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# SD Access: Troubleshooting the Fabric

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BRKENT-3820

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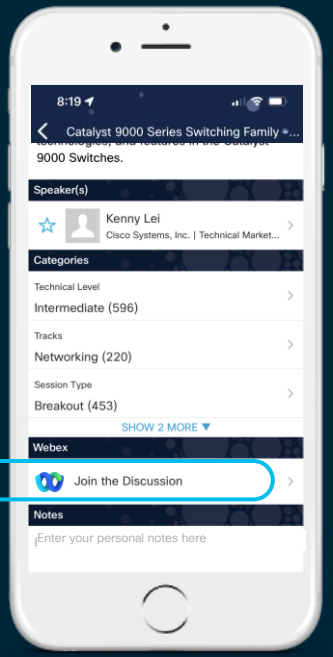


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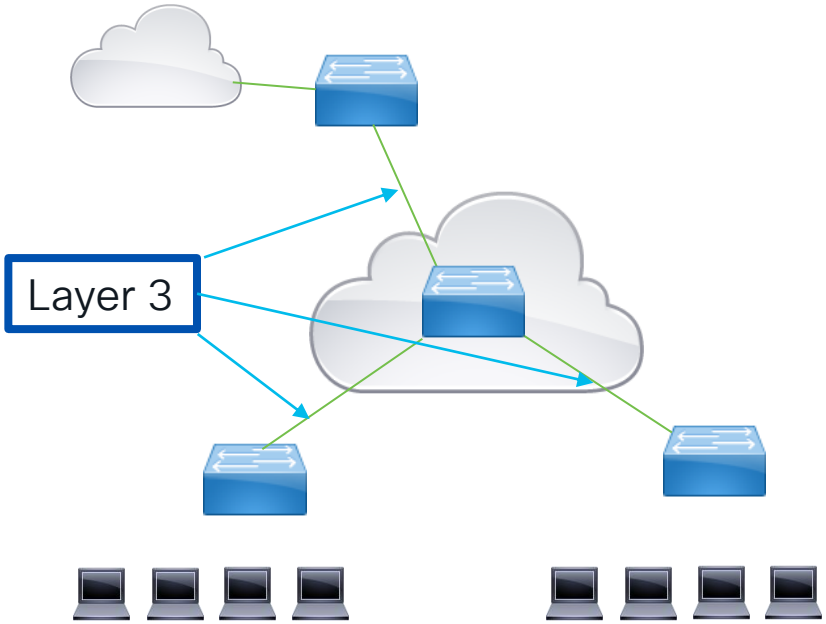
## Webex spaces will be moderated by the speaker until June 17, 2022.

# Agenda

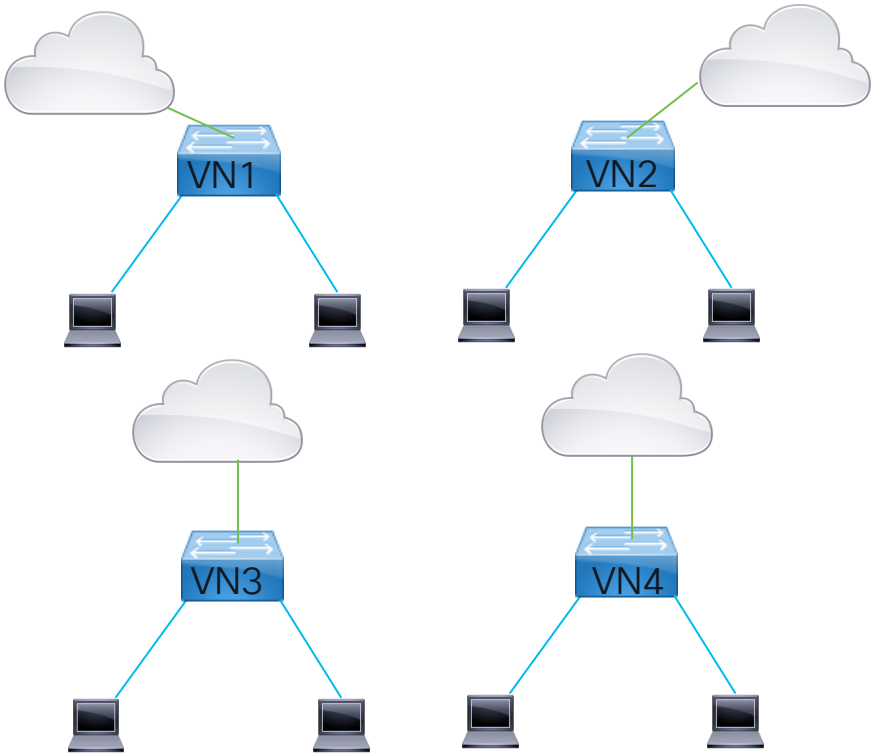
- Fabric overview
- Endpoints Registrations
- Reaching Remote Endpoints

# Fabric overview

# Overlay Technology



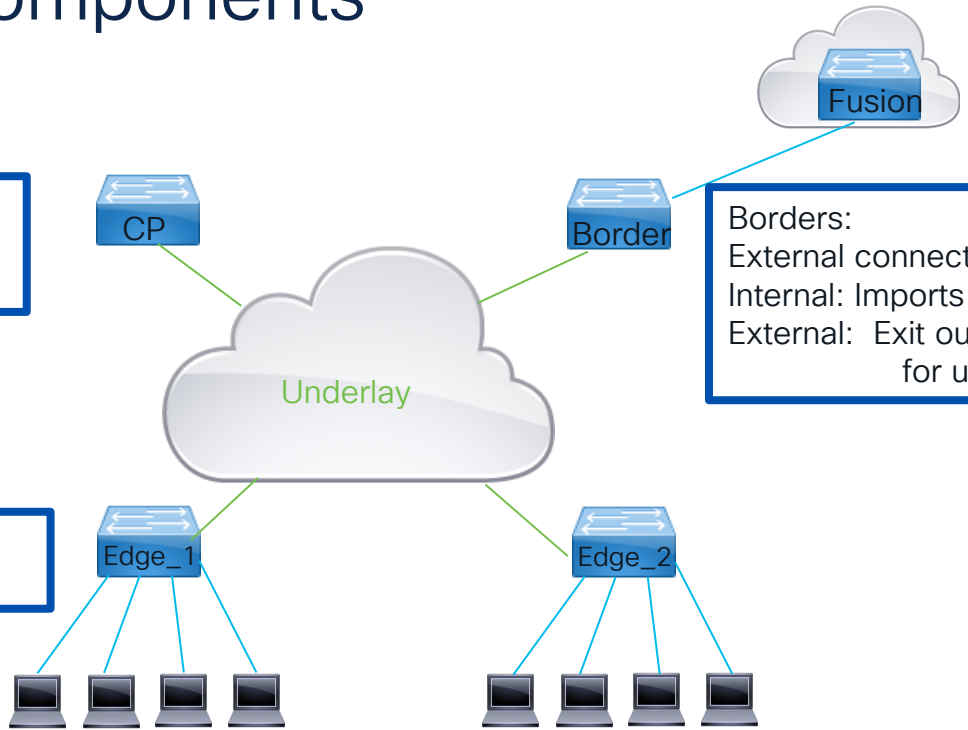

One Underlay
Layer 3 links




Multiple Virtual
Networks as Overlays

# Fabric Components

Control Plane Nodes:
Controls forwarding through the fabric




Borders:
External connectivity:
Internal: Imports routes into the fabric
External: Exit out of fabric
for unknown destinations

Edges:
Endpoint Connectivity

Fabric devices can have multiple roles

# SD Access Fabric Key Technologies

- Locator/ID Separation Protocol,
  Control plane protocol used inside the fabric for the Overlay networks
- VXLAN,
  Used for encapsulating all Dataplane traffic trough the underlay to form the overlay networks
- Cisco TrustSec,
  Assigning of a Policy label to all packets and enforcing security policies
- Authentication,
  Assigns endpoints using Dot1x/MAB with their respective authorization profiles and associated pools

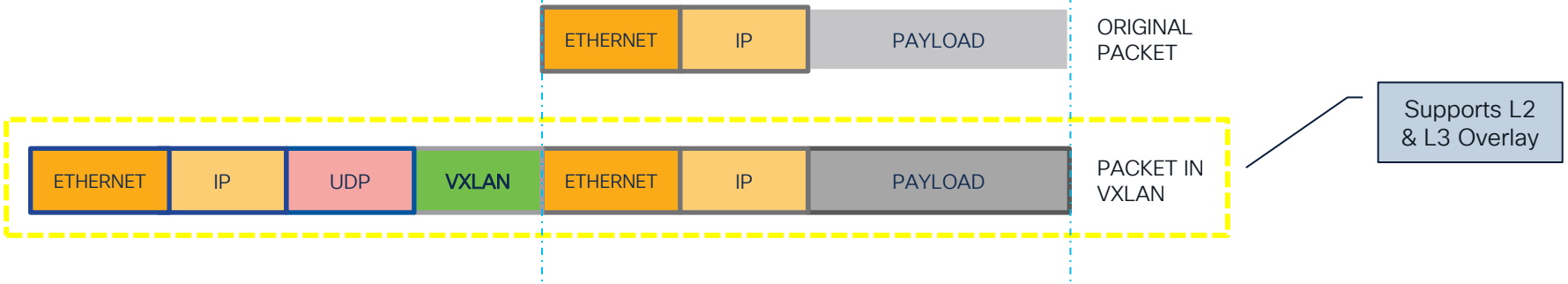
# LISP Basic operation

- LISP is a routing architecture, not just a routing protocol
- LISP creates a level of indirection by using two spaces: “locators” (RLOC) and “endpoints” (EID)
- Advertise “locators” in core routing. Removes “hosts” from routing tables. Host prefixes moved to an alternative system database
- Routers in Underlay only need routing information to RLOC space, simplifies Underlay network
- To get path information to end hosts, routers query locator-end host map servers. Mapping analogous to DNS.
- Routers hold map-cache of locator-hosts.

| LISP Device | SD Access | Function |
|---|---|---|
| RLOC (Routing Locator) | Fabric Devices | Routing Locator. Exists in global routing tables. Authoritative to reach EID space. |
| EID (Endpoint ID) | IP pools/End Points | Endpoint Identifier. IP addresses. Hidden from core network routing table. RLOC acts next-hop to reach EID space. |
| ETR (Egress Tunnel Router)& PETR (Proxy ETR) | Edge Device & Border node | Connects a LISP site to a LISP capable core network. Registers EID prefixes with Map Server (MS). Decapsulates LISP packets received from LISP core. PETR works on behalf of non-LISP domain and provides LISP-non-LISP connectivity. |
| ITR (Ingress Tunnel Router) &<br>PITR (Proxy Ingress Tunnel Router) | Edge Device and Border node | Responsible for forwarding local traffic to external destinations. Resolves RLOC for a given destination by sending Map-request to Map Resolver. Encapsulates traffic and send to fabric. Typically, this is a Access Layer Switch. PITR works on behalf of non-LISP domain and provides LISP-non-LISP connectivity. |
| XTR (X Tunnel Router) | Edge Device | When both ITR and ETR functions are handled by one router, it is called XTR. This is typical in practice. |
| MR (Map Resolver) | Control Plane Node | Responds to Map-requests from ITR. Map-requests will be replied with a (Negative) Map-reply or forwarded to appropriate ETR |
| MS (Map Server) | Control Plane Node | Registers EID space upon receiving Map-register messages from ETR. Updates Map Resolver with EID and RLOC data. |
| MSMR (Map Server Map Resolver) | Control Plane Node | When a device acts as both Map Server and Map Resolver, it is called MS MR. This is typical in practice. |

# Data Plane

- In SD Access the entire Layer 2 packet is encapsulated
- VXLAN encapsulation used. IP address in new header set to RLOC
- VXLAN Network Identifier field set to LISP instance ID
- Group Policy ID field in XVLAN set to Ingress SGT and preserved through the fabric. Enforcement occurs on egress



# Endpoints Registrations

# Virtual Networks and LISP instances

- VRF's correlate to Virtual Networks
- Dynamic EID ranges specify which EID are learned
- When Multicast enabled Loopback interfaces are created inside VRF

```
Edge_1#sh ip vrf BruEsc
  Name                    Interfaces
  BruEsc                  Lo4099
                          Vl1021
                          LI0.4099
                          Tu2
                          Vl1022
```

```
router lisp
 instance-id 4099
  dynamic-eid 172_30_3_0-BruEsc-IPV4
   database-mapping 172.30.3.0/24 locator-set rloc_1a8b95ce-6fe8-4608-b273-8453b86072c7
  !
  dynamic-eid 172_30_3_0-BruEsc-IPV6
   database-mapping 2001:DB8::/64 locator-set rloc_1a8b95ce-6fe8-4608-b273-8453b86072c7
  !     !
  service ipv4
   eid-table vrf BruEsc
   database-mapping 172.30.2.131/32 locator-set rloc_1a8b95ce-6fe8-4608-b273-8453b86072c7
   map-cache 0.0.0.0/0 map-request
```

Dynamic EID Ranges

VRF

Loopback for Multicasting

# Edge Configuration: SVI/VLAN Configuration

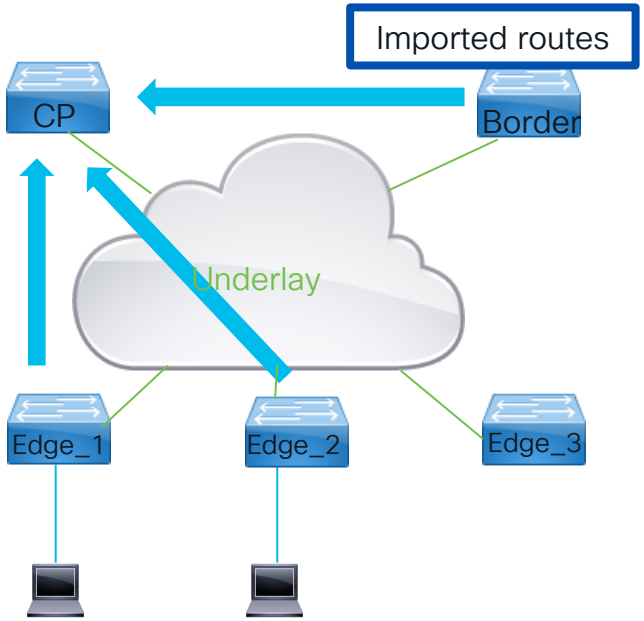
- Layer 3 Subnets and Layer 2 Pools deployed to all Edges is consistent throughout a fabric site
- Same IP address and mac are used on all edges(IP Anycast)
- Connections between edges should be L3 to avoid mac-learning issues

```
Edge_1#sh run int vlan 1021
interface Vlan1021
 mac-address 0000.0c9f.f377
 vrf forwarding BruEsc
 ip address 172.30.3.1 255.255.255.0
 ip helper-address 10.48.91.148
 no lisp mobility liveness test
 lisp mobility 172_30_3_0-BruEsc-IPV4
```

```
Edge_2#sh run int vlan 1021
interface Vlan1021
 mac-address 0000.0c9f.f377
 vrf forwarding BruEsc
 ip address 172.30.3.1 255.255.255.0
 ip helper-address 10.48.91.148
 no lisp mobility liveness test
 lisp mobility 172_30_3_0-BruEsc-IPV4
```

# LISP operation, registering with Map Server

| Instance | RLOC | EID (mac address) |
|---|---|---|
| 8189 | Edge_1 | 10f9.206d.e5b7 |
| 8189 | Edge_2 | 10f9.206d.e5b6 |
| 4099 | Edge_1 | 172.30.3.3/32 |
| 4099 | Edge_2 | 172.30.3.2/32 |
| 4099 | Border | 10.48.91.128/25 |




- Fabric devices dynamically learn the IP and Mac addresses of attached devices to register with control plane node using map-register messages
- Layer 2 Instances start with 8xxx, 1 instance per Vlan
- 4xxx Instances used for Layer 3 Virtual Networks, 1 per Virtual Network, IPv4 and IPv6 share same instance
- Control Plane nodes maintain central database mapping

# LISP Database

```
Edge_1#sh ip arp vrf BruEsc 172.30.3.3
Protocol  Address          Age (min)  Hardware Addr   Type   Interface
Internet  172.30.3.3            171   10f9.206d.e5b7  ARPA   Vlan1021
Edge_1#sh lisp instance-id 4099 ipv4 database 172.30.3.3/32
LISP ETR IPv4 Mapping Database for EID-table vrf BruEsc (IID 4099), LSBs: 0x1
172.30.3.3/32, dynamic-eid 172_30_3_0-BruEsc-IPV4,..
  Uptime: 3d15h, Last-change: 3d15h
  Locator        Pri/Wgt  Source     State
  172.30.233.6    10/10   cfg-intf   site-self, reachable
```

- LISP Database registers Learned Endpoints that are inside the EID ranges
- Endpoints can be learned via ARP/DHCP Snooping/Device Tracking
- Locator IP address is typically Loopback0 of Fabric Device in the Underlay network, needs to be reachable inside routing tables
- Wildcard (*) when used will show all instances with lisp commands

# Registration of Endpoints with Map Server (CP)

- LISP Reliable Transport used with SDA. Using TCP in stead of UDP
- LISP Session Down can be due to failed communication or no EID's to be registered
- Registration only succeeds when LISP key matches with CP node
- Map register messages send to CP nodes to register all EID's

```
Edge_1#sh lisp session
Peer                          State      Up/Down        In/Out    Users
172.31.255.182:4342           Up         00:00:25       54/22     12
Edge_1#sh tcp brief
TCB            Local Address              Foreign Address          (state)
7EFDC4E8BA90  172.30.233.6.43136         172.31.255.182.4342        ESTAB
Edge_1#sh lisp instance-id 4100 ipv4 statistics  | sec Map-Register
    Map-Register records in/out:                    0/28
    Map-Server AF disabled:                         0
    Authentication failures:                        0
```

# Layer 2 Endpoints

- Entries with Type CP_LEARN are remote entries
- Only endpoint macaddresses are registered with Control Plane

```
Edge_1#sh mac ad vlan 1021
Vlan    Mac Address       Type        Ports
----    -----------       --------    -----
1021    0000.0c9f.f377    STATIC      Vl1021
1021    10f9.206d.e5b7    STATIC      Te1/0/11
1021    701f.539b.0a75    STATIC      Vl1021
1021    10f9.206d.e5b6    CP_LEARN    L2LI0
Total Mac Addresses installed by LISP: REMOTE: 1
```

```
Edge_1#sh lisp instance-id 8189 ethernet database
LISP ETR MAC Mapping Database for EID-table Vlan 1021 (IID 8189), LSBs: 0x1
0000.0c9f.f377/48, dynamic-eid Auto-L2-group-8189, do not register, inherited from
default locator-set rloc_1a8b95
  Uptime: 3d23h, Last-change: 3d23h
    Locator        Pri/Wgt  Source     State
  172.30.233.6    10/10   cfg-intf   site-self, reachable
10f9.206d.e5b7/48, dynamic-eid Auto-L2-group-8189, inherited from default locator-set
rloc_1a8b95
  Uptime: 3d23h, Last-change: 3d23h
  Locator        Pri/Wgt  Source     State
  172.30.233.6    10/10   cfg-intf   site-self, reachable
```

# Control Plane Node (MSMR)

- Control Plane Node acts as  both Map Server and Map resolver (MSMR)
- Keeps database of all EID registrations for all AF(Ethernet/IPv4/IPV6)
- No synchronization between Control Plane nodes
- Show lisp site command gives overview of all IPv4/IPv6 registrations

```
Border_CP_1#sh lisp site instance-id 4099
LISP Site Registration Information
Site Name       Last      Up     Who Last              Inst     EID Prefix
                Register         Registered            ID
site_uci        never     no     --                    4099     0.0.0.0/0
                never     no     --                    4099     172.30.2.128/25
                05:17:04  yes#   172.30.233.6:43136    4099     172.30.2.131/32
                00:00:07  yes#   172.30.233.1:4342     4099     172.30.2.132/32
                never     no     --                    4099     172.30.3.0/24
                00:00:07  yes#   172.30.233.1:4342     4099     172.30.3.2/32
                05:17:04  yes#   172.30.233.6:43136    4099     172.30.3.3/32
                never     no     --                    4099     172.30.4.0/24
```

# Control Plane Node (MSMR) details on EID

```
Border_CP_1#sh lisp site 172.30.3.2/32 instance-id 4099
  EID-prefix: 172.30.3.2/32 instance-id 4099
    First registered:     4d23h
    Last registered:      00:00:01
    Origin:               Dynamic, more specific of 172.30.3.0/24
    Proxy reply:          Yes
    TTL:                  1d00h
    State:                complete
    Extranet IID:         Unspecified
    Registration errors:
      Authentication failures:   0
      Allowed locators mismatch: 0
    ETR 172.30.233.1, last registered 00:00:01, proxy-reply, map-notify
                      TTL 1d00h, no merge, hash-function sha1, nonce 0x768..
                      state complete, no security-capability
                      xTR-ID 0x41DCA445-0xF8480845-0x4E7EB2E4-0xFA8E33CF
                      site-ID unspecified
      Locator       Local  State      Pri/Wgt   Scope
      172.30.233.1  yes    up          10/10   IPv4 none
```

Age of EID

With proxy set Control plane responds on behalf of XTR

ETR Information

RLOC Information

# Layer 2 Control Plane

```
Border_CP_1#sh lisp instance-id 8189 ethernet server
LISP Site Registration Information
Site Name        Last       Up      Who Last              Inst      EID Prefix
                 Register           Registered            ID
site_uci         never      no      --                    8189      any-mac
                 03:57:06   yes#    172.30.233.1:51300    8189      10f9.206d.e5b6/48
                 10:12:16   yes#    172.30.233.6:43136    8189      10f9.206d.e5b7/48
```

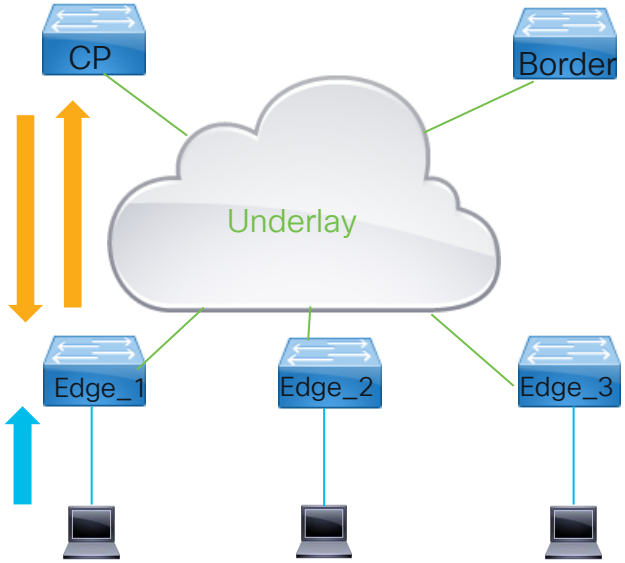
- Mac registrations on CP shown using show lisp instance-id * ethernet server

```
Border_CP_1#sh lisp inst 8189 ethernet server 10f9.206d.e5b6 registration-history
Roam = Did host move to a new location?
WLC = Did registration come from a Wireless Controller?
Prefix qualifier: + = Register Event, - = Deregister Event, * = AR register event
Timestamp (UTC)       Instance Proto Roam WLC Source              EID prefix
Jun  6 02:51:41.699       8189 TCP   No   No  172.30.233.1      + 10f9.206d.e5b6/48
Jun  6 03:51:49.913       8189 TCP   No   No  172.30.233.1      - 10f9.206d.e5b6/48
Jun  6 03:52:06.392       8189 TCP   No   No  172.30.233.1      + 10f9.206d.e5b6/48
```

# Reaching Remote Endpoints

# LISP basic operation, resolving

| Instance | RLOC | EID (mac address) |
|---|---|---|
| 8189 | Edge_1 | 10f9.206d.e5b7 |
| 8189 | Edge_2 | 10f9.206d.e5b6 |
| 4099 | Edge_1 | 172.30.3.3/32 |
| 4099 | Edge_2 | 172.30.3.2/32 |
| 4099 | Border | 10.48.91.128/25 |




- Endpoint 1 sends packet towards Endpoint 2
- Edge_1 initiates map request to CP node
- CP responds to Edge_2 with map-response containing RLOC information
- Edge_1 creates map-cache entry and is ready to forward traffic

# Map Cache

- Map-requests triggered by hitting an Entry with send-map-request action

  map-cache 0.0.0.0/0 map-request

- Responses from Control Plane Nodes are cached on fabric devices to build the map cache.
- Successful map-requests are cached with a default TTL of 1 day
  Time to Live set by registering device with “etr map-cache-ttl”
- Negative map-requests have TTL of 15 minutes
- Control plane node returns largest possible block containing requested EID when sending Negative Map Reply

# Resolving Remote Destinations

```
Edge_1#sh lisp instance-id 4099 ipv4 map-cache
LISP IPv4 Mapping Cache for EID-table vrf BruEsc (IID 4099), 7 entries
0.0.0.0/0, uptime: 5d05h, expires: never, via static-send-map-request
  Encapsulating to proxy ETR
0.0.0.0/1, uptime: 11:28:43, expires: 00:10:14, via map-reply, forward-native
  Encapsulating to proxy ETR
172.30.2.129/32, uptime: 11:30:36, expires: 00:29:39, via map-reply, complete
  Locator          Uptime    State  Pri/Wgt     Encap-IID
  172.31.255.182   11:30:36  up      10/10        -
172.30.3.0/24, uptime: 5d05h, expires: never, via dynamic-EID, send-map-request
  Encapsulating to proxy ETR
172.30.3.2/32, uptime: 00:16:31, expires: 23:43:28, via map-reply, complete
  Locator        Uptime    State  Pri/Wgt     Encap-IID
  172.30.233.1   00:16:31  up      10/10        -
172.30.4.0/24, uptime: 5d05h, expires: never, via dynamic-EID, send-map-request
  Encapsulating to proxy ETR
```

Triggers map-request

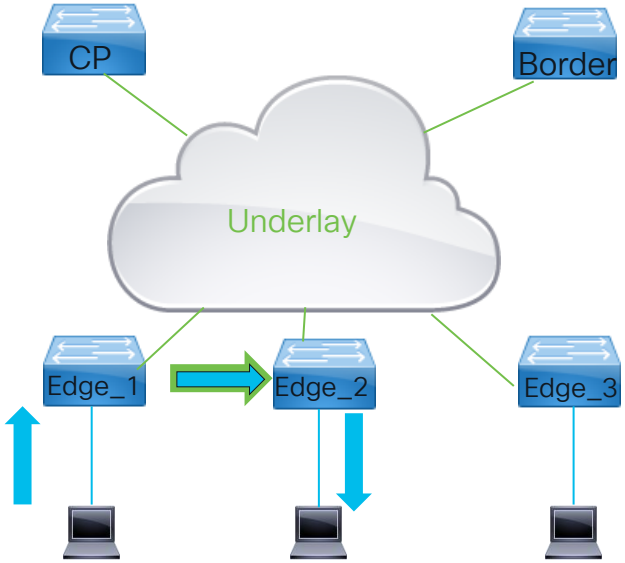
NMR, send to petr

Encapsulate to RLOC

Map Cache shows EID range, source of cache entry and action to be taken.

# LISP basic operation, packet forwarding

| Instance | RLOC | EID (mac address) |
|---|---|---|
| 8189 | Edge_1 | 10f9.206d.e5b7 |
| 8189 | Edge_2 | 10f9.206d.e5b6 |
| 4099 | Edge_1 | 172.30.3.3/32 |
| 4099 | Edge_2 | 172.30.3.2/32 |
| 4099 | Border | 10.48.91.128/25 |




- Overlay traffic in SD Access is encapsulated in Vxlan and send between RLOC addresses
- Underlay network unaware of overlay topology
- Reachability to RLOC should exist in Route table

  ipv4 locator reachability minimum-mask-length 32
  ipv4 locator reachability exclude-default

# Layer 2 or Layer 3 forwarding

- SDA supports both layer 2 and Layer 3 forwarding inside fabric
- Traffic inside  IP pool will be encapsulated using Layer 2 instance
- Traffic destined outside IP pool send using Layer 3 instance
- Layer 2 forwards traffic based on Destination Mac Address and L2 Map-cache
- Optional flooding of BUM traffic using Multicast group in underlay
- Traffic outside IP pool will be routed using an Layer 3 LISP Instance

# LISP Remote forwarding

- Show ip route does not show full detail on forwarding
- Default route and remote entries not showing on edges. As Null0 routes on Border

```
Edge_1#sh ip route vrf BruEsc
..
Gateway of last resort is not set
      172.30.0.0/16 is variably subnetted, 7 subnets, 2 masks
C        172.30.2.131/32 is directly connected, Loopback4099
C        172.30.3.0/24 is directly connected, Vlan1021
L        172.30.3.1/32 is directly connected, Vlan1021
l        172.30.3.3/32 [10/1] via 172.30.3.3, 4d07h, Vlan1021
```

```
Border_CP_1#sh ip route vrf BruEsc
..
Gateway of last resort is not set
       172.30.3.0/24 [200/0], 6w4d, Null0
C        172.30.3.1/32 is directly connected, Loopback1021
l        172.30.3.2/32 [250/1], 07:20:46, Null0
l        172.30.3.3/32 [250/1], 13:35:56, Null0
```

# LISP Remote forwarding, more detail

```
Edge_1#sh ip cef vrf BruEsc 172.30.3.2 detail
172.30.3.2/32, epoch 1, flags [subtree context, check lisp eligibility]
  SC owned,sourced: LISP remote EID - locator status bits 0x00000001
  LISP remote EID: 2 packets 1152 bytes fwd action encap, dynamic EID need encap
  SC inherited: LISP cfg dyn-EID - LISP configured dynamic-EID
  LISP EID attributes: localEID No, c-dynEID Yes, d-dynEID No
  SC inherited: LISP generalised SMR - [enabled, inheriting, 0x7EFDC4E7A0A8 locks: 4]
  LISP source path list
    nexthop 172.30.233.1 LISP0.4099
  2 IPL sources [no flags]
  nexthop 172.30.233.1 LISP0.4099
```

- CEF gives accurate view of forwarding inside fabric device
- LISP subinterface is Instance-id , nexthop IP Address is RLOC of destination
- Show ip cef <nexthop> gives egress interface information in underlay for next hop.

# Packet Encapsulation

Apply a display filter ... <⌘/>

| No. | Protocol | Source | Destination | Time | Info |
|---|---|---|---|---|---|
| 3 | ICMP | 172.30.3.2 | 172.30.3.3 | 0.116267 | Echo (ping) request id=0x069b, seq=9688/55333, ttl=64 (reply in 4) |
| 4 | ICMP | 172.30.3.3 | 172.30.3.2 | 0.116365 | Echo (ping) reply id=0x069b, seq=9688/55333, ttl=64 (request in 3) |
| 5 | ICMP | 172.30.3.3 | 172.30.2.2 | 1.023982 | Echo (ping) request id=0x0659, seq=97/24832, ttl=63 (reply in 6) |
| 6 | ICMP | 172.30.2.2 | 172.30.3.3 | 1.024255 | Echo (ping) reply id=0x0659, seq=97/24832, ttl=252 (request in 5) |
| 7 | ICMP | 172.30.3.2 | 172.30.3.3 | 1.140294 | Echo (ping) request id=0x069b, seq=9689/55589, ttl=64 (reply in 8) |
| 8 | ICMP | 172.30.3.3 | 172.30.3.2 | 1.140385 | Echo (ping) reply id=0x069b, seq=9689/55589, ttl=64 (request in 7) |
| 9 | ICMP | 172.30.3.3 | 172.30.2.2 | 2.047999 | Echo (ping) request id=0x0659, seq=98/25088, ttl=63 (reply in 10) |
| 10 | ICMP | 172.30.2.2 | 172.30.3.3 | 2.048247 | Echo (ping) reply id=0x0659, seq=98/25088, ttl=252 (request in 9) |
| 11 | ICMP | 172.30.3.2 | 172.30.3.3 | 2.164316 | Echo (ping) request id=0x069b, seq=9690/55845, ttl=64 (reply in 12) |
| 12 | ICMP | 172.30.3.3 | 172.30.3.2 | 2.164408 | Echo (ping) reply id=0x069b, seq=9690/55845, ttl=64 (request in 11) |

```
> Frame 3: 148 bytes on wire (1184 bits), 148 bytes captured (1184 bits) on interface 0
> Ethernet II, Src: Cisco_9b:0b:40 (70:1f:53:9b:0b:40), Dst: Cisco_1c:49:d8 (2c:5a:0f:1c:49:d8)
> Internet Protocol Version 4, Src: 172.30.233.1, Dst: 172.30.233.6
> User Datagram Protocol, Src Port: 65472, Dst Port: 4789
v Virtual eXtensible Local Area Network
  > Flags: 0x8800, GBP Extension, VXLAN Network ID (VNI)
    Group Policy ID: 4
    VXLAN Network Identifier (VNI): 8189
    Reserved: 0
v Ethernet II, Src: 10:f9:20:6d:e5:b6 (10:f9:20:6d:e5:b6), Dst: 10:f9:20:6d:e5:b7 (10:f9:20:6d:e5:b7)
  > Destination: 10:f9:20:6d:e5:b7 (10:f9:20:6d:e5:b7)
  > Source: 10:f9:20:6d:e5:b6 (10:f9:20:6d:e5:b6)
    Type: IPv4 (0x0800)
> Internet Protocol Version 4, Src: 172.30.3.2, Dst: 172.30.3.3
> Internet Control Message Protocol
```

New Header

VXLAN Header

SGT

LISP Instance ID

Encapsulated packet

# Questions?

# Related sessions:

- BRKTRS-3010 : SD Access: Advanced Fabric Troubleshooting
- BRKTRS-3090 : Troubleshooting the Cisco Catalyst 9000 Series Switches
- BRKTRS-2811a & BRKTRS-2811b : Overview of Packet Capturing Tools in Cisco Switches and Routers
- LABTRS-2391 Packet Capturing Tools in Enterprise Switching Environments

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https://cnb.cisco.com/

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Release Recommendations

HW-SW Compatibility

Transforming Customer Experience with Cisco AI Chatbots

# Technical Session Surveys

- Attendees who fill out a minimum of four session surveys and the overall event survey will get Cisco Live branded socks!
- Attendees will also earn 100 points in the Cisco Live Game for every survey completed.
- These points help you get on the leaderboard and increase your chances of winning daily and grand prizes.

# Cisco Learning and Certifications

From technology training and team development to Cisco certifications and learning plans, let us help you empower your business and career. www.cisco.com/go/certs

**Pay for Learning with Cisco Learning Credits**

(CLCs) are prepaid training vouchers redeemed directly with Cisco.

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**Cisco U.**
IT learning hub that guides teams and learners toward their goals

**Cisco Digital Learning**
Subscription-based product, technology, and certification training

**Cisco Modeling Labs**
Network simulation platform for design, testing, and troubleshooting

**Cisco Learning Network**
Resource community portal for certifications and learning

## Train

**Cisco Training Bootcamps**
Intensive team & individual automation and technology training programs

**Cisco Learning Partner Program**
Authorized training partners supporting Cisco technology and career certifications

**Cisco Instructor-led and Virtual Instructor-led training**
Accelerated curriculum of product, technology, and certification courses

## Certify

**Cisco Certifications and Specialist Certifications**
Award-winning certification program empowers students and IT Professionals to advance their technical careers

**Cisco Guided Study Groups**
180-day certification prep program with learning and support

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Here at the event? Visit us at **The Learning and Certifications lounge at the World of Solutions**

# Continue your education

- Visit the Cisco Showcase for related demos
- Book your one-on-one Meet the Engineer meeting
- Attend the interactive education with DevNet, Capture the Flag, and Walk-in Labs
- Visit the On-Demand Library for more sessions at www.CiscoLive.com/on-demand

# Thank you

cisco Live!

# ALL IN

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