Multicast Segment Routing & Traffic Engineering
Multicast and segment routing

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Introduction
Basic Segment routing
mLDP
mLDP with flex algorithm
Tree SID and traffic engineering
Standardization
Introduction

• Segment routing is a technology that uses Source Routing to forward packets through the network.

• A packet is forwarded from Segment to Segment based on information carried in the packet.

• Due to adding more information in the packet, less state needs to be maintained in the network and can potentially be simplified.
SR Technology Overview
Segment routing

- **Source Routing**
  - the source chooses a path and encodes it in the packet header as an ordered list of segments
  - the rest of the network executes the encoded instructions

- **Segment**: an identifier for any type of instruction
  - forwarding or service
Segment routing – forwarding plane

SR-MPLS
- Instantiation of SR on the MPLS data plane
- A segment is encoded with an MPLS label

SRv6
- Instantiation of SR on the IPv6 data plane
- A segment is encoded with an IPv6 address
# A rich set of segment types

<table>
<thead>
<tr>
<th>Segment Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGP Prefix SID</td>
<td>GLOBAL segment representing an IGP prefix</td>
</tr>
<tr>
<td></td>
<td>Forward packet along shortest-path (ECMP-aware) to reach the prefix associated with the segment</td>
</tr>
<tr>
<td>IGP Node SID</td>
<td>An IGP-Prefix segment identifying a specific router (for example its loopback prefix)</td>
</tr>
<tr>
<td>IGP Anycast SID</td>
<td>An IGP-Prefix segment assign to an IGP prefix advertised by multiple routers (anycast prefix)</td>
</tr>
<tr>
<td>IGP Adjacency SID</td>
<td>LOCAL segment representing an IGP adjacency</td>
</tr>
<tr>
<td></td>
<td>Forward packet over the interface where the adjacency is formed</td>
</tr>
<tr>
<td>BGP Prefix SID</td>
<td>GLOBAL segment representing a BGP prefix</td>
</tr>
<tr>
<td></td>
<td>Forward packet along best-path to reach the prefix associated with the segment</td>
</tr>
<tr>
<td>BGP Peering SID</td>
<td>LOCAL segment representing a BGP neighbor</td>
</tr>
<tr>
<td></td>
<td>Forward packet over the interface where the neighbor is formed</td>
</tr>
</tbody>
</table>
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, its Multicast 😊
Simplifying multicast delivery

- SR architecture and its building blocks enhance existing multicast solutions and allow for new ones.
- Depending on the requirements, we can choose the best fit from options such as:

<table>
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<tr>
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<th>Computation</th>
<th>SR-MPLS-Multicast</th>
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<td>Non Traffic engineering (shortest path)</td>
<td>Distributed</td>
<td>mLDP</td>
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<td>Traffic Engineering (Controlled path)</td>
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<td>Centralized</td>
<td>TreeSID + PCE controller</td>
<td>TreeSID + PCE controller</td>
</tr>
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mLDP
mLDP introduction

- mLDP is a protocol that builds
  - P2MP LSPs
  - MP2MP LSPs
- Very often and preferred deployed for Multicast VPNs
- It’s a receiver driven tree building protocol like PIM.
- mLDP uses the LDP Transport to exchange Label Mappings.
mLDP signaling and packet forwarding

P2MP Tree
- Root is ingress PE
- Downstream Traffic
- Upstream Traffic
- Label Map
  - P2MP Root: PE1 Opaque Label

MP2MP Tree
- Root is any P or PE
- Downstream Traffic
- Upstream Traffic
- Label Map
  - MP2MP up Root: PE1 Opaque Label

Ideal for Default MDT
Data plane is still P2MP
Multicast LDP with transport differentiation using SR Flex-Algo
SR IGP Flex Algo

- Complements the SRTE solution by adding new Prefix-Segments with specific optimization objective and constraints
  - minimize igp-metric or delay or te-metric
  - avoid SRLG or affinity

- Leverages the SRTE benefits of simplicity and automation
  - Automated sub-50msec FRR (TILFA)
  - On-Demand Policy (ODN)
  - Automated Steering (AS)
Flex-Algo participation advertisement

• Each node MUST advertise Flex-Algo(s) that it is participating in

Nodes 0 and 9 participate to Algo 0 and 128 and 129
Nodes 1/2/3/4 participate to Algo 0 and 128
Nodes 5/6/7/8 participate to Algo 0 and 129
Flex-Algo aware MLDP – highlights

- MLDP-signaled Multicast Distribution Trees built within the Flex-Algo topology
- Value Proposition:
  - Multicast LDP with transport differentiation using SR Flex-Algo
  - Low latency routing
  - Disjoint paths (multicast Live-Live)
  - Paths avoiding specific links
  - Data sovereignty / region scope
Flex-Algo aware MLDP

- BGP MVPN discovery routes carry a P-MSI tunnel attribute (PTA) which identifies the transport used for mVPN.

- For MLDP transport, MLDP FEC is carried in the PTA. The Flex-Algo instance value is stored in the PTA ID field.

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**IGP Algorithm (IPA) field = carries SR Flex algo instance ID**
Flex-Algo aware mLDP Cisco IOS-XR implementation

- mVPN profile 14 – Partitioned MDT mLDP P2MP with BGP-AD and BGP c-mcast signaling.
- mVPNv4 / mVPNv6 overlay
- Partitioned and Data MDTs
- Granular mapping of (C-S,C-G) to a Partitioned MDT / DATA MDT bound to a Flex-Algo instance
- PIM ASM, SSM, IGMPv2 and IGMPv3 as customer access protocols
- ECMP – A Flex-Algo topology may have ECMP and therefore multicast flows are load balanced if multiple paths are available.
mLDP signaling with Flex-Algo

Policy (S,G) use Algo 129

mVPN overlay route (S,G)

Allocated underlay tree, Algo

Alg129
Tree SID
Tree SID overview

• Tree-SID is a SDN controller-based approach to building P2MP trees in a SR domain
  • Cisco’s SR Path Computation Element (SR-PCE) acts as controller
• With the central knowledge at the SR-PCE, the tree can be built using constraints.
• In this presentation we’ll focus on Trees using MPLS as data-plane.
SR Path Computation Element (SR-PCE)

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 Replication Segment - A segment for P2MP delivery

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

- A Replication segment is an MPLS label

- 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
Tree-SID

SR-PCE is responsible for:

1. Learning the topology.
2. Learning the Root and Leaf’s of the Tree.
3. Computing the Tree.
4. Knowing the MPLS Labels it can use.
5. Having a mechanism to program the Forwarding state.
SR-PCE – 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.
SR-PCE – 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).
SR-PCE – computing the tree

• 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
SR-PCE – MPLS label allocation

• The allocation and programming of the Label for each TreeSID is done by the SR-PCE.
• The entire Tree can be seen as a Segment.
  • All the routers in the network allocated the same Label range for TreeSID.
  • The controller assigns the same Label for a Tree on all the routers.
  • This means its well known and predictable.
  • It makes it easier to manage and troubleshoot the network.
• Label range from the SR Local Block (SRLB).
SR-PCE – MPLS label allocation

Source

SR Replication segment label

Label 15000

R1

R2
SR-PCE – programming the tree

• SR-PCE needs to program forwarding state on all the routers in the path of the Tree.
• This is done via Path Computation Element Protocol (PCEP)
Data forwarding

• Once SR-PCE programs whole tree, data will be encapsulated with appropriate assigned label at ingress PE
Tree-SID types

- Depending on how the Root and Leaves of a tree are learnt, the following Tree-SID types exist:
  - Static SR P2MP Policies
    - User-defined root and leaves
  - Dynamic SR P2MP Policies
    - Dynamically learnt root and leaves
Static SR P2MP policies

• Highlights:
  • Static Point-to-Multipoint (P2MP) trees to deliver Multi-point services in a SR domain
  • P2MP Provider tunnels (P-tunnels) instantiated via SR P2MP Policy computed by a PCE
  • Pre configured roots and leaf’s are required
Dynamic SR P2MP policies

- **Highlights:**
  - Dynamic Point-to-Multipoint (P2MP) trees to deliver Multi-point services in a SR domain
  - P2MP Provider tunnels (P-tunnels) instantiated via SR P2MP Policy computed by a PCE
  - BGP Auto-Discovery for Distributed VPN end-point discovery and C-multicast flow mapping/signaling

- **Use Case / Value Proposition:**
  - BGP-based Multicast VPN (MVPN) without state in the core
Tree SID Use case
Disjoint Tree
Tree-SID: 18000
Root Node: PE1
Leaf Node: {R1, R2, R3}
Affinity: exclude green, red

Tree-SID: 19000
Root Node: PE2
Leaf Node: {R1, R2, R3}
Affinity: exclude blue, red
Tree SID Use case
Dynamic Min Latency Trees
Tree-SID: 18000
Root Node: PE1
Leaf Node: {R1, R2, R3}
Affinity: Latency

- “Performance Measurement” enabled on all links to measure “Unidirectional min Link Delay” metric
- Latency metric advertised in IGPs
- SR-PCE learns link latency metric via BGP-LS
Standardization
Ongoing efforts to standardize in IETF


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