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                    LISP Control Plane for SRv6 Endpoint Mobility
                         draft-rodrigueznatal-lisp-srv6-03

Abstract

   This document describes the use of the LISP Control Plane to support
   endpoint mobility and Location/ID separation in Segment Routing v6
   (SRv6) deployments.

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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   time. It is inappropriate to use Internet-Drafts as reference
   material or to cite them other than as "work in progress."

   This Internet-Draft will expire on July 26, 2020.

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1. Introduction

   This document defines how to use the LISP Control Plane
   [I-D.ietf-lisp-rfc6833bis] to support endpoint mobility and Location/
   ID separation in those IPv6 deployments that are using SRv6 Network
   Programming [I-D.ietf-spring-srv6-network-programming]. The LISP
   control plane is used to lookup "where" an endpoint is located, while
   SRv6 specifies "how" to program the SRv6 network infrastructure to
   transport traffic to that location.

   To enable this, the egress Provider Edge (PE) nodes register via LISP
   control plane their local SRv6 Segment IDs (SIDs) to be used to reach
   endpoints attached to them. Ingress PE nodes retrieve via LISP
   control plane this mapping information, and use SRv6 network
   programming to encapsulate and steer the traffic towards the
   destination egress PE node.

The LISP control plane provides on-demand endpoint-to-SID mapping, as
well as support for anchorless dynamic endpoint mobility.

2. Overview

The ingress PE nodes receive traffic from endpoints in their local
networks, encapsulate it in IPv6 packets following SRv6 policies and
forward it to the SRv6 domain. Similarly, egress PE nodes receive
SRv6 traffic from the SRv6 domain, remove the SRv6 encapsulation and
forward the traffic to one of their locally attached networks
according to the decapsulation SID received in the packets. Ingress
PE nodes and egress PE nodes can be co-located in the same node, in
this document we use "PE node" to refer to those collocated nodes.

This specification leverages the LISP Mapping System to store
mappings of endpoints to decapsulation SIDs. Endpoints are neither
LISP nor SRv6 aware and can roam freely across different PE nodes.
The mappings in the LISP Mapping System can be used by PE nodes to
know to which PE node an endpoint is currently connected. The LISP
Mapping System is composed of LISP Map-Resolvers and Map-Servers but,
for convenience, this document refers to the Mapping System as a
single logical entity.

To use the LISP Mapping System, in this specification the PE nodes
also implement the control-plane logic of LISP Ingress/Egress Tunnel
Routers (xTRs). As a LISP xTR, a PE node keeps a local database of
all the endpoints that are attached to its local network(s). It also
keeps a list of local decapsulation function SIDs that map to each of
its local network(s). A PE node registers into the LISP Mapping
System its local endpoint-to-SID mappings. These mappings also
contain the traffic steering tag associated with the endpoint. In
addition to its local mappings, a PE node also keeps a local map-
cache of remote endpoint-to-SID mappings that it uses to find the SID
to use to encapsulate traffic towards a remote endpoint.

This specification also assumes an SR Path Computation Element (PCE)
[RFC4655] that can compute and provide SRv6 paths from a given
ingress PE node to a given egress PE node. The paths are based on
the ingress and egress PE nodes and on the traffic steering tag that

is associated with the destination endpoint. Figure 1 shows an
example diagram to be used as a reference for the architecture
described in this document.

```
         +----------+              +----------------+
         |          |              |      LISP      |
         |  SR PCE  |              | Mapping System |
         |          |              |                |
         +----------+              +----------------+



              XXXXXXXXXXXXXXXXXXXXXXXXXX
            XXX                          XXX
           XX                              XX
 +------+    +------+                  +----+-+      +------+
 | UE A +----+ PE 1 |    SRv6 Network  | PE 2 +------+ UE B |
 +------+    +------+                  +------+      +------+
           XX                              XX
            XXX                          XXX
              XXXXXXXXXXXXXXXXXXXXXXXXXX
```
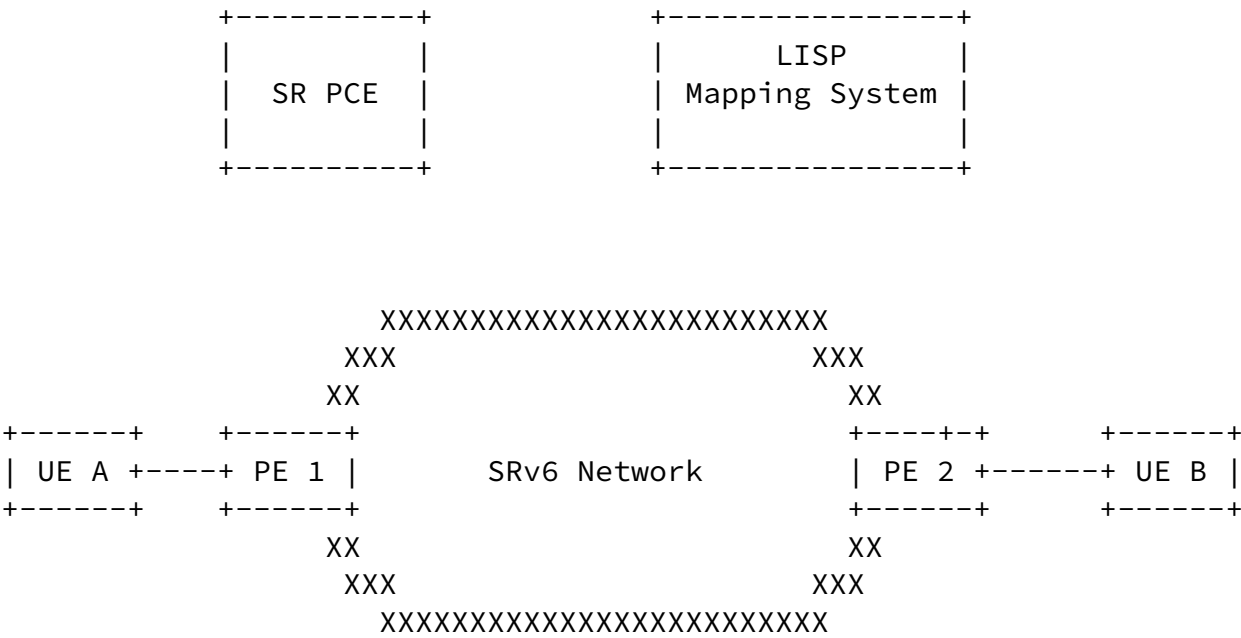

                   Figure 1: Reference Architecture

3. Operation

3.1. Provisioning

   Each PE node is connected to the SRv6 domain and to one or more local
   networks. These local networks may represent different tenants/VPNs.
   Each tenant network is globally identified via a unique Instance

Identifier (IID). Locally, these tenant networks are identified at
each PE node by the local IP table assigned to them. While the IID
for a tenant network is global across the domain, the local IP table
assigned to it in a given PE node is local to that PE node. Each PE
node needs to be provisioned with the one-to-one mapping of global
IID to local IP table per each tenant network it is serving. The
provisioning of the IID to the local IP table is out of the scope of
this document. PE nodes use this IID to local IP table information
to know which IID they need to use when requesting mappings for
traffic coming from a particular tenant network (i.e. from a
particular local IP table).

Per each local IP table, each PE node has a local SRv6 "End.DT46"
function (see [I-D.ietf-spring-srv6-network-programming]) that
decapsulates SRv6 traffic and forwards the inner traffic for lookup
into that particular IP table. The PE node concatenates one of its
local SRv6 locators with each of these decapsulation functions to
create SIDs that point to each of the different tenant networks it is
serving. These SIDs are kept onto the "My local SIDs table" of the

PE node and they are used to decapsulate incoming SRv6 traffic into
the appropriate local IP table.

Beyond SRv6 state, each PE node has to be provisioned with the
address of at least one Map-Resolver it will use to retrieve remote
endpoint-to-SID mappings from the Mapping System. Similarly, it has
to be provisioned with the address of the Map-Server to which it is
going to register their local endpoint-to-SID mappings.

3.2. Endpoint Registration

Endpoints attach to the local networks served by PE nodes. Upon
attachment of an endpoint, the PE node will correlate the local IP
table that corresponds to the local network where the endpoint
attached to a global IID. It does so by using its local information
of global IID to local IP table. The local IP table also correlates
with the local SID that remote PE nodes need to use to send SRv6
encapsulated traffic towards the endpoint. The local SID directly
translates into which local IP table the PE node should use to lookup
for the endpoint when receiving traffic for it.

It should be noted that the endpoint does not need to attach to the

PE node directly (i.e. it can attach to another network device
downlink) as long as the PE node is notified (e.g. via off-band
orchestration) of the following:

o Which endpoint has been attached (i.e. Endpoint EID)

o Which tenant network (if any) the endpoint belongs to (i.e.
   Endpoint IID)

For this version of the specification, it is assumed that the
endpoint only attaches to a single PE node and that all traffic
steering will be handled by SRv6. Therefore, for this version of the
specification, a PE only register one SID per endpoint (or group of
endpoints) into the Mapping System. Future versions of this
specification will describe how to an endpoint can be served by more
than one PE node and/or by more than one SID per PE node.

For SRv6 operation, endpoints need to be associated with a particular
tag to be used for traffic steering policies. This means that the
traffic addressed towards the endpoint may need to be steered through
a particular path in the SRv6 domain. This draft assumes that a PE
node knows the tag associated to endpoints attached to the local
networks it is serving. How a PE node knows which tag corresponds to
a particular endpoint is out of the scope of this document. In
addition to the endpoint tag, to compute the path through the SRv6
network the loopback address of the egress PE node is also used.

Therefore, to make all this information available to the LISP-SRv6
deployment, the PE node will register into the Mapping System the
mapping of endpoint address and IID to endpoint's tag, PE node local
SID and PE node loopback. To do so, the egress PE node will send a
Map-Register as specified in [I-D.ietf-lisp-rfc6833bis] with the
appropriate IID and endpoint address as EID. The endpoint's tag, the
PE node local SID and the PE node loopback are encoded using the SR
LCAF described in Section 4 as an RLOC in the Map-Register.

3.3. Endpoint Resolution

When a PE node needs to encapsulate traffic from a local endpoint
towards a remote endpoint served by a remote PE node, it looks up in
its map-cache to find the appropriate destination SID (and SR policy)
to use to reach the remote endpoint. This lookup takes into

consideration the local IP table serving the local endpoint (i.e the
IID of the mapping). If no entry is found for that remote endpoint,
the PE node has to retrieve it from the Mapping System. To do so, it
follows the procedures described in [I-D.ietf-lisp-rfc6833bis] and
sends a Map-Request towards the Mapping System. In the Map-Request
the PE node encodes its loopback address as ITR RLOC and as
destination EID the address of the remote endpoint for which a
destination SID is needed. It uses the IID associated with the local
IP table serving the local endpoint that triggered the request.

What the Mapping System replies via a Map-Reply depends on how the SR
policy is resolved. The Mapping System can reply with either the
destination SID only (along with egress PE loopback address and
endpoint tag) or with the complete SID list to be applied in the SRv6
underlay. This two options are discussed in detail in Section 3.4.
Note that the Map-Reply may return a prefix as returned EID, which
means all the endpoints within the prefix can be reached through the
same SID. Optionally, the PE node can request to also be subscribed
to updates in the endpoint(s) mapping following
[I-D.ietf-lisp-pubsub].

Alternatively, it is also possible for a PE node to subscribe in
advance for endpoint(s) mappings for a set (or sets) of endpoint
EIDs. That way the map-cache will be pre-populated for those
destination endpoint(s), avoiding the need for an on-demand Map-
Request/Map-Reply. This optimization is at the cost of keeping more
state in the PE node and Mapping System.

3.4. SR Policy Resolution

Besides retrieving the destination SID for a remote endpoint, a PE
node also needs to find a suitable SR policy to send the traffic
towards the destination SID through the SRv6 underlay. The

architecture discussed in this document offers different options to
make the SR policy available at the PE node.

3.4.1. Decentralized

```
          +---------+            +---------------+
          |         |            |      LISP      |
```

```
                   |  SR PCE  |              | Mapping System |
                   |          |              |                |
                   +----------+              +----------------+
                        |                         |        |
                        |                         |        |
                        | +---------------------+ |        |
                        | |                       |        |
                        | |    XXXXXXXXXXXXXXXXXXXXXXXXX    |
                        | |  XXX                     XXX   |
                        | | XX                        XX   |
   +------+      +------+                     +------+      +------+
   | UE A +----+ PE 1 |       SRv6 Network    | PE 2 +------+ UE B |
   +------+      +------+                     +------+      +------+
                    XX                           XX
                     XXX                       XXX
                       XXXXXXXXXXXXXXXXXXXXXXXXX
```
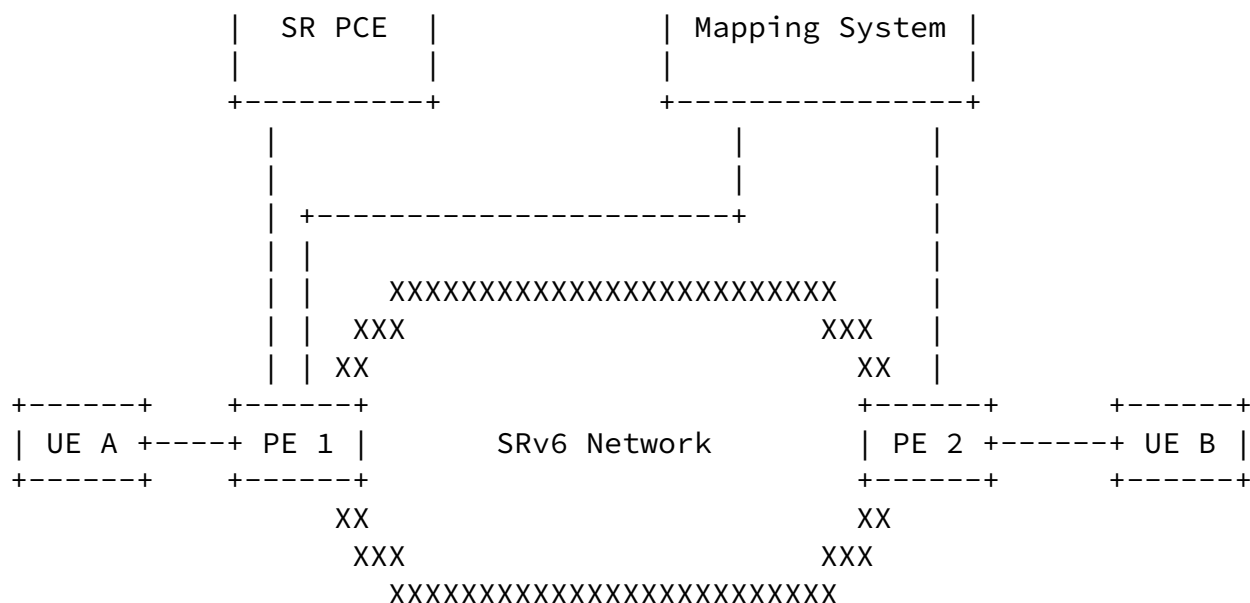
                Figure 2: Decentralized SR Policy Resolution

   With the decentralized approach, the SR policies are resolved
   independently of the endpoint resolution. In this case, the Mapping
   System will reply to the ingress PE node that sent the Map-Request
   with a Map-Reply carrying the SR LCAF described in Section 4 as RLOC.
   This SR LCAF contains the destination SID, egress PE loopback
   address, and endpoint's tag for the requested endpoint. The ingress
   PE will then use the loopback of the egress PE along with the tag
   associated with the endpoint to request a path to the SR PCE
   component via [RFC5440]. The SR PCE will return an SR policy (i.e. a
   SID list) to the ingress PE node for that egress PE node and
   endpoint's traffic steering tag. The ingress PE node will use that
   SID list received from the SR PCE (along with the destination SID
   retrieved from the LISP Mapping System) when encapsulating SRv6
   traffic towards the endpoint.

3.4.2. Centralized

```
              +----------+              +----------------+
```

```
              |           |          |  LISP          |
              |  SR PCE   |----------|  Mapping System |
              |           |          |                |
              +----------+          +----------------+
                                           |      |
                                           |      |
              +----------------------+      |
              |                      |      |
              |   XXXXXXXXXXXXXXXXXXXXXXXXX     |
              |  XXX                    XXX    |
              |  XX                      XX   |
  +------+    +------+                +----+-+      +------+
  | UE A +----+ PE 1 |    SRv6 Network | PE 2 +------+ UE B |
  +------+    +------+                +------+      +------+
                 XX                       XX
                  XXX                      XXX
                 XXXXXXXXXXXXXXXXXXXXXXXXX
```
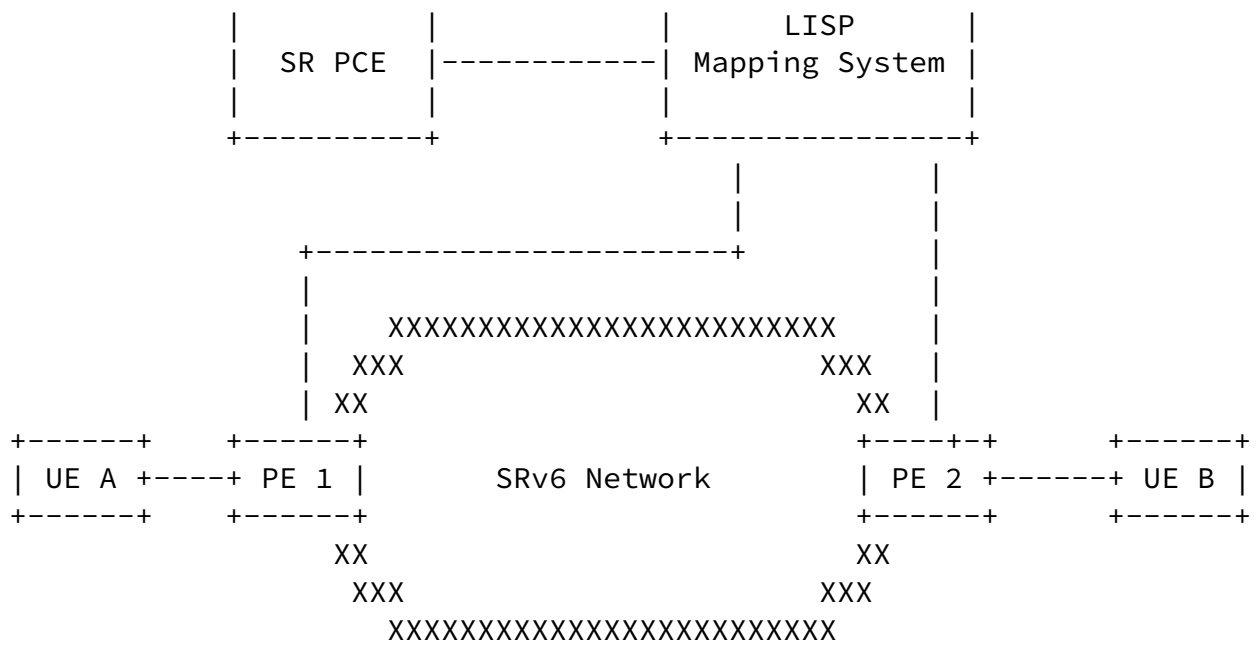
                Figure 3: Centralized SR Policy Resolution

   With the centralized approach the SR policies are resolved at the
   Mapping System when the mapping is requested by the PE node. Upon
   receiving a Map-Request for an endpoint from a PE node, the Mapping
   System queries the SR PCE to find the SR policy using [RFC5440]. To
   query the SR PCE, the Mapping System uses the ingress and egress PE
   nodes loopback addresses and the traffic steering tag of the
   requested endpoint. The Mapping System obtains the loopback address
   of the ingress PE node from the ITR-RLOC field of the Map-Request.
   In this case, the Mapping System returns not only the destination SID
   of the remote endpoint, but also the rest of the SIDs that the
   traffic has to go through from the ingress PE node to the egress PE
   node. The SR policy SID list along with the destination egress PE
   node decapsulation SID are encoded as an Explicit Locator Path (ELP)
   [RFC8060] in the Map-Reply returned. The ingress PE node can
   directly use this ELP to build the SRv6 packets and does not need to
   query the PCE to obtain the SR policy.

3.5. Traffic Encapsulation

   Once the destination SID and SR policy for a given endpoint EID are
   known by a PE node, the PE node will use this information to build
   the Segment Routing Header (SRH), if needed, and encapsulate the
   traffic through the SRv6 domain towards the egress PE node. Note
   that if there is no SR policy for a particular endpoint, no SRH is
   needed and the packets can be encapsulated using a vanilla IPv6
   header with the destination SID as destination address. This follows

common SRv6 operation as specified in
[I-D.ietf-spring-srv6-network-programming].

When the SRv6 traffic reaches the destination, the destination SID
points to the local IP table where the decapsulated traffic has to be
delivered. Once decapsulated, the traffic will be routed towards the
intended endpoint via lookup in that local IP table.

3.6. Endpoint Mobility

LISP-SRv6 deployment relies on the LISP mechanisms defined in
[I-D.ietf-lisp-eid-mobility] to support mobility of endpoints.
Following that specification, when a PE node registers an endpoint
mapping, the previous PE node that had registered a mapping for the
same endpoint will be notified. This serves to (1) notify the former
egress PE node for the endpoint that the endpoint has moved and (2)
to let former PE node know the new egress PE node for the endpoint.
Once the former PE node receives the notification, it (1) stops
registrations for the endpoint, (2) re-encapsulates any traffic
received for the endpoint towards the new egress PE node, and (3)
sends a Solicit-Map-Request message to any ingress PE node from which
it receives traffic for the endpoint to let them know that they
should trigger a Map-Request to update their map-caches.

In addition, if the Mapping System supports the Publish/Subscribe
mechanisms described in [I-D.ietf-lisp-pubsub], a PE node can ask the
Mapping System to be notified of changes in the mapping for a
particular destination endpoint when it requests the mapping. This
way a PE node subscribed to a particular endpoint will receive a
mapping update with the new destination SID for the endpoint whenever
the endpoint moves to a new PE node.

4. Segment Routing LCAF (SR LCAF)

The following Segment Routing LISP Canonical Address Format (SR LCAF)
[RFC8060] is introduced to support the operation of LISP-SR
deployments.

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |           AFI = 16387          |     Rsvd1     |     Flags     |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   Type = SR   |    SR-Type     |             Length            |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
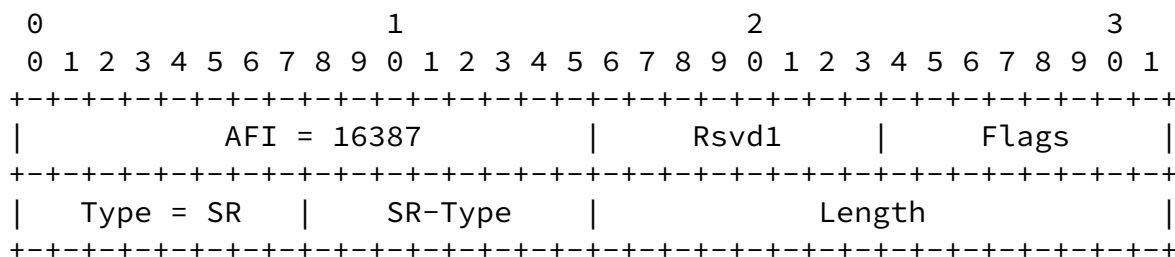
                    Figure 4: Segment Routing LCAF

   The SR LCAF defines the SR-Type field to indicate the type of Segment
   Routing and the specific format of the SR LCAF. The following values
   are defined:

      0: Reserved

      1: SR-MPLS

      2: SRv6

   For definitions of the rest of the LCAF fields please refer to
   [RFC8060].

4.1. SR-MPLS

   When the SR-Type is SR-MPLS (SR-Type = 1) the SR LCAF has the
   following format:

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |           AFI = 16387          |     Rsvd1     |     Flags     |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   Type = SR   |  SR-Type = 1   |             Length            |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |     Rsvd3       |                MPLS label                    |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

```
        |   Tag Type    |   Tag Flags   |    Traffic Steering Tag   ...
        +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
        |          AFI = x              |        SR Next Hop        ...
        +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
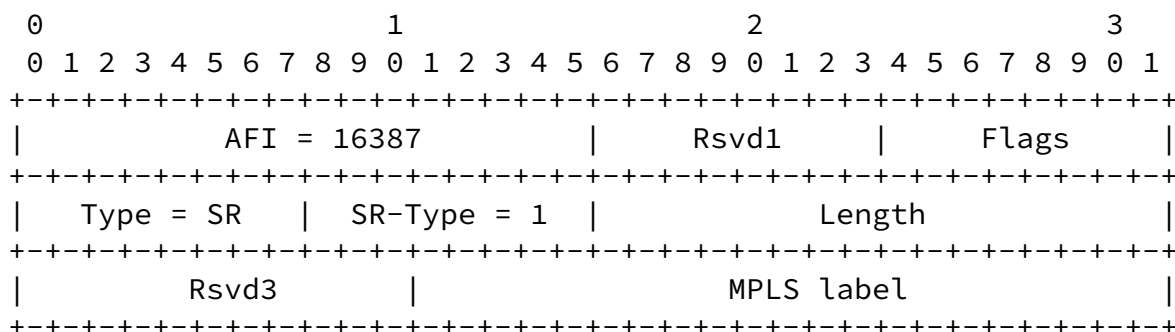
                    Figure 5: SR-MPLS Segment Routing LCAF

   The SR-MPLS SR LCAF defines the following fields:

      MPLS label: MPLS VPN label associated with the EID.

      Tag Type: Type of traffic steering tag associated with the EID.
      Details on this traffic steering tag and different Tag Types are
      discussed in [Section 4.3](#).

      Tag Flags: Flags for the particular type of traffic steering tag
      associated with the EID.
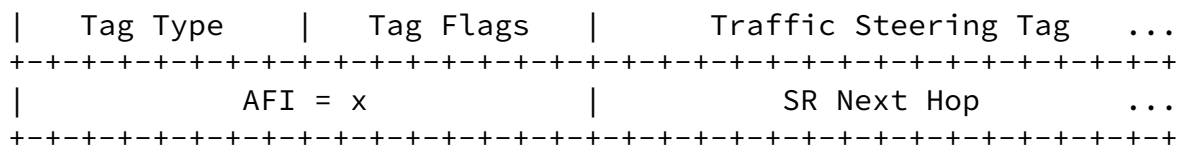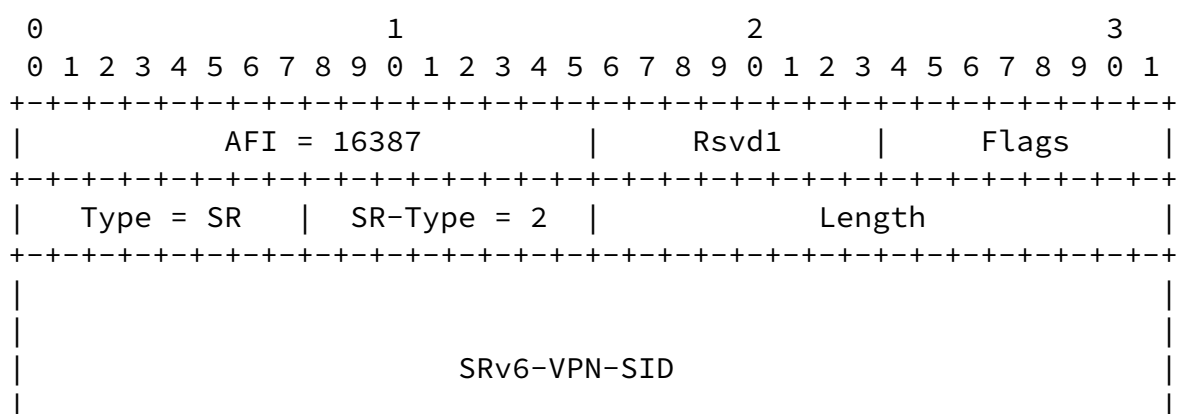
      Traffic Steering Tag: Tag associated with the EID that is used to
      compute SR paths.

      SR Next Hop: Loopback address of the egress PE node associated
      with the EID.

4.2. SRv6

   When the SR-Type is SR-SRv6 (SR-Type = 2) the SR LCAF has the
   following format:

```
       0                   1                   2                   3
       0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |           AFI = 16387         |     Rsvd1     |    Flags      |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |   Type = SR   |  SR-Type = 2  |            Length             |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |                                                               |
      |                                                               |
      |                        SRv6-VPN-SID                           |
      |                                                               |
```

```
|                        (128 bits)                             |
|                                                               |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Tag Type    |    Tag Flags   |     Traffic Steering Tag   ...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            AFI = x             |         SR Next Hop        ...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
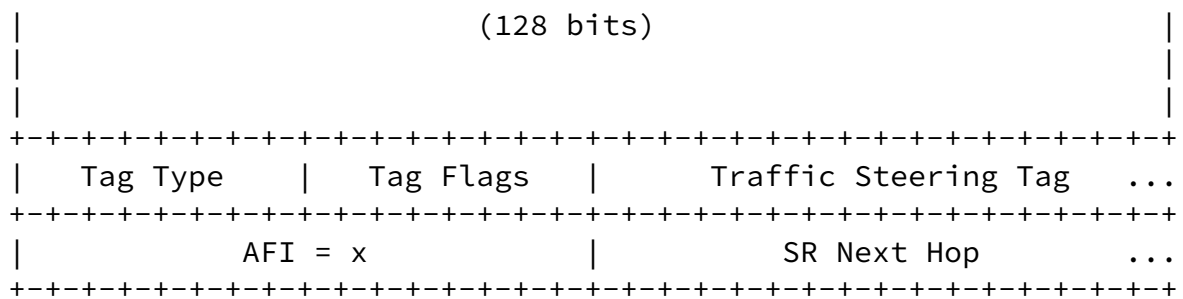
                    Figure 6: SRv6 Segment Routing LCAF

   The SRv6 SR LCAF defines the following fields:

      SRv6-VPN-SID: The SRv6 VPN SID associated with the EID.

   See Section 4.1 for definitions of the rest of the fields of the SRv6
   SR LCAF.

4.3. Traffic Steering Tag

   The SR LCAF supports different traffic steering tags to be associated
   with the EID and be used in the operation of the SR deployment. The
   following values are defined for the Tag Type field:

      0: No tag. When the Tag Type is 0 the Tag Flags are 0 and the Tag
      field has length of 0 octets.

      1: Color. When the Tag Type is 0 the Tag Flags and Tag field have
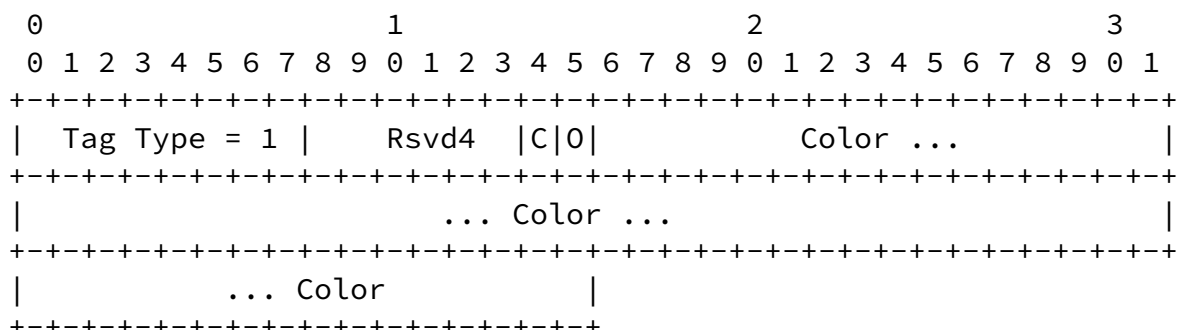   the following format.


```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Tag Type = 1 |    Rsvd4   |C|O|           Color ...           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      ... Color ...                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           ... Color       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

```
                      Figure 7: Color Tag

      2: Slice.  The tag format and flags for this Tag Type are to be
      defined in future versions of this document.
```

5. References

5.1. Normative References

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