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". These segments are advertised by routing protocols e.g. by the link state routing protocols (IS-IS, OSPFv2 and OSPFv3) within IGP topologies.

This draft defines extensions to the BGP Link-state address-family in order to carry segment routing information via BGP.

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

Segment Routing (SR) allows for a flexible definition of end-to-end paths by combining sub-paths called "segments". A segment can represent any instruction, topological or service-based. A segment can have a local semantic to an SR node or global within a domain. Within IGP topologies an SR path is encoded as a sequence of topological sub-paths, called "IGP segments". These segments are advertised by the link-state routing protocols (IS-IS, OSPFv2 and OSPFv3).

[ RFC8402 ] defines the Link-State IGP segments – Prefix, Node, Anycast and Adjacency segments. Prefix segments, by default, represent an ECMP-aware shortest-path to a prefix, as per the state of the IGP topology. Adjacency segments represent a hop over a specific adjacency between two nodes in the IGP. A prefix segment is typically a multi-hop path while an adjacency segment, in most of the cases, is a one-hop path. Node and Anycast Segments are variations of the Prefix Segment with their specific characteristics.

When Segment Routing is enabled in an IGP domain, segments are advertised in the form of Segment Identifiers (SIDs). The IGP link-state routing protocols have been extended to advertise SIDs and other SR-related information. IGP extensions are described in: IS-IS [ I-D.ietf-isis-segment-routing-extensions ], OSPFv2 [ I-D.ietf-ospf-segment-routing-extensions ] and OSPFv3 [ I-D.ietf-ospf-ospfv3-segment-routing-extensions ]. Using these extensions, Segment Routing can be enabled within an IGP domain.

Segment Routing (SR) allows advertisement of single or multi-hop paths. The flooding scope for the IGP extensions for Segment routing is IGP area-wide. Consequently, the contents of a Link State Database (LSDB) or a Traffic Engineering Database (TED) has the scope of an IGP area and therefore, by using the IGP alone it is not enough to construct segments across multiple IGP Area or AS boundaries.

In order to address the need for applications that require topological visibility across IGP areas, or even across Autonomous Systems (AS), the BGP-LS address-family/sub-address-family have been defined to allow BGP to carry Link-State information. The BGP Network Layer Reachability Information (NLRI) encoding format for BGP-LS and a new BGP Path Attribute called the BGP-LS attribute are defined in [ RFC7752 ]. The identifying key of each Link-State object, namely a node, link, or prefix, is encoded in the NLRI and the properties of the object are encoded in the BGP-LS attribute.
Figure 1: Link State info collection

Figure 1 describes a typical deployment scenario. In each IGP area, one or more nodes are configured with BGP-LS. These BGP speakers form an IBGP mesh by connecting to one or more route-reflectors. This way, all BGP speakers (specifically the route-reflectors) obtain Link-State information from all IGP areas (and from other ASes from EBGP peers). An external component connects to the route-reflector to obtain this information (perhaps moderated by a policy regarding what information is or isn’t advertised to the external component) as described in [RFC7752].

This document describes extensions to BGP-LS to advertise the SR information. An external component (e.g., a controller) then can collect SR information from across an SR domain (as described in [RFC8402]) and construct the end-to-end path (with its associated SIDs) that need to be applied to an incoming packet to achieve the desired end-to-end forwarding. The SR domain may be comprised of a single AS or multiple ASes.

2. BGP-LS Extensions for Segment Routing

This document defines SR extensions to BGP-LS and specifies the TLVs and sub-TLVs for advertising SR information within the BGP-LS
Section 2.4 and Section 2.5 lists the equivalent TLVs and sub-TLVs in IS-IS, OSPFv2 and OSPFv3 protocols.

BGP-LS [RFC7752] defines the BGP-LS NLRI that can be a Node NLRI, a Link NLRI or a Prefix NLRI. BGP-LS [RFC7752] defines the TLVs that map link-state information to BGP-LS NLRI within the BGP-LS Attribute. This document adds additional BGP-LS Attribute TLVs in order to encode SR information. It does not introduce any changes to the encoding of the BGP-LS NLRIs.

2.1. Node Attributes TLVs

The following Node Attribute TLVs are defined:

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1161</td>
<td>SID/Label</td>
<td>Section 2.1.1</td>
</tr>
<tr>
<td>1034</td>
<td>SR Capabilities</td>
<td>Section 2.1.2</td>
</tr>
<tr>
<td>1035</td>
<td>SR Algorithm</td>
<td>Section 2.1.3</td>
</tr>
<tr>
<td>1036</td>
<td>SR Local Block</td>
<td>Section 2.1.4</td>
</tr>
<tr>
<td>1037</td>
<td>SRMS Preference</td>
<td>Section 2.1.5</td>
</tr>
</tbody>
</table>

Table 1: Node Attribute TLVs

These TLVs should only be added to the BGP-LS Attribute associated with the Node NLRI describing the IGP node that is originating the corresponding IGP TLV/sub-TLV described below.

2.1.1. SID/Label Sub-TLV

The SID/Label TLV is used as a sub-TLV by the SR Capabilities (Section 2.1.2) and Segment Routing Local Block (SRLB) (Section 2.1.4) TLVs and 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               Type            |            Length             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      SID/Label (variable)                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 2: SID/Label sub-TLV Format

Where:
Type: 1161

Length: Either 3 or 4 depending whether the value is encoded as a label or an index/SID.

SID/Label: If length is set to 3, then the 20 rightmost bits represent a label (the total TLV size is 7). If length is set to 4, then the value represents a 32 bit SID (the total TLV size is 8).

2.1.2. SR Capabilities TLV

The SR Capabilities TLV is used in order to advertise the node’s SR Capabilities including its Segment Routing Global Base (SRGB) range(s). In the case of IS-IS, the capabilities also include the IPv4 and IPv6 support for the SR-MPLS forwarding plane. This information is derived from the protocol specific advertisements.

- IS-IS, as defined by the SR Capabilities sub-TLV in [I-D.ietf-isis-segment-routing-extensions].
- OSPFv2/OSPFv3, as defined by the SID/Label Range TLV in [I-D.ietf-ospf-segment-routing-extensions] and [I-D.ietf-ospf-ospfv3-segment-routing-extensions].

The SR Capabilities TLV has the following format:

```
+-------+-------+-------+-------+-------+-------+-------+
|       |       |       |       |       |       |       |
+-------+-------+-------+-------+-------+-------+-------+
|                     |                     |
+-------+-------+-------+-------+-------+-------+-------+
|  Range Size  |                     |
+-------+-------+-------+-------+-------+-------+-------+
// SID/Label sub-TLV (variable)  //
+-------+-------+-------+-------+-------+-------+-------+

Figure 3: SR Capabilities TLV Format

Where:

Type: 1034
Length: Variable. Minimum length is 12.

Flags: 1 octet of flags as defined in [I-D.ietf-isis-segment-routing-extensions] for IS-IS. The flags are not currently defined for OSPFv2 and OSPFV3 and SHOULD be set to 0 and MUST be ignored on receipt.

Reserved: 1 octet that SHOULD be set to 0 and MUST be ignored on receipt.

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

Range Size: 3 octet with a non-zero value indicating the number of labels in the range.

SID/Label sub-TLV (as defined in Section 2.1.1) which encodes the first label in the range. Since the SID/Label sub-TLV is used to indicate the first label of the SRGB range, only label encoding is valid under the SR Capabilities TLV.

2.1.3. SR Algorithm TLV

The SR Algorithm TLV is used in order to advertise the SR Algorithms supported by the node. This information is derived from the protocol specific advertisements.

- IS-IS, as defined by the SR Algorithm sub-TLV in [I-D.ietf-isis-segment-routing-extensions].

- OSPFv2/OSPFv3, as defined by the SR Algorithm TLV in [I-D.ietf-ospf-segment-routing-extensions] and [I-D.ietf-ospf-ospfv3-segment-routing-extensions].

The SR Algorithm TLV has the following format:

```
  0  1  2  3  4  5  6  7
+---------------+---------------+---------------+---------------+
| Type          | Length        |
+---------------+---------------+---------------+---------------+
| Algorithm 1   | Algorithm...  | Algorithm N   |
+---------------+---------------+---------------+---------------+

Figure 4: SR Algorithm TLV Format
Where:

Type: 1035

Length: Variable. Minimum length is 1 and maximum can be 256.

Algorithm: 1 octet identifying the algorithm.

2.1.4. SR Local Block TLV

The SR Local Block (SRLB) TLV contains the range(s) of labels the node has reserved for local SIDs. Local SIDs are used, e.g., in IGP (IS-IS, OSPF) for Adjacency-SIDs, and may also be allocated by components other than IGP protocols. As an example, an application or a controller may instruct a node to allocate a specific local SID. Therefore, in order for such applications or controllers to know the range of local SIDs available, it is required that the node advertises its SRLB.

This information is derived from the protocol specific advertisements.

- IS-IS, as defined by the SR Local Block sub-TLV in [I-D.ietf-isis-segment-routing-extensions].
- OSPFv2/OSPFv3, as defined by the SR Local Block TLV in [I-D.ietf-ospf-segment-routing-extensions] and [I-D.ietf-ospf-ospfv3-segment-routing-extensions].

The SRLB TLV has the following format:

```
|       Flags       |   Reserved   |
+-----------------+-------------|
<table>
<thead>
<tr>
<th>Type</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>-----------------</td>
<td>--------------</td>
</tr>
</tbody>
</table>
+-----------------+-------------|
|                  Range Size       |
|-----------------|--------------|
//                  SID/Label sub-TLV (variable)   //
+-----------------+-------------|
```

Figure 5: SRLB TLV Format
Where:

Type: 1036
Length: Variable. Minimum length is 12.
Flags: 1 octet of flags. None are defined at this stage.
Reserved: 1 octet that SHOULD be set to 0 and MUST be ignored on receipt.

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

Range Size: 3 octet value indicating the number of labels in the range.

SID/Label sub-TLV (as defined in Section 2.1.1) which encodes the first label in the range. Since the SID/Label sub-TLV is used to indicate the first label of the SRLB range, only label encoding is valid under the SR Local Block TLV.

2.1.5. SRMS Preference TLV

The Segment Routing Mapping Server (SRMS) Preference TLV is used in order to associate a preference with SRMS advertisements from a particular source. [I-D.ietf-spring-segment-routing-ldp-interop] specifies the SRMS functionality along with SRMS preference of the node advertising the SRMS Prefix-to-SID Mapping ranges.

This information is derived from the protocol specific advertisements.

- IS-IS, as defined by the SRMS Preference sub-TLV in [I-D.ietf-isis-segment-routing-extensions].
- OSPFv2/OSPFv3, as defined by the SRMS Preference TLV in [I-D.ietf-ospf-segment-routing-extensions] and [I-D.ietf-ospf-ospfv3-segment-routing-extensions].

The SRMS Preference TLV has the following format:
The use of the SRMS Preference TLV is defined in [I-D.ietf-isis-segment-routing-extensions], [I-D.ietf-ospf-segment-routing-extensions] and [I-D.ietf-ospf-ospfv3-segment-routing-extensions].

2.2. Link Attribute TLVs

The following Link Attribute TLVs are defined:

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1099</td>
<td>Adjacency SID TLV</td>
<td>Section 2.2.1</td>
</tr>
<tr>
<td>1100</td>
<td>LAN Adjacency SID TLV</td>
<td>Section 2.2.2</td>
</tr>
<tr>
<td>1172</td>
<td>L2 Bundle Member TLV</td>
<td>Section 2.2.3</td>
</tr>
</tbody>
</table>

Table 2: Link Attribute TLVs

These TLVs should only be added to the BGP-LS Attribute associated with the Link NLRI describing the link of the IGP node that is originating the corresponding IGP TLV/sub-TLV described below.

2.2.1. Adjacency SID TLV

The Adjacency SID TLV is used in order to advertise information related to an Adjacency SID. This information is originated as in Adj-SID sub-TLV of IS-IS [I-D.ietf-isis-segment-routing-extensions],
OSPFv2 [I-D.ietf-ospf-segment-routing-extensions] and OSPFv3 [I-D.ietf-ospf-ospfv3-segment-routing-extensions].

The Adjacency SID TLV has the following format:

\[
\begin{array}{ccccccccccc}
0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & A & B & C & D & E & F \\
\hline
\text{Type} & \text{Length} & \text{Flags} & \text{Weight} & \text{Reserved} & \text{SID/Index/Label} \\
\end{array}
\]

Figure 7: Adjacency SID TLV Format

Where:

- **Type:** 1099
- **Length:** Variable, 7 or 8 depending on Label or Index encoding of the SID
- **Flags:** 1 octet value which should be parsed as:
  - IS-IS Adj-SID flags are defined in [I-D.ietf-isis-segment-routing-extensions] section 2.2.1.
  - OSPFv2 Adj-SID flags are defined in [I-D.ietf-ospf-segment-routing-extensions] section 6.1.
  - OSPFv3 Adj-SID flags are defined in [I-D.ietf-ospf-segment-routing-extensions] section 7.1.
- **Weight:** Weight used for load-balancing purposes.
- **Reserved:** 2 octets that SHOULD be set to 0 and MUST be ignored on receipt.
- **SID/Index/Label:**
  - IS-IS: Label or index value as defined in [I-D.ietf-isis-segment-routing-extensions],
  - OSPFv2: Label or index value as defined in [I-D.ietf-ospf-segment-routing-extensions],
* OSPFv3: Label or index value as defined in
  [I-D.ietf-ospf-ospfv3-segment-routing-extensions],

The Flags and, as an extension, the SID/Index/Label fields of this TLV need to be interpreted accordingly to the respective underlying IS-IS, OSPFv2 or OSPFv3 protocol. The consumer of the BGP-LS interested in this TLV information MUST check the Protocol-ID of the BGP-LS Link NLRI and refer to the underlying protocol specification in order to parse these fields.

2.2.2. LAN Adjacency SID TLV

For a LAN, normally a node only announces its adjacency to the IS-IS pseudo-node (or the equivalent OSPF Designated and Backup Designated Routers). The LAN Adjacency Segment TLV allows a node to announce adjacencies to all other nodes attached to the LAN in a single instance of the BGP-LS Link NLRI. Without this TLV, the corresponding BGP-LS link NLRI would need to be originated for each additional adjacency in order to advertise the SR TLVs for these neighbor adjacencies.

This information is originated as in LAN Adj-SID sub-TLV of IS-IS [I-D.ietf-isis-segment-routing-extensions], OSPFv2 [I-D.ietf-ospf-segment-routing-extensions] and OSPFv3 [I-D.ietf-ospf-ospfv3-segment-routing-extensions].

The LAN Adjacency 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     |     Weight    |            Reserved           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             OSPF Neighbor ID / IS-IS System-ID             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| SID/Label/Index (variable) |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 8: LAN Adjacency SID TLV Format

Where:

Type: 1100

Length: Variable. For IS-IS it would be 13 or 14 depending on Label or Index encoding of the SID. For OSPF it would be 11 or 12 depending on Label or Index encoding of the SID.

Flags. 1 octet value which should be parsed as:

* IS-IS LAN Adj-SID flags are defined in [I-D.ietf-isis-segment-routing-extensions] section 2.2.2.

* OSPFv2 LAN Adj-SID flags are defined in [I-D.ietf-ospf-segment-routing-extensions] section 6.2.

* OSPFv3 LAN Adj-SID flags are defined in [I-D.ietf-ospf-segment-routing-extensions] section 7.3.

Weight: Weight used for load-balancing purposes.

Reserved: 2 octets that SHOULD be set to 0 and MUST be ignored on receipt.

Neighbor ID: 6 octets for IS-IS for the System-ID and 4 octets for OSPF for the OSPF Router-ID of the neighbor.

SID/Index/Label:

* IS-IS: Label or index value as defined in [I-D.ietf-isis-segment-routing-extensions],

* OSPFv2: Label or index value as defined in [I-D.ietf-ospf-segment-routing-extensions],

* OSPFv3: Label or index value as defined in [I-D.ietf-ospf-ospfv3-segment-routing-extensions],

The Neighbor ID, Flags and, as an extension, the SID/Index/Label fields of this TLV need to be interpreted accordingly to the respective underlying IS-IS, OSPFv2 or OSPFv3 protocol. The consumer of the BGP-LS interested in this TLV information MUST check the Protocol-ID of the BGP-LS Link NLRI and refer to the underlying protocol specification in order to parse these fields.
2.2.3. L2 Bundle Member Attribute TLV

The L2 Bundle Member Attribute TLV identifies an L2 Bundle Member link which in turn is associated with a parent L3 link. The L3 link is described by the Link NLRI defined in [RFC7752] and the L2 Bundle Member Attribute TLV is associated with the Link NLRI. The TLV MAY include sub-TLVs which describe attributes associated with the bundle member. The identified bundle member represents a unidirectional path from the originating router to the neighbor specified in the parent L3 Link. Multiple L2 Bundle Member Attribute TLVs MAY be associated with a Link NLRI.

This information is originated as in L2 Bundle Member Attributes TLV of IS-IS [I-D.ietf-isis-l2bundles]. The equivalent functionality has not been specified as yet for OSPF.

The L2 Bundle Member Attribute 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               Type            |          Length               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     L2 Bundle Member Descriptor               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
//                  Link attribute sub-TLVs(variable)          //
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 9: L2 Bundle Member Attributes TLV Format

Where:

Type: 1172

Length: Variable.

L2 Bundle Member Descriptor: A Link Local Identifier as defined in [RFC4202].

Link attributes for L2 Bundle Member Links are advertised as sub-TLVs of the L2 Bundle Member Attribute TLV. The sub-TLVs are identical to existing BGP-LS TLVs as identified in the table below.
<table>
<thead>
<tr>
<th>TLV Code</th>
<th>Description</th>
<th>Reference Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>1088</td>
<td>Administrative group (color)</td>
<td>[RFC7752]</td>
</tr>
<tr>
<td>1089</td>
<td>Maximum link bandwidth</td>
<td>[RFC7752]</td>
</tr>
<tr>
<td>1090</td>
<td>Max. reservable link bandwidth</td>
<td>[RFC7752]</td>
</tr>
<tr>
<td>1091</td>
<td>Unreserved bandwidth</td>
<td>[RFC7752]</td>
</tr>
<tr>
<td>1092</td>
<td>TE default metric</td>
<td>[RFC7752]</td>
</tr>
<tr>
<td>1093</td>
<td>Link protection type</td>
<td>[RFC7752]</td>
</tr>
<tr>
<td>1099</td>
<td>Adjacency Segment Identifier (Adj-SID) TLV</td>
<td>Section 2.2.1</td>
</tr>
<tr>
<td>1100</td>
<td>LAN Adjacency Segment Identifier (Adj-SID) TLV</td>
<td>Section 2.2.2</td>
</tr>
<tr>
<td>1114</td>
<td>Unidirectional link delay</td>
<td>[I-D.ietf-idr-te-pm-bgp]</td>
</tr>
<tr>
<td>1115</td>
<td>Min/Max Unidirectional link delay</td>
<td>[I-D.ietf-idr-te-pm-bgp]</td>
</tr>
<tr>
<td>1116</td>
<td>Unidirectional Delay Variation</td>
<td>[I-D.ietf-idr-te-pm-bgp]</td>
</tr>
<tr>
<td>1117</td>
<td>Unidirectional packet loss</td>
<td>[I-D.ietf-idr-te-pm-bgp]</td>
</tr>
<tr>
<td>1118</td>
<td>Unidirectional residual bandwidth</td>
<td>[I-D.ietf-idr-te-pm-bgp]</td>
</tr>
<tr>
<td>1119</td>
<td>Unidirectional available bandwidth</td>
<td>[I-D.ietf-idr-te-pm-bgp]</td>
</tr>
<tr>
<td>1120</td>
<td>Unidirectional bandwidth utilization</td>
<td>[I-D.ietf-idr-te-pm-bgp]</td>
</tr>
</tbody>
</table>

Table 3: BGP-LS Attribute TLVs also used as sub-TLVs of L2 Bundle Member Attribute TLV

2.3. Prefix Attribute TLVs

The following Prefix Attribute TLVs are defined:

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1158</td>
<td>Prefix SID</td>
<td>Section 2.3.1</td>
</tr>
<tr>
<td>1159</td>
<td>Range</td>
<td>Section 2.3.4</td>
</tr>
<tr>
<td>1170</td>
<td>Prefix Attribute Flags</td>
<td>Section 2.3.2</td>
</tr>
<tr>
<td>1171</td>
<td>Source Router-ID</td>
<td>Section 2.3.3</td>
</tr>
</tbody>
</table>

Table 4: Prefix Attribute TLVs
These TLVs should only be added to the BGP-LS Attribute associated with the Prefix NLRI describing the prefix of the IGP node that is originating the corresponding IGP TLV/sub-TLV described below.

### 2.3.1. Prefix SID TLV

The Prefix SID TLV is used in order to advertise information related to a Prefix SID. This information is originated as in Prefix-SID sub-TLV of IS-IS [I-D.ietf-isis-segment-routing-extensions], OSPFv2 [I-D.ietf-ospf-segment-routing-extensions] and OSPFv3 [I-D.ietf-ospf-ospfv3-segment-routing-extensions].

The Prefix 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               Type            |            Length             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Flags     |   Algorithm   |           Reserved            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       SID/Index/Label (variable)              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 10: Prefix SID TLV Format

Where:

- **Type**: 1158
- **Length**: Variable, 7 or 8 depending on Label or Index encoding of the SID
- **Flags**: 1 octet value which should be parsed as:
  - * IS-IS Prefix SID flags are defined in [I-D.ietf-isis-segment-routing-extensions] section 2.1.
  - * OSPFv2 Prefix SID flags are defined in [I-D.ietf-ospf-segment-routing-extensions] section 5.
  - * OSPFv3 Prefix SID flags are defined in [I-D.ietf-ospf-ospfv3-segment-routing-extensions] section 5.
- **Algorithm**: 1 octet value identify the algorithm.
Reserved: 2 octets that SHOULD be set to 0 and MUST be ignored on receipt.

SID/Index/Label:

* IS-IS: Label or index value as defined in [I-D.ietf-isis-segment-routing-extensions],
* OSPFv2: Label or index value as defined in [I-D.ietf-ospf-segment-routing-extensions],
* OSPFv3: Label or index value as defined in [I-D.ietf-ospf-ospfv3-segment-routing-extensions],

The Flags and, as an extension, the SID/Index/Label fields of this TLV need to be interpreted accordingly to the respective underlying IS-IS, OSPFv2 or OSPFv3 protocol. The consumer of the BGP-LS interested in this TLV information MUST check the Protocol-ID of the BGP-LS Prefix NLRI and refer to the underlying protocol specification in order to parse these fields.

2.3.2. Prefix Attribute Flags TLV

The Prefix Attribute Flags TLV carries IPv4/IPv6 prefix attribute flags information. These flags are defined for OSPFv2 in [RFC7684], for OSPFv3 in [RFC5340] and for IS-IS in [RFC7794].

The Prefix Attribute Flags 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 (variable)                      //
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

Figure 11: Prefix Attribute Flags TLV Format

Where:

Type: 1170

Length: variable.
Flags: a variable length flag field (according to the length field). Flags are routing protocol specific and are to be parsed as below:

* IS-IS flags correspond to the IPv4/IPv6 Extended Reachability Attribute Flags defined in [RFC7794]

* OSPFv2 flags correspond to the Flags field of the OSPFv2 Extended Prefix TLV defined in [RFC7684]

* OSPFv3 flags map to the Prefix Options field defined in [RFC5340] and extended via [RFC8362]

The Flags field of this TLV need to be interpreted accordingly to the respective underlying IS-IS, OSPFv2 or OSPFv3 protocol. The consumer of the BGP-LS interested in this TLV information MUST check the Protocol-ID of the BGP-LS Prefix NLRI and refer to the underlying protocol specification in order to parse this field.

2.3.3. Source Router Identifier (Source Router-ID) TLV

The Source Router-ID TLV contains the IPv4 or IPv6 Router-ID of the originator of the Prefix. For IS-IS protocol this is as defined in [RFC7794] IPv4 or IPv6 Router-ID of the originating router. For OSPF protocol, this is as defined in [I-D.ietf-lsr-ospf-prefix-originator] and is a 32 bit OSPF Router-ID of the originating router.

The Source Router-ID 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 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            Type               |            Length             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
//                  4 or 6 octet Router-ID                     //
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 12: Source Router-ID TLV Format**

Where:

Type: 1171

Length: 4 or 16 in case of IS-IS and 4 in case of OSPF.

Router-ID: the IPv4 or IPv6 Router-ID in case of IS-IS and the OSPF Router-ID in the case of OSPF.
2.3.4. Range TLV

The range TLV is used in order to advertise a range of prefix-to-SID mappings as part of the Segment Routing Mapping Server (SRMS) functionality [I-D.ietf-spring-segment-routing-ldp-interop], as defined in the respective underlying IGP SR extensions [I-D.ietf-ospf-segment-routing-extensions], [I-D.ietf-ospf-ospfv3-segment-routing-extensions] and [I-D.ietf-isis-segment-routing-extensions].

A consumer of the BGP-LS information MUST NOT mis-interpret a Prefix NLRI, that been advertised with a Range TLV associated with it on account of an SRMS prefix-to-SID mapping in the underlying IGP, as a normal routing prefix (i.e. prefix reachability) unless there is also an IGP metric TLV (TLV 1095) attached to it.

The format of the Range TLV is as follows:

```
+-----------------------------------------------+
|             Type              |             Length            |
+-----------------------------------------------+
|     Flags     | Reserved      |             Range Size        |
+-----------------------------------------------+
//                          sub-TLVs                           //
+-----------------------------------------------+
```

Figure 13: Range TLV Format

Where:

Type: 1159

Length: Variable, 11 or 12 depending on Label or Index encoding of the SID

Flags: as defined in [I-D.ietf-ospf-segment-routing-extensions], [I-D.ietf-ospf-ospfv3-segment-routing-extensions] and [I-D.ietf-isis-segment-routing-extensions].

Reserved: 1 octet that SHOULD be set to 0 and MUST be ignored on receipt.

Range Size: 2 octets as defined in [I-D.ietf-ospf-segment-routing-extensions].
The Flags field of this TLV need to be interpreted accordingly to the respective underlying IS-IS, OSPFv2 or OSPFv3 protocol. The consumer of the BGP-LS interested in this TLV information MUST check the Protocol-ID of the BGP-LS Prefix NLRI and refer to the underlying protocol specification in order to parse this field.

Within the Range TLV, the prefix-to-SID mappings are advertised using sub-TLVs as below:

**Range TLV**
- Prefix-SID TLV (used as a sub-TLV in this context)

Where:
- The Range TLV is defined in Section 2.3.4.
- The Prefix-SID TLV (used as sub-TLV in this context) is defined in Section 2.3.1.

The following sub-sections describe the procedures for mapping of information from the underlying IGP protocols into the Range TLV.

### 2.3.4.1. Advertisement Procedure for OSPF

The OSPFv2/OSPFv3 Extended Prefix Range TLV is encoded in the Range TLV. The flags of the Range TLV have the semantic mapped to the definition in [I-D.ietf-ospf-segment-routing-extensions] section 4 or [I-D.ietf-ospf-ospfv3-segment-routing-extensions] section 4.

Then the prefix-to-SID mapping from the OSPF Prefix SID sub-TLV is encoded using the BGP-LS Prefix-SID TLV as defined in Section 2.3.1 with the flags set according to the definition in [I-D.ietf-ospf-segment-routing-extensions] section 5 or [I-D.ietf-ospf-ospfv3-segment-routing-extensions] section 5.

### 2.3.4.2. Advertisement Procedure for IS-IS

The IS-IS SID/Label Binding TLV, when used to signal mapping server label bindings, is encoded in the Range TLV. The flags of the Range TLV have the semantic mapped to the definition in [I-D.ietf-isis-segment-routing-extensions] section 2.4.1.

Then the prefix-to-SID mappings from the IS-IS Prefix SID sub-TLV is encoded using the BGP-LS Prefix-SID TLV as defined in Section 2.3.1 with the flags set according to the definition in [I-D.ietf-isis-segment-routing-extensions] section 2.4.4.1.
2.4. Equivalent IS-IS Segment Routing TLVs/Sub-TLVs

This section illustrate the IS-IS Segment Routing Extensions TLVs and sub-TLVs mapped to the ones defined in this document.

The following table, illustrates for each BGP-LS TLV, its equivalence in IS-IS.

<table>
<thead>
<tr>
<th>Description</th>
<th>IS-IS TLV/sub-TLV</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR Capabilities</td>
<td>2</td>
<td>draft-ietf-isis-segment-routing-extensions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>section-3.1</td>
</tr>
<tr>
<td>SR Algorithm</td>
<td>19</td>
<td>draft-ietf-isis-segment-routing-extensions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>section-3.2</td>
</tr>
<tr>
<td>SR Local Block</td>
<td>22</td>
<td>draft-ietf-isis-segment-routing-extensions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>section-3.3</td>
</tr>
<tr>
<td>SRMS Preference</td>
<td>19</td>
<td>draft-ietf-isis-segment-routing-extensions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>section-3.2</td>
</tr>
<tr>
<td>Adjacency SID</td>
<td>31</td>
<td>draft-ietf-isis-segment-routing-extensions</td>
</tr>
<tr>
<td>LAN Adjacency SID</td>
<td>32</td>
<td>sections-2.2.1</td>
</tr>
<tr>
<td>Prefix SID</td>
<td>3</td>
<td>draft-ietf-isis-segment-routing-extensions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>section-2.1</td>
</tr>
<tr>
<td>Range</td>
<td>149</td>
<td>draft-ietf-isis-segment-routing-extensions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>section-2.4</td>
</tr>
<tr>
<td>SID Label SID</td>
<td>1</td>
<td>draft-ietf-isis-segment-routing-extensions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>section-2.3</td>
</tr>
<tr>
<td>Prefix Attribute</td>
<td>4</td>
<td>RFC7794 section-2.1</td>
</tr>
<tr>
<td>Flags Source</td>
<td>11/12</td>
<td>RFC7794 section-2.2</td>
</tr>
<tr>
<td>Router-ID</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2 Bundle</td>
<td>25</td>
<td>draft-ietf-isis-12bundles section-2</td>
</tr>
<tr>
<td>Member Attributes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5: IS-IS Segment Routing Extensions TLVs/Sub-TLVs

2.5. Equivalent OSPFv2/OSPFv3 Segment Routing TLVs/Sub-TLVs

This section illustrate the OSPFv2 and OSPFv3 Segment Routing Extensions TLVs and sub-TLVs mapped to the ones defined in this document.
The following table illustrates for each BGP-LS TLV, its equivalence in OSPFv2 and OSPFv3.

<table>
<thead>
<tr>
<th>Description</th>
<th>OSPFv2 TLV/sub-TLV</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR Capabilities</td>
<td>9</td>
<td><code>draft-ietf-ospf-segment-routing-extensions</code> section-3.2</td>
</tr>
<tr>
<td>SR</td>
<td>8</td>
<td><code>draft-ietf-ospf-segment-routing-extensions</code> section-3.1</td>
</tr>
<tr>
<td>Algorithm</td>
<td>8</td>
<td><code>draft-ietf-ospf-segment-routing-extensions</code> section-3.1</td>
</tr>
<tr>
<td>SR Local Block</td>
<td>14</td>
<td><code>draft-ietf-ospf-segment-routing-extensions</code> section-3.3</td>
</tr>
<tr>
<td>SRMS Preference</td>
<td>15</td>
<td><code>draft-ietf-ospf-segment-routing-extensions</code> section-3.4</td>
</tr>
<tr>
<td>Adjacency SID</td>
<td>2</td>
<td><code>draft-ietf-ospf-segment-routing-extensions</code> section-6.1</td>
</tr>
<tr>
<td>LAN Adjacency</td>
<td>3</td>
<td><code>draft-ietf-ospf-segment-routing-extensions</code> section-6.2</td>
</tr>
<tr>
<td>SID</td>
<td>14</td>
<td><code>draft-ietf-ospf-segment-routing-extensions</code> section-6.3</td>
</tr>
<tr>
<td>Prefix SID</td>
<td>2</td>
<td><code>draft-ietf-ospf-segment-routing-extensions</code> section-5</td>
</tr>
<tr>
<td>Range</td>
<td>2</td>
<td><code>draft-ietf-ospf-segment-routing-extensions</code> section-4</td>
</tr>
<tr>
<td>SID/Label Attribute Flags Source</td>
<td>1</td>
<td><code>draft-ietf-ospf-segment-routing-extensions</code> section-2.1</td>
</tr>
<tr>
<td>Prefix Attribute Flags Source</td>
<td>4</td>
<td><code>RFC7684</code> section-2.1</td>
</tr>
<tr>
<td>Source</td>
<td>TBD</td>
<td><code>draft-ietf-lsr-ospf-prefix-originator</code> section-4</td>
</tr>
<tr>
<td>Router-ID</td>
<td>TBD</td>
<td><code>draft-ietf-ospf-segment-routing-extensions</code> section-4</td>
</tr>
</tbody>
</table>

Table 6: OSPFv2 Segment Routing Extensions TLVs/Sub-TLVs
3. IANA Considerations

Early allocation of codepoints has been done by IANA for this document from the registry "BGP-LS Node Descriptor, Link Descriptor, Prefix Descriptor, and Attribute TLVs" based on Table 8. The column "IS-IS TLV/Sub-TLV" defined in the registry does not require any value and should be left empty.

3.1. TLV/Sub-TLV Code Points Summary

This section contains the global table of all TLVs/sub-TLVs defined in this document.
4. Manageability Considerations

This section is structured as recommended in [RFC5706].

The new protocol extensions introduced in this document augment the existing IGP topology information that is distributed via [RFC7752]. Procedures and protocol extensions defined in this document do not affect the BGP protocol operations and management other than as discussed in the Manageability Considerations section of [RFC7752]. Specifically, the malformed attribute tests for syntactic checks in the Fault Management section of [RFC7752] now encompass the new BGP-LS Attribute TLVs defined in this document. The semantic or content checking for the TLVs specified in this document and their association with the BGP-LS NLRI types or their BGP-LS Attribute is left to the consumer of the BGP-LS information (e.g. an application or a controller) and not the BGP protocol.

A consumer of the BGP-LS information retrieves this information from a BGP protocol component that is doing the signaling over a BGP-LS session, via some APIs or a data model (refer Section 1 and 2 of [RFC7752]). The handling of semantic or content errors by the consumer would be dictated by the nature of its application usage and hence is beyond the scope of this document.

This document only introduces new Attribute TLVs and any syntactic error in them would result in only that specific attribute being discarded with an error log. The SR information introduced in BGP-LS by this specification, may be used by BGP-LS consumer applications like a SR path computation engine (PCE) to learn the SR capabilities.
of the nodes in the topology and the mapping of SR segments to those nodes. This can enable the SR PCE to perform path computations based on SR for traffic engineering use-cases and to steer traffic on paths different from the underlying IGP based distributed best path computation. Errors in the encoding or decoding of the SR information may result in the unavailability of such information to the SR PCE or incorrect information being made available to it. This may result in the SR PCE not being able to perform the desired SR based optimization functionality or to perform it in an unexpected or inconsistent manner. The handling of such errors by applications like SR PCE may be implementation specific and out of scope of this document.

The extensions, specified in this document, do not introduce any new configuration or monitoring aspects in BGP or BGP-LS other than as discussed in [RFC7752]. The manageability aspects of the underlying SR features are covered by [I-D.ietf-spring-sr-yang], [I-D.ietf-isis-sr-yang] and [I-D.ietf-ospf-sr-yang].

5. Security Considerations

The new protocol extensions introduced in this document augment the existing IGP topology information that was distributed via [RFC7752]. The Security Considerations section of [RFC7752] also applies to these extensions. The procedures and new TLVs defined in this document, by themselves, do not affect the BGP-LS security model discussed in [RFC7752].

BGP-LS SR extensions enable traffic engineering use-cases within the Segment Routing domain. SR operates within a trusted domain (refer Security Considerations section in [RFC8402] for more detail) and its security considerations also apply to BGP-LS sessions when carrying SR information. The SR traffic engineering policies using the SIDs advertised via BGP-LS are expected to be used entirely within this trusted SR domain (e.g. between multiple AS/domains within a single provider network). Therefore, precaution is necessary to ensure that the SR information collected via BGP-LS is limited to specific controllers or applications in a secure manner within this SR domain.

The isolation of BGP-LS peering sessions is also required to ensure that BGP-LS topology information (including the newly added SR information) is not advertised to an external BGP peering session outside an administrative domain.
6. Contributors

The following people have substantially contributed to the editing of this document:

Peter Psenak
Cisco Systems
Email: ppsenak@cisco.com

Les Ginsberg
Cisco Systems
Email: ginsberg@cisco.com

Acee Lindem
Cisco Systems
Email: acee@cisco.com

Saikat Ray
Individual
Email: raysaikat@gmail.com

Jeff Tantsura
Apstra Inc.
Email: jefftant.ietf@gmail.com

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8. References

8.1. Normative References

[I-D.ietf-idr-te-pm-bgp]

[I-D.ietf-isis-l2bundles]


8.2. Informative References


Authors’ Addresses

Stefano Previdi
Huawei Technologies
Rome
Italy

Email: stefano@previdi.net

Ketan Talaulikar (editor)
Cisco Systems, Inc.
India

Email: ketant@cisco.com

Clarence Filsfils
Cisco Systems, Inc.
Brussels
Belgium

Email: cfilfsfil@cisco.com

Hannes Gredler
RtBrick Inc.

Email: hannes@rtbrick.com

Mach(Guoyi) Chen
Huawei Technologies
Huawei Building, No. 156 Beiqing Rd.
Beijing 100095
China

Email: mach.chen@huawei.com