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

The Segment Routing (SR) architecture allows flexible definition of the end-to-end path by encoding it as a sequence of topological elements called "segments". It can be implemented over the MPLS or the IPv6 data plane. This document describes the IS-IS extensions required to support Segment Routing over the IPv6 data plane.

This document updates RFC 7370 by modifying an existing registry.

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

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

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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 [RFC8986] 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 [RFC8986] is necessary to understand the extensions specified in this document.

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 Capabilities sub-TLV announces the ability to support SRv6.

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

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.

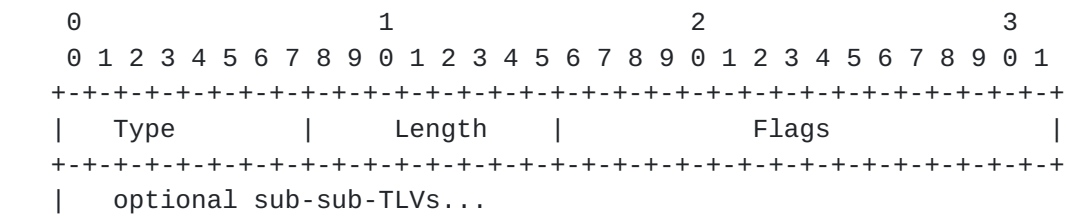
This document updates [RFC7370] by modifying an existing registry (Section 11.1.2).

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.

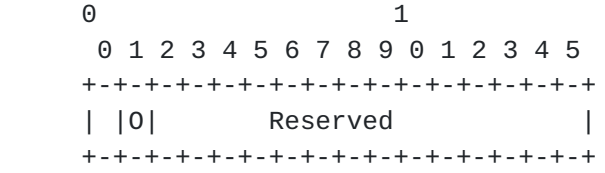
The SRv6 Capabilities sub-TLV has the following format:



Type: 25

Length: 2 + length of sub-sub-TLVs

Flags: 2 octets The following flags are defined:



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].

The remaining bits, including bit 0, are reserved for future use. They MUST be set to zero on transmission and MUST be ignored on receipt.

3. Advertising Supported Algorithms

An SRv6 capable router indicates supported algorithm(s) by advertising the Segment Routing Algorithm sub-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, 25, 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 signals the maximum value of the "Segments Left" field [RFC8754] in the SRH of a received packet before applying the Endpoint behavior associated with a SID.

SRH Max Segments Left Type: 41

If no value is advertised, the supported value is 0.

4.2. Maximum End Pop MSD Type

The Maximum End Pop MSD Type signals the maximum number of SIDs in the SRH to which the router can apply "Penultimate Segment Pop of the SRH" or "Ultimate Segment Pop of the SRH" behavior, as defined in [RFC8986] flavors.

SRH Max End Pop Type: 42

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

4.3. Maximum H.Encaps MSD Type

The Maximum H.Encaps MSD Type signals the maximum number of SIDs that can be added to the Segment List of an SRH as part of the "H.Encaps" behavior as defined in [RFC8986].

SRH Max H.encaps Type: 44

If the advertised value is zero or no value is advertised, then the headend can apply an SR Policy that only contains one segment, without inserting any SRH header.

A non-zero SRH Max H.encaps MSD indicates that the headend can insert an SRH up to the advertised number of SIDs.

4.4. Maximum End D MSD Type

The Maximum End D MSD Type specifies the maximum number of SIDs present in an SRH when performing decapsulation. As specified in [RFC8986] the permitted SID types include, but are not limited to End.DX6, End.DT4, End.DT46, End with USD, End.X with USD.

SRH Max End D Type: 45

If the advertised value is zero or no value is advertised then the router cannot apply any behavior that results in decapsulation and forwarding of the inner packet if the outer IPv6 header contains an SRH.

5. SRv6 SIDs and Reachability

As discussed in [RFC8986], 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. The processing of the prefix advertised in the SRv6 Locator TLV, the calculation of its reachability and the installation in the forwarding plane follows the process defined for the Prefix Reachability TLV 236 [RFC5308], or TLV 237 [RFC5120].

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 the same prefix, with the same prefix-length, Multi Topology ID (MT ID), and algorithm 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. Such preference of Prefix Reachability advertisement does not have any impact on the rest of the data advertised in the SRv6 Locator TLV.

Locators associated with Flexible Algorithms (see Section 4 of [I-D.ietf-lsr-flex-algo]) SHOULD NOT be advertised in Prefix Reachability TLVs (236 or 237). Advertising the Flexible Algorithm locator in regular Prefix Reachability TLV (236 or 237) would make the forwarding for it to follow algo 0 path.

SRv6 SIDs are advertised as sub-TLVs in the SRv6 Locator TLV except for SRv6 SIDs which are associated with a specific Neighbor/Link and are therefore advertised as sub-TLVs in TLVs 22, 23, 25, 141, 222, and 223.

SRv6 SIDs received from other nodes 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. In order to ensure correct forwarding, network operators should take steps to make sure that this requirement is not compromised. For example, the following situations should be avoided:

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

- Another 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 Prefix Attribute Flags Sub-TLV [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 the advertisement is 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 is considered node specific.

All the nodes advertising the same anycast locator MUST instantiate the exact same set of SIDs under that 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 the same flags in the Prefix Attribute Flags Sub-TLV in both TLVs. However, unlike TLVs 236 [RFC5308] and 237 [RFC5120] the X-flag in the Prefix Attributes Flags sub-TLV is valid when sent in the SRv6 Locator TLV. The state of the X-flag in the Prefix Attributes Flags sub-TLV when included in the Locator TLV MUST match the setting of the embedded "X-bit" in any advertisement for the same prefix in TLVs 236 [RFC5308] and 237 [RFC5120]. In case of any inconsistency between the Prefix Attribute Flags advertised in the Locator TLV and in the Prefix Reachability TLV, the ones advertised in Prefix Reachability TLV MUST be preferred.

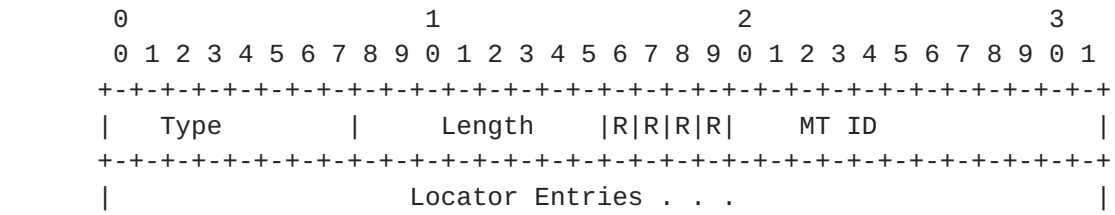
7. Advertising Locators and End SIDs

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:



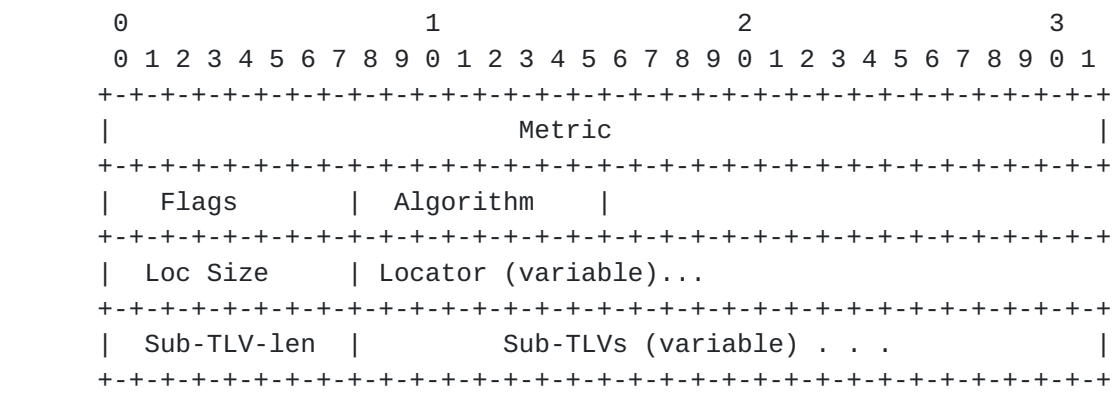
Type: 27

Length: variable.

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

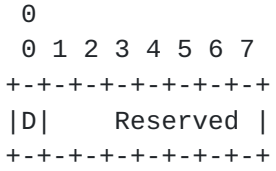
MT ID: Multitopology Identifier as defined in [RFC5120]. Note that the value 0 is legal.

Followed by one or more locator entries of the form:



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

Flags: 1 octet. The following flags are defined:



D-flag: Same as described in section 4.1. of [RFC5305].

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. As defined in IGP Algorithm Types registry [RFC8665].

Loc-Size: 1 octet. Number of bits in the SRv6 Locator field. MUST be from the range (1 - 128). The TLV MUST be ignored if the Loc-Size is outside this range.

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: Supported sub-TLVs are specified in Section 11.1.2. Any Sub-TLV that is not allowed in the SRv6 Locator TLV MUST be ignored.

Prefix Attribute Flags Sub-TLV [RFC7794] SHOULD be included in the Locator TLV.

Prefix Attribute Flags Sub-TLV MUST be included in the the Locator TLV when it is leaked upwards in the hierarchy or originated as a result of the redistribution from another protocol or another ISIS instance. If the Prefix Attribute Flags Sub-TLV is not included in these cases, receivers will be unable to determine the correct source of the advertisement. The receivers will be unable to detect the violation.

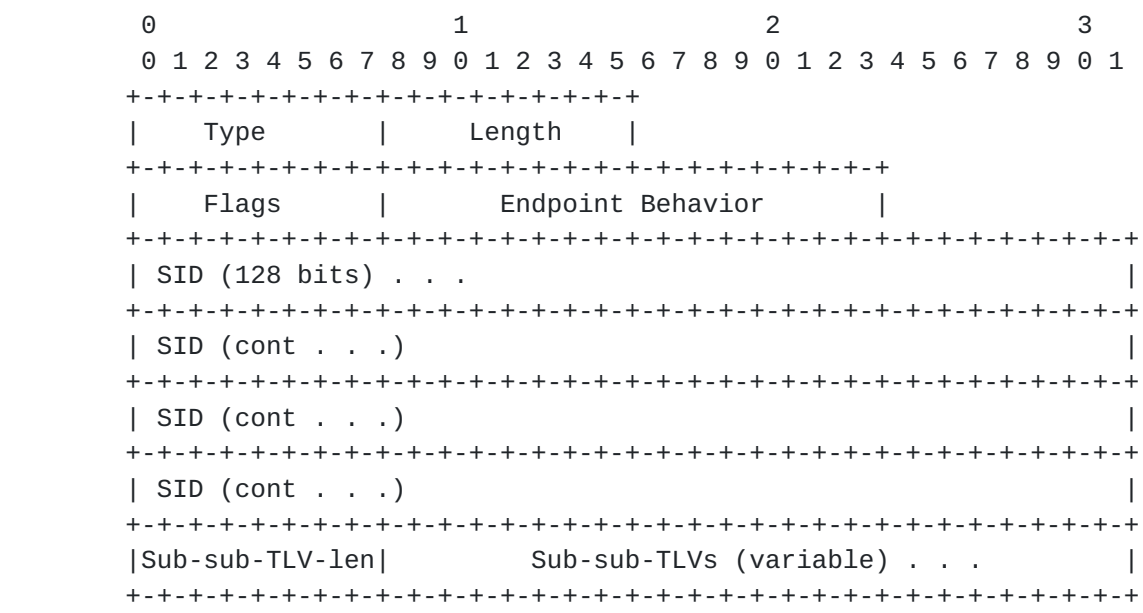
7.2. SRv6 End SID sub-TLV

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. SRv6 SIDs associated with a neighbor are advertised using the sub-TLVs defined in Section 8.

Supported behavior values, together with parent TLVs in which they are advertised, are specified in Section 10 of this document. Please note that not all behaviors defined in [RFC8986] are defined in this document, e.g. END.T is not.

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:



Type: 5.

Length: variable.

Flags: 1 octet. No flags are currently defined. All bits are reserved for future use. They MUST be set to zero on transmission and MUST be ignored on receipt.

Endpoint Behavior: 2 octets, as defined in [RFC8986]. Supported behavior values for this sub-TLV are defined in Section 10 of this document. Unsupported or unrecognized behavior values are ignored by the receiver.

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: Supported Sub-sub-TLVs are specified in Section 11.6. Any Sub-sub-TLV that is not allowed in SRv6 End SID sub-TLV MUST be ignored.

The SRv6 End SID MUST be allocated from its associated locator. SRv6 End SIDs that are not allocated from 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 [RFC8986] are associated with a particular adjacency.

This document defines two new sub-TLVs of TLV 22, 23, 25, 141, 222, and 223 - namely "SRv6 End.X SID sub-TLVs" and "SRv6 LAN End.X SID sub-TLVs".

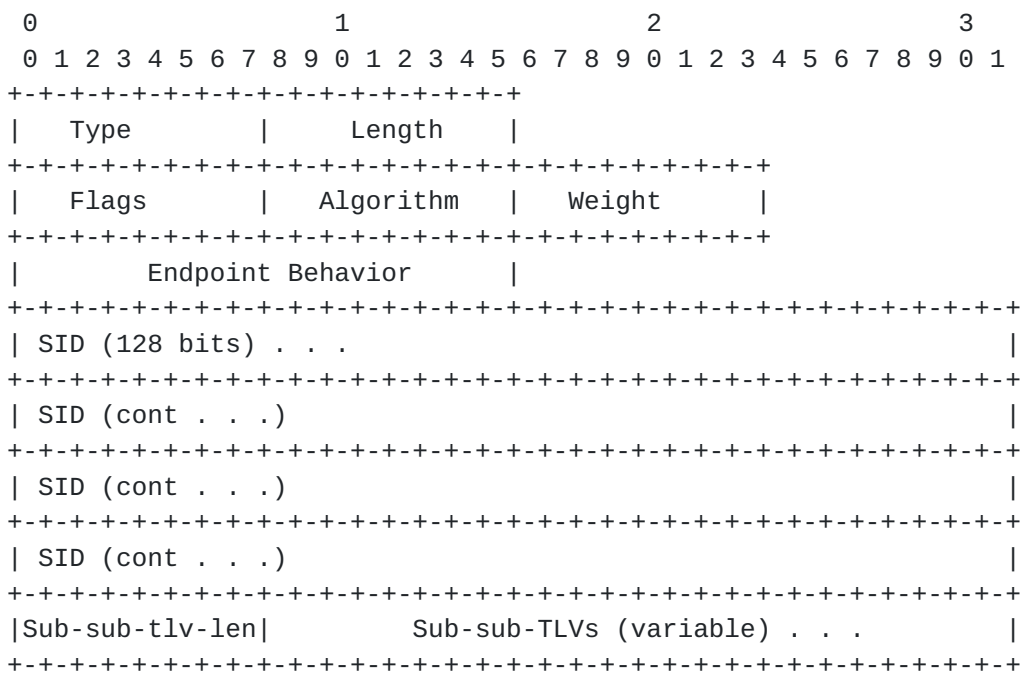
IS-IS Neighbor advertisements are topology specific - but not algorithm specific. SIDs advertised in SRv6 End.X SID and SRv6 LAN End.X SID sub-TLVs therefore inherit the topology from the associated neighbor advertisement, but the algorithm is specified in the individual SID.

All SIDs advertised in SRv6 End.X SID and SRv6 LAN End.X SID sub-TLVs MUST be a subnet of a Locator with matching topology and algorithm which is advertised by the same node in an SRv6 Locator TLV. SIDs that do not meet this requirement MUST be ignored. This ensures that the node advertising these SIDs 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.

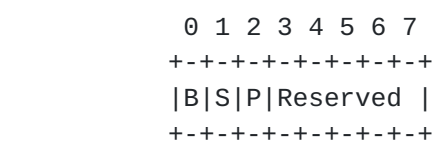
The SRv6 End.X SID sub-TLV has the following format:



Type: 43

Length: variable.

Flags: 1 octet.



where:

B-Flag: Backup flag. If set, the SID is eligible for protection, e.g., using IP Fast Re-route (IPFRR) [RFC5286], as described in [RFC8355].

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

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

Algorithm: 1 octet. As defined in IGP Algorithm Types registry [RFC8665].

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

Endpoint Behavior: 2 octets. As defined in [RFC8986]. Supported behavior values for this sub-TLV are defined in Section 10 of this document. Unsupported or unrecognized behavior values are ignored by the receiver.

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

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

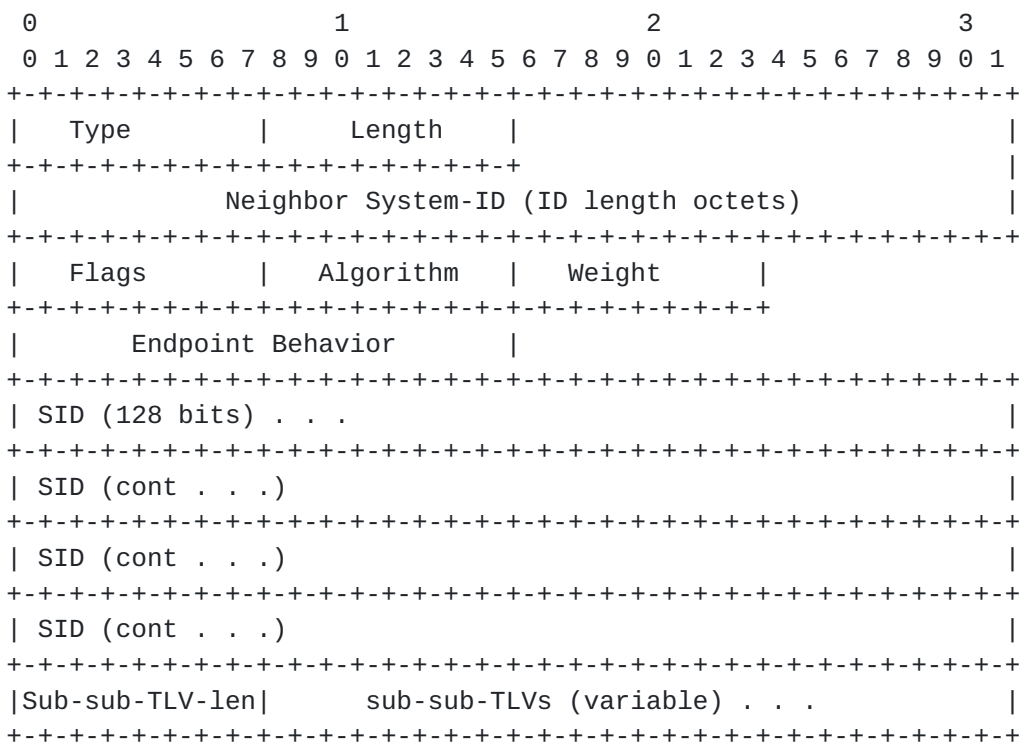
Optional Sub-sub-TLVs: Supported Sub-sub-TLVs are specified in Section 11.6. Any Sub-sub-TLV that is not allowed in SRv6 End.X SID sub-TLV MUST be ignored.

Note that multiple TLVs for the same neighbor may be required in order to advertise all the SRv6 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 many neighbors may exist on a given LAN, multiple 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 the SRv6 SIDs associated with that neighbor.

The SRv6 LAN End.X SID sub-TLV has the following format:

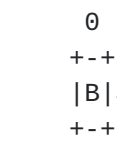


Type: 44

Length: variable.

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

Flags: 1 octet.



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. As defined in IGP Algorithm Types registry [RFC8665].

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

Endpoint Behavior: 2 octets. As defined in [RFC8986]. Supported behavior values for this sub-TLV are defined in Section 10 of this document. Unsupported or unrecognized behavior values are ignored by the receiver.

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: Supported Sub-sub-TLVs are specified in Section 11.6. Any Sub-sub-TLV that is not allowed in SRv6 LAN End.X SID sub-TLV MUST be ignored.

Note that multiple TLVs for the same neighbor, on the same LAN, may be required in order to advertise all the SRv6 SIDs associated with that neighbor.

9. SRv6 SID Structure Sub-Sub-TLV

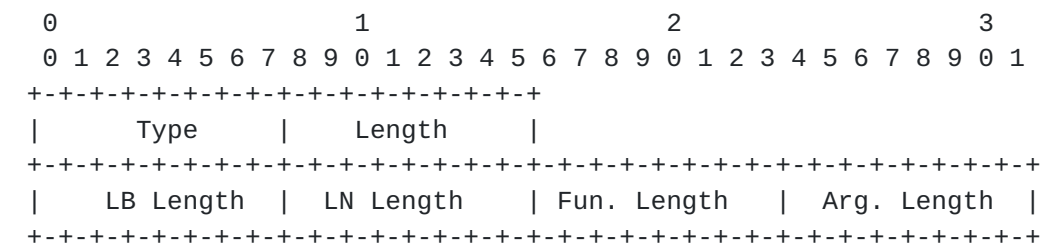
SRv6 SID Structure Sub-Sub-TLV is an optional Sub-Sub-TLV of:

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 structure of the SRv6 SID as defined in [RFC8986]. It has the following format:



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 less than 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.

The SRv6 SID Structure Sub-Sub-TLV is intended for informational use by the control and management planes. It MUST NOT be used at a transit node (as defined in [RFC8754]) for forwarding packets. As an example, this information could be used for:

- validation of SRv6 SIDs being instantiated in the network and advertised via ISIS. These can be learnt by controllers via BGP-LS and then be monitored for conformance to the SRv6 SID allocation scheme chosen by the operator as described in Section 3.2 of [RFC8986].

- verification and the automation for securing the SRv6 domain by provisioning filtering rules at SR domain boundaries as described in Section 5 of [RFC8754].

The details of these potential applications are outside the scope of this document.

10. Advertising Endpoint Behaviors

Endpoint behaviors are defined in [RFC8986]. The codepoints for the Endpoint behaviors are defined in the "SRv6 Endpoint Behaviors" registry defined in [RFC8986]. If a 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.DT46	20	Y	N	N

11. IANA Considerations

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

11.1. SRv6 Locator TLV

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

Type	Description	IIH	LSP	SNP	Purge
27	SRv6 Locator TLV	n	y	n	n

11.1.1. SRv6 End SID sub-TLV

The SRv6 Locator TLV shares sub-TLV space with TLVs 135, 235, 236 and 237. This document updates the "Sub-TLVs for TLVs 135, 235, 236, and 237 (Extended IP reachability, MT IP. Reach, IPv6 IP. Reach, and MT IPv6 IP. Reach TLVs)" registry defined in [RFC7370]. IANA is requested to update the name of the "Sub-TLVs for TLVs 135, 235, 236, and 237 (Extended IP reachability, MT IP. Reach, IPv6 IP. Reach, and MT IPv6 IP. Reach TLVs)" registry to "Sub-TLVs for TLVs 27, 135, 235, 236, and 237 (SRv6 Locator, Extended IP reachability, MT IP. Reach, IPv6 IP. Reach, and MT IPv6 IP. Reach TLVs)".

IANA is asked to add this document as a reference to (renamed) "Sub-TLVs for TLVs 27, 135, 235, 236, and 237 (SRv6 Locator, Extended IP

reachability, MT IP. Reach, IPv6 IP. Reach, and MT IPv6 IP. Reach TLVs)" registry.

This document makes the following registrations in the (renamed) "Sub-TLVs for TLVs 27, 135, 235, 236, and 237 (SRv6 Locator, Extended IP reachability, MT IP. Reach, IPv6 IP. Reach, and MT IPv6 IP. Reach TLVs)" registry:

Type: 5

Description: SRv6 End SID sub-TLV.

Reference: This document (Section 7.2).

11.1.2. Revised sub-TLV table

The revised table of sub-TLVs for the (renamed) "Sub-TLVs for TLVs 27, 135, 235, 236, and 237 (SRv6 Locator, Extended IP reachability, MT IP. Reach, IPv6 IP. Reach, and MT IPv6 IP. Reach TLVs)" 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

11.2. SRv6 Capabilities sub-TLV

This document makes the following registrations in the "Sub-TLVs for TLV 242 (IS-IS Router CAPABILITY TLV)":

Type: 25

Description: SRv6 Capabilities sub-TLV.

Reference: This document (Section 2).

11.3. Sub-Sub-TLVs of the SRv6 Capability sub-TLV

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 SRv6 Capability sub-TLV specified in this document - Section 2. The suggested name of the new registry is "sub-sub-TLVs of the SRv6 Capability sub-TLV". The registration procedure is "Expert Review" as defined in [RFC8126]. Guidance for the Designated Experts is provided in the [RFC7370]. No sub-sub-TLVs are defined by this document except for the reserved value.

0: Reserved

1-255: Unassigned

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

This document makes the following registrations in the "Sub-TLVs for TLVs 22, 23, 25, 141, 222, and 223 (Extended IS reachability, IS Neighbor Attribute, L2 Bundle Member Attributes, inter-AS reachability information, MT-ISN, and MT IS Neighbor Attribute TLVs)" 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

11.5. MSD Types

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

Value	Name	Reference
41	SRH Max SL	[This Document]
42	SRH Max End Pop	[This Document]
44	SRH Max H.encaps	[This Document]
45	SRH Max End D	[This Document]

11.6. 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 SRv6 End SID (5) (sub-TLV of TLVs 27, 135, 235, 236 and 237) and SRv6 End.X SID (43)/SRv6 LAN End.X SID (44) (Sub-TLVs for TLVs 22, 23, 25, 141, 222, and 223)". The registration procedure is "Expert Review" as defined in [RFC8126]. Guidance for the Designated Experts is provided in [RFC7370]. The following assignments are made by this document:

Type	Description	Encoding Reference
0	Reserved	
1	SRv6 SID Structure Sub-Sub-TLV	[This Document]
2-255	Unassigned	

Type	5	43	44
1	y	y	y

11.7. 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: Anycast Flag (A-flag)

Reference: This document (Section 6).

11.8. ISIS SRv6 Capabilities sub-TLV Flags Registry

This document requests a new IANA registry be created under the IS-IS TLV Codepoints Registry to control the assignment of bits 0 to 15 in the Flags field of the ISIS SRv6 Capabilities sub-TLV specified in this document (Section 2). The suggested name of the new registry is "ISIS SRv6 Capabilities sub-TLV Flags". The registration procedure is "Expert Review" as defined in [RFC8126]. Guidance for the Designated Experts is provided in [RFC7370]. The following assignments are made by this document:

Bit #: 1

Description: O-flag

Reference: This document (Section 2).

11.9. ISIS SRv6 Locator TLV Flags Registry

This document requests a new IANA registry be created under the IS-IS TLV Codepoints Registry to control the assignment of bits 0 to 7 in the Flags field of the ISIS SRv6 Locator TLV specified in this document (Section 7.1). The suggested name of the new registry is "ISIS SRv6 Locator TLV Flags". The registration procedure is "Expert Review" as defined in [RFC8126]. Guidance for the Designated Experts is provided in [RFC7370]. The following assignments are made by this document:

Bit #: 0

Description: D-flag

Reference: This document (Section 7.1).

11.10. ISIS SRv6 End SID sub-TLV Flags Registry

This document requests a new IANA registry be created under the IS-IS TLV Codepoints Registry to control the assignment of bits 0 to 7 in the Flags field of the ISIS SRv6 End SID sub-TLV specified in this document (Section 7.2). The suggested name of the new registry is "ISIS SRv6 End SID sub-TLV Flags". The registration procedure is "Expert Review" as defined in [RFC8126]. Guidance for the Designated Experts is provided in [RFC7370]. No assignments are made by this document.

11.11. ISIS SRv6 End.X SID and LAN End.X SID sub-TLVs Flags Registry

This document requests a new IANA registry be created under the IS-IS TLV Codepoints Registry to control the assignment of bits 0 to 7 in the Flags field of the ISIS SRv6 End.X SID and LAN End.X SID sub-TLVs (Section 8.1 and Section 8.2). The suggested name of the new registry is "ISIS SRv6 End.X SID and LAN End.X SID sub-TLVs Flags". The registration procedure is "Expert Review" as defined in [RFC8126]. Guidance for the Designated Experts is provided in [RFC7370]. The following assignments are made by this document:

Bit #: 0

Description: B-flag

Reference: This document (Section 8.1).

Bit #: 1

Description: S-flag

Reference: This document (Section 8.1).

Bit #: 2

Description: P-flag

Reference: This document (Section 8.1).

12. Security Considerations

Security concerns for IS-IS are addressed in [ISO10589], [RFC5304], and [RFC5310]. While IS-IS is deployed under a single administrative domain, there can be deployments where potential attackers have access to one or more networks in the IS-IS routing domain. In these deployments, the stronger authentication mechanisms defined in the aforementioned documents SHOULD be used.

This document describes the IS-IS extensions required to support Segment Routing over an IPv6 data plane. The security considerations for Segment Routing are discussed in [RFC8402]. [RFC8986] defines the SRv6 Network Programming concept and specifies the main Segment Routing behaviors to enable the creation of interoperable overlays; the security considerations from that document apply too.

The advertisement for an incorrect MSD value may have negative consequences, see [RFC8491] for additional considerations.

Security concerns associated with the setting of the O-flag are described in [I-D.ietf-6man-spring-srv6-oam].

Security concerns associated with the usage of Flex-Algorithms are described in [I-D.ietf-lsr-flex-algo]).

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