --> V4 Global VRF
Router(config-bgp-af) # exit
!
Router(config-bgp) # address-family ipv4 unicast      ---> VRF
Router(config-bgp-af) # vrf all
Router(config-bgp-af) # label mode per-vrf
Router(config-bgp-af) # exit
!
Router(config-bgp) # address-family ipv6 unicast      ---> For 6PE
Router(config-bgp-af) # label mode per-vrf
Router(config-bgp-af) # maximum-paths ibgp 8
Router(config-bgp-af) # redistribute static
Router(config-bgp-af) # allocate-label all
Router(config-bgp-af) # exit
!
Router(config-bgp) # address-family vpnv6 unicast      ---> 6 VPE
Router(config-bgp-af) # vrf all
Router(config-bgp-af) # label mode per-vrf
Router(config-bgp-af) # exit
!
Router(config-bgp) # address-family l2vpn evpn      ----> EVPN
Router(config-bgp-af) # bgp implicit-import      ----> Global VRF
Router(config-bgp-af) # exit
!
Router(config-bgp) # neighbor-group evpn-rr
Router(config-bgp-nbr) # remote-as 100
Router(config-bgp-nbr) # bfd fast-detect
Router(config-bgp-nbr) # update-source loopback0

```

```

Router(config-bgp-nbr)# address-family ipv4 unicast
Router(config-bgp-nbr-af)# route-policy pass-all in
Router(config-bgp-nbr-af)# route-policy nh-lo10 out
Router(config-bgp-nbr-af)# exit
!
Router(config-bgp-nbr)# address-family ipv6 labeled-unicast ----> For 6PE
Router(config-bgp-nbr-af)# route-policy pass-all out
Router(config-bgp-nbr-af)# exit
!
Router(config-bgp-nbr)# address-family l2vpn evpn
Router(config-bgp-nbr-af)# route-policy pass-all in
Router(config-bgp-nbr-af)# route-policy nh-lo10 out
Router(config-bgp-nbr-af)# advertise vpnv4 unicast re-originated -> For Route Type 5
Router(config-bgp-nbr-af)# advertise vpnv6 unicast re-originated -> For Route Type 5
Router(config-bgp-nbr-af)# exit
!
Router(config-bgp)# neighbor 160.0.0.1
Router(config-bgp-nbr)# use neighbor-group evpn-rr
Router(config-bgp-nbr)# exit
!
Router(config-bgp)# neighbor 160.0.0.2
Router(config-bgp-nbr)# use neighbor-group evpn-rr
Router(config-bgp-nbr)# exit
!
Router(config-bgp)# vrf all
Router(config-bgp-vrf)# rd 1605:102
Router(config-bgp-vrf)# address-family ipv4 unicast
Router(config-bgp-vrf-af)# label mode per-vrf
Router(config-bgp-vrf-af)# maximum-paths ibgp 10 unequal-cost
Router(config-bgp-vrf-af)# redistribute connected ---> Triggers Route Type 5
Router(config-bgp-vrf-af)# exit
!
Router(config-bgp-vrf)# address-family ipv6 unicast
Router(config-bgp-vrf-af)# label mode per-vrf
Router(config-bgp-vrf-af)# maximum-paths ibgp 10 unequal-cost
Router(config-bgp-vrf-af)# redistribute connected
Router(config-bgp-vrf-af)# exit
!

/* Configure AC interface */

Router(config)# interface Bundle-Ether1.102 l2transport
Router(config-l2vpn-subif)# encapsulation dot1q 102
Router(config-l2vpn-subif)# rewrite ingress tag pop 1 symmetric
Router(config-l2vpn-subif)# commit
Router(config-l2vpn-subif)# exit

/* Configure BVI interface */

Router(config)# interface BVI100
Router(config-if)# ipv4 address 56.78.100.1 255.255.255.0
Router(config-if)# ipv6 address 56:78:100::1/64
Router(config-if)# mac-address 22.22.22
Router(config-if)# exit
!
Router(config)# interface BVI102
Router(config-if)# host-routing
Router(config-if)# vrf cust102
Router(config-if-vrf)# ipv4 address 56.78.102.1 255.255.255.0
Router(config-if-vrf)# ipv6 nd dad attempts 0
Router(config-if-vrf)# ipv6 address 56:78:100::1/64
Router(config-if-vrf)# ipv6 address 56:78:102::1/64
Router(config-if-vrf)# mac-address 22.22.22

```

```

Router(config-if)# commit

/* Configure CEF */ [Required for dual homing]

Router# configure
Router(config)# cef adjacency route override rib

/* Configure EVPN, and configure main bundle ethernet segment parameters in EVPN */

Router# configure
Router(config)# evpn
Router(config-evpn)# evi 102
Router(config-evpn-evi)# bgp
Router(config-evpn-evi)# rd 1605:102
Router(config-evpn-evi-bgp)# route-target import 160102:102
Router(config-evpn-evi-bgp)# route-target export 160102:102
Router(config-evpn-evi-bgp)# exit
Router(config-evpn-evi)# advertise-mac
Router(config-evpn-evi)# exit
!
Router(config-evpn)# interface Bundle-Ether1
Router(config-evpn-ac)# ethernet-segment
Router(config-evpn-ac-es)# identifier type 0 56.56.56.56.56.56.56.01
Router(config-evpn-ac-es)# exit
!
Router(config-evpn)# interface Bundle-Ether2
Router(config-evpn-ac)# ethernet-segment
Router(config-evpn-ac-es)# identifier type 0 56.56.56.56.56.56.56.02
Router(config-evpn-ac-es)# commit

/* Configure L2VPN */

Router# configure
Router(config)# l2vpn
Router(config-l2vpn)# bridge group bg102
Router(config-l2vpn-bg)# bridge-domain bd102
Router(config-l2vpn-bg-bd)# interface Bundle-Ether1.102
Router(config-l2vpn-bg-bd-ac)# exit
!
Router(config-l2vpn-bg-bd)# interface Bundle-Ether2.102
Router(config-l2vpn-bg-bd-ac)# exit
!
Router(config-l2vpn-bg-bd)# interface Bundle-Ether3.102
Router(config-l2vpn-bg-bd-ac)# exit
!
Router(config-l2vpn-bg-bd)# interface Bundle-Ether4.102
Router(config-l2vpn-bg-bd-ac)# exit
!
Router(config-l2vpn-bg-bd)# interface Bundle-Ether5.102
Router(config-l2vpn-bg-bd-ac)# routed interface BVI102
Router(config-l2vpn-bg-bd-bvi)# evi 102
Router(config-l2vpn-bg-bd-bvi-evi)# commit

```

Running Configuration

```

/* Configure VRF */

vrf cust102
address-family ipv4 unicast
import route-target
160102:16102

```

```

!
export route-target
160102:16102
!
!
address-family ipv6 unicast
import route-target
6160102:16102
!
export route-target
6160102:16102
!
!
!

/ * Configure ISIS */

router isis v6
net 49.0001.0000.0160.0005.00
nsr
log adjacency changes
lsp-gen-interval maximum-wait 5000 initial-wait 1 secondary-wait 20
lsp-mtu 1468
lsp-refresh-interval 65000
max-lsp-lifetime 65535
address-family ipv4 unicast
metric-style wide
microloop avoidance protected
spf-interval maximum-wait 5000 initial-wait 1 secondary-wait 20
segment-routing mpls sr-prefer
segment-routing prefix-sid-map advertise-local
!
interface Bundle-Ether10
point-to-point
address-family ipv4 unicast
fast-reroute per-prefix
fast-reroute per-prefix ti-lfa
metric 10
!
!
interface Bundle-Ether20
point-to-point
address-family ipv4 unicast
fast-reroute per-prefix
fast-reroute per-prefix ti-lfa
metric 10
!
!
interface Loopback0
passive
address-family ipv4 unicast
!
!
interface Loopback10
passive
address-family ipv4 unicast
prefix-sid index 1605
!
!
!

/ * Configure Segment Routing */

segment-routing

```

```

global-block 16000 23999
!

/ * Configure BGP */

router bgp 100
bfd minimum-interval 50
bfd multiplier 3
bgp router-id 160.0.0.5
address-family ipv4 unicast      ---> To support V4 Global VRF
  maximum-paths ibgp 10 unequal-cost ---> ECMP
  redistribute connected        --> V4 Global VRF
!
address-family vpnv4 unicast ---> VRF
  vrf all
  label mode per-vrf
!
address-family ipv6 unicast  ---> For 6PE
  label mode per-vrf
  maximum-paths ibgp 8
  redistribute connected
  redistribute static
  allocate-label all
!
address-family vpnv6 unicast  ---> 6VPE
  vrf all
  label mode per-vrf
!
address-family l2vpn evpn  ----> EVPN
bgp implicit-import        ----> Global VRF
!

neighbor-group evpn-rr
remote-as 100
bfd fast-detect
update-source Loopback0
address-family ipv4 unicast
  route-policy pass-all in
  route-policy nh-lo10 out
!
address-family ipv6 labeled-unicast ----> For 6PE
route-policy pass-all out
!
address-family l2vpn evpn
route-policy pass-all in
route-policy nh-lo10 out
advertise vpnv4 unicast re-originated ---> For Route Type 5
advertise vpnv6 unicast re-originated ----> For Route Type 5
!
!
neighbor 160.0.0.1
use neighbor-group evpn-rr
!
neighbor 160.0.0.2
use neighbor-group evpn-rr
!
vrf cust102
rd 1605:102
address-family ipv4 unicast
label mode per-vrf
maximum-paths ibgp 10 unequal-cost
redistribute connected <----- Triggers Route Type 5
!
address-family ipv6 unicast

```



```
label mode per-vrf
maximum-paths ibgp 10 unequal-cost
redistribute connected
!
!

/* Configure AC interface */

interface Bundle-Ether1.102 l2transport
encapsulation dot1q 102
rewrite ingress tag pop 1 symmetric
!
/* Configure BVI interface */
interface BVI100
ipv4 address 56.78.100.1 255.255.255.0
ipv6 address 56:78:100::1/64
mac-address 22.22.22
!
interface BVI102
host-routing
vrf cust102
ipv4 address 56.78.102.1 255.255.255.0
ipv6 nd dad attempts 0
ipv6 address 56:78:100::1/64
ipv6 address 56:78:102::1/64
mac-address 22.22.22
!

/* Configure CEF */ [ Required for Dual homing]

cef adjacency route override rib

/* Configure EVPN */

evpn
evi 102
bgp
rd 1605:102
route-target import 160102:102
route-target export 160102:102
!
advertise-mac
!
!
!
interface Bundle-Ether1
ethernet-segment
identifier type 0 56.56.56.56.56.56.56.56.01
!
!
interface Bundle-Ether2
ethernet-segment
identifier type 0 56.56.56.56.56.56.56.56.02
!
!

/* Configure L2VPN */

l2vpn
bridge group bg102
bridge-domain bd102
interface Bundle-Ether1.102
!
```



```

Received Path ID 0, Local Path ID 0, version 0
mac: 10:11:04:64:f2:7f
Originator: 160.0.0.6, Cluster list: 100.0.0.4
Path #2: Received by speaker 0
Advertised to update-groups (with more than one peer):
0.2
Local
56:78:100::2 from :: (160.0.0.5)
Origin incomplete, metric 0, localpref 100, weight 32768, valid, redistributed, best,
group-best
Received Path ID 0, Local Path ID 0, version 9
mac: 10:11:04:64:f2:7f

```

```
/* Verify Ethernet Segments are peering for Dual homing */
```

```
Router# show evpn ethernet-segment int bundle-Ether 1
```

```

Ethernet Segment Id Interface Nexthops
-----
0056.5656.5656.5656.5601 BE1 160.5.5.5
                           160.6.6.6
-----

```

```
/* Verify DF election */
```

```
Router# show evpn ethernet-segment int bundle-Ether 1 carving detail
```

```
Legend:
```

```

A - Load-balancing mode and Access Protection incompatible,
B - No Forwarders EVPN-enabled,
C - Backbone Source MAC missing (PBB-EVPN),
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

```

```

Ethernet Segment Id Interface Nexthops
-----
0056.5656.5656.5656.5601 BE1 160.5.5.5
                           160.6.6.6
ES to BGP Gates : Ready
ES to L2FIB Gates : Ready
Main port :
Interface name : Bundle-Ether1
Interface MAC : 008a.9644.acdd
IfHandle : 0x080004dc
State : Up
Redundancy : Not Defined
ESI type : 0
Value : 56.5656.5656.5656.5601
ES Import RT : 5656.5656.5656 (from ESI)
Source MAC : 0000.0000.0000 (N/A)
Topology :
Operational : MH
Configured : All-active (AApF) (default)
Primary Services : Auto-selection
Secondary Services: Auto-selection

```

```

Service Carving Results:
Forwarders : 161
Permanent : 10
EVI:ETag P : 700:1, 701:1, 702:1, 703:1, 704:1, 705:1
EVI:ETag P : 706:1, 707:1, 708:1, 709:1
Elected : 76
EVI E : 100, 102, 104, 106, 108, 110
EVI E : 112, 114, 116, 118, 120, 122,
EVI E : 124, 126, 128, 130, 132, 134,
EVI E : 136, 138, 140, 142, 144, 146,
EVI E : 148, 150, 152, 154, 156, 158,
EVI E : 160, 162, 164, 166, 168, 170,
EVI E : 172, 174, 176, 178, 180, 182,
EVI E : 184, 186, 188, 190, 192, 194,
EVI E : 196, 198, 200, 202, 204, 206,
EVI E : 208, 210, 212, 214, 216, 218,
EVI E : 220, 222, 224, 226, 228, 230,
EVI E : 232, 234, 236, 238, 240, 242,
EVI E : 244, 246, 248, 250
Not Elected : 75
EVI NE : 101, 103, 105, 107, 109, 111
EVI NE : 113, 115, 117, 119, 121, 123,
EVI NE : 125, 127, 129, 131, 133, 135,
EVI NE : 137, 139, 141, 143, 145, 147,
EVI NE : 149, 151, 153, 155, 157, 159,
EVI NE : 161, 163, 165, 167, 169, 171,
EVI NE : 173, 175, 177, 179, 181, 183,
EVI NE : 185, 187, 189, 191, 193, 195,
EVI NE : 197, 199, 201, 203, 205, 207,
EVI NE : 209, 211, 213, 215, 217, 219,
EVI NE : 221, 223, 225, 227, 229, 231,
EVI NE : 233, 235, 237, 239, 241, 243,
EVI NE : 245, 247, 249
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 : 68663
Remote SHG labels : 1
68670 : nexthop 160.6.6.6

```

EVPN IRB: DHCPv4 and DHCPv6 Relay

EVPN IRB: DHCPv4 and DHCPv6 Relay feature provides DHCP support for the end users in EVPN multi-homing Active-Active (MH-AA) deployment scenario. This feature enables reduction of traffic flooding, increase in load sharing at VTEP, faster convergence during link and device failures, and simplification of data center automation.

DHCPv4 and DHCPv6 Relay agents relay request packets, coming over the access interface, to external DHCPv4 and DHCPv4 server to request allocation of addresses (/32) and IANA (::/128) for the end user.

DHCPv4 and DHCPv6 Relay profiles are configured on BVI interfaces which relay DHCPv4 or DHCPv4 requests from Layer 2 (L2) attachment circuit (AC) to external DHCP servers for host IPv4 addresses (/32) and IANA (::/128) IPv6 addresses.

This feature is compliant with RFC-6607.

Multi-homing Active-Active EVPN Gateways

Multi-homing Active-Active EVPN Gateways are configured with anycast IP address and MAC addresses. ASR 9000 devices have centralized L2/Layer 3 (L3) gateway. Based on native EVPN and MAC learning, IRB uses distributed anycast IP and anycast MAC address. Static clients are configured with anycast gateway address as the default gateway. DHCP client sends DHCP requests for IP addresses with BVI as the gateway. L2 access can be either single homing or multi-homing, Not all access protocols is supported with IRB. There may or may not be L2 stretch between DC centers. Internet gateway is also included for clients to access external network. No EVPN is configured on the Internet gateway.

EVPN IRB Route Distribution

In EVPN IRB DHCPv4 and DHCPv6, DHCP application processes and DHCP packet forwarding are independent of EVPN IRB L2 and L3 routing. There is no subscriber routing information with the stateless DHCP relay. But DHCP clients work similar to static clients in the EVPN core for L2 and L3 bridging and routing. When the **relay information option**, **relay information option vpn**, **relay information option von-mode cisco** and **relay information option von-mode rfc** commands are configured on the DHCP relay agent, the DHCP relay agent inserts the sub options of DHCP Option 82, such as subnet selection and VPN ID options. These options are considered by DHCP server while allocating IP address.

DHCP clients use the L2 AC interface to access EVPN bridge domain and use BVI interface as default gateway. So the clients must get the IP addresses from the DHCP server as in the same subnet of BVI interface.

DHCP Request Forwarding Path

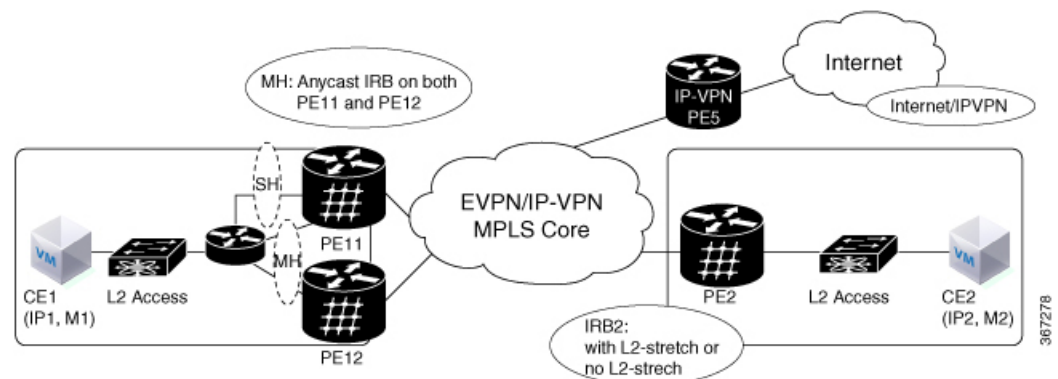
Clients broadcast requests to the access switch with DHAA to EVPN PE routers. The access switch does load balancing. The load balancing configurations in access switch will impact PE in DH-AA and DHCP to send the DHCP requests. The DHCP request reaches the Bridge Domain (BD) BVI interface which is configured with DHCP relay. Because AA PE routers are configured the same IP addresses, BVI IP addresses cannot be used as DHCP relay source IP address.

For DHCPv4, configuring GIADDR field for each DHCP relay profile is allowed. Loopback interface with unique IP addresses can be configured in VRF which is reachable to DHCP servers. Configuring DHCP relay source address is not supported.

In case of DHCPv6 servers, DHCPv6 relay picks up an available Loopback interface IPv6 address as DHCPv6 relay source IP address. After the DHCP clients get the IP address. DHCP clients are not normally routable to DHCP servers. DHCP clients send unicast DHCP renew messages to the DHCP server. If the DHCP servers are not routable, the DHCP unicast messages fail, then the DHCP client sends broadcast rebinding messages with the corresponding DHCP relay.

In the below figure, DHCP clients are configured on PE11 and PE12.

Figure 2: EVPN IRB with ASR 9000 as Centralized DCI Gateway



Configuration

Perform the following tasks to configure the EVPN IRB: DHCPv4 and DHCPv6 Relay feature:

```

/* PE11 configuration */

Router# dhcp ipv4
Router(config-dhcpv4)# profile DHCPv4_RELAY relay
Router(config-dhcpv4-relay-profile)# helper-address vrf default 10.20.20.20 giaddr 192.0.2.1
Router(config-dhcpv4-relay-profile)# relay information option vpn
Router(config-dhcpv4-relay-profile)# relay information option vpn-mode rfc
Router(config-dhcpv4-relay-profile)# exit
Router(config-dhcpv4)# exit
Router(config)# interface BVI1 relay profile DHCPv4_RELAY
Router(config)# dhcp ipv6
Router(config-dhcpv6)# profile DHCPv6_RELAY relay
Router(config-dhcpv6-relay-profile)# helper-address vrf default 20::20
Router(config-dhcpv6-relay-profile)# exit
Router(config-dhcpv6)# exit
Router(config)# interface BVI1 relay profile DHCPv6_RELAY
Router(config)# interface Loopback 5
Router(config)# exit
Router(config-if)# ipv4 address 192.0.2.1 255.255.255.255

Router(config)# interface BVI1
Router(config-if)# host-routing
Router(config-if)# exit
Router(config-if)# ipv4 address 10.10.10.2 255.255.255.0
Router(config-if)# ipv6 address 2001:DB8:0:ABCD::1/64
Router(config-if)# ipv6 enable
Router(config-if)# mac-address 1122.3344.5566

/* PE12 configuration */
Router# dhcp ipv4
Router(config-dhcpv4)# profile DHCPv4_RELAY relay
Router(config-dhcpv4-relay-profile)# helper-address vrf default 10.20.20.20 giaddr 127.0.0.1
Router(config-dhcpv4-relay-profile)# relay information option vpn
Router(config-dhcpv4-relay-profile)# relay information option vpn-mode cisco
Router(config-dhcpv4-relay-profile)# exit
Router(config-dhcpv4)# exit
Router(config)# interface BVI1 relay profile DHCPv4_RELAY
Router(config)# dhcp ipv6
Router(config-dhcpv6)# profile DHCPv6_RELAY relay
Router(config-dhcpv6-relay-profile)# helper-address vrf default 20::20
Router(config-dhcpv6-relay-profile)# exit
Router(config-dhcpv6)# exit
Router(config)# interface BVI1 relay profile DHCPv6_RELAY
Router(config)# interface Loopback 6
Router(config)# exit
Router(config-if)# ipv4 address 127.0.0.1 255.255.255.255

Router(config)# interface BVI1
Router(config-if)# host-routing
Router(config-if)# vrf evpn 1
Router(config-if)# exit
Router(config-if)# ipv4 address 10.10.10.2 255.255.255.0
Router(config-if)# proxy-arp
Router(config-if)# ipv6 address 3000:0:0:8003::2/64
Router(config-if)# ipv6 enable

```

```
Router(config-if)# mac-address 1122.3344.5566
```

Running Configuration

```
/* PE11 Configuration */

dhcp ipv4
profile DHCPv4_RELAY relay
  helper-address vrf default 10.20.20.20 giaddr 192.0.2.1
  relay information option vpn
relay information option vpn-mode cisco
!
interface BVI1 relay profile DHCPv4_RELAY
!
dhcp ipv6
profile DHCPv6_RELAY relay
  helper-address vrf default 20::20
!
interface BVI1 relay profile DHCPv4_RELAY
!
interface Loopback5
ipv4 address 192.0.2.1 255.255.255.0
!
interface BVI1
host-routing
ipv4 address 10.10.10.2 255.255.255.0
ipv6 address 2001:DB8:0:ABCD::1/64
ipv6 enable
mac-address 0.12.3456
!

/* PE12 Configuration */

dhcp ipv4
profile DHCPv4_RELAY relay
  helper-address vrf default 10.20.20.20 giaddr 127.0.0.1
  relay information option vpn
  relay information option vpn-mode cisco
!
interface BVI1 relay profile DHCPv6_RELAY
!
dhcp ipv6
profile DHCPv6_RELAY relay
  helper-address vrf default 20::20
!
interface BVI1 relay profile DHCPv4_RELAY
!
interface Loopback6
ipv4 address 127.0.0.1 255.255.255.255
!
interface BVI1
host-routing
vrf evpn1
ipv4 address 10.10.10.2 255.255.255.0
proxy-arp
ipv6 address 2001:DB8:0:ABCD::1/64
ipv6 enable
mac-address 0.12.3456
!
```

Verification

Verify the DHCPv4 configuration.

```
Router# show running-configuration dhcp ipv4
Thu Feb 15 21:44:31.550 IST
dhcp ipv4
profile TEST relay
  helper-address vrf default 10.11.11.3
  relay information option vpn
  relay information option vpn-mode rfc
!
interface GigabitEthernet0/1/0/0 relay profile TEST
!
```

Verify the DHCPv4 relay profile details.

```
Router# show dhcp ipv4 relay profile name test
Thu Feb 15 21:47:32.247 IST

Profile: test
Helper Addresses:None
Information Option: Disabled
Information Option Allow Untrusted: Disabled
Information Option VPN: Enabled
Information Option VPN Mode: RFC
Information Option Policy: Replace
Information Option Check: Disabled
GIADDR Policy: Keep
Broadcast-flag Policy: Ignore
Mac Mismatch Action: Forward
VRF References:
Interface References:
    GigabitEthernet 0/1/0/0
```

Verify the DHCPv4 relay packet statistics.

```
Router# show dhcp ipv4 relay statistics

Fri Feb 16 12:34:51.202 IST

-----
VRF                |    RX    |    TX    |    DR    |
-----
default             |         4 |         4 |         0 |
**nVSatellite      |         0 |         0 |         0 |
```

Verify DHCPv4 relay packet statistics in detail.

```
Router# show dhcp vrf default ipv4 relay statistics
Fri Feb 16 12:36:05.544 IST

DHCP IPv4 Relay Statistics for VRF default:

TYPE                | RECEIVE  | TRANSMIT | DROP     |
```


DISCOVER	1	1	0
OFFER	1	1	0
REQUEST	1	1	0
DECLINE	0	0	0
ACK	1	1	0
NAK	0	0	0
RELEASE	0	0	0
INFORM	0	0	0
LEASEQUERY	0	0	0
LEASEUNASSIGNED	0	0	0
LEASEUNKNOWN	0	0	0
LEASEACTIVE	0	0	0
BOOTP-REQUEST	0	0	0
BOOTP-REPLY	0	0	0
BOOTP-INVALID	0	0	0

Verify the DHCPv6 configuration.

```
Router# show running-configuration dhcp ipv6
Fri Feb 16 15:40:52.721 IST
dhcp ipv6
profile TEST relay
  helper-address vrf default 1::1
!
interface GigabitEthernet0/2/0/0 relay profile TEST
!
```

Verify DHCPv6 relay profile.

```
Router# show dhcp ipv6 relay statistics
Fri Feb 16 15:41:00.456 IST
```

VRF	RX	TX	DR
default	4	4	0
**nVSatellite	0	0	0

Verify DHCPv6 relay packet statistics in detail.

```
Routerr# show dhcp ipv6 relay statistics vrf default
Fri Feb 16 15:41:09.991 IST

DHCP IPv6 Relay Statistics for VRF default:
```

TYPE	RECEIVE	TRANSMIT	DROP
SOLICIT	1	0	0
ADVERTISE	0	1	0
REQUEST	1	0	0
REPLY	0	1	0
CONFIRM	0	0	0
DECLINE	0	0	0
RENEW	0	0	0
REBIND	0	0	0

RELEASE		0		0		0	
RECONFIG		0		0		0	
INFORM		0		0		0	
RELAY_FWD		0		0		0	
RELAY_REP		0		0		0	
LEASEQUERY		0		0		0	
LEASEQUERY_REP		0		0		0	
LEASEQUERY_DONE		0		0		0	
LEASEQUERY_DATA		0		0		0	