Network Working Group
Internet-Draft
Intended status: Standards Track
Expires: April 1, 2021

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September 28, 2020

SRv6 Point-to-Multipoint Path
draft-chen-pim-srv6-p2mp-path-01

Abstract

This document describes a solution for a SRv6 Point-to-Multipoint (P2MP) Path/Tree to deliver the traffic from the ingress of the path to the multiple egresses/leaves of the path in a SR domain. There is no state stored in the core of the network for a SR P2MP path like a SR Point-to-Point (P2P) path in this solution.

Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on April 1, 2021.

Table of Contents

1. Introduction

The Segment Routing (SR) for unicast or Point-to-Point (P2P) path is described in [RFC8402]. For SR multicast or Point-to-Multipoint (P2MP) path/tree, it may be implemented through using multiple SR P2P paths. The function of a SR P2MP path/tree from an ingress node to multiple (say n) egress/leaf nodes is implemented by n SR P2P paths. These n P2P paths are from the ingress to those n egress/leaf nodes of the P2MP path/tree. This solution may waste some network resources such as link bandwidth.

An alternative solution proposed in [I-D.shen-spring-p2mp-transport-chain] uses a number of P2MP chain tunnels to implement a P2MP path/tree from an ingress to n egress/ leaf nodes. Each P2MP chain tunnel is a tunnel from the ingress to a leaf node as its tail end and may have some leaf nodes as its bud nodes along the tunnel. This alternative solution improves the usage of network resources over the solution above using pure P2P paths. However, these two solutions are based on SR P2P paths.

A solution for a SR P2MP path/tree using a P2MP multicast tree is proposed in [I-D.voyer-pim-sr-p2mp-policy]. For a SR P2MP path/tree from an ingress/root to multiple egress/leaf nodes, a multicast P2MP tree is created to deliver the traffic from the ingress/root to the egress/leaf nodes. The state of the tree is instantiated in the forwarding plane by a controller such as PCE at Root node, intermediate Replication nodes and Leaf nodes of the tree. This is not consistent with the SR principles in which no state is stored at the core of the network.

This document describes a new solution for a SRv6 Point-to-Multipoint (P2MP) Path/Tree to deliver the traffic from the ingress of the path to the multiple egresses/leaves of the path in a SR domain. This solution uses a P2MP multicast tree without storing its state in the core of the network for a SR P2MP path/tree like a SR P2P path.

2. Overview of P2MP Multicast Tree

For a SR P2P path from its ingress to its egress, a segment list for the path is provided to the ingress. The ingress pushes the list into a packet, and the packet is delivered to the egress according to the segment list without any state in the core of the network.

For a SR P2MP path from its ingress to multiple egress/leaf nodes, a segment list for the P2MP path is provided to the ingress. The ingress pushes the list into a packet, and the packet is delivered to the multiple egress/leaf nodes according to the segment list without any state in the core of the network.

Figure 1 shows a SR P2MP path from ingress/root R to four egress/leaf nodes L1, L2, L3 and L4. Nodes P1, P2, P3 and P4 are the transit nodes of the P2MP path.

Suppose that X-m is the segment identifier (SID) of node X. X-m is an adjacent SID or node SID. For simplicity, we assume X-m is a node SID in the illustrations below. R-m, P1-m, P2-m, P3-m, P4-m, L1-m, L2-m, L3-m and L4-m are the SIDs of the nodes on the SR P2MP path. They are multicast SIDs or replication SIDs in general.

A multicast SID is a SID from a multicast SID block. In a SR domain supporting SR multicast, each node has a multicast node SID, which is globally significant; each adjacency of a node has a multicast adjacency SID, which is locally significant. A multicast SID of a node on a SR P2MP path is associated with the SIDs of the next hop (or say downstream) nodes. When the node receives a packet with its multicast SID, it duplicates and sends the packet to each of the next hop nodes according to their SIDs.

If node P on a SR P2MP path has B (B > 1) next hop nodes along the path, the SID of node P, P-m, MUST be a multicast SID when it is in the segment list for the P2MP path. The SIDs of the B next hop nodes just follow P-m in the segment list. When node P receives the packet with P-m, it duplicates and sends the packet to each of the B next hop nodes along the P2MP path.

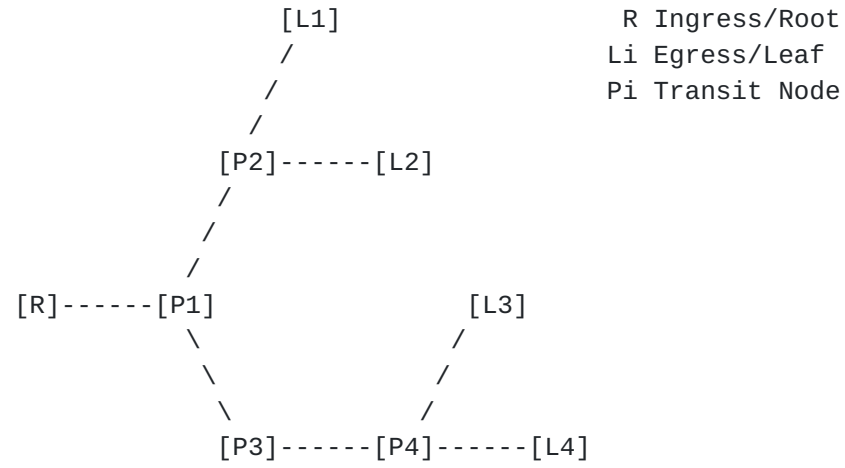


Figure 1: SR P2MP Path from R to L1, L2, L3 and L4

<P1-m, P2-m, P3-m, L1-m, L2-m, P4-m, L3-m, L4-m> is a segment list for the SR P2MP path in Figure 1 to be pushed into a packet at ingress/root R. Node P1 has 2 next hop nodes P2 and P3 along the P2MP path. The next hop nodes' SIDs P2-m and P3-m follow P1-m, which is P1's multicast SID. When P1 receives a packet transported by the P2MP path, it duplicates and sends the packet to the next hop nodes P2 and P3 according to P1-m, P2-m and P3-m.

The number of branches or next hops from node P1 is a value of one argument in P1-m, called N-Branches. The value of N-Branches in P1-m is 2. With this information, node P1 duplicates and sends the packet to 2 next hop nodes P2 and P3, which are indicated by the 2 SIDs P2-m and P3-m following P1-m.

The number of SIDs of the nodes under node P1 is a value of another argument in P1-m, called N-SIDs. The value of N-SIDs in P1-m is 7, indicating that there are 7 SIDs following P1-m in the segment list.

There are 2 branches or next hops (i.e., L1 and L2) from node P2 and 2 SIDs (i.e., L1-m and L2-m) of the nodes under node P2. The values of N-Branches and N-SIDs in P2-m are 2 and 2. with this information, before sending the packet to node P2, node P1 pushes the SIDs under node P2 into the packet (i.e., the packet has a new segment list with the SIDs under node P2. The new segment list replaces the old one in the packet).

There are 1 branch or next hop (i.e., P4) from node P3 and 3 SIDs (i.e., P4-m, L3-m and L4-m) of the nodes under node P3. The values of N-Branches and N-SIDs in P3-m are 1 and 3 respectively. with this information, before sending the packet to node P3, node P1 pushes the SIDs under node P3 into the packet.

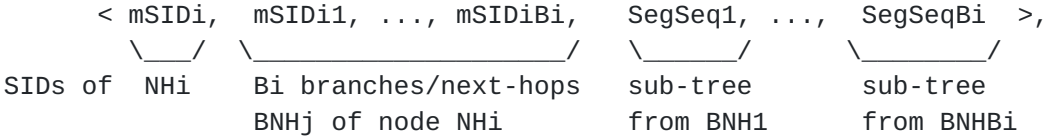
Each node on the SR P2MP path sends the packet to its next hop nodes according to the segment list and no state is stored in any transit node (i.e., the core of the network). The packet is delivered to the egress/leaf nodes from the ingress.

3. Encoding P2MP Multicast Tree

For each sub-tree STi of a SR P2MP path from the ingress node of the P2MP path, suppose that

- the multicast SID of the next hop node NHi is mSIDi;
- there are Bi branches (i.e., outgoing interfaces) to the next hop node BNHj (j = 1, ..., Bi) from node NHi along the sub-tree, the multicast SID of BNHj is mSIDij;
- the number of branches (i.e., outgoing interfaces) under the node BNHj (j = 1, ..., Bi) is BBj; and the number of SIDs of the nodes under each of the Bi branches from node BNHj is NSj (j = 1, ..., Bi).

Sub-tree STi is encoded as segment list



where mSIDi contains the number of branches, Bi, in its N-Branches field, and the number of SIDs under mSIDi in its N-SIDs field; mSIDij

(j = 1, ..., Bi) contains the number of branches, BBj, in its N-Branches field and the number of SIDs, NSj, in its N-SIDs field; SegSeqj (j = 1, ..., Bi) is the SID sequence in the segment list encoding the sub-trees from node BNHj.

For the P2MP path in Figure 1 from ingress node R to egress nodes L1, L2, L3 and L4, there is one sub-tree from R.

For this sub-tree,

- the next hop node is P1 and the multicast SID of P1 is P1-m;
- there are 2 branches to the next hop nodes P2 and P3 from node P1 along the sub-tree; the number of SIDs of the nodes under P1 is 7; the multicast SIDs of P2 and P3 are P2-m and P3-m respectively;
- the numbers of SIDs of the nodes under these two branches are 2 and 3 respectively. The SIDs of the nodes under P2 are L1-m and L2-m. The SIDs of the nodes under P3 are P4-m, L3-m and L4-m.

The sub-tree is encoded as segment list

```
      < P1-m,  P2-m, P3-m,          L1-m, L2-m,  P4-m, L3-m, L4-m >,
        \__/  \___________/         \________/   \_______________/
SIDs of  P1   2 branches/next-hops   sub-tree     sub-tree
              P2 and P3 of node P1   from P2      from P3
```

where

P1-m's N-Branches field is set to 2 and its N-SIDs field to 7;
P2-m's N-Branches field is set to 2 and its N-SIDs field to 2;
P3-m's N-Branches field is set to 1 and its N-SIDs field to 3;

L1-m and L2-m are the SID sequence in the segment list encoding the sub-trees from P2;

P4-m, L3-m and L4-m are the SID sequence in the segment list encoding the sub-trees from P3; and

P4-m's N-Branches field is set to 2 and its N-SIDs field to 2.

Figure 2 shows in details the segment list, which is an encoding of the P2MP multicast tree for the SR P2MP path from R to L1, L2, L3 and L4.

	N-Branches	N-SIDs		
P1's Multicast SID Locator	2	7	Arguments	P1-m
P2's Multicast SID Locator	2	2	Arguments	P2-m
P3's Multicast SID Locator	1	3	Arguments	P3-m
L1's Multicast SID Locator	0	0	Arguments	L1-m
L2's Multicast SID Locator	0	0	Arguments	L2-m
P4's Multicast SID Locator	2	2	Arguments	P4-m
L3's Multicast SID Locator	0	0	Arguments	L3-m
L4's Multicast SID Locator	0	0	Arguments	L4-m

Figure 2: Encoding of P2MP Multicast Tree from R to L1 - L4

SID P1-m indicates that there are 2 branches and 7 SIDs under P1. SID P2-m indicates that there are 2 branches and 2 SIDs under P2. SID P3-m indicates that there are 1 branch and 3 SIDs under P3. SIDs L1-m and L2-m indicate that there is no branch under them. SID P4-m indicates that there are 2 branches and 2 SIDs under P4. L3-m and L4-m indicate that there is no branch under them.

4. Procedures/Behaviors

This section describes the procedures or behaviors on the ingress, transit and egress/leaf node of a SR P2MP path to deliver a packet received from the path to its destinations.

4.1. Procedure/Behavior on Ingress Node

For a packet to be transported by a SR P2MP Path, the ingress of the P2MP path duplicates the packet for each sub-tree of the SR P2MP path branching from the ingress, pushes the segment list encoding the sub-tree into the packet by executing H.Encaps [I-D.ietf-spring-srv6-network-programming] and sends the packet to the next hop node along the sub-tree.

For example, there is one sub-tree from the ingress R of the SR P2MP path in Figure 1 via next hop node P1 towards egress/leaf nodes L1, L2, L3 and L4.

For this sub-tree, the ingress R duplicates the packet, set the destination address (DA) to P1-m (i.e., multicast SID of node P1), pushes the segment list without P1-m (i.e., <P2-m, P3-m, L1-m, L2-m, P4-m, L3-m, L4-m>) encoding the sub-tree in a Segment Routing Header (SRH) of the packet by executing H.Encaps and sends the packet to DA (i.e., node P1). The contents of the multicast SIDs P1-m, P2-m, P3-m, L1-m, L2-m, P4-m, L3-m, L4-m are shown in Figure 2.

Suppose that the duplicated packet is Pkt0 for the sub-tree. The execution of H.Encaps pushes an IPv6 header (i.e., SRH) to Pkt0 and sets some fields in the header to produce an encapsulated packet Pkt'. Pkt' is represented in the following:

```
    Pkt' = (SA=R, DA=P1-m)( L4-m, L3-m,..., P3-m,P2-m; SL=7)Pkt0
                            \_____________________________/
           corresponds to: <P2-m,P3-m, ..., L3-m,L4-m>
```

where DA=P1-m means that the destination address (DA) is set to P1-m; SA=R means that the source address (SA) is set to R; SL=7 means that the number of Segments Left (SL) is 7.

4.2. Procedure/Behavior on Transit Node

When a transit node of a SR P2MP path receives a packet transported by the P2MP path, the DA of the packet is a multicast SID of the node and the packet contains a segment list for the sub-trees under the transit node. The DA and the segment list comprise the information for encoding the sub-trees.

For example, when node P1 receives a packet transported by the SR P2MP path in Figure 1, the packet's DA is P1-m (which is a multicast SID of node P1) and the segment list in the packet is <P2-m, P3-m, L1-m, L2-m, P4-m, L3-m, L4-m>.

The N-Branches field (which has value of n) of the DA indicates that there are n branches (or say sub-trees) under the transit node. The N-SIDs field of the DA indicates the number of SIDs for these n sub-trees under the transit node. The multicast SIDs of the next hop nodes of these n sub-trees are the first n multicast SIDs of the segment list in the packet.

For example, the N-Branches field (which has value of 2) of DA = P1-m indicates that there are 2 branches (or say sub-trees) under node P1. The N-SIDs field (which has value of 7) of the DA = P1-m indicates that there are 7 SIDs for these 2 sub-trees under node P1.

The first multicast SID (P2-m) of the segment list is the SID of the next hop node (P2) of the first sub-tree; The second multicast SID

(P3-m) of the segment list is the SID of the next hop node (P3) of the second sub-tree.

After the multicast SIDs of the next hop nodes, there are n blocks of SIDs for those n sub-trees. The N-SIDs field (which has value of B1) of the first multicast SID of the next hop nodes indicates that there are B1 SIDs in the first block for the first sub-tree; the N-SIDs field (which has value of B2) of the second multicast SID of the next hop nodes indicates that there are B2 SIDs in the second block for the second sub-tree after the first block; and so on.

For example, there are 2 blocks of SIDs for the 2 sub-trees under node P1 after the multicast SIDs P2-m and P3-m of the next hop nodes P2 and P3. The N-SIDs field of P2-m (the first multicast SID of the next hop nodes) has value of 2, indicating that there are 2 SIDs in the first block for the first sub-tree, which are L1-m and L2-m.

The N-SIDs field of P3-m (the second multicast SID of the next hop nodes) has value of 3, indicating that there are 3 SIDs in the second block for the second sub-tree after the first block, which are P4-m, L3-m and L4-m.

The transit node duplicates the packet without top header for each sub-tree under it and adds a new header with a new segment list built from the SID block for the sub-tree to the duplicated packet by executing H.Encaps. It sets the DA of the packet to the multicast SID of the next hop node along the sub-tree and sends the packet to the DA.

For example, node P1 duplicates the packet for the first sub-tree towards L1 and L2 and adds a new header with a new segment list <L1-m, L2-m>. It sets DA = P2-m (multicast SID of next hop P2), and sends the packet to the DA (i.e., P2).

Suppose that the duplicated packet is Pkt0 for the sub-tree. The execution of H.Encaps pushes a new IPv6 header (i.e., SRH) to Pkt0 and sets some fields in the header to produce an encapsulated packet Pkt'. Pkt' is represented in the following:

```
    Pkt' = (SA=P1, DA=P2-m)( L2-m, L1-m;  SL=2)Pkt0.
                            \__________/
          corresponds to:   <L1-m, L2-m>
```

where DA=P2-m means that the destination address (DA) is set to P2-m; SA=P1 means that the source address (SA) is set to P1; SL=2 means that the number of Segments Left (SL) is 2.

Node P1 duplicates the packet for the second sub-tree via P3 towards L3 and L4 and adds a new header with a new segment list <P4-m, L3-m, L4-m>. It sets DA = P3-m (multicast SID of next hop P3), and sends the packet to the DA (i.e., P3).

4.3. Procedure/Behavior on Egress Node

When an egress node of a SR P2MP path receives a packet transported by the P2MP path, the DA of the packet is a SID of the egress node. The egress node sends the packet to its destination accordingly. If the SID is a multicast SID of the egress, the N-Branches field and N-SIDs field are all zeros.

5. Protection

Protections for a SR P2MP path can be classified into two types: global protection and local protection.

5.1. Global Protection

For a primary SR P2MP path from an ingress node R1 to multiple egress nodes Li (i = 1, ..., n), a backup SR P2MP path from an ingress node R1' to multiple egress nodes Li' (i = 1, ..., n) is set up to provide global protection for the primary SR P2MP path. If R1' is the same as R1, the failure of the ingress node R1 of the primary SR P2MP path is not protected; otherwise (i.e., R1' and R1 are different and connected to the same traffic source), the failure of the ingress node R1 is protected. If Li' is the same as Li (i = 1, ..., n), the failure of the egress nodes Li (i = 1, ..., n) of the primary SR P2MP path is not protected; otherwise (i.e., Li' and Li are different and connected to the same destination), the failure of the egress nodes Li is protected.

When a failure happens on the primary SR P2MP path and is detected by the source of the traffic or other entity, the traffic to be transported by the primary SR P2MP path is switched to the backup SR P2MP path, which sends the traffic from its ingress node R1' to its egress nodes Li' (i = 1, ..., n).

5.2. Local Protection

Local protection or say Fast Reroute (FRR) of a node and adjacency segment on a SR P2P path is proposed in [I-D.ietf-rtgwg-segment-routing-ti-lfa] and [I-D.ietf-rtgwg-srv6-egress-protection]. It can be applied to FRR of a node and adjacency segment on a SR P2MP path in a similar way. But FRR for SR P2MP path is more complicated.

More details will be added later.

6. IANA Considerations

TBD

7. Security Considerations

TBD

8. Acknowledgements

The authors would like to thank Acee Lindem and Daniel Voyer for their valuable comments and suggestions on this draft.

9. References

9.1. Normative References

[I-D.ietf-6man-segment-routing-header]
Filsfils, C., Dukes, D., Previdi, S., Leddy, J., Matsushima, S., and D. Voyer, "IPv6 Segment Routing Header (SRH)", draft-ietf-6man-segment-routing-header-26 (work in progress), October 2019.

[I-D.ietf-rtgwg-segment-routing-ti-lfa]
Litkowski, S., Bashandy, A., Filsfils, C., Decraene, B., Francois, P., Voyer, D., Clad, F., and P. Camarillo, "Topology Independent Fast Reroute using Segment Routing", draft-ietf-rtgwg-segment-routing-ti-lfa-04 (work in progress), August 2020.

[I-D.ietf-rtgwg-srv6-egress-protection]
Hu, Z., Chen, H., Chen, H., Wu, P., Toy, M., Cao, C., Liu, L., and X. Liu, "SRv6 Path Egress Protection", draft-ietf-rtgwg-srv6-egress-protection-01 (work in progress), July 2020.

[I-D.ietf-spring-srv6-network-programming]
Filsfils, C., Camarillo, P., Leddy, J., Voyer, D., Matsushima, S., and Z. Li, "SRv6 Network Programming", draft-ietf-spring-srv6-network-programming-20 (work in progress), September 2020.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC8200] Deering, S. and R. Hinden, "Internet Protocol, Version 6 (IPv6) Specification", STD 86, RFC 8200, DOI 10.17487/RFC8200, July 2017, <https://www.rfc-editor.org/info/rfc8200>.

[RFC8402] Filsfils, C., Ed., Previdi, S., Ed., Ginsberg, L., Decraene, B., Litkowski, S., and R. Shakir, "Segment Routing Architecture", RFC 8402, DOI 10.17487/RFC8402, July 2018, <https://www.rfc-editor.org/info/rfc8402>.

[RFC8754] Filsfils, C., Ed., Dukes, D., Ed., Previdi, S., Leddy, J., Matsushima, S., and D. Voyer, "IPv6 Segment Routing Header (SRH)", RFC 8754, DOI 10.17487/RFC8754, March 2020, <https://www.rfc-editor.org/info/rfc8754>.

9.2. Informative References

[I-D.shen-spring-p2mp-transport-chain]
Shen, Y., Zhang, Z., Parekh, R., Bidgoli, H., and Y. Kamite, "Point-to-Multipoint Transport Using Chain Replication in Segment Routing", draft-shen-spring-p2mp-transport-chain-02 (work in progress), April 2020.

[I-D.voyer-pim-sr-p2mp-policy]
Voyer, D., Filsfils, C., Parekh, R., Bidgoli, H., and Z. Zhang, "Segment Routing Point-to-Multipoint Policy", draft-voyer-pim-sr-p2mp-policy-02 (work in progress), July 2020.

[I-D.voyer-spring-sr-replication-segment]
Voyer, D., Filsfils, C., Parekh, R., Bidgoli, H., and Z. Zhang, "SR Replication Segment for Multi-point Service Delivery", draft-voyer-spring-sr-replication-segment-04 (work in progress), July 2020.

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