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**IS-IS Extensions 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.

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1. Introduction

With Segment Routing (SR)[[9](#)], 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 [[10](#)]. SRv6 refers to this SR instantiation on the IPv6 dataplane.

The network programming paradigm [[11](#)] is central to SRv6.

It describes how any function can be bound to a SID and how any network program can be expressed as a combination of SID's.

It defines several well-known functions such as End, End.X, T.Insert, T.Encaps, etc.

This document specifies IS-IS extensions that allow IS-IS protocol to encode some of these functions.

Familiarity with the network programming paradigm [[11](#)] is necessary to understand the extensions specified in this document.

This document defines one new top level IS-IS_TLV and three new IS-IS sub-TLVs.

The SRv6 Capabilities sub-TLV announces the ability to support SRv6 and some functions defined in [[11](#)] as well as advertising limitations when applying such functions.

The SRv6 SID top level TLV, the P2P SRv6 X-SID sub-TLV, and the LAN SRv6 X-SID sub-TLV are used to advertise which SIDs are instantiated at a node and what function is bound to each instantiated SID.

Only ISIS-related functions such as End and its variants D and X [[11](#)] are defined in this document.

1.1. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC-2119](#) [[8](#)].

In this document, these words will appear with that interpretation only when in ALL CAPS. Lower case uses of these words are not to be interpreted as carrying [RFC-2119](#) [8] significance.

2. SRv6-Capabilities sub-TLV

As described in [\[10\]](#) and [\[11\]](#), the list of Segments is stored in the segment routing header referred hereafter as "SRH".

A router that supports SRv6 MUST be able to process the segment routing header as described in [\[10\]](#) and [\[11\]](#) up to the limitations set by the advertised SRv6-capabilities sub-TLV.

To announce this ability, a router uses the newly defined SRv6-capabilities sub-TLV of the router capabilities TLV [\[1\]](#). The SRv6-capabilities sub-TLV may contain optional sub-sub-TLVs in the future.

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      |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|      max-SL   |Max-End-Pop-SRH| Max-T-Ins-SRH |Max-T-Encap-SRH|
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
| max-End-D-SRH |
+---+---+---+---+---+---+

```

Type: Suggested value 22, to be assigned by IANA

Length: 7 + 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
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|E|
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

where:

E-flag: If set, then router is able to apply "T.Encap" operation

Max-SL: 1 octet.

This field specifies the maximum value of the "SL" field [[10](#)] in the SRH of a received packet before applying the function associated with a SID.

Max-End-Pop-SRH: 1 Octet

This field specifies the maximum number of SIDs in the top SRH in an SRH stack that the router can apply "PSP" or USP" [[11](#)] flavors to. If the value of this field is zero, then the router cannot apply PSP or USP flavors.

Max-T-Ins-SRH: 1 octet

This field specifies the maximum number of SIDs that can be inserted as part of the "T.insert" behavior [[11](#)]. If the value of this field is zero, then the router cannot apply any variation of the "T.insert" behavior.

Max-T-Encap-SRH: 1 octet

This field specifies the maximum number of SIDs that can be included as part of the "T.Encap" behavior [[11](#)]. If this field is zero and the "E" flag is set, then the router can apply T.Encap by encapsulating the incoming packet in another IPv6 header without SRH the same way IPinIP encapsulation is performed. If the "E" flag is clear, then this field SHOULD be transmitted as zero and MUST be ignored on receipt.

max-End-D-SRH: 1 octet

This field specifies the maximum number of SIDs in an SRH when applying "End.DX6" and "End.DT6" functions. If this field is zero, then the router cannot apply "End.DX6" or "End.DT6" functions if the extension header right underneath the outer IPv6 header is an SRH.

3. SRv6-function Descriptor

The SRv6 SID TLV defined in [Section 4](#), P2P SRv6 X-SID sub-TLV specified in [Section 6.1](#), and LAN SRv6 X-SID sub-TLV specified in [section 6.2](#) MUST include one SRv6 function Descriptor.

When included in the SRv6 SID TLV, the descriptor is encoded as a sub-TLV. When included in a P2P/LAN SRv6 X-SID sub-TLV, the descriptor is encoded as a sub-sub-TLV.

The SRv6-function Descriptor encodes the function (and its flavors) bound to the SRv6 SID advertised in the SRv6 SID TLV [[11](#)].

The SRv6 SID function Descriptor 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      | Behavior (variable) ..
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

Type: See IANA considerations in [Section 7](#).

Length: 3 * (number of functions)

Behavior: One function (with its associated flavors) encoded in 3 octets as shown in the following diagram

```

0                               1
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|P|U| Reserved  |      Function      |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

The first octet encodes flags. This document defines two flags to specify the flavor(s) [[11](#)] associated with the SRv6 function specified in the "Function" field:

P bit: If set, then the PSP flavor [[11](#)] is associated with the function encoded in the "function" field

U bit: If set, then the USP flavor [[11](#)] is associated with the function encoded in the "function" field

Reserved Bits SHOULD be transmitted as 0 and MUST be ignored on receipt.

The second two octets encode the function. Function code points are defined in [Section 5](#).

For a given SRv6 SID function encoded in the "Function" field, the "P" and "U" bits are set/cleared according to the rules of enabling/disabling the PSP and USP flavors, respectively, for that function as specified in [\[11\]](#).

4. SRv6-SID TLV

A new top level TLV is introduced to advertise SRv6 Segment Identifiers (SID) and their attributes.

The new TLV is used to advertise SRv6 SIDs with any of the functions defined in [\[11\]](#) whose code point is defined in this document except those SIDs which must be associated with a particular neighbor in order to be correctly applied [\[11\]](#). SRv6 SIDs associated with a neighbor are advertised in the sub-TLVs defined in [Section 6](#).

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

The SRv6 SID 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      |  SID-size  |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|      SID (variable) . . .      |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
| sub-tlv-len    |      Sub-TLVs (variable) . . .      |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

Type: 27 (Suggested value to be assigned by IANA)

Length: variable.

One or more SID entries, each of which has the following format:

Flags: 1 octet. The following flags are defined

```

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

```

where:

D bit: When the SID is leaked from level-2 to level-1, the D bit MUST be set. Otherwise, this bit MUST be clear. SIDs 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 SHOULD be set to zero on transmission and MUST be ignored on receipt.

SID-Size: 1 octet. Number of bits in the SID field.

SID: 1-16 octets. This field encodes the advertised SRv6 SID. The "SID-size" field can have the values 1-128 and indicates the number of bits in the SID. The SRv6 SID is encoded in the minimal number of octets for the given number of bits. The owning router may associate one or more functions as specified in [\[11\]](#), in other documents, or as locally configured.

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

The function associated with the advertised SID is specified by the SRv6-Function Descriptor sub-TLV specified in [Section 3](#).

5. Function Code points.

This section defines the code points for supported functions associated with SRv6 SIDs. Functions are defined in [\[11\]](#).

- o 0: Reserved
- o 1: End Function.
- o 2: End.DX6 Function.
- o 3: End.DT6 Function.
- o 4: End.X Function.

6. Advertising SRv6 SIDs associated with a Neighbor.

Certain SRv6 functions [\[11\]](#) must be associated with a particular neighbor, and in case of multiple layer 3 links to the same neighbor, with a particular link in order to be correctly applied.

This document specifies how to advertise two such functions in IS-IS, namely End.X and End.DX6 [\[11\]](#).

SIDs associated with End.X and End.DX6 functions are advertised within neighbor reachability TLVs.

This document defines two new sub-TLVs of TLV 22 [4], 23 [6], 222 [5], 223[6], and 141 [7] namely "P2P SRv6 X-SID" and "LAN SRv6 X-SID".

6.1. P2P SRv6 X-SID sub-TLV

This sub-TLV is used to advertise one or more SRv6 SIDs associated with End.X and End.DX6 [11] functions over a point to point adjacency.

The "P2P SRv6 X-SID" sub-TLV has the following format

```

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       |  SID-size   |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|      SID (variable) . . .                               |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|sub-sub-tlv-len|      Sub-sub-TLVs (variable) . . .       |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

Type: 40 (Suggested value to be assigned by IANA)

Length: variable.

One or more SIDs each of which has the following format:

Flags: 1 octet. No flags defined in this document

SID-Size: 1 octet. Number of bits in the SID field.

SID: 1-16 octets. This field encodes the advertised SRv6 SID. The "SID-size" field can have the values 1-128 and indicates the number of bits in the SID. The SRv6 SID is encoded in the minimal number of octets for the given number of bits. The owning router may associate one or more functions as specified in [11], in other documents, or as locally configured.

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

The function associated with the advertised SID is specified by the SRv6-Function Descriptor sub-sub-TLV specified in [Section 3](#). If the SRv6-Function Descriptor is encoded in the P2P SRv6 X-SID sub-TLV, then the encoded SRv6 SID function MUST include only the code points of SRv6 SID functions that require the specification of a neighbor to be correctly applied. This document specifies the code points of two such functions, namely End.X and End.DX6 [\[11\]](#).

6.2. LAN SRv6 X-SID sub-TLV

This sub-TLV is used to advertise one or more SRv6 SIDs associated with End.X and End.DX6 [\[11\]](#) functions over a LAN adjacency. The "LAN SRv6 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								
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--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+																																							

Type: 41 (Suggested value to be assigned by IANA)

Length: variable.

System-ID: 6 octets of IS-IS System-ID of length "ID Length" as defined in [\[2\]](#).

One or more SIDs each of which has the following format:

Flags 1 Octet. No flags are defined in this document

SID-Size: 1 octet. Number of bits in the SID field.

SID: 1-16 octets. This field encodes the advertised SRv6 SID. The "SID-size" field can have the values 1-128 and indicates the number of bits in the SID. The SRv6 SID is encoded in the minimal number of octets for the given number of bits. The owning router may associate one or more functions as specified in [\[11\]](#), in other documents, or as locally configured.

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

The function associated with the advertised SID is specified by the SRv6-Function Descriptor sub-sub-TLV specified in [Section 3](#). If the SRv6-Function Descriptor is encoded in the P2P SRv6 X-SID sub-TLV, then the encoded SRv6 SID function MUST include only the code points of SRv6 SID functions that require the specification of a neighbor to be correctly applied. This document specifies the code points of two such functions, namely End.X and End.DX6 [\[11\]](#).

7. IANA Considerations

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

7.1. SRv6 SID TLV and sub-TLVs

This document adds the following new TLV to the IS-IS TLV Codepoints registry.

Value: 27 (suggested - to be assigned by IANA)

Name: SRv6 SID

The name of the "Sub-TLVs for TLVs 135, 235, 236 and 237 registry" needs to be changed to "Sub-TLVs for TLVs 27, 135, 235, 236 and 237 registry".

This document adds a new sub-TLV to the (renamed) "Sub-TLVs for TLVs 27, 135, 235, 236 and 237 registry".

Value: 5 (Suggested - to be assigned by IANA)

Name: SRv6-function Descriptor

The revised table of sub-TLVs in the registry should be:

Type	27	135	235	236	237
1	n	y	y	y	y
2	n	y	y	y	y
3	y	y	y	y	y
4	y	y	y	y	y
5(new)	y	n	n	n	n
11	y	y	y	y	y

12	y	y	y	y	y
----	---	---	---	---	---

7.2. IS-IS SRv6-functions Codepoints Registry

This document requests the creation of a new IANA managed registry to identify SRv6 SID functions. The registration procedure is "Expert Review" as defined in [3]. Suggested registry name is "SRv6 SID Function Types". A function identifier is an unsigned 8 bits value. The following values are defined by this document:

0 Reserved

1 End function.

2 End.DX6 function.

3 End.DT6 function.

4 End.X function.

7.3. SRv6 Capabilities sub-TLV

This document adds the definition of a new sub-TLV in the "Sub-TLVs for TLV 242 registry".

Type: 22 (Suggested - to be assigned by IANA)

Description: SRv6 Capabilities

7.4. P2P SRv6 X-SID and LAN SRv6 X-SID sub-TLVs

This document adds the definition of two new sub-TLVs in the "sub-TLVs for TLV 22, 23, 141, 222 and 223 registry".

Type: 40 (suggested - to be assigned by IANA)

Description: Point-to-Point SRv6 X-SID

Type: 41 (suggested - to be assigned by IANA)

Description: LAN SRv6 X-SID

Type	22	23	141	222	223
------	----	----	-----	-----	-----

40	y	y	y	y	y
----	---	---	---	---	---

41	y	y	y	y	y
----	---	---	---	---	---

7.5. IS-IS SRv6 X-SID sub-sub-TLV Codepoints Registry

This document requests the creation of a new IANA managed registry to identify SRv6 SID functions encoded in P2P/LAN X-SID sub-TLVs. The registration procedure is "Expert Review" as defined in [3]. Suggested registry name is "SRv6 X-SID sub-sub-TLV Codepoints Registry". The following values are defined by this document:

Value: 5 (Suggested - to be assigned by IANA)

Name: SRv6-function Descriptor

This sub-sub-TLV MAY appear in either the Point-to-Point SRv6 X-SID or the LAN SRv6 X-SID sub-TLVs described in [Section 7.4](#).

8. Security Considerations

TBD

9. Contributors

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

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11. Acknowledgments

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