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#CiscoLive
Multicast over Segment Routing
Deployment and Troubleshooting

Nagendra Kumar Nainar, Principal Engineer
Mankamana Mishra, Technical Leader
BRK MPL-2257
I am a **Principal Engineer** with the CX team, leading / co-leading various innovation activities around **Future of Work** and **Full Stack Observability**.

I have been with Cisco for more than 10 years playing different roles. I am one of the contributing architect for various technologies and co-invented various solutions implemented in different Cisco and other vendor products.

I am the co-inventor of more than **150 patent applications** and have co-authored various **Internet Standards and RFCs**.

**Nagendra Kumar Nain**
Principal Engineer, CX
naikumar@cisco.com
I am Sr. Technical leader in the Engineering working on Multicast, BGP and MPLS. I have been involved in Multicast for about 10 years working on many different aspects of multicast, like PIM, IGMP, MSDP, MVPN and EVPN. I have worked on the integration of Multicast and EVPN SR MPLS. I am (co)author of many IETF drafts related to Multicast, MPLS and mVPN, EVPN technologies.

Mankamana Mishra
Sr. Technical Leader, XR
mankamis@cisco.com
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Agenda

- Segment Routing Primer
- SR P2MP Policy
- SR P2MP Policy Configuration
- mLDP P2MP
- mVPN Primer
- Troubleshooting mLDP
Segment Routing

• **Source Routing**
  • Source chooses a path and encodes it in the packet header as an ordered list of segments
  • Rest of the network executes the encoded instructions without any further per-flow state

• **Segment ID**
  • Identifier for any type of instruction
  • Forwarding or service

• **Control Plane Paradigm**
  • Distributed intelligence is used to build these segments
  • Centralized intelligence maps application to path for resource optimization
Segment Routing Unified Fabric

Simplify   Virtualize   Automate   Program

SR Unified Fabric

New business capabilities built on the network as the platform; Enabling customers to achieve business outcomes faster with ruthless ease
IGP Prefix Segment

- Aka Node Segment ID
- Shortest-path to the IGP prefix
- Global
- Signaled by ISIS/OSPF
- Manually assigned or using centralized controller.

Illustration:
Prefix-SID NodeX = 16000+X
IGP Adjacency Segment

- Forward on the IGP adjacency
- Locally Assigned
- Local significance
- Signaled by ISIS/OSPF
- Programmed only in originator’s forwarding table

Illustration:
Adj-SID X→Y = 24nXY, n is index
Segment Routing – Technology Overview

Node SID (Prefix SID)
- Globally Significant
- Locally Significant

Adjacency SID
- Locally Significant
- Unidirectional

Anycast SID
- Globally Significant

Binding SID
- Globally or Locally Significant

Peering SID (EPE)
- Locally Significant

Tree SID
- Locally Significant

Diagram:
- AS 65001
  - Node SID: 15001
  - Adjacency SID: 24010, 24035
  - Anycast SID: 16003
  - Binding SID: 16005

- AS 65002
  - Peering SID (EPE): 32001, 32002

Connections:
- 1 to 3
- 3 to 5
- 2 to 4
- 4 to 6
- 5 to 7
- 6 to 8
SR Control Plane – Path Computation Element

**SRTE Head-End**

Distributed Mode – SR-TE Head-End
Visibility is limited to its own IGP domain

**Solution**

Multi-Domain SRTE Visibility
Centralized SR-PCE for Multi-Domain Topology view

Integration with Applications
North-bound APIs for topology/deployment

Delivers **across the unified SR Fabric** the SLA requested by the service

**Benefits**

Simplicity and Automation
End-to-End network topology awareness
SLA-aware path computation across network domains
SR Header – Path Encoding

- Path Information is encoded as stack of segments in the header.
- Each segment is an instruction that will be executed by the transit devices.
Traffic Engineering using SR

• Traffic is classified based on the path attributes requested
  • Low Latency vs High BW
• Packet is encoded with relevant segment list to steer the traffic
Segment Routing Data Plane

Segment = **Instructions** such as "go to node N using the shortest path"

**Control Plane:** IGP with SR  
**Data Plane:** MPLS  
SID replaces Label  
Label Stack → SID Stack

**Control Plane:** IGP with SR  
**Data Plane:** IPv6  
Source Routing Extension Header  
SID = IPv6 Address  
SRH Extension → SID Stack
Why Multicast?

- Various End Applications leverages multicast for data synchronization, backup etc.
  - Video and Collaboration Solutions
  - Distributed File systems
  - Data Replication and Synchronization
  - Media conferencing
  - Video Surveillance
- Common to see servers deployed in Datacenters.
  - Servers acting as multicast source
- Hosts can be senders or receivers.
Why Multicast?

- Multicast VPN (MVPN) is one of the service offered by most of the Service Provider.
  - Enterprise Applications
  - IPTV Streaming
  - Financial Applications
  - Internet of Things

- Multicast Distribution Tree (MDT) are created for each VRF tenants.
Traditional Multicast Solution

- Different control plane protocol used for multicast tree building
- Different Data plane used for traffic forwarding
  - IP lookup
  - GRE Encapsulation
Traditional Multicast Options

• Deploying SR for unicast is orthogonal to solution used for Multicast.

• Nothing prevents existing protocols to continue to work, like:
  • Ingress Replication (IR)
  • PIM
  • mLDP
  • RSVP-TE

• In that sense, there is no requirement to change the Multicast deployment.

• However, if there is a technology that would benefit from being simplified and scale improved, it is Multicast ☺
Session Focus

SR P2MP Policy
Centralized Approach

Multipoint LDP
Distributed Approach
Segment Routing P2MP Policy
SR P2MP Policy

- SR P2MP Policy is a **SDN controller-based** approach to building P2MP trees in a SR domain
  - SR-PCE computes and instantiates the Tree
- A tree can be built using **Traffic Engineering** criteria (like TE metric optimization or affinity constraints).
- Static Tree-SID
  - User-defined root, leaves and multicast flow mapping
- Dynamic Tree-SID Policies
  - Dynamic discovery of root, leaves and multicast flow mapping using BGP mVPN

**Use cases:** IPTV / Streaming media / Business mVPN
SR Replication Segment

- Replication segment allows node (Replication Node) to replicate packets to a set of other nodes (Downstream Nodes) in a Segment Routing Domain

- Replication segments provide building blocks for Point-to-Multipoint Service delivery via SR Point-to-Multipoint (SR P2MP) policy

- A Replication segment can replicate packet to directly connected nodes or to downstream nodes (without need for state on the transit routers)

- The use of one or more stitched Replication segments constructed for SR P2MP Policy tree
SR PCE Functionalities

- Learn the Topology details
- Learn the Tree details
- Compute the Tree path
- Program the Forwarding Plane
Learning the Topology

- A common mechanism to learn the topology is using BGP Link State (LS).
- Through BGP-LS, the controller sucks up the Link State database.
- Through the LS database, the controller can use any sort of algorithm (like Dijkstra) to calculate paths.
- Topology may change!
Learning the Tree

- SR-PCE also needs to know the Tree Root and End-points.
  - This can be defined by an operator.
  - Dynamically through a protocol, like BGP Auto Discovery (AD).

Root Node: A
Leaf Node: \{C, E\}
Metric
Affinity (optional)
Computing the Multipoint Path

• With the central knowledge at the controller, the tree can be computed according to different metrics and constraints.
  • Optimization objective (metric)
    • IGP / TE / Delay
  • Affinity constraints
Tree SID Instantiation

- PCEP is used to program the relevant devices with the Tree SID forwarding information.
- Forwarding Plane is programmed with replication semantics
Tree SID SSM Mapping

- The MRIB of the root node is programmed by mapping the P2MP SR Policy as the OIL to the (S,G).
- The MRIB of the leaf node is programmed by mapping the P2MP SR Policy as the incoming interface for (S,G).
Tree SID Policy Configuration

Static Tree

- User defines the Tree SID policy (Root, endpoint)
- SR-PCE computes the P2MP path
  - Metrics Optimization
  - Affinity Constraints

```c
policy p2mp-tree-1
  source ipv4 <addr>
  color 10 endpoint-set tree-1
treesid mpls 18001
candidate-paths
  constraints
    affinity
      include-any | include-all | exclude
    color1
  !
  !
  preference 100
dynamic
  metric
type igp | te | latency
```

```c
pce
  address ipv4 <pce>
! segment-routing
  traffic-eng
  p2mp
  endpoint-set tree-1
  ipv4 <endpoint>
ipv4 <endpoint>
! policy p2mp-tree-1 ...
```
Tree SID Configuration
Sample ROOT node Configuration

```
multicast-routing
  address-family ipv4
    mdt source Loopback0
    interface all enable
    mdt static segment-routing
    !
    !
router pim
  address-family ipv4
    sr-p2mp-policy p2mp-tree-1
      static-group 232.101.1.1 inc-mask 0.0.0.1 count 200 192.101.1.2
      !
      !
vrf vpn1
  address-family ipv4
    sr-p2mp-policy p2mp-vpn1-1
      static-group 232.1.2.1 192.201.1.2
      !
    sr-p2mp-policy p2mp-vpn1-2
      static-group 232.1.3.1 inc-mask 0.0.0.1 count 200 192.201.1.2 inc-mask 0.0.0.1 count 200
      !
```
Sample Leaf Node Configuration

```plaintext
multicast-routing
address-family ipv4
  mdt source Loopback0
interface all enable
  static sr-policy p2mp-tree-1
  mdt static segment-routing
!
vrf vpn1
address-family ipv4
  interface all enable
  static sr-policy p2mp-vpn1-1
  static sr-policy p2mp-vpn1-2
  mdt static segment-routing
!
```

Tree SID State Entries

RP/0/RP0/CPU0:R1#show mrib vrf vpn1 ipv4 route detail
(192.101.1.2,232.1.4.1) Ver: 0xad8a RPF nbr: 192.101.1.2 Flags: RPF EID,
Incoming Interface List
  GigabitEthernet0/0/0/0 Flags: A, Up: 08:10:24
Outgoing Interface List
  TRmdtvpn1 Flags: F NS TRMI, Up: 02:11:26, Head LSM-ID: 0x0000c
RP/0/RP0/CPU0:A#sh mrib mpls forwarding
LSP information (XTC) :
  LSM-ID: 0x0000C, Role: Head, Head LSM-ID: 0x0000C
  Incoming Label : (18101)
  Outsegment Info #1 [M/Swap]:
    OutLabel: 18001, NH: 192.1.2.2, IF: GigabitEthernet0/0/0/0

RP/0/RP0/CPU0:SR-PCE1#sh pce lsp p2mp
Tree: <>
  Label: 18001 Operational: up Admin: up
  Source: <>
  Destinations<Leaf-Nodes>
      Nodes:
        Role: Transit
        Hops:
          Incoming: 18001 CC-ID: 137
          Outgoing: 18001 CC-ID: 137
        Node[2]: <>
        Role: Ingress
        Hops:
          Incoming: 18001 CC-ID: 138
          Outgoing: 18001 CC-ID: 138 (192.1.2.1)
          Outgoing: 18001 CC-ID: 138 (192.1.3.1)
        Node[3]: <>
        Role: Egress
        Hops:
          Incoming: 1801 CC-ID: 139
          Outgoing: 1801 CC-ID: 139 (192.1.3.1)

RP/0/RP0/CPU0:R4#show mrib vrf vpn1 ipv4 route detail
(192.101.1.2,232.1.3.1) RPF nbr: 6.1.1.101 Flags: RPF
Up: 00:00:11
Incoming Interface List
  TRmdtvpn1 Flags: A TRMI, Up: 00:00:11
Outgoing Interface List
  GigabitEthernet0/0/0/2 Flags: F IC NS II LI, Up: 00:00:11
RP/0/RP0/CPU0:E#sh mrib mpls forwarding
LSP information (XTC) :
  LSM-ID: 0x0006F, Role: Mid
  Incoming Label : 18001
  Transported Protocol : <unknown>
  Explicit Null : None
  IP lookup : disabled
  Outsegment Info #1 [M/Swap]:
    OutLabel: 18001, NH: 192.1.2.5, IF: GigabitEthernet0/0/0/3
  Outsegment Info #2 [M/Swap]:
    OutLabel: 18001, NH: 192.1.2.6, IF: GigabitEthernet0/0/0/4

RP/0/RP0/CPU0:R2#sh mrib mpls forwarding
LSP information (XTC) :
  LSM-ID: 0x0006F, Role: Mid
  Incoming Label : 18001
  Transported Protocol : <unknown>
  Explicit Null : None
  IP lookup : disabled
  Outsegment Info #1 [M/Swap]:
    OutLabel: 18001, NH: 192.1.2.5, IF: GigabitEthernet0/0/0/3
  Outsegment Info #2 [M/Swap]:
    OutLabel: 18001, NH: 192.1.2.6, IF: GigabitEthernet0/0/0/4
Tree SID Forwarding

- ROOT Node is programmed to encapsulate the incoming multicast payload with tree SID
- Transit nodes are programmed to replicate and forward
- Leaf nodes are programmed to decapsulate the tree SID.
Disjointed Tree for High Resiliency

- Multi Plane Topology using link affinity colors
  - Green and Blue planes.
- SR-PCE learns link affinities via BGP-LS
- Path computation satisfying the constrains with link affinity
P2MP SR Path Make-Before-Break

- Event occurs in the network.
- Topology change is notified to SR-PCE
- SR-PCE recomputes the path based on the new topology
- SR-PCE Updates the transit and leaf nodes with new Tree SID.
  - Old entries are retained as stale entry.
- SR-PCE updates the ROOT to use the new Tree SID
- ROOT confirms the update
- SR-PCE updates all the nodes to remove the stale entries.
Dynamic SR P2MP Policy

Default MDT SR P2MP tree

• PE1 assigns a unique Tree ID for the default MDT of VPN1.

• PE1 creates a P2MP policy by invoking CreatePolicy API of the PCE

• PMSI route advertised by PE1 to all remote PEs via BGP-AD
Dynamic SR P2MP Policy

Default MDT SR P2MP tree

- PE1 discovers remote PEs participating in the VPN via received BGP-AD routes.
- PE1 requests the PCE to add the leaf nodes to the tree by invoking UpdateLeafSet API of the PCE.
- PCE computes the replication segments and programs the relevant nodes.
Tree SID FRR

- LFA path is computed for redirecting the traffic over backup path.
- Appends Prefix SID to unicast the traffic to the downstream node via backup path.
Tree SID FRR

- LFA path is computed for redirecting the traffic over backup path.
- Appends Prefix SID to unicast the traffic to the downstream node via backup path.
Session Focus

Multipoint LDP
Distributed Approach

Segment Routing
mLDP based P2MP Trees
mLDP-only SAC

- RFC 7473: State Advertisement Control for Non-negotiated LDP apps
- Have an LDP peer negotiate to advertise label bindings for certain MPLS apps or not by means of capability exchange at LDP session establishment
- Configure LDP to negotiate the label advertisement for IPv4, IPv6, FEC128, FEC129, and mLDP
- Request: run (m)LDP for advertisement of mLDP label bindings, but not for unicast label bindings
- Use-case: Segment Routing network (no LDP for unicast is needed)

```bash
RP/0/0/CPU0:PE(config-ldp)#capabilities sac ?

  fec128-disable  Disable exchanging PW FEC128 label bindings
  fec129-disable  Disable exchanging PW FEC129 label bindings
  ipv4-disable    Disable exchanging IPv4 prefix label bindings
  ipv6-disable    Disable exchanging IPv6 prefix label bindings
  mldp-only       Only exchange mLDP label bindings
```

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LDP without mLDP—only SAC

RP/0/0/CPU0:PE1#show running-config mpls ldp
mpls ldp
mldp
router-id 192.168.0.2
interface Bundle-Ether1
interface GigabitEthernet0/0/0/0
interface GigabitEthernet0/0/0/1
interface GigabitEthernet0/0/0/2

RP/0/0/CPU0:PE1#show mpls ldp summary
AFIs : IPv4
Routes : 6 prefixes
Bindings : 7 prefixes
  Local : 6
  Remote : 6
Neighbors : 1
Adj Groups: 1
Hello Adj : 1
Addresses : 3
Interfaces: 1 LDP configured

RP/0/0/CPU0:P#show running-config mpls ldp
mpls ldp
mldp
router-id 192.168.0.1
interface Bundle-Ether1
interface GigabitEthernet0/0/0/0

RP/0/0/CPU0:P#show mpls ldp summary
AFIs : IPv4
Routes : 6 prefixes
Bindings : 8 prefixes
  Local : 6
  Remote : 12
Neighbors : 2
Adj Groups: 2
Hello Adj : 2
Addresses : 3
Interfaces: 2 LDP configured

RP/0/0/CPU0:PE2#show running-config mpls ldp
mpls ldp
mldp
router-id 192.168.0.3
interface Bundle-Ether2
interface GigabitEthernet0/0/0/0

RP/0/0/CPU0:PE2#show mpls ldp summary
AFIs : IPv4
Routes : 6 prefixes
Bindings : 7 prefixes
  Local : 6
  Remote : 6
Neighbors : 1
Adj Groups: 1
Hello Adj : 1
Addresses : 3
Interfaces: 1 LDP configured
Impact of mLDP-only SAC

RP/0/0/CPU0:PE1#show running-config mpls ldp
mpls ldp
capabilities sac mldp-only
mldp
router-id 192.168.0.2
interface Bundle-Ether1
interface GigabitEthernet0/0/0/0
interface GigabitEthernet0/0/0/1
interface GigabitEthernet0/0/0/2

RP/0/0/CPU0:PE1#show mpls ldp summary
AFIs : IPv4
Routes : 0 prefixes
Bindings : 0 prefixes
Local : 0
Remote : 0
Neighbors : 1
Adj Groups: 1
Hello Adj : 1
Addresses : 3
Interfaces: 1 LDP configured

RP/0/0/CPU0:P#show running-config mpls ldp
mpls ldp
capabilities sac mldp-only
mldp
router-id 192.168.0.1
interface Bundle-Ether1
interface GigabitEthernet0/0/0/0
interface GigabitEthernet0/0/0/1
interface GigabitEthernet0/0/0/2

RP/0/0/CPU0:P#show mpls ldp summary
AFIs : IPv4
Routes : 0 prefixes
Bindings : 0 prefixes
Local : 0
Remote : 0
Neighbors : 2
Adj Groups: 2
Hello Adj : 2
Addresses : 4
Interfaces: 2 LDP configured

RP/0/0/CPU0:PE2#show running-config mpls ldp
mpls ldp
capabilities sac mldp-only
mldp
router-id 192.168.0.3
interface Bundle-Ether2
interface GigabitEthernet0/0/0/0
interface GigabitEthernet0/0/0/1

RP/0/0/CPU0:PE2#show mpls ldp summary
AFIs : IPv4
Routes : 0 prefixes
Bindings : 0 prefixes
Local : 0
Remote : 0
Neighbors : 1
Adj Groups: 1
Hello Adj : 1
Addresses : 3
Interfaces: 1 LDP configured
LDP Label Mapping Message: 4 Important Fields

- **FEC TLV**
  - **FEC Element**
    - **FEC Type 0x100**
      - **Type**
      - **Root**
      - **Opaque**

- **Label TLV**

These 3 items uniquely identify the mLDP tree:

1. **Type**
2. **Root**
3. **Opaque**

**P2MP**
**Ingress PE**
**Global Identifier**
P routers do not interpret this value

**MPLS label!**
Replication in Core

- Core (P) routers signal mLDP

Control plane  mLDP  Data plane  MPLS

Modified LDP
1 additional FEC for LDP Label Mapping Message

- Replicate MPLS Multicast packets

Replication list programmed in data plane

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```
RP/0/0/CPU0:PS2# show mpls forwarding p2mp
Local Label  Outgoing Label  Prefix or ID  Outgoing Interface  Next Hop
--------  ---------------  ------------  ---------------------  -------
24006     24004           mLDP/IR: 0x00001  Gi0/0/0/0               10.1.4.1
24009     24009           mLDP/IR: 0x00001  Gi0/0/0/2               10.3.4.3
```
mLDP Protection in Underlay

• Backup path is precomputed

• Two possibilities
  • LFA and Ti-LFA (aka FRR)
    • Loop Free Alternate
    • Per-prefix FRR
    • No signalling involved
    • Link protection only (no node protection)
mLDP -> LFIB

mLDP Signaling
- mLDP signalling hop-per-hop
- Label binding, FEC 0x100
- Egress PE towards ingress PE (root)

mLDP DB
- 1 mLDP DB entry per tree

LFIB
- 1 LFIB entry per tree

mLDP database
LSM-ID: 0x00001  Type: P2MP
FEC Root : 10.0.0.2
Opaque decoded : [global-id 1]
Upstream neighbor(s): 
Is CSI accepting : N 10.0.0.2:0 [Active] Uptime: 00:28:37
Local Label (D) : 24006
Downstream client(s):
LDP 10.0.0.1:0
Next Hop : 10.1.4.1
Interface : GigabitEthernet0/0/0/0
Remote label (D) : 24004
LDP 10.0.0.3:0  Uptime: 00:20:31
Next Hop : 10.3.4.3
Interface : GigabitEthernet0/0/0/2
Remote label (D) : 24009

Packet replication
mVPN Basics
Core Tree Types

- **Default MDT**
  - Connects all PEs
  - Bidirectional
  - Always present

- **Data MDT**
  - Connects subset of PEs
  - Unidirectional
  - On-demand

- **Partitioned MDT**
  - Connects subset of PEs
  - Uni- or Bidirectional
  - On-demand

---

**Multi-Directional Inclusive PMSI (MI-PMSI)**

**Selective PMSI (S-PMSI)**

**Multidirectional Selective PMSI (MS-PMSI)**

**MDT** = Multicast Distribution Tree

**PMSI** = Provider Multicast Service Interface
Planes – Overlay Signaling

VPN plane

core tree

core plane
Encapsulation
Why so many mVPN profiles?
ENCAPSULATION OPTIONS IN CORE
- IP/GRE
- MPLS

OPTIONS TO DISCOVER PEs
- PIM
- BGP

CORE/PROVIDER-TREE
- PIM-ASM/SSM/BIDIR
- mLDP, P2MP-TE, INGRESS-REPLICATION

C-MCAST ROUTING OPTIONS (PE-PE)
- PIM
- mLDP, BGP

PE-CE MCAST ROUTING
- PIM-ASM/SSM/BIDIR
- mLDp, BGP

BINDING BTW FLOW & P-TREE
- PIM
- BGP
Global mLDP inBand Signaling

mVPN profile 7
### Global mLDP inBand Signaling base config

#### PE1 - PE2

```
RP/0/0/CPU0:PE1#show running-config multicast-routing
Fri Jun 2 10:25:19.829 PDT
multicast-routing
address-family ipv4
mtd source Loopback0
rate-per-route
interface all enable
mtd mldp in-band-signaling ipv4
```

```
RP/0/0/CPU0:PE2#show running-config multicast-routing
Fri Jun 2 10:14:25.675 PDT
multicast-routing
address-family ipv4
mtd source Loopback0
rate-per-route
interface all enable
mtd mldp in-band-signaling ipv4
```

#### PE1 - P - PE2

```
RP/0/0/CPU0:PE1#show mpls ldp neighbor brief
Fri Jun 2 11:34:34.518 PDT

<table>
<thead>
<tr>
<th>Peer</th>
<th>GR</th>
<th>NSR</th>
<th>Up Time</th>
<th>Discovery</th>
<th>Addresses</th>
<th>Labels</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.168.0.1:0</td>
<td>N</td>
<td>N</td>
<td>01:44:30</td>
<td></td>
<td>1 0 4 0 6 0</td>
<td></td>
</tr>
</tbody>
</table>
```

```
RP/0/0/CPU0:PE2#show mpls ldp neighbor brief
Fri Jun 2 11:34:51.670 PDT

<table>
<thead>
<tr>
<th>Peer</th>
<th>GR</th>
<th>NSR</th>
<th>Up Time</th>
<th>Discovery</th>
<th>Addresses</th>
<th>Labels</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.168.0.2:0</td>
<td>N</td>
<td>N</td>
<td>01:44:43</td>
<td></td>
<td>1 0 3 0 6 0</td>
<td></td>
</tr>
<tr>
<td>192.168.0.3:0</td>
<td>N</td>
<td>N</td>
<td>01:44:41</td>
<td></td>
<td>1 0 3 0 6 0</td>
<td></td>
</tr>
</tbody>
</table>
```

#### P - BE-1

```
RP/0/0/CPU0:PE1#show running-config multicast-routing
Fri Jun 2 10:25:19.829 PDT
multicast-routing
address-family ipv4
mtd source Loopback0
rate-per-route
interface all enable
mtd mldp in-band-signaling ipv4
```

```
RP/0/0/CPU0:PE2#show running-config multicast-routing
Fri Jun 2 10:14:25.675 PDT
multicast-routing
address-family ipv4
mtd source Loopback0
rate-per-route
interface all enable
mtd mldp in-band-signaling ipv4
```

#### BE-1 - BE-2

```
RP/0/0/CPU0:PE1#show mpls ldp neighbor brief
Fri Jun 2 11:34:34.518 PDT

<table>
<thead>
<tr>
<th>Peer</th>
<th>GR</th>
<th>NSR</th>
<th>Up Time</th>
<th>Discovery</th>
<th>Addresses</th>
<th>Labels</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.168.0.1:0</td>
<td>N</td>
<td>N</td>
<td>01:44:30</td>
<td></td>
<td>1 0 4 0 6 0</td>
<td></td>
</tr>
</tbody>
</table>
```

```
RP/0/0/CPU0:PE2#show mpls ldp neighbor brief
Fri Jun 2 11:34:51.670 PDT

<table>
<thead>
<tr>
<th>Peer</th>
<th>GR</th>
<th>NSR</th>
<th>Up Time</th>
<th>Discovery</th>
<th>Addresses</th>
<th>Labels</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.168.0.2:0</td>
<td>N</td>
<td>N</td>
<td>01:44:43</td>
<td></td>
<td>1 0 3 0 6 0</td>
<td></td>
</tr>
<tr>
<td>192.168.0.3:0</td>
<td>N</td>
<td>N</td>
<td>01:44:41</td>
<td></td>
<td>1 0 3 0 6 0</td>
<td></td>
</tr>
</tbody>
</table>
```

### Diagram

```
RP/0/0/CPU0:PE1#show running-config multicast-routing
Fri Jun 2 10:25:19.829 PDT
multicast-routing
address-family ipv4
mtd source Loopback0
rate-per-route
interface all enable
mtd mldp in-band-signaling ipv4
```

```
RP/0/0/CPU0:PE2#show running-config multicast-routing
Fri Jun 2 10:14:25.675 PDT
multicast-routing
address-family ipv4
mtd source Loopback0
rate-per-route
interface all enable
mtd mldp in-band-signaling ipv4
```
Validate if LDP is running for mLDP
mLDP neighborship

RP/0/0/CPU0-PE1#show mpls mldp neighbors
Sat Jun 3 19:01:50.522 PDT
mLDP neighbor database
MLDP peer ID : 192.168.0.1:0, uptime 00:08:28 Up,
Capabilities : Typed Wildcard FEC, P2MP, MP2MP
Target Adj   : No
Upstream count: 0
Branch count : 1
Label map timer : never
Policy filter in :
Path count : 1
Path(s)   : 1.0.0.1 Bundle-Ether1 LDP
Adj list : 1.0.0.1 Bundle-Ether1
Peer addr list : 10.10.10.1
 : 192.168.0.1
 : 1.0.0.1
 : 2.0.0.1

MLDP peer ID : 192.168.0.2:0, uptime 00:08:56 Up,
Capabilities : Typed Wildcard FEC, P2MP, MP2MP
Target Adj   : No
Upstream count: 0
Branch count : 0
Label map timer : never
Policy filter in :
Path count : 1
Path(s)   : 1.0.0.2 Bundle-Ether1 LDP
Adj list : 1.0.0.2 Bundle-Ether1
Peer addr list : 11.11.11.12
 : 192.168.0.2
 : 1.0.0.2

MLDP peer ID : 192.168.0.3:0, uptime 00:09:00 Up,
Capabilities : Typed Wildcard FEC, P2MP, MP2MP
Target Adj   : No
Upstream count: 0
Branch count : 1
Label map timer : never
Policy filter in :
Path count : 1
Path(s)   : 2.0.0.1 Bundle-Ether2 LDP
Adj list : 2.0.0.1 Bundle-Ether2
Peer addr list : 10.10.10.1
 : 192.168.0.1
 : 1.0.0.1
 : 2.0.0.1

RP/0/0/CPU0-PE2#show mpls mldp neighbors
Sat Jun 3 19:02:18.165 PDT
mLDP neighbor database
MLDP peer ID : 192.168.0.2:0, uptime 00:08:56 Up,
Capabilities : Typed Wildcard FEC, P2MP, MP2MP
Target Adj   : No
Upstream count: 0
Branch count : 1
Label map timer : never
Policy filter in :
Path count : 1
Path(s)   : 1.0.0.2 Bundle-Ether1 LDP
Adj list : 1.0.0.2 Bundle-Ether1
Peer addr list : 11.11.11.12
 : 192.168.0.2
 : 1.0.0.2

MLDP peer ID : 192.168.0.3:0, uptime 00:09:00 Up,
Capabilities : Typed Wildcard FEC, P2MP, MP2MP
Target Adj   : No
Upstream count: 0
Branch count : 1
Label map timer : never
Policy filter in :
Path count : 1
Path(s)   : 2.0.0.1 Bundle-Ether2 LDP
Adj list : 2.0.0.1 Bundle-Ether2
Peer addr list : 12.12.12.3
 : 192.168.0.3
 : 2.0.0.3

RP/0/0/CPU0-PE2#
Originate IGMP join from receiver

```
RP/0/0/CPU0:PE2#show running-config router igmp
Sat Jun 3 19:14:53.958 PDT
router igmp
interface GigabitEthernet0/0/0/3
  static-group 232.1.1.1 11.11.11.2
!
!
RP/0/0/CPU0:PE2#
```
Processing at last hop router before creating P2MP mapping

RP/0/0/CPU0/PE2#show ip route 11.11.11.2
Sat Jun 3 19:17:51.213 PDT
Routing entry for 11.11.11.0/24
Known via "bgp 100", distance 200, metric 0, type internal
Installed Jun 2 09:50:18.217 for 1d09h
Routing Descriptor Blocks
192.168.0.2, from 192.168.0.2
Route metric is 0
No advertising protos.

RP/0/0/CPU0/PE2#show bgp ipv4 unicast 11.11.11.2
Sat Jun 3 19:18:10.819 PDT
BGP routing table entry for 11.11.11.0/24
Versions:
    Process bRIB/RIB SendTblVer
    Speaker 7 7
Last Modified: Jun 2 09:50:18.000 for 1d09h
Paths: (1 available, best #1)
    Not advertised to any peer
    Path #1: Received by speaker 0
    Not advertised to any peer
    Local
    192.168.0.2 (metric 3) from 192.168.0.2 (192.168.0.2)
    Origin incomplete, metric 0, localpref 100, valid, internal, best, group-best
    Received Path ID 0, Local Path ID 1, version 7
RP/0/0/CPU0/PE2#show ip route 192.168.0.2
Sat Jun 3 19:18:53.230 PDT
Routing entry for 192.168.0.0/24
Known via "ospf 100", distance 110, metric 3, type intra area
Installed Jun 2 09:50:07.884 for 1d09h
Routing Descriptor Blocks
    2.0.0.1, from Bundle-Ether2
    Route metric is 3
    No advertising protos.
    RP/0/0/CPU0/PE2#show ip brief | in 2.0.0.1
    RP/0/0/CPU0/PE2#
Verifying mLDP state end to end

```plaintext
RP/0/0/CPU0:PE1#show mpls mldp database p2mp
Sat Jun 3 19:06:14.735 PDT
mLDP database
LSM-ID: 0x00002 Type: P2MP Uptime: 00:12:57
FEC Root : 192.168.0.2 (we are the root)
Opaque decoded : [ipv4 11.11.11.2 232.1.1.1]
Upstream neighbor(s): None
Downstream client(s):
  LDP 192.168.0.1:0 Uptime: 00:12:35
  Next Hop : 1.0.0.1
  Interface : Bundle-Ether1
  Remote label (D) : 24002
  Local Uptime: 00:12:35
  Local Label : 24003 (internal)
RP/0/0/CPU0:PE1#
```

```plaintext
RP/0/0/CPU0:PE2#show mpls mldp database p2mp
Sat Jun 3 19:06:40.961 PDT
mLDP database
LSM-ID: 0x00002 Type: P2MP Uptime: 1d06h
FEC Root : 192.168.0.2
Opaque decoded : [ipv4 11.11.11.2 232.1.1.1]
Upstream neighbor(s): None
Downstream client(s):
  PIM MDT Egress intf: Imddefault Table ID : IPv4: 0xe00000000
  RPF ID : 3
RP/0/0/CPU0:PE2#
```
Multicast state

RP/0/0/CPU0:PE1#show mrib route 11.11.11.2 232.1.1.1 detail
Sun Jun 4 09:04:59.433 PDT

IP Multicast Routing Information Base
Entry flags: L - Domain-Local Source, E - External Source to the Domain, C - Directly-Connected Check, S - Signal, IA - Inherit Accept, IF - Inherit From, D - Drop, ME - MDT Encap, EID - Encap ID, MD - MDT Decap, MT - MDT Threshold Crossed, MH - MDT interface handle, CD - Conditional Decap, MPLS - MPLS Decap, EX - Extranet, MoFE - MoFRR Enabled, MoFS - MoFRR State, MoFP - MoFRR Primary
MoFB - MoFRR Backup, RPFD - RPFD ID Set, X - VXLAN
(11.11.11.2,232.1.1.1) Ver: 0xe5a RPF nbr: 2.0.0.1 Flags: RPF RPFID, FMA: 0x10000 Up: 1d07h RPF ID: 3, Encap ID: 0x00000000
Incoming Interface List
GigabitEthernet0/0/0/3 Flags: A, Up: 14:11:37
Outgoing Interface List
Imdtdefault Flags: F LMI, Up: 14:11:37, Head LSM-ID: 0x00002

RP/0/0/CPU0:PE2#show mrib route 11.11.11.2 232.1.1.1 detail
Sat Jun 3 19:34:23.108 PDT

IP Multicast Routing Information Base
Entry flags: L - Domain-Local Source, E - External Source to the Domain, C - Directly-Connected Check, S - Signal, IA - Inherit Accept, IF - Inherit From, D - Drop, ME - MDT Encap, EID - Encap ID, MD - MDT Decap, MT - MDT Threshold Crossed, MH - MDT interface handle, CD - Conditional Decap, MPLS - MPLS Decap, EX - Extranet, MoFE - MoFRR Enabled, MoFS - MoFRR State, MoFP - MoFRR Primary
MoFB - MoFRR Backup, RPFD - RPFD ID Set, X - VXLAN
(11.11.11.2,232.1.1.1) Ver: 0xe19ac RPF nbr: 11.11.11.2 Flags: RPF EID, FMA: 0x10000 Up: 14:11:37
Incoming Interface List
GigabitEthernet0/0/0/3 Flags: A, Up: 14:11:37
Outgoing Interface List
Imdtdefault Flags: A LMI, Up: 1d07h
mLDP profile 14
A New-Found Role for BGP

**Auto-Discovery**

- Discovering PE endpoints automatically
  - Replacing some PIM signalling, signalling Data MDT

**Customer Multicast Signalling**

- Control plane replacing PIM
  - Shared tree (*,G)
  - Source tree (S,G)
  - Replacing PIM Joins, Prunes, Hellos

- New BGP address family: IPv4 mVPN
- PMSI Tunnel Attribute (PTA) information
  - Describes the core tree (PIM, mLDP, MPLS TE, IR)
- Prefix (NLRI)
  - Describes multicast state
  - Source, Group, Originator, Route Distinguisher

*PMSI = Provider Multicast Service Instance*
BGP in Overlay

- PE-CE is PIM signaling
- PE-PE is BGP signaling
- BGP scales well
- BGP is not a multicast signaling protocol per design
  - Receiver to Source signaling ...
  - PIM Sparse Mode works differently in BGP → new procedures
- New address family “IPv4 mVPN”
  1. Signal Auto-Discovery (AD)
  2. Signal multicast information
     - (*,G) or (S,G)
     - Which tunnel to use (core tree protocol and tunnel type: mLDP and Partitioned MDT)
Partitioned MDT

- Unidirectional
- Connects subset of PEs
- BGP AD is needed
- BGP Overlay signaling for (*,G) and (S,G)
- MDT built on-demand when customer traffic is present
  - Optimized for sources mostly co-located in few sites
Initial underlay config to enable mLDP profile 14

RP/0/0/CPU0:PE1#show running-config multicast-routing vrf p14_v4_1400
multicast-routing
vrf p14_v4_1400
address-family ipv4
interface all enable
bgp auto-discovery mldp
mdt partitioned mldp ipv4 p2mp
mdt data 10
RP/0/0/CPU0:PE1#

RP/0/0/CPU0:P#show running-config router pim
Sun Jun 4 09:39:20.991 PDT
mpls ldp
capabilities sac mldp-only
mldp
router-id 192.168.0.2
interface Bundle-Ether1

RP/0/0/CPU0:PE1#show running-config router pim
vrf p14_v4_1400
router pim
vrf p14_v4_1400
address-family ipv4
rpf topology route-policy rpf-for-p14_v4_1400
mdt c-multicast-routing bgp
BGP overlay config

RP/0/0/CPU0:PE1#show running-config router bgp
router bgp 100
mvpn
bgp router-id 192.168.0.2
disable family ipv4 unicast
disable family vpnv4 unicast
disable family ipv4 mvpn
neighbor 192.168.0.3
disable remote-as 100
update-source Loopback0
disable address-family ipv4 unicast
disable address-family vpnv4 unicast
disable address-family ipv4 mvpn
vrf p14_v4_1400
disable id 1400:1
disable address-family ipv4 unicast
disable address-family ipv4 mvpn
RP/0/0/CPU0:PE1#show running-config router bgp
Sun Jun 4 09:50:56.634 PDT
% No such configuration item(s)

RP/0/0/CPU0:P#show running-config router bgp
router bgp 100
mvpn
bgp router-id 192.168.0.3
disable family ipv4 unicast
disable family vpnv4 unicast
disable family ipv4 mvpn
neighbor 192.168.0.2
disable remote-as 100
update-source Loopback0
disable address-family ipv4 unicast
disable address-family vpnv4 unicast
disable address-family ipv4 mvpn
vrf p14_v4_1400
disable id 1400:1
disable address-family ipv4 unicast
disable address-family ipv4 mvpn

RP/0/0/CPU0:PE2#show running-config router bgp
router bgp 100
mvpn
bgp router-id 192.168.0.3
disable family ipv4 unicast
disable family vpnv4 unicast
disable family ipv4 mvpn
neighbor 192.168.0.2
disable remote-as 100
update-source Loopback0
disable address-family ipv4 unicast
disable address-family vpnv4 unicast
disable address-family ipv4 mvpn
vrf p14_v4_1400
disable id 1400:1
disable address-family ipv4 unicast
disable address-family ipv4 mvpn

RP/0/0/CPU0:P#
Verify BGP AF IPv4 mVPN

```
RP/0/0/CPU0:PE1#show bgp ipv4 mvpn summary
.....
Process RcvTblVer bRIB/RIB LabelVer ImportVer SendTblVer
StandbyVer Speaker 12 12 12 12 12 0
Neighbor Spk AS MsgRcvd MsgSent TblVer InQ OutQ Up/Down
St/PfxRcd 192.168.0.3 0 100 40 37 12 0 00:25:41 2
RP/0/0/CPU0:PE1#
```

```
RP/0/0/CPU0:PE2#show bgp ipv4 mvpn summary
.....
Process RcvTblVer bRIB/RIB LabelVer ImportVer SendTblVer
StandbyVer Speaker 11 11 11 11 11 0
Neighbor Spk AS MsgRcvd MsgSent TblVer InQ OutQ Up/Down
St/PfxRcd 192.168.0.2 0 100 37 40 11 0 00:25:59 2
RP/0/0/CPU0:PE2#
```
Verify BGP AD for mVPN

RP/0/0/CPU0:PE1#show bgp ipv4 mvpn vrf p14_v4_1400 route-type 1

Network       Next Hop       Metric   LocPrf   Weight Path
Route Distinguisher: 1400:1 (default for vrf p14_v4_1400)
Route Distinguisher Version: 11
*> [1][192.168.0.2]/40
  0.0.0.0       0 i
*> [1][192.168.0.3]/40
  192.168.0.3   100   0 i

Processed 2 prefixes, 2 paths
RP/0/0/CPU0:PE1#

RP/0/0/CPU0:PE2#show bgp ipv4 mvpn vrf p14_v4_1400 route-type 1

Network       Next Hop       Metric   LocPrf   Weight Path
Route Distinguisher: 1400:1 (default for vrf p14_v4_1400)
Route Distinguisher Version: 11
*> [1][192.168.0.2]/40
  0.0.0.0       0 i
*> [1][192.168.0.3]/40
  192.168.0.3   100   0 i

Processed 2 prefixes, 2 paths
RP/0/0/CPU0:PE2#
Verify BGP AD for (*,*)

[0][0.0.0.0][0][0.0.0.0] means (*,*) in multicast speak. So, any source, and any group.

This means that each PE is willing to do Partitioned MDT for any source, any group.
Decoding (*,*) route

RP/0/0/CPU0:PE2#show bgp ipv4 mvpn vrf p14_v4_1400 [3][0][0.0.0.0][0][0.0.0.0][192.168.0.2]/120 det
Sun Jun 4 10:48:10.813 PDT
BGP routing table entry for [3][0][0.0.0.0][0][0.0.0.0][192.168.0.2]/120, Route Distinguisher: 1400:1

Versions:
- Process: bRIB/RIB, SendTblVer: 9
- Speaker: 9
- Flags: 0x00041001 + 0x00000000;
- Last Modified: Jun 4 09:29:09.000 for 01:19:02
- Paths: (1 available, best #1, not advertised to EBGP peer)
  - Not advertised to any peer
  - Path #1: Received by speaker 0
    - Flags: 0x2000000085060005 + 0x00, import: 0x39f
    - Not advertised to any peer
    - Local: 192.168.0.2 (metric 3) from 192.168.0.2 (192.168.0.2), if-handle 0x00000000
      - Origin: IGP, localpref 100, valid, internal, best, group-best, import-candidate, imported
      - Received Path ID 0, Local Path ID 1, version 9
      - Community: no-export
      - Extended community: RT:1400:1
      - PMSI: flags 0x0, type 2, label 0, ID 0x0600010420a80002000701000400000001
      - PPMP: label 24000
      - Source AFI: IPv4 MVPN, Source VRF: p14_v4_1400, Source Route Distinguisher: 1400:1

RP/0/0/CPU0:PE2#
Initial MPLS mLDP database

RP/0/0/CPU0:PE1#show mpls mldp database
Sun Jun 4 10:14:33.838 PDT
mpls database
LSM-ID: 0x00001  Type: P2MP  Uptime: 00:46:14
FEC Root : 192.168.0.2 (we are the root)
Opaque decoded : [global-id 1]
Upstream neighbor(s) :
None
Downstream client(s):
PIM MDT Uptime: 00:46:14
Egress intf : Lmdtp14/v4/1400
Table ID : IPv4: 0xe0000011 IPv6: 0xe0800011
HLI : 0x000001
Ingress : Yes
PPMP : Yes
Local Label : 24000 (internal)
RP/0/0/CPU0:PE1#

RP/0/0/CPU0:PE2#show mpls mldp database
Sun Jun 4 10:14:10.959 PDT
mpls database
LSM-ID: 0x00001  Type: P2MP  Uptime: 00:45:51
FEC Root : 192.168.0.3 (we are the root)
Opaque decoded : [global-id 1]
Upstream neighbor(s) :
None
Downstream client(s):
PIM MDT Uptime: 00:45:51
Egress intf : Lmdtp14/v4/1400
Table ID : IPv4: 0xe0000011 IPv6: 0xe0800011
HLI : 0x000001
Ingress : Yes
PPMP : Yes
Local Label : 24000 (internal)
RP/0/0/CPU0:PE2#

RP/0/0/CPU0:P#show mpls mldp database
Sun Jun 4 10:15:28.376 PDT
No entries in the table to display
RP/0/0/CPU0:P#
Multicast membership & Tree building
mLDP underlay join with first join

Verifies, if we have unicast route

Verifies, if we (*,*) route

Join underlay mLDP to root from (*,*)

Verifies, if we have unicast route

RP/0/0/CPU0:PE2# show running-config router igmp
Sun Jun 4 10:27:29.974 PDT
router igmp
vrf p14_v4_1400
interface GigabitEthernet0/0/0/3.1400
static-group 232.1.1.1 11.5.120.20

RP/0/0/CPU0:PE2# show ip route vrf p14_v4_1400 11.5.120.20
Sun Jun 4 10:29:43.940 PDT
Routing entry for 11.5.120.0/24
Known via "bgp 100", distance 200, metric 0, type internal
Installed Jun 4 09:29:09.244 for 01:00:34
Routing Descriptor Blocks
192.168.0.2, from 192.168.0.2
Nexthop in Vrf: "default", Table: "default", IPv4 Unicast, Table Id: 0xe0000000
Route metric is 0
No advertising protos.

RP/0/0/CPU0:PE2# show bgp ipv4 mvpn vrf p14_v4_1400 route-type 3
Network Next Hop Metric LocPrf Weight Path
*>[3][0][0.0.0.0][0][0.0.0.0][192.168.0.2]/120
   192.168.0.2 100 0 i
*>[3][0][0.0.0.0][0][0.0.0.0][192.168.0.3]/120
   0.0.0.0 0 i

Processed 2 prefixes, 2 paths
RP/0/0/CPU0:PE2#
Verify mLDP underlay join

```plaintext
RP/0/0/CPU0:PE1#show mpls mldp database
Sun Jun  4 11:09:53.804 PDT
mpls database
LSM-ID: 0x00001   Type: P2MP   Uptime: 01:41:34
FEC Root : 192.168.0.2 (we are the root)
Opaque decoded : [global-id 1]
Upstream neighbor(s):
None
Downstream client(s):
  LDP 192.168.0.1:0   Uptime: 00:42:51
    Next Hop : 1.0.0.1
    Interface : Bundle-Ether1
    Remote label (D) : 24000
    PIM MDT   Uptime: 01:41:34
    Egress intf : Lmdtp14/v4/1400
    Table ID : IPv4: 0xe0000011 IPv6: 0xe0800011
    HLI    : 0x000001
    Ingress : Yes
    PPMP   : Yes
    Local Label : 24000 (internal)
```

```plaintext
RP/0/0/CPU0:PE2#show mpls mldp database
Sun Jun  4 11:09:06.572 PDT
mpls database
LSM-ID: 0x00003   Type: P2MP   Uptime: 00:42:04
FEC Root : 192.168.0.2
Opaque decoded : [global-id 1]
Upstream neighbor(s):
Is CSI accepting : N
  192.168.0.2:0 [Active] Uptime: 00:42:04
    Local Label (D) : 24000
    Next Hop         : 2.0.0.3
    Interface        : Bundle-Ether2
    Remote label (D) : 24000
    PIM MDT          : Yes
    PPMP             : Yes
    HLI              : 0x0000001
    Ingress          : Yes
    RD               : 1400:1
```

```
RP/0/0/CPU0:P#show mpls mldp database
Sun Jun  4 11:09:06.572 PDT
mpls database
LSM-ID: 0x00002   Type: P2MP   Uptime: 00:42:04
FEC Root : 192.168.0.2
Opaque decoded : [global-id 1]
Upstream neighbor(s):
Is CSI accepting : N
  192.168.0.2:0 [Active] Uptime: 00:42:04
    Local Label (D) : 24000
    Next Hop         : 2.0.0.3
    Interface        : Bundle-Ether2
    Remote label (D) : 24000
    PIM MDT          : Yes
    PPMP             : Yes
    HLI              : 0x000001
    Ingress          : Yes
    RD               : 1400:1
```

```
RP/0/0/CPU0:PE1#show mpls mldp database
Sun Jun  4 11:09:53.804 PDT
mpls database
LSM-ID: 0x00001   Type: P2MP   Uptime: 01:41:34
FEC Root : 192.168.0.2 (we are the root)
Opaque decoded : [global-id 1]
Upstream neighbor(s):
None
Downstream client(s):
  LDP 192.168.0.2:0 [Active] Uptime: 00:42:51
    Next Hop : 2.0.0.3
    Interface : Bundle-Ether2
    Remote label (D) : 24000
    PIM MDT          : Yes
    PPMP             : Yes
    HLI              : 0x000001
    Ingress          : Yes
    RD               : 1400:1
```

```
RP/0/0/CPU0:PE2#show mpls mldp database
Sun Jun  4 11:09:06.572 PDT
mpls database
LSM-ID: 0x00003   Type: P2MP   Uptime: 00:42:04
FEC Root : 192.168.0.2
Opaque decoded : [global-id 1]
Upstream neighbor(s):
Is CSI accepting : N
  192.168.0.2:0 [Active] Uptime: 00:42:04
    Local Label (D) : 24000
    Next Hop         : 2.0.0.3
    Interface        : Bundle-Ether2
    Remote label (D) : 24000
    PIM MDT          : Yes
    PPMP             : Yes
    HLI              : 0x0000001
    Ingress          : Yes
    RD               : 1400:1
```

```
RP/0/0/CPU0:P#show mpls mldp database
Sun Jun  4 11:09:06.572 PDT
mpls database
LSM-ID: 0x00002   Type: P2MP   Uptime: 00:42:04
FEC Root : 192.168.0.2
Opaque decoded : [global-id 1]
Upstream neighbor(s):
Is CSI accepting : N
  192.168.0.2:0 [Active] Uptime: 00:42:04
    Local Label (D) : 24000
    Next Hop         : 2.0.0.3
    Interface        : Bundle-Ether2
    Remote label (D) : 24000
    PIM MDT          : Yes
    PPMP             : Yes
    HLI              : 0x00001
    Ingress          : Yes
    RD               : 1400:1
```
```
Multicast processing at Last hop router

RP/0/0/CPU0:PE2#show mrib vrf p14_v4_1400 route 11.5.120.20 232.1.1.1
******
(11.5.120.20,232.1.1.1) RPF nbr: 192.168.0.2 Flags: RPF
Up: 00:51:42
Incoming Interface List
  Lmdtp14/v4/1400 Flags: A LMI, Up: 00:51:42
Outgoing Interface List
  GigabitEthernet0/0/0/3.1400 Flags: F NS LI, Up: 00:51:42
RP/0/0/CPU0:PE2#

RP/0/0/CPU0:PE2#show pim vrf p14_v4_1400 topo 11.5.120.20 232.1.1.1
******
(11.5.120.20,232.1.1.1)SPT SSM Up: 00:52:44
JP: Join(BGP) RPF: Lmdtp14/v4/1400 Flags: 00:52:44
fwd LI LH
RP/0/0/CPU0:PE2#

RP/0/0/CPU0:PE2#show pim vrf p14_v4_1400 rpf
Sun Jun  4 11:21:25.870 PDT
Table: IPv4-Unicast-default
  * 11.5.120.20/32 [200/0]
    via Lmdtp14/v4/1400 with rpf neighbor 192.168.0.2
    Connector: 1400:1:192.168.0.2, Nexthop: 192.168.0.2
RP/0/0/CPU0:PE2#
Multicast Overlay join

RP/0/0/CPU0:PE1#show bgp ipv4 mvpn vrf p14_v4_1400 route-type 7
Sun Jun 4 11:15:25.507 PDT
BGP router identifier 192.168.0.2, local AS number 100
BGP generic scan interval 15 secs
Non-stop routing is enabled
BGP table state: Active
Table ID: 0x0
BGP table nexthop route policy:
BGP main routing table version 17
BGP NSR Initial initsync version 2 ( Reached)
BGP NSR/ISSU Sync-Group versions 0/0
BGP scan interval 60 secs

Status codes: s suppressed, d damped, h history, * valid, > best
i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete

Network            Next Hop            Metric            LocPrf        Weight        Path
Route Distinguisher: 1400:1 (default for vrf p14_v4_1400)
Route Distinguisher Version: 17
*>[7][1400:1][100][32][11.5.120.20][32][232.1.1.1][184 192.168.0.3 100 0 i]

Processed 1 prefixes, 1 paths
RP/0/0/CPU0:PE1#

RP/0/0/CPU0:PE2#show bgp ipv4 mvpn vrf p14_v4_1400 route-type 7
Sun Jun 4 11:13:11.513 PDT
BGP router identifier 192.168.0.3, local AS number 100
BGP generic scan interval 15 secs
Non-stop routing is enabled
BGP table state: Active
Table ID: 0x0
BGP table nexthop route policy:
BGP main routing table version 14
BGP NSR Initial initsync version 2 ( Reached)
BGP NSR/ISSU Sync-Group versions 0/0
BGP scan interval 60 secs

Status codes: s suppressed, d damped, h history, * valid, > best
i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete

Network            Next Hop            Metric            LocPrf        Weight        Path
Route Distinguisher: 1400:1 (default for vrf p14_v4_1400)
Route Distinguisher Version: 14
*> [7][1400:1][100][32][11.5.120.20][32][232.1.1.1][184 0.0.0.0 0 i]

Processed 1 prefixes, 1 paths
RP/0/0/CPU0:PE2#
**Multicast First hop router processing**

```
RP/0/0/CPU0:PE1#show pim vrf p14_v4_1400 topo 11.5.120.20 232.1.1.1
Sun Jun  4 11:24:17.305 PDT
......
(11.5.120.20,232.1.1.1)SPT SSM Up: 00:57:43
JP: Join(00:00:05) RPF: GigabitEthernet0/0/0/3.1400,11.5.120.20* Flags:
Lmdtp14/v4/1400             00:57:15  fwd BGP
RP/0/0/CPU0:PE1#
```

```
RP/0/0/CPU0:PE1#show mrib vrf p14_v4_1400 route 11.5.120.20 232.1.1.1

(11.5.120.20,232.1.1.1) RPF nbr: 11.5.120.20 Flags: RPF
Up: 01:10:20
Incoming Interface List
  GigabitEthernet0/0/0/3.1400 Flags: A, Up: 01:10:20
Outgoing Interface List
  Lmdtp14/v4/1400 Flags: F LMI TR, Up: 01:09:51
RP/0/0/CPU0:PE1#
```
End to End MPLS P2MP forwarding

RP/0/0/CPU0:PE1#show mpls forwarding p2mp
Sun Jun  4 11:42:42.627 PDT
Local  Outgoing    Prefix             Outgoing     Next Hop        Bytes
Label  Label       or ID              Interface                    Switched
------  ----------- ------------------ -------------- ---------------
24000  24000       mLDP/IR: 0x00001   BE1          1.0.0.1         0

RP/0/0/CPU0:P#show mpls forwarding p2mp
Sun Jun  4 11:45:28.614 PDT
Local  Outgoing    Prefix             Outgoing     Next Hop        Bytes
Label  Label       or ID              Interface                    Switched
------  ----------- ------------------ -------------- ---------------
24000  24001       mLDP/IR: 0x00002   BE2          2.0.0.3         0

RP/0/0/CPU0:PE2#show mpls forwarding p2mp
Local  Outgoing    Prefix             Outgoing     Next Hop        Bytes
Label  Label       or ID              Interface                    Switched
------  ----------- ------------------ -------------- ---------------
24000 Unlabelled  mLDP/IR: 0x000001
24001 Unlabelled  mLDP/IR: 0x000003
New join in same VRF and its impact

```
RP/0/0/CPU0:PE2#show running-config router igmp
router igmp
vrf p14_v4_1400
interface GigabitEthernet0/0/0/3.1400
  static-group 232.1.1.1 11.5.120.20
  static-group 233.1.1.1 11.5.120.21
```

```
RP/0/0/CPU0:PE2#show mpls mldp database
Sun Jun  4 12:04:29.156 PDT
mLDP database
LSM-ID: 0x00003 Type: P2MP Uptime: 01:37:27
  FEC Root : 192.168.0.2
  Opaque decoded : [global-id 1]
  Upstream neighbor(s): Is CSI accepting : N
    192.168.0.1:0 [Active] Uptime: 01:37:27
    Local Label (D) : 24001
Downstream client(s):
  PIM MDT Uptime: 01:37:27
    Egress intf : Lmdtp14/v4/1400
    Table ID : IPv4: 0xe0000011 IPv6: 0xe0800011
    RPF ID : 3
    RD : 1400:1

RP/0/0/CPU0:PE2#show mrib vrf p14_v4_1400 route
(11.5.120.20,232.1.1.1) RPF nbr: 192.168.0.2 Flags: RPF
  Up: 01:38:35
  Incoming Interface List
    Lmdtp14/v4/1400 Flags: A LMI, Up: 01:38:35
  Outgoing Interface List
    GigabitEthernet0/0/0/3.1400 Flags: F NS LI, Up: 01:38:35

(11.5.120.21,233.1.1.1) RPF nbr: 192.168.0.2 Flags: RPF
  Up: 00:02:43
  Incoming Interface List
    Lmdtp14/v4/1400 Flags: A LMI, Up: 00:02:43
  Outgoing Interface List
    GigabitEthernet0/0/0/3.1400 Flags: F NS LI, Up: 00:02:43
```
Data MDT (S-PMSI) Processing

• With current approach, every flow rooted at Ingress PE is being delivered using same underlay tree

• What would be option if we need to create multiple optimal tree?
Switching to Data MDT

```
RP/0/0/CPU0:PE1(config-mcast-p14_v4_1400-ipv4)# mdt data 10 ?
WORD ACL for Customer VRF groups allowed to do Data MDT
immediate-switch Switch to Data MDT immediately
route-policy DATA MDT Route policy
threshold Traffic rate threshold in Kbps to trigger Data MDT
<cr>
RP/0/0/CPU0:PE1(config-mcast-p14_v4_1400-ipv4)# mdt data 10
```

```
RP/0/0/CPU0:PE1# show running-config multicast-routing
multicast-routing vrf p14_v4_1400
address-family ipv4
interface all enable
bgp auto-discovery mldp
mdt partitioned mldp ipv4 p2mp
mdt data 10 immediate-switch
RP/0/0/CPU0:PE1#
```
Flows mapped to MDT

RP/0/0/CPU0:PE1#show pim vrf p14_v4_1400 mdt cache
Sun Jun  4 12:23:27.842 PDT

Core Source Cust (Source, Group) Core Data Expires Name
192.168.0.2 (11.5.120.20, 232.1.1.1) [global-id 4] 00:02:44
192.168.0.2 (11.5.120.21, 233.1.1.1) [global-id 6] 00:02:44

RP/0/0/CPU0:PE1#show bgp ipv4 mvpn vrf p14_v4_1400 route-type 3

Network Next Hop Metric LocPrf Weight Path
Route Distinguisher: 1400:1 (default for vrf p14_v4_1400)
Route Distinguisher Version: 27

*>[3][0]0.0.0.0[0][0.0.0.0][192.168.0.2]/120
0.0.0.0 192.168.0.2 100 0 i

*>[3][32][11.5.120.20][32][232.1.1.1][192.168.0.2]/120
192.168.0.2 100 0 i
*>[3][32][11.5.120.21][32][233.1.1.1][192.168.0.2]/120
192.168.0.2 100 0 i

Processed 4 prefixes, 4 paths
RP/0/0/CPU0:PE2#
Flows mapped to MDT

RP/0/0/CPU0:P#show mpls mldp database opaque-type global-id 4
Sun Jun 4 12:31:19.065 PDT
mLDP database
LSM-ID: 0x00005 Type: P2MP Uptime: 00:18:08
  FEC Root : 192.168.0.2
  Opaque decoded : [global-id 4]
  Upstream neighbor(s):

RP/0/0/CPU0:P#show mpls mldp database opaque-type global-id 6
Sun Jun 4 12:32:01.903 PDT
mLDP database
LSM-ID: 0x00006 Type: P2MP Uptime: 00:18:51
  FEC Root : 192.168.0.2
  Opaque decoded : [global-id 6]
  Upstream neighbor(s):

RP/0/0/CPU0:PE2#show mpls mldp database opaque-type global-id 4
Sun Jun 4 12:29:42.839 PDT
mLDP database
LSM-ID: 0x00006 Type: P2MP Uptime: 00:16:32
  FEC Root : 192.168.0.2
  Opaque decoded : [global-id 4]
  Upstream neighbor(s):

RP/0/0/CPU0:PE2#show mpls mldp database opaque-type global-id 6
Sun Jun 4 12:30:08.231 PDT
mLDP database
LSM-ID: 0x00007 Type: P2MP Uptime: 00:16:57
  FEC Root : 192.168.0.2
  Opaque decoded : [global-id 6]
  Upstream neighbor(s):

RP/0/0/CPU0:PE2#show mpls mldp database opaque-type global-id 4
Sun Jun 4 12:29:42.839 PDT
mLDP database
LSM-ID: 0x00006 Type: P2MP Uptime: 00:16:32
  FEC Root : 192.168.0.2
  Opaque decoded : [global-id 4]
  Upstream neighbor(s):

RP/0/0/CPU0:PE2#show mpls mldp database opaque-type global-id 6
Sun Jun 4 12:30:08.231 PDT
mLDP database
LSM-ID: 0x00007 Type: P2MP Uptime: 00:16:57
  FEC Root : 192.168.0.2
  Opaque decoded : [global-id 6]
  Upstream neighbor(s):
Try out in Lab

mVPN: Profile 14 - LABMPL-2012

Luc De Ghein, Technical Leader, Cisco Systems, Inc. - Distinguished Speaker
JC Rode, Principal Engineer, Cisco Systems, Inc. - Distinguished Speaker

mVPN is popular and profile 14 is by far the most popular multicast VPN solution today. This profile is based on the core tree protocol mLDP and uses BGP as customer signalling protocol. You will learn how this profile works, and how to configure and troubleshoot mVPN profile 14 in this lab on IOS-XR devices.

Please note Walk-in Labs cannot be pre-scheduled, however you can add them to your favorites as a reminder. Check in at the Walk-in Lab desk for availability.

NOTE: Interested in this session? Add it to your Personal Time and select a day/time that fits your schedule.
Monday: 8:30 a.m. - 6 p.m.
Tuesday: 8:30 a.m. - 6 p.m.
Wednesday: 8:30 a.m. - 5 p.m.
Thursday: 8:30 a.m. - 1 p.m.

Session Type: Walk-in Lab
Technical Level: Intermediate
Technology: Routing, Service Provider
Track: Service Provider
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