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Applying BGP-LS Segment Routing over IPv6(SRv6) Extensions to BGP-LS-SPF
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Abstract

For network scenarios such as Massively Scaled Data Centers (MSDCs), BGP is extended for Link-State (LS) distribution and the Shortest Path First (SPF) algorithm based calculation. BGP-LS-SPF leverages the mechanisms of both BGP protocol and BGP-LS protocol extensions. Segment Routing over IPv6 (SRv6) provides a source routing mechanism that allows a flow to be restricted to a specific topological path, while maintaining per-flow state only at the ingress node(s) to the SRv6 domain. In some networks, it may be useful to enable SRv6 based source routing mechanism together with BGP-LS-SPF. This document proposes to introduce the BGP Link-State (BGP-LS) extensions for SRv6 to the BGP-LS-SPF SAFI.

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1. Introduction

[RFC9815] extends BGP for Link-State (LS) distribution and the Shortest Path First (SPF) algorithm based calculation. BGP-LS-SPF leverages the mechanisms of both BGP protocol [RFC4271] and BGP-LS protocol extensions [RFC9552], with the extensions to BGP-LS attribute and new NLRI selection rules.

Segment Routing over IPv6 (SRv6) allows for a flexible definition of end-to-end paths within various topologies by encoding paths as sequences of topological or functional sub-paths called "segments". SRv6 provides a mechanism that allows a flow to be restricted to a specific topological path, while maintaining per-flow state only at the ingress node(s) to the SRv6 domain.

In network scenarios such as Data Center networks, WAN networks or other networks where BGP-LS-SPF can be used as the underlay routing protocol, it may be useful to enable SRv6 based source routing mechanism for traffic engineering and optimization. This document proposes to introduce the BGP Link-State (BGP-LS) extensions for SRv6 to the BGP-LS-SPF SAFI, and discusses which SRv6 extensions can be applied to BGP-LS-SPF SAFI.

1.1. 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.

2. SRv6 Node Attribute TLVs

Based on [RFC9514], the following SRv6 Node Attributes TLV SHOULD be supported in BGP-LS-SPF.

Type	Description	Reference
1138	SRv6 Capabilities TLV	RFC 9514
266	Node MSD TLV	RFC 8814
1035	SR Algorithm TLV	RFC 9085

Table 1: Node Attribute TLVs for SRv6 with BGP-LS-SPF

These SRv6 Node Attributes TLVs are advertised associated with the BGP-LS-SPF Node NLRI.

2.1. SRv6 Capabilities TLV

The SRv6 Capabilities TLV defined in [RFC9514] is used to announce the SRv6 capabilities of the node along with the BGP-LS Node NLRI and indicates the SRv6 support by the node.

For BGP-LS-SPF, it SHOULD support this TLV for a BGP-LS-SPF node to advertise its support for the SRv6-related capabilities. This is an optional TLV of BGP-LS-SPF Node NLRI that MUST be advertised by an SRv6-capable node.

This TLV MUST be advertised only once in the attributes of BGP-LS-SPF Node NLRI. When multiple SRv6 Capabilities TLVs are received from a given node, the receiver MUST use the first occurrence of the TLV in the attributes of BGP-LS-SPF Node NLRI.

If no SRv6 Capabilities TLV is advertised in the BGP-LS-SPF Node NLRI, then it indicates that the originator of this NLRI does not support SRv6.

The format and flags of SRv6 Capabilities TLV of BGP-LS-SPF is consistent with that in BGP-LS. The format of BGP-LS-SPF SRv6 Capability TLV is shown as follow:

```
 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             |            Reserved           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1: SRv6 Capability TLV format

where:

Type: 1038

Length: 4

Flags: 2-octet field. the following flags are defined:

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

where:

O-flag: If set, the node supports use of the O-bit in the SRH, as defined in [RFC9259].

Other flags are not defined and are reserved for future use. They MUST be set to 0 on transmission and MUST be ignored on receipt.

Reserved: 2-octet field that MUST be set to 0 when originated and ignored on receipt.

2.2. SRv6 Node MSD Types

The Node MSD TLV defined in [RFC8814] is used to advertise the limits and the Segment Routing Header (SRH) operations supported by the SRv6-capable node in BGP-LS.

For BGP-LS-SPF, different SRv6-capable node may have different limits related to SRH processing, therefore, BGP-LS-SPF SHOULD support this TLV for nodes to advertise the limits and operations.

The SRv6 Node MSD TLV is an optional TLV of BGP-LS-SPF Node Attribute that MAY be advertised by an SRv6-capable node.

This TLV MUST be advertised only once in the attributes of BGP-LS-SPF Node NLRI. When multiple SRv6 Node MSD TLVs are received from a given node, the receiver MUST use the first occurrence of the TLV in the attributes of BGP-LS-SPF Node NLRI.

The MSD types for SRv6 that are defined in Section 4 of [RFC9352] for IS-IS are also used by BGP-LS-SPF. These MSD types are allocated in the "IGP MSD-Types" registry maintained by IANA and are shared by IS-IS, OSPF, and BGP-LS-SPF. They are described in the subsections below.

The format of this TLV is the same as that in BGP-LS:

```
 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             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    MSD-Type   |  MSD-Value    |  MSD-Type...  |  MSD-Value... |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 2: SRv6 Node MSD TLV format

where:

Type: 266.

Length: variable, represents the total length of the value field in octets.

Value: consists of one or more pairs of a 1-octet MSD-Type and 1-octet MSD-Value. The detail description of MSD-Type and MSD-Value is in Section 3 of [RFC8814].

Node MSD is the smallest MSD supported by the node on the set of interfaces configured for use by the advertising BGP-LS-SPF instance. MSD values may be learned via a hardware API or may be provisioned.

If there are multiple MSD-Types that have the same code point in a Node MSD TLV, then the Node MSD TLV MUST be ignored by the receiver.

2.2.1. Maximum Segments Left MSD Type

The Maximum Segments Left MSD Type signals the maximum value of the Segments Left field in the SRH of a received packet before applying the Endpoint behavior associated with a SID.

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

2.2.2. Maximum End Pop MSD Type

The Maximum End Pop MSD Type signals the maximum number of SIDs in the SRH to which the node can apply "Penultimate Segment Pop (PSP) of the SRH" or "Ultimate Segment Pop (USP) of the SRH" behaviors, which defined in Section 4.16 of [RFC8986].

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

2.2.3. Maximum H.Encaps MSD Type

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

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.

A non-zero SRH Max H.Encaps MSD indicates that the headend can insert an SRH with SIDs up to the advertised value.

2.2.4. Maximum End D MSD Type

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

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

2.3. SR-Algorithm TLV

[RFC9514] specifies that the algorithm support for SRv6 is advertised via the SR-Algorithm TLV specified in [RFC9085]. The SR-Algorithm is used to advertise the SR algorithms supported by the node.

This TLV is a basic TLV of SR and SHOULD be supported in BGP-LS-SPF. The SR-Algorithm TLV is an optional TLV of BGP-LS-SPF Node Attribute that MAY be advertised by an SRv6-capable node.

This TLV MUST be advertised only once in the attributes of BGP-LS-SPF Node NLRI. If a node receiving multiple SR-Algorithm TLVs in the BGP-LS-SPF Node Attribute, the receiver MUST use the first occurrence of the TLV in the attributes of BGP-LS-SPF Node NLRI.

If a SRv6-capable node does not advertise the SR-Algorithm TLV, it implies that algorithm 0 is the only algorithm supported by the node.

If the originating node does advertise the SR-Algorithm sub-TLV, then algorithm 0 MUST be present while non-zero algorithms MAY be present.

The format of Algorithm fields in this TLV is consistent with that in BGP-LS, as defined in Section 2.1.3 of [RFC9085].

```
  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    |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 | Algorithm 1   |  Algorithm 2  | Algorithm ... |  Algorithm n  |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 3: SRv6 Algorithm TLV format

where:

Type: 1035

Length: Variable

Algorithm: 1 octet of algorithm.

The algorithm values are allocated in the "IGP Algorithm Type" registry defined in [RFC8665], these values are shared by IS-IS, OSPF, and BGP-LS-SPF.

3. SRv6 SIDs and Reachability

An SRv6 SID is 128 bits and consists of locator, function, and argument parts as described in [RFC8986].

An BGP-LS-SPF router is provisioned with algorithm-specific locators for each algorithm supported by that router. Each locator is a covering prefix for all SIDs provisioned on that router that have the matching algorithm.

Locators MUST be advertised as BGP-LS-SPF Prefix NLRI objects along with the SRv6 Locator TLVs (see Section 5.1) in its BGP-LS-SPF Attribute. Forwarding entries for the locators advertised in the BGP-LS-SPF Prefix NLRI MUST be installed in the forwarding plane of receiving SRv6-capable routers when the associated algorithm is supported by the receiving BGP-LS-SPF router. The processing of the prefix of the Locator, the calculation of its reachability, and the installation in the forwarding plane follows the process of BGP-LS-SPF [RFC9815].

SRv6 SIDs are advertised as SRv6 SID Information TLVs (see Section 6.1) in the SRv6 SID NLRI, except for SRv6 SIDs that are associated with a specific neighbor/link and are therefore advertised as SRv6 End.X SID TLV (see Section 4.1).

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 ensure that SRv6 SIDs associated with a supported algorithm will be forwarded correctly, while SRv6 SIDs associated with an unsupported algorithm will be dropped. NOTE: The drop behavior depends on the absence of a default/summary route covering a given locator.

4. SRv6 Link Attribute TLVs

Based on [RFC9514] and [RFC9085], the following Link Attributes SHOULD be supported in BGP-LS-SPF.

Type	Description	Reference
1106	SRv6 End.X SID TLV	RFC 9514
1106	L2 Bundle Member Attributes TLV	RFC 9085
267	SRv6 Link MSD TLV	RFC 8814

Table 2: Link Attribute TLVs for SRv6 with BGP-LS-SPF

These SRv6 Link Attribute TLVs are advertised associated with the BGP-LS-SPF Link NLRI.

4.1. SRv6 End.X SID TLV

The SRv6 End.X SID TLV defined in [RFC9514] is used to advertise the SRv6 SIDs associated with an IGP Adjacency SID behavior that correspond to a point-to-point or point-to-multipoint link or adjacency of the node running the IS-IS or OSPFv3 protocols. It is also used by BGP-LS to advertise the BGP EPE Peer Adjacency SID for SRv6 on the same lines as specified for SR-MPLS in [RFC9086].

BGP-LS-SPF SHOULD support this TLV to advertise the SRv6 SIDs correspond to a point-to-point or adjacency of the node running the BGP-LS-SPF.

The SRv6 End.X SID TLV is an optional TLV of BGP-LS-SPF Link Attribute that MAY be advertised by an SRv6-capable node.

More than one instance of this TLV (one for each SRv6 End.X SID) can be included in the BGP-LS-SPF Attribute. Multiple SRv6 End.X SID TLVs MAY be associated with the same adjacency.

Every SRv6-enabled node SHOULD instantiate at least one unique SRv6 End.X SID corresponding to each of its neighbors, although it MAY omit doing so if features like TE or TI-LFA that require End.X SID are not in use.

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

The format of this TLV is the same as in BGP-LS:

```
 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               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Endpoint Behavior      |      Flags    |   Algorithm   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Weight    |   Reserved    |  SID (16 octets) ...          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    SID (cont ...)                                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    SID (cont ...)                                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    SID (cont ...)                                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    SID (cont ...)             | Sub-TLVs (variable) . . .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4: SRv6 End.X SID TLV format

where:

Type: 1106

Length: variable

Endpoint Behavior: 2-octet field. The Endpoint behavior code point for this SRv6 SID as defined in Section 10.2 of [RFC8986].

Flags: 1 octet. The definition of flags are same as that in IS-IS SRv6 End.X SID sub-TLV (Section 8.1 of [RFC9352]) and the OSPFv3 SRv6 End.X SID sub-TLV (Section 9.1 of [RFC9513]).

Algorithm: 1-octet field. Algorithm associated with the SID. The algorithm associated with the SRv6 Locator from which the SID is allocated.

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

Reserved: 1-octet field that MUST be set to 0 when originated and ignored on receipt.

SID: 16-octet field. This field encodes the advertised SRv6 SID as a 128-bit value.

Sub-TLVs: Used to advertise sub-TLVs that provide additional attributes for the specific SRv6 SID.

4.2. L2 Bundle Member Attributes TLV

The L2 Bundle Member Attributes TLV is defined in [RFC9085], it identifies an L2 Bundle Member link, which in turn is associated with a parent L3 link. This TLV is useful when entities external to BGP-LS-SPF wish to control traffic flows on the individual physical links that comprise the Layer 2 interface bundle.

The network deployed BGP-LS-SPF may include trunk links. Therefore, BGP-LS-SPF MAY support this TLV to advertise L2 bundle member link attributes.

The L2 Bundle Member Attributes TLV is an optional TLV of BGP-LS-SPF Link Attribute with BGP-LS-SPF Link NLRI that MAY be advertised by an SRv6-capable node.

This TLV MAY include sub-TLVs that describe attributes associated with the bundle member. The identified bundle member represents a unidirectional path from the originating node to the neighbor specified in the parent L3 link.

Multiple L2 Bundle Member Attributes TLVs MAY be associated with a BGP-LS-SPF Link NLRI.

Advertisement of this TLV implies that the identified link is a member of the L2 Bundle associated with the Parent L3 Link, and the member link is operationally up. Therefore, advertisements MUST be withdrawn if the link becomes operationally down or it is no longer a member of the identified L2 Bundle.

The format of this TLV is the same as that in BGP-LS:

```
 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            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  L2 Bundle Member Descriptor                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                 Link Attribute Sub-TLVs(variable)           //
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5: L2 Bundle Member Attributes TLV format

Where:

Type: 1172

Length: Variable.

L2 Bundle Member Descriptor: 4-octet field that carries a link-local identifier as defined in [RFC4202].

Link attribute Sub-TLVs: variable, the detail description of these Sub-TLVs is specified in Section 2.2.3 of [RFC9085].

4.3. SRv6 Link MSD Types

The Link MSD TLV defined in [RFC8814] is used to advertise the limits and the SRH operations supported on the specific link by the SRv6-capable node. BGP-LS-SPF SHOULD support this TLV to advertise the limits and operations supported on the specific link to enable segment routing. The SRv6 MSD types specified in Section 4 of [RFC9352] are also used with the BGP-LS-SPF Link MSD TLV, as these code points are shared between the IS-IS, OSPF, and BGP-LS-SPF.

The SRv6 Node MSD TLV is an optional TLV of BGP-LS-SPF Link Attributes that MAY be advertised by an SRv6-capable node.

This TLV MUST be advertised only once in the attributes of BGP-LS-SPF Link NLRI. When multiple SRv6 Link MSD TLVs are received from a given node, the receiver MUST use the first occurrence of the TLV in the attributes of BGP-LS-SPF Link NLRI.

The format and different MSD Types of SRv6 Link MSD TLV is the same as Section 2.2, the Type of Link MSD TLV is 267[RFC8814].

5. SRv6 Prefix Attribute TLVs

Based on [RFC9514], the BGP-LS SRv6 Prefix Attributes only includes the SRv6 Locator TLV. This TLV SHOULD be supported by BGP-LS-SPF.

Type	Description	Reference
1162	SRv6 Locator TLV	RFC 9514

Table 3: Prefix Attribute TLVs for SRv6 with BGP-LS-SPF

These SRv6 Prefix Attribute TLVs are advertised associated with the BGP-LS-SPF Prefix NLRI.

5.1. SRv6 Locator TLV

The SRv6 Locator TLV defined in [RFC9514] is used to advertise the locators supported by each node. Locator is the key component of SRv6 SID, BGP-LS-SPF SHOULD support this TLV to enable segment routing.

A node is provisioned with one or more locators supported by that node. Locators are covering prefixes for the set of SIDs provisioned on that node. Each locator is advertised as a BGP-LS-SPF Prefix NLRI object along with the SRv6 Locator TLV in its BGP-LS-SPF Attribute.

Only one SRv6 Locator TLVs SHOULD be advertised in the BGP-LS-SPF Attribute, associating with the BGP-LS-SPF prefix NLRI.

This TLV MUST be advertised only once in the BGP-LS-SPF Attribute associated with the the BGP-LS-SPF Prefix NLRI.

When multiple SRv6 Locator TLVs are received from a given node in the BGP-LS-SPF Attribute, the receiver MUST use the first occurrence of the TLV.

The format of the SRv6 Locator TLV is the same as BGP-LSSection 5.1 of [RFC9514].

```
 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   |           Reserved            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            Metric                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Sub-TLVs (variable) . . .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 6: SRv6 Locator TLV format

where:

Type: 1162

Length: variable

Flags: 1 octet of flags. Currently, the flags field is not used and MUST be set to zero on transmission and MUST be ignored on receipt.

Algorithm: 1-octet field. Algorithm associated with the SID, as defined in the "IGP Algorithm Types" registry [RFC8665].

Reserved: 2-octet field. The value MUST be set to 0 when originated and ignored on receipt.

Metric: 4-octet field. The value of the metric for the locator.

Sub-TLVs: Used to advertise sub-TLVs that provide additional attributes for the given SRv6 Locator. Currently, none are defined.

Since BGP-LS-SPF defines the Prefix Metric TLV is mandatory for Prefix NLRI, so the Metric field in this TLV is no longer usable. It SHOULD be set to 0 and MUST be ignored on receipt.

6. SRv6 SID NLRI

The SRv6 SID NLRI defined in [RFC9514] is used to carry the SRv6 SID information. When SRv6 SIDs need to be advertised in BGP-SPF, the following NLRI type and attributes TLV for SRv6 SID SHOULD be supported in BGP-LS-SPF SAFI:

Type	NLRI Type	Reference
6	SRv6 SID NLRI	RFC 9514
518	SRv6 SID Information TLV	RFC 9514

Table 4: SRv6 SID NLRI with BGP-LS-SPF

The format of SRv6 SID NLRI is the same as that in BGP-LSSection 6 of [RFC9514].

An SRv6-enabled node SHOULD advertise at least one SRv6 SID associated with an End behavior encapsulated in the SRv6 NLRI for itself as specified in [RFC8986].

An SRv6-enabled node MAY advertise multiple instances of the SRv6 SID NLRI -- one for each of the SRv6 SIDs to be advertised.

6.1. SRv6 SID Information TLV

The SRv6 SID Information TLV is used to carry the SRv6 SID that do not require a particular neighbor in a SRv6 SID NLRI. This TLV SHOULD be supported in BGP-LS-SPF to advertise SRv6 SIDs of each node.

SRv6 SID Information TLV is a mandatory TLV in SRv6 NLRI. For each SRv6 SID NLRI, it MUST contain a single SRv6 SID Information TLV.

When multiple SRv6 SID Information TLVs are received from a given node in an BGP-LS-SPF SRv6 SID NLRI for the same SID, the receiver MUST use the first occurrence of the TLV in the NLRI.

The format of SRv6 SID Information TLV is the same as Section 6.1 of [RFC9514].

```
 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               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    SID (16 octets) ...                                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    SID (cont ...)                                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    SID (cont ...)                                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    SID (cont ...)                                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 7: SRv6 SID Information TLV format

where:

Type: 518

Length: 16

SID: 16-octet field. This field encodes the advertised SRv6 SID as a 128-bit value.

The SRv6 SID MUST be allocated from its associated locator. SRv6 SIDs that are NOT allocated from the associated locator MUST be ignored.

7. SRv6 SID Attribute TLVs

7.1. SRv6 Endpoint Behavior TLV

The Endpoint Behavior TLV defined in [RFC9514] is used to advertise the behaviors associated with a SID. The BGP-LS-SPF SHOULD support this TLV to enable the advertisement of behaviors associated with a SRv6 SID.

The SRv6 Endpoint Behavior TLV is a mandatory TLV that MUST be included once in the BGP-LS Attribute associated with the BGP-LS-SPF SRv6 SID NLRI.

When multiple SRv6 Endpoint Behavior TLVs are received from a given node in the BGP-LS Attribute, the receiver MUST use the first occurrence of the TLV.

The format of SRv6 Endpoint is the same as that in BGP-LS.

```
 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               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Endpoint Behavior      |      Flags    |   Algorithm   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 8: SRv6 Endpoint Behavior TLV format

Where:

Type: 1250

Length: 4

Endpoint Behavior: 2-octet field. The Endpoint behavior code point for this SRv6 SID.

Flags: 1 octet of flags. No flags are currently defined, and this field MUST be set to 0 on transmission and MUST be ignored on receipt.

Algorithm: 1-octet field. Algorithm associated with the SID.

Supported behavior values for this TLV are defined in Section 8 of this document. Unsupported or unrecognized behavior values are ignored by the receiver.

7.2. SRv6 SID Structure TLV

The SRv6 SID Structure TLV defined in [RFC9514] is used to advertise the length of each individual part of the SRv6 SID as defined in [RFC8986]. BGP-LS-SPF MAY support this TLV to indicate the length of each individual part of the SRv6 SID of BGP-LS-SPF, which is useful in some scenarios using compressed SID.

It is an optional TLV that MAY be used in the BGP-LS-SPF Attribute for SRv6 SID NLRI and as a sub-TLV of the SRv6 End.X SID TLV.

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

The format of SRv6 Structure TLV is the same as that in BGP-LS.

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

Figure 9: SRv6 SID Structure TLV format

where:

Type: 1252

Length: 4

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

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

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

Arg. Length: 1-octet field. SRv6 SID Argument length in bits.

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

The SRv6 SID Structure 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. The typical use cases for this information are described in the Section 10 of [RFC9513] and Section 9 of [RFC9352].

8. Advertsing Endpoint Behaviors

Endpoint behaviors are defined in [RFC8986]. The code points for the Endpoint behaviors are defined in the "SRv6 Endpoint Behaviors" registry of [RFC8986]. This section lists the Endpoint behaviors and their code points, which MAY be advertised by BGP-LS-SPF and the TLVs in which each type MAY appear.

Endpoint Behavior	Endpoint Behavior Code Point	End SID	End.X SID
End(PSP, USP, USD)	1-4, 28-31	Y	N
End.X(PSP, USP, USD)	5-8, 32-35	N	Y

Table 5: SRv6 Endpoint Behaviors in BGP-LS-SPF

9. Security Considerations

This document introduces no additional security vulnerabilities in addition to the ones as described in [RFC9552].

10. IANA Considerations

This document has no IANA actions.

11. Acknowledgements

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