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LISP Extensions for Segment Routing
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Abstract

Segment Routing (SR) combines source routing and tunneling to steer traffic through the transit network. The Locator/ID Separation Protocol (LISP) separates IP addresses into Endpoint Identifiers (EIDs) and Routing Locators (RLOCs) and also leverages tunneling mechanisms. Mapping between EIDs and RLOCs is facilitated by the LISP mapping system. Combining LISP and SR enables the LISP mapping system to provide SR information to encapsulating routers so that traffic can be steered in the transit network or the list of segments a particular packet traverses is recorded in the packet header.

This document describes extensions required to the Locator/ID Separation Protocol (LISP) to enable a LISP mapping system to communicate list of segment identifiers or the request to record the list of segments a particular packet traverses to the encapsulating router.

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1. Introduction

Segment Routing (SR) allows for a flexible definition of end-to-end paths within network topologies by encoding paths as sequences of topological sub-paths, called "segments" as described in [I-D.filsfils-rtgwg-segment-routing]. Segment routing can be applied to IPv6 with a new type of routing extension header. The Locator/ID Separation Protocol [RFC6830] specifies an architecture and mechanism for replacing the addresses currently used by IP with two separate name spaces: Endpoint IDs (EIDs), used within sites; and Routing Locators (RLOCs), used on the transit networks that make up the Internet infrastructure. To achieve this separation, LISP defines protocol mechanisms for mapping from EIDs to RLOCs. In addition, LISP assumes the existence of a database to store and propagate those mappings globally.

When LISP is combined with SR, the EID to RLOC mapping information can be extended with segment routing information. This allows for a closer correlation between the transit network, that is sometimes also referred to as the underlay network, and the overlay network. It is beyond the scope of this document to describe how the LISP mapping system obtains a segment list for a particular EID-to-RLOC mapping. This draft outlines use-cases for combining LISP and SR as well as extensions to the LISP Canonical Address Format (LCAF) for traffic engineering (LCAF type 10) [I-D.ietf-lisp-lcaf]. These extensions are to be integrated into a future revision of [I-D.ietf-lisp-lcaf].

2. Conventions

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 [RFC2119].

This document uses the Terminology as defined in [I-D.filsfils-rtgwg-segment-routing] and [I-D.ietf-lisp-lcaf].

Abbreviations used in this document:

AFI: Address Family Identifier

EID: Endpoint Identifier

ELP: Explicit Locator Path

ETR: Egress Tunnel Router

ITR: Ingress Tunnel Router

LCAF: LISP Canonical Address Format

LISP: Locator/ID Separation Protocol

OAM: Operation Administration Maintenance

RLOC: Routing Locator

SR: Segment Routing

SID: Segment Identifier

Segment List: Ordered list of segment identifiers

3. Use cases that combine LISP and SR

Use-cases that combine LISP and SR include traffic steering/traffic engineering as well as traffic tracing in the underlay network.

3.1. Traffic steering/traffic engineering

LISP combined with SR can be used to steer traffic in the underlay network: The mapping system communicates a segment list to the LISP ingress tunnel router (ITR) when resolving the EID-to-RLOC mapping as part of a LISP Map-Reply. This extension allows the LISP mapping system to provide a list of segment identifiers to encapsulating routers so that traffic can be steered in the transit network. In a typical setup the LISP ingress tunnel router would retrieve the segment list from the mapping system along with the associated RLOC using the EID as the lookup key. The ITR encapsulates the packet to the RLOC, also including the segment list in the segment routing extension header. The packet is forwarded to the ETR using segment routing techniques. The ETR decapsulates the packet and delivers the packet to the destination EID. Given that in SR with IPv6 transport the entire segment list is available in the SR-specific extension header of the outer IPv6 header, the LISP egress tunnel router, which is the tunnel endpoint is also informed about the path a particular packet took in the transport network.

LISP with SR for traffic engineering adds to the LISP traffic engineering use-cases described in [I-D.farinacci-lisp-te]. LISP combined with SR offers traffic engineering without using reencapsulating tunnels [RFC6830]. Reencapsulating tunnels and SR with LISP are complementary traffic engineering techniques and could be combined. SR could for example be used in an explicit locator path (ELP) to further traffic engineer a path between two reencapsulating routers.

3.2. Traffic tracing

LISP combined with SR can be used to get more information about the path a packet took in the underlay network without sending extra probe traffic. When SR is applied to IPv6, the segment list describing the path that a packet takes through the network can be recorded in the SR-specific extension header of the outer IPv6 packet header. This activity is referred to as segment tracing. Segment tracing can be performed independently from steering traffic using SR techniques. It can also be used in a transit network which performs normal IPv6 routing. When tracing is enabled, the segment ID of every segment that a packet traverses is recorded in the SR-specific extension header. This means that the egress tunnel router receives information about the path, represented by the segment list, a particular packet has taken in the underlay network. Different from OAM mechanisms which send active probe packets, tracing information can be made available for production traffic. The egress tunnel router can choose to provide the traced segment list back to the mapping system, for example through a LISP Map-Register. This information can be used to ensure path symmetry send/receive traffic in the transit network, or can serve other OAM or statistical purposes.

4. LISP extensions to support SR

Segment routing information can be contained within the LISP mapping system. A segment identifier is a 32-bit identification either for a topological instruction or a service instruction. See [I-D.filsfils-rtgwg-segment-routing] for details.

An EID can be associated with one or multiple ordered lists of segment identifiers, also referred to as "segment lists", encoding the topological and service source route of a packet. The segment list can serve either traffic engineering or operational purposes. In case of traffic engineering purposes, the segment list describes the set of segments a packet visits when traversing the transit network. The segment list enables the ITR to steer traffic using segment routing techniques. The ITR retrieves the segment list from the mapping system along with the associated RLOC using the EID as the lookup key. For operations and maintenance use, the segment list documents the set of segments a packet visited on its way through the transit network. It is beyond the scope of this document to describe the detailed procedures how the LISP mapping system obtains a segment list for a particular EID-to-RLOC mapping.

Segment routing extensions for LISP extend the Explicit Locator Path (ELP) Canonical Address Format, which is LCAF type 10, see[I-D.ietf-lisp-lcaf] for details. A new Address Family Identifier (AFI) in LISP Canonical Address Format (LCAF) type [I-D.ietf-lisp-lcaf] carries the 32-bit segment identifier. For a given EID lookup in the mapping database, the segment routing list in ELP LCAF type can be returned to provide a segment list to each locator in the Map-Reply locator set. The ELP LCAF type can also be used to send the segment list that a particular packet traversed to the LISP mapping system using a Map-Register message defined in [RFC6833].

The segment identification AFI to be allocated is described below:

```
 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 = TBD_SID    |           Reserved            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                              SID                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

AFI=TBD_SID: TBD_SID is a value allocated from [AFI] for segment identifiers.

Reserved: this 8-bit field reserved for future use and to carry specific control bits. If used with the ELP LCAF, this field carries several bits (see below).

SID: 4 byte segment identifier

The segment identification AFI is used within the ELP LCAF to describe the list of segments a packet is to visit or has visited on its way through the transit network. Further below examples are shown how the segment identification AFI is used for the ELP LCAF type. A new bit, the T-bit, is added to the LISP LCAF type 10 described in [I-D.ietf-lisp-lcaf]. This addition is to be integrated into a future revision of [I-D.ietf-lisp-lcaf].

For the segment routing AFI, the T-bit is defined as follows:

T-Bit: An additional bit in the Rsvd3 field is to be allocated in LCAF type 10. The T-bit (T=1) is used by the LISP mapping system to indicate to an ITR that for particular EID-to-RLOC mapping the segments traversed by packets SHOULD be recorded as a segment list in the SR IPv6 extension header. This bit is ignored if present in a Map-Register message. A Map-Register message could be used by the ETR to inform the mapping system about the segments that a packet visited in the transit network.

4.1. Example ELPs

4.1.1. Example: ELP with only SR used

This example shows the Explicit Locator Path (ELP) Canonical Address Format in a setup where segment routing is used in the transit network between ITR and ETR. Traffic engineering using reencapsulating routers is not used.

The reply to an EID-to-RLOC lookup contains the SIDs to be visited in the underlay network to reach the RLOC address returned in AFI=x. In the example below SID_1,...,SID_p are to be used for segment routing towards the "Address" RLOC. SID_p is the identifier of the last segment which takes the packet to the "Address" RLOC.

```
 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 = 10   |     Rsvd2     |               n               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              AFI = TBD_SID    |           Rsvd3             |T|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            SID_1                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              AFI = TBD_SID    |           Rsvd3             |T|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            SID_p                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              AFI = x          |           Rsvd3               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            Address  ...                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

4.1.2. Example: ELP with SR and reencapsulating routers combined

This example shows the Explicit Locator Path (ELP) Canonical Address Format when using SR combined with reencapsulation routers.

Segment routing and traffic engineering using reencapsulating routers can be combined. In the example below, segment routing is used to steer traffic in the underlay between reencapsulating routers "f" and "g". There is no segment routing used between any of the other reencapsulating router hops.

```
     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 = 10   |     Rsvd2     |               n               |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |              AFI = x          |           Rsvd3         |L|P|S|
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                          Reencap Hop 1  ...                   |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |              AFI = x          |           Rsvd3         |L|P|S|
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                          Reencap Hop f  ...                   |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |              AFI = TBD_SID    |           Rsvd3       |T|L|P|S|
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                          SID_1                                |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |              AFI = TBD_SID    |           Rsvd3       |T|L|P|S|
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                          SID_p                                |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |              AFI = x          |           Rsvd3         |L|P|S|
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                          Reencap Hop g  ...                   |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |              AFI = x          |           Rsvd3         |L|P|S|
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                          Reencap Hop k  ...                   |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

5. IANA Considerations

A new AFI for segment identifiers is to be allocated by IANA (see [AFI] for a list of currently allocated AFIs).

6. Manageability Considerations

Manageability considerations will be addressed in a later version of this document..

7. Security Considerations

Security considerations will be addressed in a later version of this document.

8. Acknowledgements

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9. References

9.1. Normative References

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