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P. Psenak, Ed.
C. Filsfils
Cisco Systems
A. Bashandy
Individual
B. Decraene
Orange
Z. Hu
Huawei Technologies

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IS-IS Extension to Support Segment Routing over IPv6 Dataplane
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Abstract

Segment Routing (SR) allows for a flexible definition of end-to-end paths by encoding paths as sequences of topological sub-paths, called "segments". Segment routing architecture can be implemented over an MPLS data plane as well as an IPv6 data plane. This draft describes the IS-IS extensions required to support Segment Routing over an IPv6 data plane.

Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

Status of This Memo

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1. Introduction

With Segment Routing (SR) [RFC8402], a node steers a packet through an ordered list of instructions, called segments.

Segments are identified through Segment Identifiers (SIDs).

Segment Routing can be directly instantiated on the IPv6 data plane through the use of the Segment Routing Header defined in [RFC8754]. SRv6 refers to this SR instantiation on the IPv6 dataplane.

The network programming paradigm [I-D.ietf-spring-srv6-network-programming] is central to SRv6. It describes how any behavior can be bound to a SID and how any network program can be expressed as a combination of SIDs.

This document specifies IS-IS extensions that allow the IS-IS protocol to encode some of these SIDs and their behaviors.

Familiarity with the network programming paradigm [I-D.ietf-spring-srv6-network-programming] is necessary to understand the extensions specified in this document.

This document defines one new top level IS-IS TLV and several new IS-IS sub-TLVs.

The SRv6 Capabilities sub-TLV announces the ability to support SRv6.

Several new sub-TLVs are defined to advertise various SRv6 Maximum SID Depths.

The new SRv6 Locator top level TLV announces SRv6 locators - a form of summary address for the set of topology/algorithm specific SIDs instantiated at the node.

The SRv6 End SID sub-TLV, the SRv6 End.X SID sub-TLV, and the SRv6 LAN End.X SID sub-TLV are used to advertise which SIDs are

instantiated at a node and what Endpoint behavior is bound to each instantiated SID.

2. SRv6 Capabilities sub-TLV

A node indicates that it supports the SR Segment Endpoint Node functionality as specified in [RFC8754] by advertising a new SRv6 Capabilities sub-TLV of the router capabilities TLV [RFC7981].

The SRv6 Capabilities sub-TLV may contain optional sub-sub-TLVs. No sub-sub-TLVs are currently defined.

The SRv6 Capabilities sub-TLV 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
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |   Type        |     Length    |             Flags             |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |   optional sub-sub-TLVs...
```

Type: 25

Length: 2 + length of sub-sub-TLVs

Flags: 2 octets The following flags are defined:

```
 0                   1
  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 | |O|                           |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

where:

O-flag: If set, the router supports use of the O-bit in the Segment Routing Header(SRH) as defined in [I-D.ietf-6man-spring-srv6-oam].

3. Advertising Supported Algorithms

SRv6 capable router indicates supported algorithm(s) by advertising the SR Algorithm TLV as defined in [RFC8667].

4. Advertising Maximum SRv6 SID Depths

[RFC8491] defines the means to advertise node/link specific values for Maximum SID Depths (MSD) of various types. Node MSDs are advertised in a sub-TLV of the Router Capabilities TLV [RFC7981]. Link MSDs are advertised in a sub-TLV of TLVs 22, 23, 141, 222, and 223.

This document defines the relevant SRv6 MSDs and requests MSD type assignments in the MSD Types registry created by [RFC8491].

4.1. Maximum Segments Left MSD Type

The Maximum Segments Left MSD Type specifies the maximum value of the "SL" field [RFC8754] in the SRH of a received packet before applying the Endpoint behavior associated with a SID.

SRH Max SL Type: 41

If no value is advertised the supported value is assumed to be 0.

4.2. Maximum End Pop MSD Type

The Maximum End Pop MSD Type specifies the maximum number of SIDs in the SRH to which the router can apply "PSP" or USP" behavior, as defined in [I-D.ietf-spring-srv6-network-programming] flavors.

SRH Max End Pop Type: 42

If the advertised value is zero or no value is advertised then it is assumed that the router cannot apply PSP or USP flavors.

4.3. Maximum H.Encaps MSD Type

The Maximum H.Encaps MSD Type specifies the maximum number of SIDs that can be included as part of the "H.Encaps" behavior as defined in [I-D.ietf-spring-srv6-network-programming].

SRH Max H.encaps Type: 44

If the advertised value is zero or no value is advertised then the router can apply H.Encaps only by encapsulating the incoming packet in another IPv6 header without SRH the same way IPinIP encapsulation is performed.

If the advertised value is non-zero then the router supports both IPinIP and SRH encapsulation subject to the SID limitation specified by the advertised value.

4.4. Maximum End D MSD Type

The Maximum End D MSD Type specifies the maximum number of SIDs in an SRH when performing decapsulation associated with "End.Dx" behaviors (e.g., "End.DX6" and "End.DT6") as defined in [I-D.ietf-spring-srv6-network-programming].

SRH Max End D Type: 45

If the advertised value is zero or no value is advertised then it is assumed that the router cannot apply "End.DX6" or "End.DT6" behaviors if the outer IPv6 header contains an SRH.

5. SRv6 SIDs and Reachability

As discussed in [I-D.ietf-spring-srv6-network-programming], an SRv6 Segment Identifier (SID) is 128 bits and consists of Locator, Function and Argument parts.

A node is provisioned with topology/algorithm specific locators for each of the topology/algorithm pairs supported by that node. Each locator is a covering prefix for all SIDs provisioned on that node which have the matching topology/algorithm.

Locators MUST be advertised in the SRv6 Locator TLV (see Section 7.1). Forwarding entries for the locators advertised in the SRv6 Locator TLV MUST be installed in the forwarding plane of receiving SRv6 capable routers when the associated topology/algorithm is supported by the receiving node.

Locators are routable and MAY also be advertised in Prefix Reachability TLVs (236 or 237).

Locators associated with Flexible Algorithms [I-D.ietf-lsr-flex-algo] SHOULD NOT be advertised in Prefix Reachability TLVs (236 or 237).

Locators associated with algorithm 0 and 1 (for all supported topologies) SHOULD be advertised in a Prefix Reachability TLV (236 or 237) so that legacy routers (i.e., routers which do NOT support SRv6) will install a forwarding entry for algorithm 0 and 1 SRv6 traffic.

In cases where a locator advertisement is received in both a Prefix Reachability TLV and an SRv6 Locator TLV, the Prefix Reachability advertisement MUST be preferred when installing entries in the forwarding plane. This is to prevent inconsistent forwarding entries between SRv6 capable and SRv6 incapable routers.

SRv6 SIDs are advertised as sub-TLVs in the SRv6 Locator TLV except for SRv6 End.X SIDs/LAN End.X SIDs which are associated with a specific Neighbor/Link and are therefore advertised as sub-TLVs in TLVs 22, 23, 222, 223, and 141.

SRv6 SIDs are not directly routable and MUST NOT be installed in the forwarding plane. Reachability to SRv6 SIDs depends upon the existence of a covering locator.

Adherence to the rules defined in this section will assure that SRv6 SIDs associated with a supported topology/algorithm pair will be forwarded correctly, while SRv6 SIDs associated with an unsupported topology/algorithm pair will be dropped. NOTE: The drop behavior depends on the absence of a default/summary route covering a given locator.

In order for forwarding to work correctly, the locator associated with SRv6 SID advertisements MUST be the longest match prefix installed in the forwarding plane for those SIDs. There are a number of ways in which this requirement could be compromised. In order to ensure correct forwarding, network operators should take steps to make sure that this requirement is not compromised.

- o Another locator associated with a different topology/algorithm is the longest match

- o A prefix advertisement (i.e., from TLV 236 or 237) is the longest match

6. Advertising Anycast Property

Both prefixes and SRv6 Locators may be configured as anycast and as such the same value can be advertised by multiple routers. It is useful for other routers to know that the advertisement is for an anycast identifier.

A new flag in "Bit Values for Prefix Attribute Flags Sub-TLV" registry [RFC7794] is defined to advertise the anycast property:

Bit #: 4
Name: Anycast Flag (A-flag)

When the prefix/SRv6 locator is configured as anycast, the A-flag SHOULD be set. Otherwise, this flag MUST be clear.

The A-flag MUST be preserved when leaked between levels.

The A-flag and the N-flag MUST NOT both be set.

If both N-flag and A-flag are set in the prefix/SRv6 Locator advertisement, the receiving routers MUST ignore the N-flag.

The same prefix/SRv6 Locator can be advertised by multiple routers. If at least one of them sets the A-Flag in its advertisement, the prefix/SRv6 Locator SHOULD be considered as anycast.

A prefix/SRv6 Locator that is advertised by a single node and without an A-Flag SHOULD be interpreted as a node specific locator.

All the nodes advertising the same anycast locator MUST instantiate the exact same set of SIDs under such anycast locator. Failure to do so may result in traffic being black-holed or mis-routed.

The Prefix Attribute Flags Sub-TLV can be carried in the SRv6 Locator TLV as well as the Prefix Reachability TLVs. When a router originates both the Prefix Reachability TLV and the SRv6 Locator TLV for a given prefix, and the router is originating the Prefix Attribute Flags Sub-TLV in one of the TLVs, the router SHOULD advertise identical versions of the Prefix Attribute Flags Sub-TLV in both TLVs.

7. Advertising Locators and End SIDs

The SRv6 Locator TLV is introduced to advertise SRv6 Locators and End SIDs associated with each locator.

This new TLV shares the sub-TLV space defined for TLVs 135, 235, 236 and 237.

7.1. SRv6 Locator TLV Format

The SRv6 Locator TLV 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Type        |     Length    |R|R|R|R|    MTID               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Type: 27

Length: variable.

R bits: reserved for future use. They MUST be set to zero on transmission and MUST be ignored on receipt.

MTID: Multitopology Identifier as defined in [RFC5120].
Note that the value 0 is legal.

Followed by one or more locator entries of the form:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Metric                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Flags       |  Algorithm    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Loc Size     | Locator (variable)...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Sub-tlv-len  |         Sub-TLVs (variable) . . .             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Metric: 4 octets. As described in [RFC5305].

Flags: 1 octet. The following flags are defined

```
 0
 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+
|D|    Reserved |
+-+-+-+-+-+-+-+-+
```

where:
D bit: When the Locator is leaked from level-2 to level-1, the D bit MUST be set. Otherwise, this bit MUST be clear. Locators with the D bit set MUST NOT be leaked from level-1 to level-2. This is to prevent looping.

The remaining bits are reserved for future use. They MUST be set to zero on transmission and MUST be ignored on receipt.

Algorithm: 1 octet. Associated algorithm. Algorithm values are defined in the IGP Algorithm Type registry.

Loc-Size: 1 octet. Number of bits in the SRv6 Locator field. (1 - 128)

Locator: 1-16 octets. This field encodes the advertised SRv6 Locator. The Locator is encoded in the minimal number of octets for the given number of bits. Trailing bits MUST be set to zero and ignored when received.

Sub-TLV-length: 1 octet. Number of octets used by sub-TLVs

Optional sub-TLVs.

7.2. SRv6 End SID sub-TLV

The SRv6 End SID sub-TLV is introduced to advertise SRv6 Segment Identifiers (SID) with Endpoint behaviors which do not require a particular neighbor in order to be correctly applied [I-D.ietf-spring-srv6-network-programming]. SRv6 SIDs associated with a neighbor are advertised using the sub-TLVs defined in Section 8.

This new sub-TLV is advertised in the SRv6 Locator TLV defined in the previous section. SRv6 End SIDs inherit the topology/algorithm from the parent locator.

The SRv6 End SID sub-TLV 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Type       |     Length    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Flags      |       Endpoint Behavior       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| SID (128 bits) . . .                                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| SID (cont . . .)                                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| SID (cont . . .)                                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| SID (cont . . .)                                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Sub-sub-tlv-len|         sub-sub-TLVs (variable) . . .         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Type: 5.

Length: variable.

Flags: 1 octet. No flags are currently defined.

Endpoint Behavior: 2 octets, as defined in [I-D.ietf-spring-srv6-network-programming]. Legal behavior values for this sub-TLV are defined in Section 10 of this document.

SID: 16 octets. This field encodes the advertised SRv6 SID.

Sub-sub-TLV-length: 1 octet. Number of octets used by sub-sub-TLVs.

Optional sub-sub-TLVs.

The SRv6 End SID MUST be a subnet of the associated Locator. SRv6 End SIDs which are NOT a subnet of the associated locator MUST be ignored.

Multiple SRv6 End SIDs MAY be associated with the same locator. In cases where the number of SRv6 End SID sub-TLVs exceeds the capacity of a single TLV, multiple Locator TLVs for the same locator MAY be advertised. For a given MTID/Locator the algorithm MUST be the same in all TLVs. If this restriction is not met all TLVs for that MTID/Locator MUST be ignored.

8. Advertising SRv6 Adjacency SIDs

Certain SRv6 Endpoint behaviors [I-D.ietf-spring-srv6-network-programming] are associated with a particular adjacency.

This document defines two new sub-TLVs of TLV 22, 23, 222, 223, and 141 - namely "SRv6 End.X SID" and "SRv6 LAN End.X SID".

IS-IS Neighbor advertisements are topology specific - but not algorithm specific. End.X SIDs therefore inherit the topology from the associated neighbor advertisement, but the algorithm is specified in the individual SID.

All End.X SIDs MUST be a subnet of a Locator with matching topology and algorithm which is advertised by the same node in an SRv6 Locator TLV. End.X SIDs which do not meet this requirement MUST be ignored.

All End.X and LAN End.X SIDs MUST be subsumed by the subnet of a Locator with the matching algorithm which is advertised by the same node in an SRv6 Locator TLV. End.X SIDs which do not meet this requirement MUST be ignored. This ensures that the node advertising the End.X or LAN End.X SID is also advertising its corresponding Locator with the algorithm that will be used for computing paths destined to the SID.

8.1. SRv6 End.X SID sub-TLV

This sub-TLV is used to advertise an SRv6 SID associated with a point to point adjacency. Multiple SRv6 End.X SID sub-TLVs MAY be associated with the same adjacency.

The SRv6 End.X SID sub-TLV 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
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |   Type        |     Length     |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |   Flags       |   Algorithm    |   Weight      |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |        Endpoint Behavior       |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 | SID (128 bits) . . .                                            |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 | SID (cont . . .)                                                |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 | SID (cont . . .)                                                |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 | SID (cont . . .)                                                |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |Sub-sub-tlv-len|         Sub-sub-TLVs (variable) . . .           |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Type: 43

Length: variable.

Flags: 1 octet.

```
 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+
|B|S|P|Reserved |
+-+-+-+-+-+-+-+-+
```

where:

B-Flag: Backup flag. If set, the End.X SID is eligible for protection (e.g., using IPFRR) as described in [RFC8355].

S-Flag. Set flag. When set, the S-Flag indicates that the End.X SID refers to a set of adjacencies (and therefore MAY be assigned to other adjacencies as well).

P-Flag. Persistent flag. When set, the P-Flag indicates that the End.X SID is persistently allocated, i.e., the End.X SID value remains consistent across router restart and/or interface flap.

Reserved bits: MUST be zero when originated and ignored when received.

Algorithm: 1 octet. Associated algorithm. Algorithm values are defined in the IGP Algorithm Type registry.

Weight: 1 octet. The value represents the weight of the End.X SID for the purpose of load balancing. The use of the weight is defined in [RFC8402].

Endpoint Behavior: 2 octets. As defined in [I-D.ietf-spring-srv6-network-programming] Legal behavior values for this sub-TLV are defined in Section 10.

SID: 16 octets. This field encodes the advertised SRv6 SID.

Sub-sub-TLV-length: 1 octet. Number of octets used by sub-sub-TLVs.

Note that multiple TLVs for the same neighbor may be required in order to advertise all of the SRv6 End.X SIDs associated with that neighbor.

8.2. SRv6 LAN End.X SID sub-TLV

This sub-TLV is used to advertise an SRv6 SID associated with a LAN adjacency. Since the parent TLV is advertising an adjacency to the Designated Intermediate System(DIS) for the LAN, it is necessary to include the System ID of the physical neighbor on the LAN with which the SRv6 SID is associated. Given that a large number of neighbors may exist on a given LAN a large number of SRv6 LAN END.X SID sub-TLVs may be associated with the same LAN. Note that multiple TLVs for the same DIS neighbor may be required in order to advertise all of the SRv6 End.X SIDs associated with that neighbor.

The SRv6 LAN End.X SID sub-TLV 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Type        |     Length    |                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+                               |
|             Neighbor System-ID (ID length octets)             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Flags       |   Algorithm   |   Weight      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       Endpoint Behavior       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| SID (128 bits) . . .                                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| SID (cont . . .)                                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| SID (cont . . .)                                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| SID (cont . . .)                                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Sub-sub-tlv-len|      sub-sub-TLVs (variable) . . .            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Type: 44

Length: variable.

Neighbor System-ID: IS-IS System-ID of length "ID Length" as defined in [ISO10589].

Flags: 1 octet.

```
 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+
|B|S|P|Reserved |
+-+-+-+-+-+-+-+-+
```

where B,S, and P flags are as described in Section 8.1. Reserved bits MUST be zero when originated and MUST be ignored when received.

Algorithm: 1 octet. Associated algorithm. Algorithm values are defined in the IGP Algorithm Type registry.

Weight: 1 octet. The value represents the weight of the End.X SID for the purpose of load balancing. The use of the weight is defined in [RFC8402].

Endpoint Behavior: 2 octets. As defined in [I-D.ietf-spring-srv6-network-programming] Legal behavior values for this sub-TLV are defined in Section 10.

SID: 16 octets. This field encodes the advertised SRv6 SID.

Sub-sub-TLV-length: 1 octet. Number of octets used by sub-sub-TLVs.

9. SRv6 SID Structure Sub-Sub-TLV

SRv6 SID Structure Sub-Sub-TLV is an optional Sub-Sub-TLV of:

SRv6 End SID Sub-TLV (Section 7.2)

SRv6 End.X SID Sub-TLV (Section 8.1)

SRv6 LAN End.X SID Sub-TLV (Section 8.2)

SRv6 SID Structure Sub-Sub-TLV is used to advertise the length of each individual part of the SRv6 SID as defined in [I-D.ietf-spring-srv6-network-programming]. It 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      Type     |    Length     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    LB Length  |  LN Length    | Fun. Length   |  Arg. Length  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

where:

Type: 1

Length: 4 octets.

LB Length: 1 octet. SRv6 SID Locator Block length in bits.

LN Length: 1 octet. SRv6 SID Locator Node length in bits.

Fun. Length: 1 octet. SRv6 SID Function length in bits.

Arg. Length: 1 octet. SRv6 SID Arguments length in bits.

ISIS SRv6 SID Structure Sub-Sub-TLV MUST NOT appear more than once in its parent Sub-TLV. If it appears more than once in its parent Sub-TLV, the parent Sub-TLV MUST be ignored by the receiver.

The sum of all four sizes advertised in ISIS SRv6 SID Structure Sub-Sub-TLV must be lower or equal to 128 bits. If the sum of all four sizes advertised in the ISIS SRv6 SID Structure Sub-Sub-TLV is larger than 128 bits, the parent Sub-TLV MUST be ignored by the receiver.

10. Advertising Endpoint Behaviors

Endpoint behaviors are defined in [I-D.ietf-spring-srv6-network-programming]. The codepoints for the Endpoint behaviors are defined in the "SRv6 Endpoint Behaviors" registry defined in [I-D.ietf-spring-srv6-network-programming]. This section lists the Endpoint behaviors which MAY be advertised by ISIS, together with their codepoints. If this behavior is advertised it MUST only be advertised in the TLV[s] as indicated by "Y" in the table below, and MUST NOT be advertised in the TLV[s] as indicated by "N" in the table below.

Endpoint Behavior	Endpoint Behavior Codepoint	End SID	End.X SID	Lan End.X SID
End (PSP, USP, USD)	1-4, 28-31	Y	N	N
End.X (PSP, USP, USD)	5-8, 32-35	N	Y	Y
End.DX6	16	N	Y	Y
End.DX4	17	N	Y	Y
End.DT6	18	Y	N	N
End.DT4	19	Y	N	N
End.DT64	20	Y	N	N

11. Implementation Status

RFC Ed.: Please remove this section prior to publication.

This section describes the implementation status of the ISIS SRv6 extensions.

11.1. Cisco

Cisco's ISIS SRv6 implementation supports following functionalities:

Types of SID supported: End, End.X, LAN End.X, END.OP

Intra/Inter area/level support: Yes

Anycast SID support: Yes, including A-flag (Section 6)

SID Structure Sub-Sub-TLV: Yes

11.2. Huawei

Huawei's ISIS SRv6 implementation supports following functionalities:

Types of SID supported: End, End.X, LAN End.X

Intra/Inter area/level support: Yes

Anycast SID support: Yes, no A-flag support (Section 6)

SID Structure Sub-Sub-TLV: Yes

11.3. Juniper

Juniper's ISIS SRv6 implementation supports following functionalities:

Types of SID supported: End, End.X, LAN End.X

Intra/Inter area/level support: Yes

Anycast SID support: Yes, no A-flag support (Section 6)

SID Structure Sub-Sub-TLV: No

11.4. Arrcus

Arrcus's ISIS SRv6 implementation supports following functionalities:

Types of SID supported: End, End.X, LAN End.X

Intra/Inter area/level support: Yes

Anycast SID support: No (Section 6)

SID Structure Sub-Sub-TLV: Yes

11.5. Interoperability Testing.

EANTC interoperability testing has been performed in April 2019. Results can be found at EANTC site [1].

12. IANA Considerations

This document requests allocation for the following TLVs, sub-TLVs, and sub-sub-TLVs as well updating the ISIS TLV registry and defining a new registry.

12.1. SRv6 Locator TLV

This document makes the following registrations in the the IS-IS TLV Codepoints registry:

Type: 27

Description: SRv6 Locator TLV.

Reference: This document (Section 7.1).

A Locator TLV shares sub-TLV space with existing "Sub-TLVs for TLVs 135, 235, 236 and 237 registry". The name of this registry needs to be changed to "Sub-TLVs for TLVs 27, 135, 235, 236 and 237 registry".

12.1.1. SRv6 End SID sub-TLV

This document makes the following registrations in the (renamed) "Sub-TLVs for TLVs 27, 135, 235, 236 and 237 registry":

Type: 5

Description: SRv6 End SID sub-TLV.

Reference: This document (Section 7.2).

12.1.2. Revised sub-TLV table

The revised table of sub-TLVs for the (renamed) "Sub-TLVs for TLVs 27, 135, 235, 236 and 237 registry" is shown below:

Type	27	135	235	236	237
1	y	y	y	y	y
2	y	y	y	y	y
3	n	y	y	y	y
4	y	y	y	y	y
5	y	n	n	n	n
6	n	y	y	y	y
11	y	y	y	y	y
12	y	y	y	y	y
32	n	y	y	y	y

12.2. SRv6 Capabilities sub-TLV

This document makes the following registrations in the "Sub- TLVs for TLV 242 registry":

Type: 25

Description: SRv6 Capabilities sub-TLV.

Reference: This document (Section 2).

This document requests the creation of a new IANA managed registry for sub-sub-TLVs of the SRv6 Capability sub-TLV. The registration procedure is "Expert Review" as defined in [RFC8126]. Suggested registry name is "sub-sub-TLVs for SRv6 Capability sub-TLV". No sub-sub-TLVs are defined by this document except for the reserved value.

0: Reserved

1-255: Unassigned

12.3. SRv6 End.X SID and SRv6 LAN End.X SID sub-TLVs

This document makes the following registrations in the "sub- TLVs for TLV 22, 23, 25, 141, 222 and 223 registry":

Type: 43

Description: SRv6 End.X SID sub-TLV.

Reference: This document (Section 8.1).

Type: 44

Description: SRv6 LAN End.X SID sub-TLV.

Reference: This document (Section 8.2).

Type	22	23	25	141	222	223
43	y	y	y	y	y	y
44	y	y	y	y	y	y

12.4. MSD Types

This document makes the following registrations in the IGP MSD Types registry:

Type	Description
41	SRH Max SL
42	SRH Max End Pop
44	SRH Max H.encaps
45	SRH Max End D

12.5. Sub-Sub-TLVs for SID Sub-TLVs

This document requests a new IANA registry be created under the IS-IS TLV Codepoints Registry to control the assignment of sub-TLV types for the SID Sub-TLVs specified in this document - Section 7.2, Section 8.1, Section 8.2. The suggested name of the new registry is "Sub-Sub-TLVs for SID Sub-TLVs". The registration procedure is "Expert Review" as defined in [RFC8126]. The following assignments are made by this document:

0: Reserved

1: SRv6 SID Structure Sub-Sub-TLV (Section 9).

12.6. Prefix Attribute Flags Sub-TLV

This document adds a new bit in the "Bit Values for Prefix Attribute Flags Sub-TLV" registry:

Bit #: 4

Description: A bit

Reference: This document (Section 6).

13. Security Considerations

Security concerns for IS-IS are addressed in [ISO10589], [RFC5304], and [RFC5310].

14. Contributors

The following people gave a substantial contribution to the content of this document and should be considered as co-authors:

Stefano Previdi
Huawei Technologies
Email: stefano@previdi.net

Paul Wells
Cisco Systems
Saint Paul,
Minnesota
United States
Email: pauwells@cisco.com

Daniel Voyer
Email: daniel.voyer@bell.ca

Satoru Matsushima
Email: satoru.matsushima@g.softbank.co.jp

Bart Peirens
Email: bart.peirens@proximus.com

Hani Elmalky
Email: hani.elmalky@ericsson.com

Prem Jonnalagadda
Email: prem@barefootnetworks.com

Milad Sharif
Email: msharif@barefootnetworks.com>

Robert Hanzl
Cisco Systems
Millenium Plaza Building, V Celnici 10, Prague 1,
Prague, Czech Republic
Email rhanzl@cisco.com

Ketan Talaulikar
Cisco Systems, Inc.
Email: ketant@cisco.com

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Authors' Addresses

Peter Psenak (editor)
Cisco Systems
Pribinova Street 10
Bratislava 81109
Slovakia

Email: ppsenak@cisco.com

Clarence Filsfils
Cisco Systems
Brussels
Belgium

Email: cfilsfil@cisco.com

Ahmed Bashandy
Individual

Email: abashandy.ietf@gmail.com

Bruno Decraene
Orange
Issy-les-Moulineaux
France

Email: bruno.decraene@orange.com

Zhibo Hu
Huawei Technologies

Email: huzhibo@huawei.com