# Troubleshoot DHCP in Layer 2 Only VLAN - Wired

## Contents

## Introduction

This document describes how to troubleshoot DHCP for wired endpoints in a Layer-2 Only network in SD-Access (SDA) fabric.

## Prerequisites

### Requirements

Cisco recommends that you have knowledge of these topics:

- Internet Protocol (IP) Forwarding

- Locator/ID Separation Protocol (LISP)
- Protocol Independent Multicast (PIM) Sparse-Mode

**Hardware & Software Requirements**

- Catalyst 9000 series switches
- Catalyst Center Version 2.3.7.9
- Cisco IOS® XE 17.12 and later

**Limitations**

- Only one L2 Border can handoff a unique VLAN/VNI concurrently, unless robust loop prevention mechanisms, such as FlexLink+ or EEM scripts to disable links, are properly configured.

# L2 Only Overview

## Overview

In typical SD-Access deployments, the L2/L3 boundary resides at the Fabric Edge (FE), where the FE hosts the client's gateway in the form of an SVI, which is often called "Anycast Gateway". L3 VNIs (Routed) are established for inter-subnet traffic, while L2 VNIs (Switched) manage intra-subnet traffic. Consistent configuration across all FEs enables seamless client roaming. Forwarding is optimized: intra-subnet (L2) traffic is directly bridged between FEs, and inter-subnet (L3) traffic is routed either between FEs or between an FE and a Border Node.

For endpoints in SDA Fabrics that require a strict network entry point outside the fabric, the SDA Fabric must provide an L2 channel from the Edge to an external gateway.

This concept is analogous to traditional Ethernet campus deployments where a Layer 2 access network connects to a Layer 3 router. Intra-VLAN traffic remains within the L2 network, while inter-VLAN traffic is routed by the L3 device, often returns to a different VLAN on the L2 network.

Within a LISP context, the Site Control Plane primarily tracks MAC addresses and their corresponding MAC-to-IP bindings, much like traditional ARP entries. L2 VNI/L2-only pools are designed to facilitate registration, resolution, and forwarding exclusively based on these two EID types. Therefore, any LISP-based forwarding in an L2-only environment relies solely on MAC and MAC-to-IP information, it completely disregards IPv4 or IPv6 EIDs. To complement LISP EIDs, L2-only pools heavily depend on flood-and-learn mechanisms, similar to the behavior of traditional switches. Consequently, L2 Flooding becomes a critical component for handling Broadcast, Unknown Unicast, and Multicast (BUM) traffic within this solution, requires the use of Underlay Multicast. Conversely, normal unicast traffic is forwarded using standard LISP forwarding processes, primarily via Map-Caches.

Both Fabric Edges and the "L2 Border" (L2B) maintain L2 VNIs, which map to local VLANs (this mapping is locally device-significant within SDA, allowing different VLANs to map to the same L2 VNI across nodes). In this specific use case, no SVI is configured on these VLANs at these nodes, meaning there is no corresponding L3 VNI.

## DHCP Behavior Change in L2 Only VLANs

In Anycast Gateway pools, DHCP presents a challenge because every Fabric Edge acts as the gateway for its directly connected endpoints, with the same gateway IP across all FEs. To properly identify the original source of a DHCP relayed packet, FEs must insert DHCP Option 82 and its sub-options, including the LISP RLOC information. This is achieved with DHCP Snooping on the client VLAN at the Fabric Edge. DHCP Snooping serves a dual purpose in this context: it facilitates the insertion of Option 82 and, crucially, prevents the flood of DHCP broadcast packets across the bridge-domain (VLAN/VNI). Even when Layer-2 Flooding is enabled for an Anycast Gateway, DHCP Snooping effectively suppresses the broadcast packet to be forwarded out of the Fabric Edge as a broadcast.

In contrast, a Layer 2 Only VLAN lacks a gateway, which simplifies DHCP source identification. Since packets are not relayed by any Fabric Edges, complex mechanisms for source identification are unnecessary. Without DHCP Snooping on the L2 Only VLAN, the flood-control mechanism for DHCP packets is effectively bypassed. This allows DHCP broadcasts to be forwarded via L2 Flooding to their final destination, which could be a DHCP server directly connected to a Fabric Node or a Layer 3 device that provides DHCP relay functionality.

**Warning**: The "Multiple IP to MAC" functionality within an L2 Only pool automatically activates DHCP Snooping in Bridge VM mode, which enforces DHCP flood control. Consequently, this renders the L2 VNI pool incapable to support DHCP for its endpoints.

## Underlay Multicast

Given DHCP's heavy reliance on broadcast traffic, Layer 2 flooding must be leveraged to support this protocol. As with any other L2 Flooding-enabled pool, the underlay network must be configured for multicast traffic, specifically Any-Source-Multicast utilizing PIM Sparse-Mode. While underlay multicast configuration is automated via the LAN Automation workflow, if this step was omitted, additional configuration is required (manual or template).

- Enable IP Multicast Routing on all nodes (Borders, Edges, Intermediate Nodes, etc.).
- Configure PIM Sparse-Mode on the Loopback0 interface of each Border and Edge node.
- Enable PIM Sparse-Mode on each IGP (underlay routing protocol) interface.
- Configure the PIM Rendezvous Point (RP) on all nodes (Borders, Edges, Intermediate Nodes), RP placement on Borders is encouraged.
- Verify PIM Neighbors, PIM RP, and PIM Tunnel status.

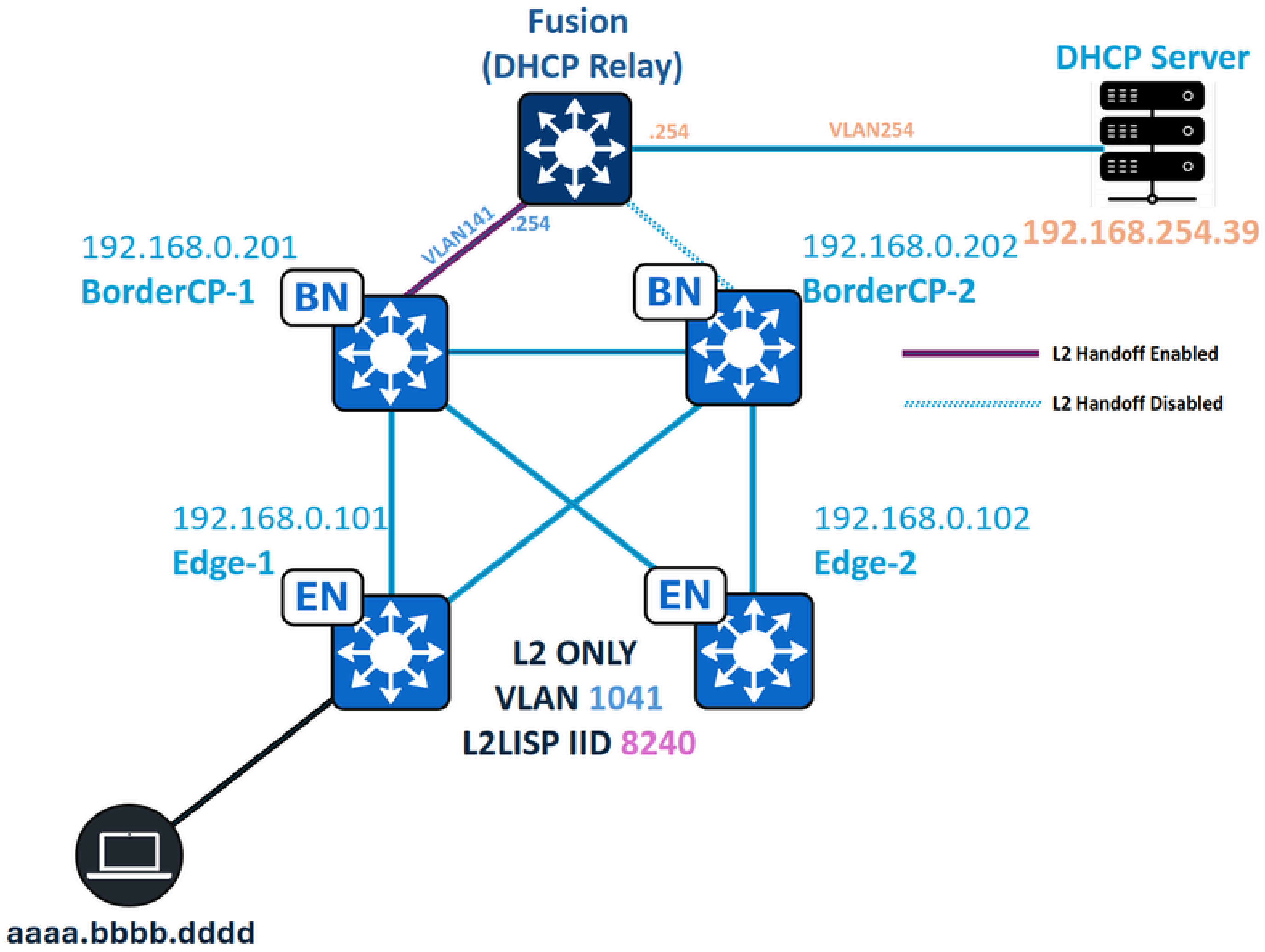
### DHCP Server Inside the SD-Access Fabric

A common design question is whether a DHCP Server can be deployed within an SD-Access fabric. The answer, in essence, is both yes and no.

The official Cisco Validated Design recommends that the DHCP Server should be placed outside the fabric, typically within the Shared Services block. However, if circumstances necessitate the DHCP server's physical attachment to a Fabric Node (e.g., an Edge or Border), the only supported method is via an L2 Only network. This is due to the inherent behavior of Anycast Gateway pools, where DHCP Snooping is enabled by default. This not only blocks DHCP Offers and Acknowledges from the server but also prevents DHCP Discover and Request packets, even when encapsulated in VXLAN, from being forwarded. While "DHCP Snooping Trust" on DHCP server ports allow Offers and Acknowledges, Discover and Request packets are not forwarded using the same method. Furthermore, the removal of DHCP Snooping in an Anycast Gateway pool is not a supported option, as Catalyst Center flags such a configuration deviation during compliance validation.

Conversely, when the DHCP server is placed within an L2 Only network, DHCP Snooping is not enforced, allowing all DHCP packets to pass without policy-based inspection or blockage. The network device upstream of the SD-Access fabric (e.g., a Fusion Router) is configured as the gateway for the L2 Only network, enabling traffic from multiple VRFs to access the same DHCP server within that L2 Only segment.

## Topology



*Network Topology*

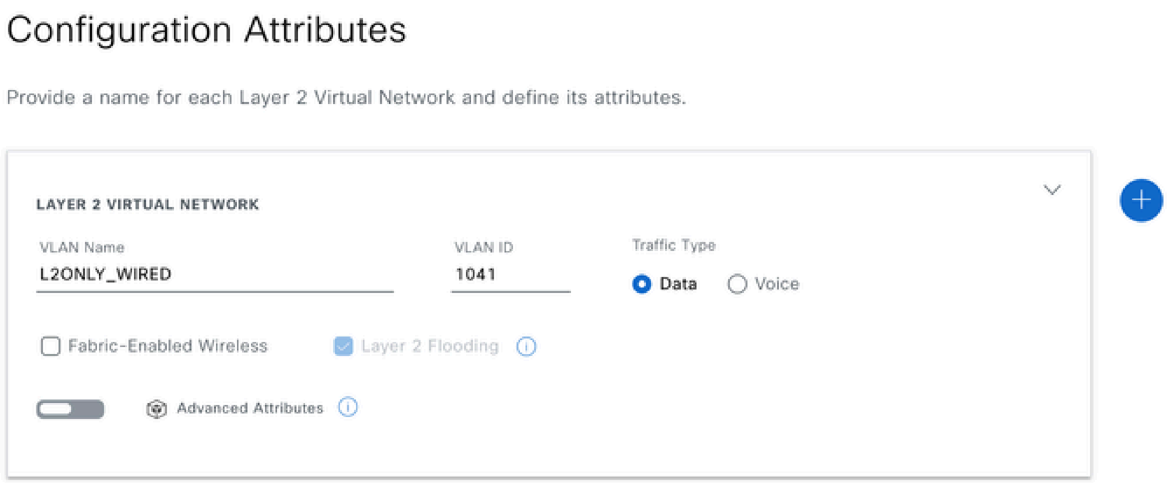
In this topology:

- 192.168.0.201 and 192.168.0.202 are Collocated Borders for the Fabric Site, BorderCP-1 is the only Border with the Layer 2 Hand-off feature enabled.
- 192.168.0.101 and 192.168.0.102 are Fabric Edge Nodes
- 192.168.254.39 is the DHCP Server
- aaaa.bbbb.dddd is the DHCP-enabled endpoint
- The Fusion device acts as DHCP Relay for the fabric subnets.

# L2 Only VLAN Configuration

## L2 Only VLAN  Deployment from Catalyst Center

**Path: Catalyst Center / Provision / Fabric Site / Layer 2 Virtual Networks / Edit Layer 2 Virtual Networks**



Configuration Attributes

Provide a name for each Layer 2 Virtual Network and define its attributes.

LAYER 2 VIRTUAL NETWORK

VLAN Name: L2ONLY_WIRED

VLAN ID: 1041

Traffic Type: ● Data ○ Voice

□ Fabric-Enabled Wireless

☑ Layer 2 Flooding

Advanced Attributes

*L2VNI Configuration*

# L2 Only VLAN Configuration - Fabric Edges

Fabric Edge nodes have the VLAN configured with CTS enabled, IGMP and IPv6 MLD disabled, and the required L2 LISP configuration. This L2 Only pool is **not** a Wireless pool; therefore, features typically found in L2 Only Wireless Pools, such as RA-Guard, DHCPGuard, and Flood Access Tunnel, are not configured. Instead, the flooding of ARP packets is explicitly enabled with "**flood arp-nd**"

### Fabric Edge (192.168.0.101) Configuration

```
<#root>

cts role-based enforcement vlan-list

1041



vlan

1041



name L2ONLY_WIRED



no ip igmp snooping vlan 1041 querier



no ip igmp snooping vlan 1041



no ipv6 mld snooping vlan 1041



router lisp
```

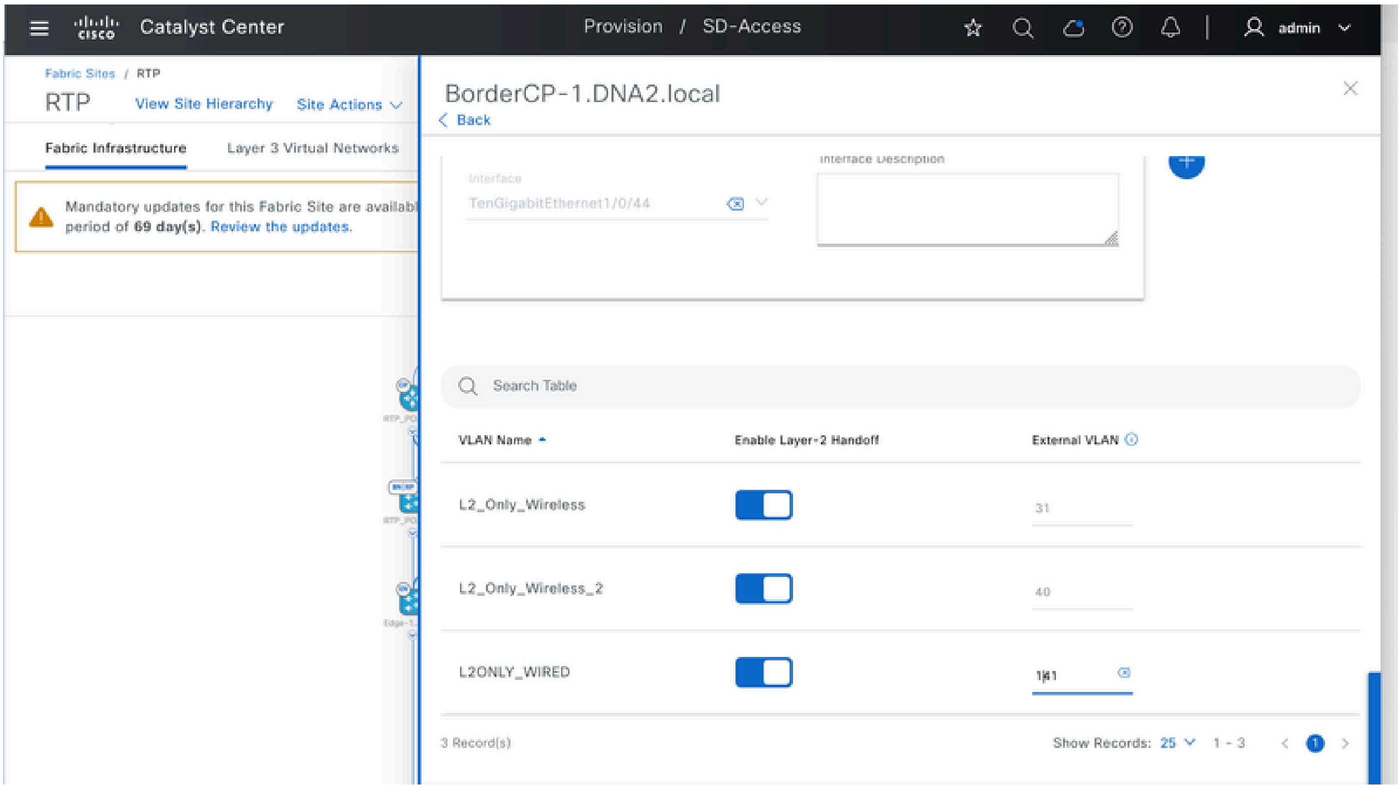
```
 instance-id
8240

  remote-rloc-probe on-route-change
  service ethernet

eid-table vlan

1041

   broadcast-underlay
239.0.17.1

flood arp-nd

 flood unknown-unicast

   database-mapping mac locator-set rloc_91947dad-3621-42bd-ab6b-379ecebb5a2b
   exit-service-ethernet
```

## L2 Hand-off Configuration - Fabric Border

From an operational perspective, the DHCP server (or Router/Relay) is allowed to be connected to any Fabric Node, including both Borders and Edges.

Using Border nodes to connect the DHCP server is the recommended approach, however, requires careful design consideration. This is because the Border must be configured for L2 Hand-Off on a per-interface basis. This allows the Fabric Pool to be handed off to either the same VLAN as within the Fabric or a different one. This flexibility in VLAN IDs between Fabric Edges and Borders is possible because both are mapped to the same L2 LISP Instance-ID. L2 Hand-off physical ports must not be simultaneously enabled with the same VLAN to prevent Layer 2 loops within the SD-Access network. For redundancy, methods such as StackWise Virtual, FlexLink+, or EEM scripts are required.

In contrast, connecting the DHCP Server or Gateway Router to a Fabric Edge requires no additional configuration.



Mandatory updates for this Fabric Site are availabl
period of 69 day(s). Review the updates.

Interface: TenGigabitEthernet1/0/44

Interface Description:

Search Table

| VLAN Name | Enable Layer-2 Handoff | External VLAN |
|---|---|---|
| L2_Only_Wireless | ● | 31 |
| L2_Only_Wireless_2 | ● | 40 |
| L2ONLY_WIRED | ● | 141 |

3 Record(s)     Show Records: 25     1 - 3     1

*L2 Hand-off Configuration*

## Fabric Border (192.168.0.201) Configuration

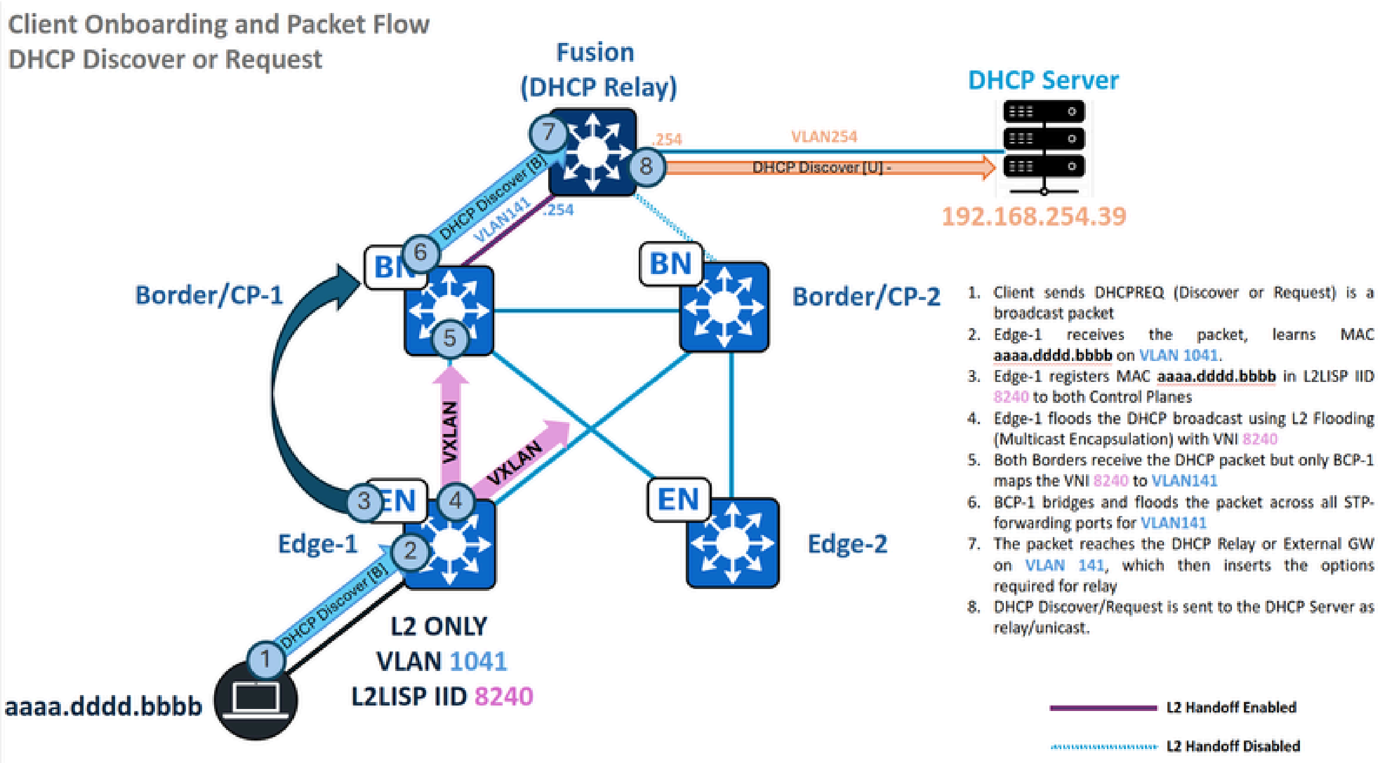
<#root>

```
cts role-based enforcement vlan-list
141


vlan
141

 name L2ONLY_WIRED


no ip igmp snooping vlan 141 querier

no ip igmp snooping vlan 141

no ipv6 mld snooping vlan 141

router lisp
 instance-id
8240
```

```
  remote-rloc-probe on-route-change
  service ethernet

eid-table

vlan 141

 broadcast-underlay 239.0.17.1

   flood arp-nd

   flood unknown-unicast

   database-mapping mac locator-set rloc_91947dad-3621-42bd-ab6b-379ecebb5a2b
   exit-service-ethernet

interface TenGigabitEthernet1/0/44

  switchport mode trunk
```

# DHCP Traffic Flow

## DHCP Discover and Request - Edge



1. Client sends DHCPREQ (Discover or Request) is a broadcast packet
2. Edge-1 receives the packet, learns MAC **aaaa.dddd.bbbb** on VLAN 1041.
3. Edge-1 registers MAC **aaaa.dddd.bbbb** in L2LISP IID 8240 to both Control Planes
4. Edge-1 floods the DHCP broadcast using L2 Flooding (Multicast Encapsulation) with VNI 8240
5. Both Borders receive the DHCP packet but only BCP-1 maps the VNI 8240 to VLAN141
6. BCP-1 bridges and floods the packet across all STP-forwarding ports for VLAN141
7. The packet reaches the DHCP Relay or External GW on VLAN 141, which then inserts the options required for relay
8. DHCP Discover/Request is sent to the DHCP Server as relay/unicast.

| | |
|---|---|
| ▬ | **L2 Handoff Enabled** |
| ┄ | **L2 Handoff Disabled** |

*Traffic Flow - DHCP Discover and Reqeuest in L2 Only*

## MAC Learning and Endpoint Registration

When endpoint **aaaa.dddd.bbbb** sends a DHCP Discover or Request (a broadcast packet), the Edge node must learn the endpoint's MAC address, add it to its MAC address table, then to the L2/MAC SISF table, and finally to the L2LISP Database for VLAN **1041**, mapped to L2LISP Instance **8240**.

<#root>

```
Edge-1#

show mac address-table interface te1/0/2


          Mac Address Table
-------------------------------------------
Vlan    Mac Address       Type        Ports
----    -----------       --------    -----

1041



aaaa.dddd.bbbb

    DYNAMIC

 Te1/0/2



Edge-1#

show vlan id 1041


VLAN Name                                 Status    Ports
```

```
---- ------------------------------- --------- -------------------------------

1041 L2ONLY_WIRED


active

    L2LI0:

8240

, Te1/0/2, Te1/0/17, Te1/0/18, Te1/0/19, Te1/0/20, Ac2, Po1

Edge-1#

show device-tracking database mac | i aaaa.dddd.bbbb|vlan


 MAC                      Interface  vlan       prlvl      state            Time left        Policy
 aaaa.dddd.bbbb           Te1/0/2    1041       NO TRUST   MAC-REACHABLE    123 s            IPDT_POLICY

Edge-1#

show lisp instance-id 8240 dynamic-eid summary | i Name|aaaa.dddd.bbbb


Dyn-EID Name         Dynamic-EID      Interface     Uptime    Last      Pending
Auto-L2-group-

8240


aaaa.dddd.bbbb

   N/A           6d04h     never

0



Edge-1#

show lisp instance-id 8240 ethernet database aaaa.dddd.bbbb


LISP ETR MAC Mapping Database for LISP 0 EID-table

Vlan 1041 (IID 8240)

, LSBs: 0x1
Entries total 1, no-route 0, inactive 0, do-not-register 0

aaaa.dddd.bbbb/48

,

dynamic-eid Auto-L2-group-8240

, inherited from default locator-set rloc_91947dad-3621-42bd-ab6b-379ecebb5a2b
  Uptime: 6d04h, Last-change: 6d04h
  Domain-ID: local
  Service-Insertion: N/A
  Locator        Pri/Wgt  Source     State

 192.168.0.101

   10/10   cfg-intf   site-self, reachable
  Map-server     Uptime         ACK  Domain-ID

  192.168.0.201

  6d04h

Yes

  0

  192.168.0.202

 6d04h

Yes

  0
```

If the MAC address of the endpoint is correctly learned and the ACK flag has been marked as "**Yes**" for the Fabric Control planes, this stage is considered completed.

## DHCP Broadcast Bridged in L2 Flooding

When DHCP Snooping is disabled, DHCP Broadcasts are not blocked; instead, they are encapsulated in multicast for Layer 2 Flooding. Conversely, enabling DHCP Snooping prevents the flooding of these broadcast packets.

<#root>

```
Edge-1#

show ip dhcp snooping



Switch DHCP snooping is enabled


Switch DHCP gleaning is disabled
DHCP snooping is configured on following VLANs:
12-13,50,52-53,333,1021-1026
DHCP snooping is operational on following VLANs:

12-13,50,52-53,333,1021-1026



<--

VLAN1041 should not be listed, as DHCP snooping must be disabled in L2 Only pools.


 Proxy bridge is configured on following VLANs:
1024
 Proxy bridge is operational on following VLANs:
1024
<snip>
```

Since DHCP Snooping is disabled, the DHCP Discover/Request utilizes the L2LISP0 interface, bridging traffic via L2 Flooding. Depending on the Catalyst Center version and applied Fabric Banners, the L2LISP0 interface may have access-lists configured in both directions; therefore, ensure DHCP traffic (UDP ports 67 and 68) is not explicitly denied by any Access Control Entries (ACEs).

<#root>

```
interface L2LISP0


 ip access-group

SDA-FABRIC-LISP



in


 ip access-group

SDA-FABRIC-LISP out



Edge-1#

show access-list SDA-FABRIC-LISP


Extended IP access list SDA-FABRIC-LISP
    10 deny ip any host 224.0.0.22
    20 deny ip any host 224.0.0.13
    30 deny ip any host 224.0.0.1


40 permit ip any any
```

Utilize the configured broadcast-underlay group for the L2LISP instance and the Fabric Edge's Loopback0 IP address to verify the L2 Flooding (S,G) entry that bridges this packet to other Fabric Nodes. Consult the mroute and mfib tables to validate parameters such as the incoming interface, outgoing interface list, and forwarding counters.

<#root>

```
Edge-1#

show ip interface loopback 0 | i Internet


  Internet address is

192.168.0.101/32



Edge-1#

show running-config | se 8240


interface L2LISP0.8240

instance-id 8240


  remote-rloc-probe on-route-change
  service ethernet
```

```
   eid-table vlan 1041

 broadcast-underlay 239.0.17.1

Edge-1#

show ip mroute 239.0.17.1 192.168.0.101 | be \(

(192.168.0.101, 239.0.17.1)

, 00:00:19/00:03:17, flags: FT
  Incoming interface:

Null0

, RPF nbr 0.0.0.0

<--

Local S,G IIF must be Null0

  Outgoing interface list:

 TenGigabitEthernet1/1/2

,

Forward

/Sparse, 00:00:19/00:03:10, flags:

<--

1st OIF = Te1/1/2 = Border2 Uplink

 TenGigabitEthernet1/1/1

,

Forward

/Sparse, 00:00:19/00:03:13, flags:

<--

2nd OIF = Te1/1/1 = Border1 Uplink

Edge-1#

show ip mfib 239.0.17.1 192.168.0.101 count
```

```
Forwarding Counts: Pkt Count/Pkts per second/Avg Pkt Size/Kilobits per second
Other counts:      Total/RPF failed/Other drops(OIF-null, rate-limit etc)
Default
 13 routes, 6 (*,G)s, 3 (*,G/m)s
Group:

239.0.17.1


  Source:

192.168.0.101

,
   SW Forwarding: 1/0/392/0, Other: 1/1/0
   HW Forwarding:

 7

/0/231/0, Other: 0/0/0

<--



HW Forwarding counters (First counter = Pkt Count) must increase


  Totals - Source count: 1, Packet count: 8
```

**Tip**: If an (S,G) entry is not found or the Outgoing Interface List (OIL) contains no Outgoing Interfaces (OIFs), it indicates an issue with the underlay multicast configuration or operation.

**Packet Captures**

Configure a simultaneous embedded packet capture on the switch to record both the incoming DHCP packet from the endpoint and the corresponding egress packet for L2 Flooding. Upon packet capture, two distinct packets should be observed: the original DHCP Discover/Request and its VXLAN-encapsulated counterpart, destined for the Underlay Group (239.0.17.1).

**Fabric Edge (192.168.0.101) packet catpures**

<#root>

```
monitor capture cap interface TenGigabitEthernet1/0/2 IN     <-- Endpoint Interface
monitor capture cap interface TenGigabitEthernet1/1/1 OUT    <-- One of the OIFs from the multicast rout

monitor capture cap match any
monitor capture cap buffer size 100
monitor capture cap limit pps 1000
monitor capture cap start
monitor capture cap stop

Edge-1#

show monitor capture cap buffer display-filter "bootp and dhcp.hw.mac_addr==aaaa.dddd.bbbb"


<-- aaaa.dddd.bbbb is the endpoint MAC


Starting the packet display ........ Press Ctrl + Shift + 6 to exit
   22   2.486991      0.0.0.0 -> 255.255.255.255 DHCP

356 DHCP Discover

 - Transaction ID 0xf8e

<--


356 is the Length of the original packet


   23   2.487037      0.0.0.0 -> 255.255.255.255 DHCP

406 DHCP Discover

 - Transaction ID 0xf8e

<--


406 is the Length of the VXLAN encapsulated packet


Edge-1#

show monitor capture cap buffer display-filter "bootp and dhcp.hw.mac_addr==aaaa.dddd.bbbb and vxlan"


Starting the packet display ........ Press Ctrl + Shift + 6 to exit
   23   2.487037      0.0.0.0 -> 255.255.255.255 DHCP

406 DHCP Discover

 - Transaction ID 0xf8e

Edge-1#

show monitor capture cap buffer display-filter "bootp and dhcp.hw.mac_addr==aaaa.dddd.bbbb and vxlan" de


Internet Protocol Version 4, Src:

192.168.0.101, Dst: 239.0.17.1  <-- DHCP Discover is encapsulated for Layer 2 Flooding
```

```
Internet Protocol Version 4, Src:

0.0.0.0, Dst: 255.255.255.255
```

## DHCP Discover and Request - L2 Border

After the Edge sends the DHCP Discover and Request packets via Layer 2 Flooding, encapsulated with the Broadcast-Underlay group 239.0.17.1, these packets are received by the L2 Hand-off Border, specifically Border/CP-1 in this scenario.

For this to occur, Border/CP-1 must possess a multicast route with the (S,G) of the Edge, and its outgoing interface list must include the L2LISP instance of the L2 Handoff VLAN. It's important to note that L2 Hand-off Borders share the same L2LISP Instance-ID, even if they utilize different VLANs for the Hand-off.

<#root>

```
BorderCP-1#

show vlan id 141


VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------

141  L2ONLY_WIRED



active

    L2LI0:

8240

, Te1/0/44

BorderCP-1#

show ip mroute 239.0.17.1 192.168.0.101 | be \(



(192.168.0.101, 239.0.17.1)

, 00:03:20/00:00:48, flags: MTA
  Incoming interface:

TenGigabitEthernet1/0/42

, RPF nbr 192.168.98.3

<--



Incoming Interface Te1/0/42 is the RPF interface for 192.168.0.101 (Edge RLOC)


  Outgoing interface list:
   TenGigabitEthernet1/0/26, Forward/Sparse, 00:03:20/00:03:24, flags:
    L2LISP0.

8240

, Forward/Sparse-Dense, 00:03:20/00:02:39, flags:

BorderCP-1#

show ip mfib 239.0.17.1 192.168.0.101 count


Forwarding Counts: Pkt Count/Pkts per second/Avg Pkt Size/Kilobits per second
Other counts:      Total/RPF failed/Other drops(OIF-null, rate-limit etc)
Default
 13 routes, 6 (*,G)s, 3 (*,G/m)s
Group:

239.0.17.1


  Source:

192.168.0.101

,
   SW Forwarding: 1/0/392/0, Other: 0/0/0
   HW Forwarding:

3

/0/317/0, Other: 0/0/0

<-- HW Forwarding counters (First counter = Pkt Count) must increase


  Totals - Source count: 1, Packet count: 4
```

**Tip**: If an (S,G) entry is not found, it indicates an issue with the underlay multicast configuration or operation. If the L2LISP for the requried instance is not present as OIF, it indicates an issue with the operation UP/DOWN status of the L2LISP sub-interface or the IGMP enablement status of the L2LISP interface.

Similar to the Fabric Edge node, ensure no Access Control Entry  denies the ingerss DHCP packet on the L2LISP0 interface.

<#root>

```
BorderCP-1#

show access-list SDA-FABRIC-LISP


Extended IP access list SDA-FABRIC-LISP
    10 deny ip any host 224.0.0.22
    20 deny ip any host 224.0.0.13
    30 deny ip any host 224.0.0.1
```

```
40 permit ip any any
```

After the packet is de-encapsulated and placed on the VLAN matching VNI 8240, its broadcast nature dictates that it is flooded out all Spanning Tree Protocol forwarding ports for hand-off VLAN 141.

<#root>

```
BorderCP-1#

show spanning-tree vlan 141 | be Interface


Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------


Te1/0/44

          Desg

FWD

 2000      128.56   P2p
```

The Device-Tracking table confirms that interface Te1/0/44, which connects to the Gateway/DHCP Relay, must be an STP-forwarding port.

<#root>

```
BorderCP-1#

show device-tracking database address 172.16.141.254 | be Network


   Network Layer Address                    Link Layer Address     Interface  vlan       prlvl      age
ARP

172.16.141.254



f87b.2003.7fc0



Te1/0/44



 141

       0005       133s       REACHABLE  112 s try 0
```

## Packet Captures

Configure a simultaneous embedded packet capture on the switch to record both the incoming DHCP packet from L2 Flooding (S,G incoming interface)  and the corresponding egress packet to the DHCP Relay. Upon packet capture, two distinct packets should be observed: the VXLAN encapsulated packet from Edge-1, and the de-encapsulated packet that goes to the DHCP Relay.

## Fabric Border/CP (192.168.0.201) packet catpures

<#root>

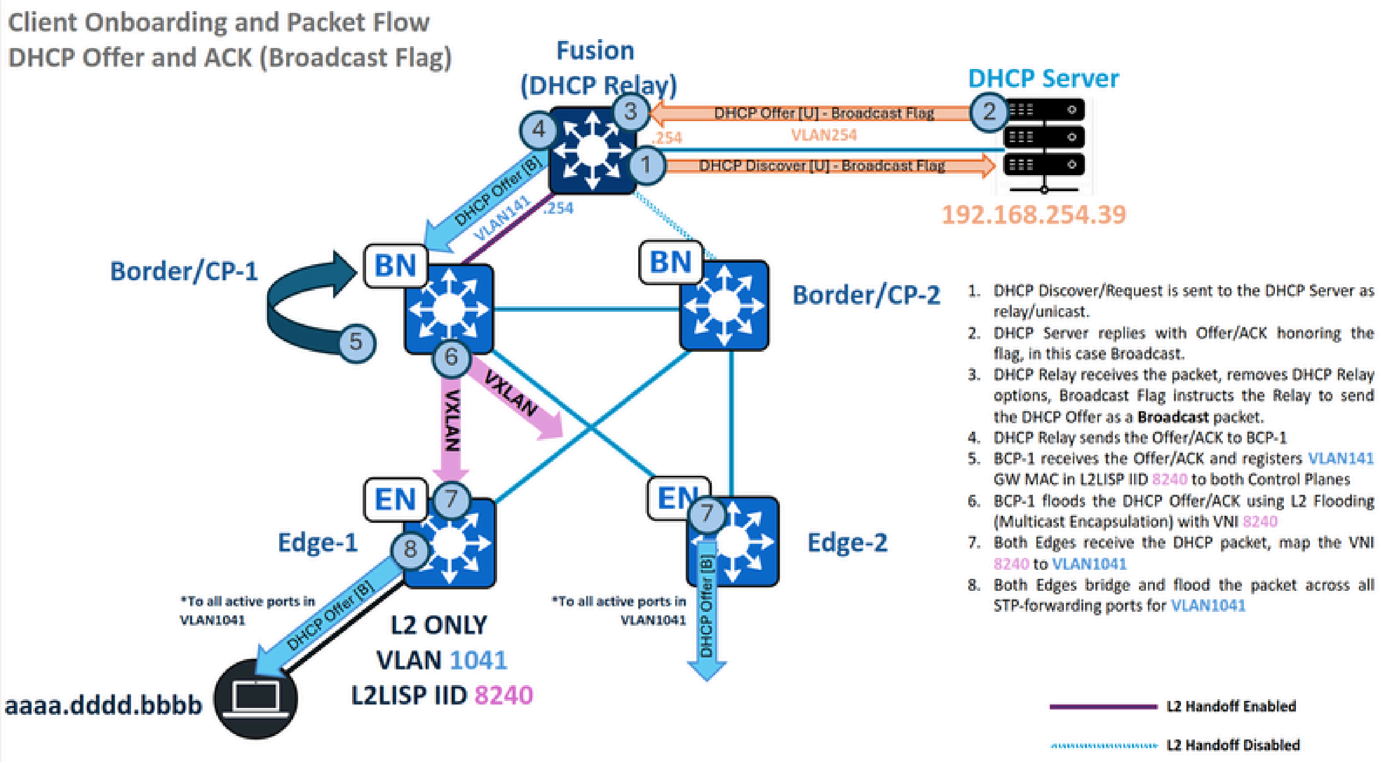
```
monitor capture cap interface TenGigabitEthernet1/0/42 IN    <-- Incoming interface for Edge's S,G Mrout


monitor capture cap interface TenGigabitEthernet1/0/44 OUT   <-- Interface that connects to the DHCP Rel


monitor capture cap match any

monitor capture cap buffer size 100


monitor capture cap start


monitor capture cap stop
```

```
BorderCP-1#

show monitor capture cap buffer display-filter "bootp and dhcp.hw.mac_addr==aaaa.dddd.bbbb"


Starting the packet display ........ Press Ctrl + Shift + 6 to exit

  427  16.695022      0.0.0.0 -> 255.255.255.255 DHCP

406

 DHCP Discover - Transaction ID 0x2030

<-- 406 is the Lenght of the VXLAN encapsulated packet


  428  16.695053      0.0.0.0 -> 255.255.255.255 DHCP

364

 DHCP Discover - Transaction ID 0x2030

<-- 364 is the Lenght of the VXLAN encapsulated packet
```

**Packet 427: VXLAN Encapsulated**

```
BorderCP-1#

show monitor capture cap buffer display-filter "bootp and dhcp.hw.mac_addr==aaaa.dddd.bbbb and vxlan" de

Internet Protocol Version 4, Src:

192.168.0.101, Dst: 239.0.17.1


Internet Protocol Version 4, Src:

 0.0.0.0, Dst: 255.255.255.255




Packet 428: Plain (dot1Q cannot be captured at egress direction)


BorderCP-1#

show monitor capture cap buffer display-filter "bootp and dhcp.hw.mac_addr==aaaa.dddd.bbbb and not vxlan

Internet Protocol Version 4, Src: 0.0.0.0, Dst: 255.255.255.255
```

## DHCP Offer and ACK - Broadcast - L2 Border



1. DHCP Discover/Request is sent to the DHCP Server as relay/unicast.
2. DHCP Server replies with Offer/ACK honoring the flag, in this case Broadcast.
3. DHCP Relay receives the packet, removes DHCP Relay options, Broadcast Flag instructs the Relay to send the DHCP Offer as a **Broadcast** packet.
4. DHCP Relay sends the Offer/ACK to BCP-1
5. BCP-1 receives the Offer/ACK and registers VLAN141 GW MAC in L2LISP IID 8240 to both Control Planes
6. BCP-1 floods the DHCP Offer/ACK using L2 Flooding (Multicast Encapsulation) with VNI 8240
7. Both Edges receive the DHCP packet, map the VNI 8240 to VLAN1041
8. Both Edges bridge and flood the packet across all STP-forwarding ports for VLAN1041

*Traffic Flow - Broadcast DHCP Offer and ACK in L2 Only*

Now that the DHCP Discover has exited the SD-Access fabric, the DHCP relay inserts traditional DHCP Relay Options (e.g., GiAddr/GatewayIPAddress) and forwards the packet as a unicast transmission to the DHCP Server. In this flow, the SD-Access fabric does not append any special DHCP options.

Upon the arrival of a DHCP Discover/Request to the server, the server honors the embedded **Broadcast** or

**Unicast** flag. This flag dictates whether the DHCP Relay Agent forwards the DHCP Offer to the downstream device (our Borders) as a broadcast or unicast frame. For this demonstration, a broadcast scenario is assumed.

## MAC Learning and Gateway Registration

When the DHCP relay sends a DHCP Offer or ACK, the L2BN node must learn the gateway's MAC address, add it to its MAC address table, then to the L2/MAC SISF table, and finally to the L2LISP Database for VLAN **141**, mapped to L2LISP Instance **8240**.

<#root>

```
BorderCP-1#

show mac address-table interface te1/0/44


          Mac Address Table
-------------------------------------------
Vlan    Mac Address       Type        Ports
----    -----------       --------    -----


141



f87b.2003.7fc0

    DYNAMIC

Te1/0/44





BorderCP-1#

show vlan id 141



VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------


141



L2ONLY_WIRED

               active    L2LI0:

8240

,

Te1/0/44


BorderCP-1#

show device-tracking database mac | i 7fc0|vlan
```

```
 MAC                    Interface  vlan       prlvl      state            Time left        Policy

 f87b.2003.7fc0


 Te1/0/44   141

       NO TRUST

 MAC-REACHABLE

   61 s             LISP-DT-GLEAN-VLAN 64

BorderCP-1#

show lisp ins 8240 dynamic-eid summary | i Name|f87b.2003.7fc0


Dyn-EID Name         Dynamic-EID      Interface     Uptime    Last      Pending


Auto-L2-group-8240



f87b.2003.7fc0

 N/A          6d06h     never

  0



BorderCP-1#

show lisp instance-id 8240 ethernet database f87b.2003.7fc0


LISP ETR MAC Mapping Database for LISP 0 EID-table Vlan

141

 (IID

8240

), LSBs: 0x1
Entries total 1, no-route 0, inactive 0, do-not-register 0


f87b.2003.7fc0/48

, dynamic-eid Auto-L2-group-8240, inherited from default locator-set rloc_0f43c5d8-f48d-48a5-a5a8-094b8
  Uptime: 6d06h, Last-change: 6d06h
  Domain-ID: local
  Service-Insertion: N/A
  Locator        Pri/Wgt  Source     State


 192.168.0.201

  10/10   cfg-intf   site-self, reachable
  Map-server     Uptime         ACK  Domain-ID


192.168.0.201
```

```
 6d06h

Yes

  0


192.168.0.202

  6d06h

Yes

  0
```

If the MAC address of the gateway is correctly learned and the ACK flag has been marked as "**Yes**" for the Fabric Control planes, this stage is considered completed.

### DHCP Broadcast Bridged in L2 Flooding

Without DHCP Snooping enabled, DHCP Broadcasts are not blocked and are encapsulated in multicast for Layer 2 Flooding. Conversely, if DHCP Snooping is enabled, the flood of DHCP Broadcast packets is prevented.

<#root>

```
BorderCP-1#

show ip dhcp snooping


Switch DHCP snooping is enabled
Switch DHCP gleaning is disabled
DHCP snooping is configured on following VLANs:
1001

DHCP snooping is operational on following VLANs:



1001     <-- VLAN141 should not be listed, as DHCP snooping must be disabled in L2 Only pools.


 Proxy bridge is configured on following VLANs:
none
 Proxy bridge is operational on following VLANs:
none
<snip>
```

**Tip**: Because DHCP Snooping is not enabled in the L2Border, DHCP Snooping Trust configuration is not needed.

At this stage, L2LISP ACL validation is already done in both devices.

Utilize the configured broadcast-underlay group for the L2LISP instance and the L2Border Loopback0 IP address to verify the L2 Flooding (S,G) entry that  bridges this packet to other Fabric Nodes. Consult the mroute and mfib tables to validate parameters such as the incoming interface, outgoing interface list, and forwarding counters.

<#root>

```
BorderCP-1#

show ip int loopback 0 | i Internet
```

```
  Internet address is
192.168.0.201/32


BorderCP-1#
show run | se 8240

interface L2LISP0.8240

instance-id 8240

  remote-rloc-probe on-route-change
  service ethernet
   eid-table vlan 1041

broadcast-underlay 239.0.17.1


BorderCP-1#
show ip mroute 239.0.17.1 192.168.0.201 | be \(

(
192.168.0.201, 239.0.17.1
), 1w5d/00:02:52, flags: FTA
  Incoming interface:
Null0
, RPF nbr 0.0.0.0
          <-- Local S,G IIF must be Null0

  Outgoing interface list:

 TenGigabitEthernet1/0/42
, Forward/Sparse, 1w3d/00:02:52, flags:
<-- Edge1 Downlink
    TenGigabitEthernet1/0/43
, Forward/Sparse, 1w3d/00:02:52, flags:
<-- Edge2 Downlink


BorderCP-1#
show ip mfib 239.0.17.1 192.168.0.201 count
```

```
Forwarding Counts: Pkt Count/Pkts per second/Avg Pkt Size/Kilobits per second
Other counts:      Total/RPF failed/Other drops(OIF-null, rate-limit etc)
Default
 13 routes, 6 (*,G)s, 3 (*,G/m)s
Group:

239.0.17.1


  Source:

192.168.0.201

,
   SW Forwarding: 1/0/392/0, Other: 1/1/0
   HW Forwarding:

  92071

/0/102/0, Other: 0/0/0

<-- HW Forwarding counters (First counter = Pkt Count) must increase


  Totals - Source count: 1, Packet count: 92071
```

**Tip**: If an (S,G) entry is not found or the Outgoing Interface List (OIL) contains no Outgoing Interfaces (OIFs), it indicates an issue with the underlay multicast configuration or operation.

With these validations, along packet captures similar to the previous steps, this section is concluded, as the DHCP Offer is forwaded as a broadcast to all Fabric Edges using the outgoing interface list contents, in this case, out of interface TenGig1/0/42 and TenGig1/0/43.

## DHCP Offer and ACK - Broadcast - Edge

Exactly as the previous flow, verify the L2Border S,G in the Fabric Edge, where the incoming interface points towards the L2BN and the OIL contains the L2LISP instance mapped to VLAN 1041.

<#root>

```
Edge-1#
```

```
show vlan id 1041

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------

1041

L2ONLY_WIRED

active
    L2LIO:
8240
,
Te1/0/2
, Te1/0/17, Te1/0/18, Te1/0/19, Te1/0/20, Ac2, Po1
Edge-1#
show ip mroute 239.0.17.1 192.168.0.201 | be \(

(
192.168.0.201
,
239.0.17.1
), 1w3d/00:01:52, flags: JT
  Incoming interface:
TenGigabitEthernet1/1/2
, RPF nbr 192.168.98.2
<-- IIF Te1/1/2 is the RPF interface for 192.168.0.201 (L2BN RLOC)

  Outgoing interface list:

L2LISP0.8240,
Forward/Sparse-Dense
,
 1w3d/00:02:23, flags:
Edge-1#
show ip mfib 239.0.17.1 192.168.0.201 count

Forwarding Counts: Pkt Count/Pkts per second/Avg Pkt Size/Kilobits per second
Other counts:      Total/RPF failed/Other drops(OIF-null, rate-limit etc)
Default
```

```
 13 routes, 6 (*,G)s, 3 (*,G/m)s
Group:

 239.0.17.1


  Source:

192.168.0.201,

   SW Forwarding: 1/0/96/0, Other: 0/0/0
   HW Forwarding:

76236

/0/114/0, Other: 0/0/0

<-- HW Forwarding counters (First counter = Pkt Count) must increase


  Totals - Source count: 1, Packet count: 4
```

**Tip**: If an (S,G) entry is not found, it indicates an issue with the underlay multicast configuration or operation. If the L2LISP for the requried instance is not present as OIF, it indicates an issue with the operation UP/DOWN status of the L2LISP sub-interface or the IGMP enablement status of the L2LISP interface.

L2LISP ACL validation is already done in both devices.

After the packet is de-encapsulated and placed on the VLAN matching VNI 8240, its broadcast nature dictates that it is flooded out all Spanning Tree Protocol forwarding ports for VLAN1041.

```
<#root>

Edge-1#

show spanning-tree vlan 1041 | be Interface
```

```
Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------


Te1/0/2

         Desg

FWD

 20000     128.2    P2p Edge
Te1/0/17            Desg

FWD

 2000      128.17   P2p
Te1/0/18            Back

BLK

 2000      128.18   P2p
Te1/0/19            Desg

FWD

 2000      128.19   P2p
Te1/0/20            Back

BLK

 2000      128.20   P2p
```

The MAC address table identifies port Te1/0/2 as the endpoint port, which is in FWD state by STP, the packet is flooded out to the endpoint.

<#root>

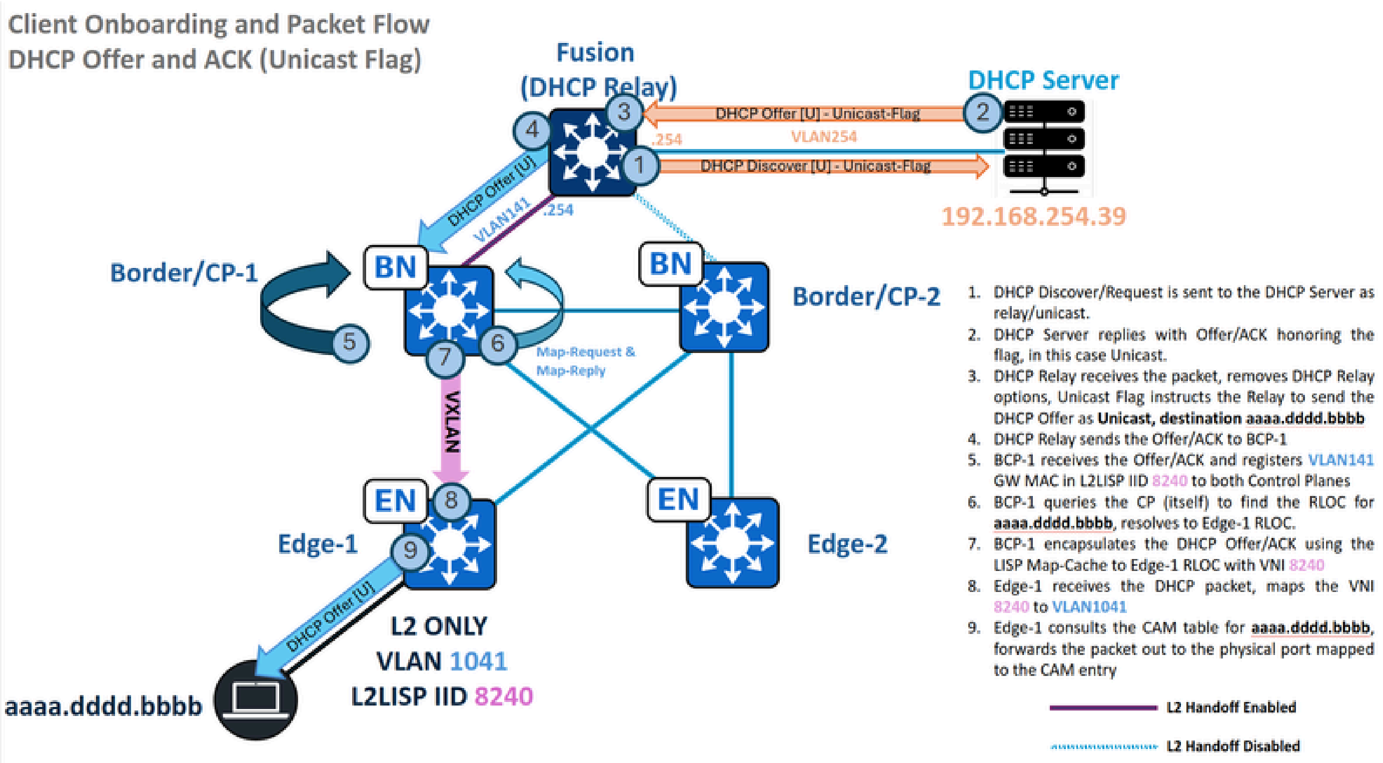
```
Edge-1#

show mac address-table interface te1/0/2


          Mac Address Table
-------------------------------------------
Vlan    Mac Address       Type        Ports
----    -----------       --------    -----


1041



aaaa.dddd.bbbb

    DYNAMIC

Te1/0/2
```

The DHCP Offer and ACK process remains consistent. Without DHCP Snooping enabled, no entries are created in the DHCP Snooping table. Consequently, the Device-Tracking entry for the DHCP-enabled endpoint is generated by the glean of ARP packets. It is also expected that commands like "show platform dhcpsnooping client stats" display no data, as DHCP snooping is disabled.

<#root>

```
Edge-1#
show device-tracking database interface te1/0/2 | be Network

    Network Layer Address                    Link Layer Address     Interface  vlan       prlvl      ag

ARP


172.16.141.1


 aaaa.dddd.bbbb
       Te1/0/2
1041
       0005       45s        REACHABLE  207 s try 0
Edge-1#
show ip dhcp snooping  binding vlan 1041

MacAddress          IpAddress        Lease(sec)  Type           VLAN  Interface
------------------  ---------------  ----------  -------------  ----  --------------------
Total number of bindings: 0
```

## DHCP Offer and ACK - Unicast - L2 Border



1. DHCP Discover/Request is sent to the DHCP Server as relay/unicast.
2. DHCP Server replies with Offer/ACK honoring the flag, in this case Unicast.
3. DHCP Relay receives the packet, removes DHCP Relay options, Unicast Flag instructs the Relay to send the DHCP Offer as **Unicast, destination aaaa.dddd.bbbb**
4. DHCP Relay sends the Offer/ACK to BCP-1
5. BCP-1 receives the Offer/ACK and registers VLAN141 GW MAC in L2LISP IID 8240 to both Control Planes
6. BCP-1 queries the CP (itself) to find the RLOC for **aaaa.dddd.bbbb**, resolves to Edge-1 RLOC.
7. BCP-1 encapsulates the DHCP Offer/ACK using the LISP Map-Cache to Edge-1 RLOC with VNI 8240
8. Edge-1 receives the DHCP packet, maps the VNI 8240 to VLAN1041
9. Edge-1 consults the CAM table for **aaaa.dddd.bbbb**, forwards the packet out to the physical port mapped to the CAM entry

*Traffic Flow - Unicast DHCP Offer and ACK in L2 Only*

Here the scenario is a bit different, the endpoint sets the DHCP Broadcast Flag as unset or "0".

The DHCP Relay does not send the DHCP Offer/ACK as Broadcast, but as a unicast packet instead, with a destination MAC address derived from the client hardware address inside the DHCP payload. This drastically modifies the way the packet is handled by the SD-Access fabric, it uses the L2LISP Map-Cache to forward the traffic, not the Layer 2 Flooding multicast encapsulation method.

**Fabric Border/CP (192.168.0.201) packet catpure: Ingress DHCP Offer**

<#root>

```
BorderCP-1#

show monitor capture cap buffer display-filter "bootp.type==1 and dhcp.hw.mac_addr==aaaa.dddd.bbbb" deta


Dynamic Host Configuration Protocol (

Discover

)
    Message type: Boot Request (1)
    Hardware type: Ethernet (0x01)
    Hardware address length: 6
    Hops: 0
    Transaction ID: 0x00002030
    Seconds elapsed: 0

    Bootp flags: 0x0000, Broadcast flag (Unicast)


        0... .... .... .... = Broadcast flag: Unicast
        .000 0000 0000 0000 = Reserved flags: 0x0000
    Client IP address: 0.0.0.0
    Your (client) IP address: 0.0.0.0
    Next server IP address: 0.0.0.0
    Relay agent IP address: 0.0.0.0


Client MAC address: aa:aa:dd:dd:bb:bb (aa:aa:dd:dd:bb:bb)
```

In this scenario, L2 Flooding is exclusively used for Discover/Requests, while Offers/ACKs are forwarded via L2LISP Map-Caches, simplifying the overall operation. Adhering to unicast forwarding principles, the L2 Border queries the Control Plane for the destination MAC address (aaaa.dddd.bbbb). Assuming successful "**MAC Learning and Endpoint Registration**" on the Fabric Edge, the Control Plane has this Endpoint ID (EID) registered.

<#root>

```
BorderCP-1#

show

 lisp instance-id 8240 ethernet server aaaa.dddd.bbbb


LISP Site Registration Information
Site name: site_uci
Description: map-server configured from Catalyst Center
Allowed configured locators: any
Requested EID-prefix:
  EID-prefix:

aaaa.dddd.bbbb/48

 instance-id

8240


    First registered:     00:36:37
    Last registered:      00:36:37
    Routing table tag:    0
    Origin:               Dynamic, more specific of any-mac
    Merge active:         No
    Proxy reply:          Yes
    Skip Publication:     No
    Force Withdraw:       No
    TTL:                  1d00h
    State:                complete
    Extranet IID:         Unspecified

    Registration errors:


      Authentication failures:   0


      Allowed locators mismatch: 0
 ETR 192.168.0.101:51328

, last registered 00:36:37, proxy-reply, map-notify
                             TTL 1d00h, no merge, hash-function sha1
                             state complete, no security-capability
                             nonce 0x1BF33879-0x707E9307
                             xTR-ID 0xDEF44F0B-0xA801409E-0x29F87978-0xB865BF0D
                             site-ID unspecified
                             Domain-ID 1712573701
                             Multihoming-ID unspecified
                             sourced by reliable transport
      Locator        Local  State      Pri/Wgt  Scope


 192.168.0.101  yes    up          10/10   IPv4 none
```

After the Border's query to the Control Plane (local or remote), the LISP resolution establishes a Map-Cache entry for the endpoint's MAC address.

<#root>

```
BorderCP-1#

show lisp instance-id 8240 ethernet map-cache aaaa.dddd.bbbb


LISP MAC Mapping Cache for LISP 0 EID-table Vlan

141

 (IID

8240

), 1 entries


aaaa.dddd.bbbb/48

, uptime: 4d07h, expires: 16:33:09,

via map-reply

,

complete

, local-to-site
  Sources: map-reply
  State: complete, last modified: 4d07h, map-source: 192.168.0.206
  Idle, Packets out: 46(0 bytes), counters are not accurate (~ 00:13:12 ago)
  Encapsulating dynamic-EID traffic
  Locator        Uptime    State  Pri/Wgt     Encap-IID


  192.168.0.101

 4d07h     up      10/10        -
<snip>
```

With the RLOC resolved, the DHCP Offer is encapsulated in unicast and sent directly to Edge-1 at

192.168.0.101, utilizing VNI 8240.

<#root>

```
BorderCP-1#

show mac address-table address aaaa.dddd.bbbb


          Mac Address Table
-------------------------------------------
Vlan    Mac Address       Type        Ports
----    -----------       --------    -----


141



 aaaa.dddd.bbbb



CP_LEARN



L2LI0



BorderCP-1#

show platform software fed switch active matm macTable vlan 141 mac aaaa.dddd.bbbb


VLAN   MAC                  Type  Seq# EC_Bi  Flags  machandle      siHandle        riHandle         di
----------------------------------------------------------------------------------------------------------


141    aaaa.dddd.bbbb

  0x1000001    0      0    64  0x718eb5271228  0x718eb52b4d68  0x718eb52be578   0x0            0    10

 RLOC 192.168.0.101

adj_id 747  No

BorderCP-1#

show ip route 192.168.0.101


Routing entry for 192.168.0.101/32
  Known via "

isis

", distance 115, metric 20, type level-2
  Redistributing via isis, bgp 65001T
  Advertised by bgp 65001 level-2 route-map FABRIC_RLOC
  Last update from 192.168.98.3 on TenGigabitEthernet1/0/42, 1w3d ago
  Routing Descriptor Blocks:
  * 192.168.98.3, from 192.168.0.101, 1w3d ago,

via TenGigabitEthernet1/0/42
```

```
      Route metric is 20, traffic share count is 1
```

With the same methodology as in previous sections, capture traffic both ingress from the DHCP Relay and to the RLOC egress interface to observe the VXLAN encapsulation in unicast to the Edge RLOC.

## DHCP Offer and ACK - Unicast - Edge

The Edge receives the unicast DHCP Offer/ACK from the Border, de-encapsulates the traffic and consult its MAC address table to determine the correct egress port. Unlike broadcast Offer/ACKs, the Edge node forwards the packet only to the specific port where the endpoint is connected, rather than flooding it to all ports.

The MAC address table identifies port Te1/0/2 as our client port, which is in FWD state by STP, the packet is forwarded out to the endpoint.

<#root>

```
Edge-1#

show mac address-table interface te1/0/2

          Mac Address Table
-------------------------------------------
Vlan    Mac Address       Type        Ports
----    -----------       --------    -----

1041

aaaa.dddd.bbbb

    DYNAMIC

Te1/0/2
```

The DHCP Offer and ACK process remains consistent. Without DHCP Snooping enabled, no entries are created in the DHCP Snooping table. Consequently, the Device-Tracking entry for the DHCP-enabled endpoint is generated by the glean ARP packets. It is also expected that commands like "show platform dhcpsnooping client stats"  display no data, as DHCP snooping is disabled.

<#root>

```
Edge-1#

show device-tracking database interface te1/0/2 | be Network

    Network Layer Address                    Link Layer Address     Interface  vlan       prlvl      ag

ARP
```

```
172.16.141.1


 aaaa.dddd.bbbb

       Te1/0/2

1041

       0005       45s        REACHABLE  207 s try 0

Edge-1#

show ip dhcp snooping  binding vlan 1041


MacAddress          IpAddress        Lease(sec)  Type           VLAN  Interface
------------------  ---------------  ----------  -------------  ----  --------------------

Total number of bindings: 0
```

It is crucial to note that the SD-Access fabric does not influence the use of the Unicast or Broadcast flag, as this is solely an endpoint behavior. While this functionality might be overridden by the DHCP Relay or the DHCP Server itself, both mechanisms are essential for seamless DHCP operation in an L2 Only environment: L2 Flooding with Underlay Multicast for Broadcast Offers/ACKs, and proper Endpoint registration in the Control Plane for Unicast Offer/ACKs.