Inter-Domain Routing
Internet-Draft
Intended status: Standards Track
Expires: April 22, 2019

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October 19, 2018

BGP Link-State extensions for Segment Routing
draft-ietf-idr-bgp-ls-segment-routing-ext-10

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.

Requirements Language

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 [RFC2119].

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Table of Contents

1. Introduction 3
2. BGP-LS Extensions for Segment Routing 5
  2.1. Node Attributes TLVs 5
    2.1.1. SID/Label Sub-TLV 6
    2.1.2. SR-Capabilities TLV 7
    2.1.3. SR-Algorithm TLV 8
    2.1.4. SR Local Block TLV 8
    2.1.5. SRMS Preference TLV 9
  2.2. Link Attribute TLVs 10
    2.2.1. Adjacency SID TLV 11
    2.2.2. LAN Adjacency SID TLV 12
    2.2.3. L2 Bundle Member 13
  2.3. Prefix Attribute TLVs 14
    2.3.1. Prefix-SID TLV 15
    2.3.2. Prefix Attribute Flags TLV 16
    2.3.3. Source Router Identifier (Source Router-ID) TLV . . . 17
    2.3.4. Range TLV 17
  2.4. Equivalent IS-IS Segment Routing TLVs/Sub-TLVs 19
  2.5. Equivalent OSPFv2/OSPFv3 Segment Routing TLVs/Sub-TLVs . 20
3. Implementation Status 21
4. IANA Considerations 21
  4.1. TLV/Sub-TLV Code Points Summary 21
5. Manageability Considerations 22
6. Security Considerations 23
7. Contributors 23
8. Acknowledgements 24
9. References 24
  9.1. Normative References 24
  9.2. Informative References 25
  9.3. URIs 26
Authors' Addresses 28

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).

Two types of IGP segments are defined, Prefix segments 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. [RFC8402].

When Segment Routing is enabled in a 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.

```
                        +------------+
                        |  Consumer  |
                        +------------+
                              ^
                              |
                              v
                    +-------------------+
                    |    BGP Speaker    |         +-----------+
                    | (Route-Reflector) |         | Consumer  |
                    +-------------------+         +-----------+
                          ^   ^   ^                     ^
                          |   |   |                     |
           +---------------+   |   +-------------------+   |
           |                   |                       |   |
           v                   v                       v   v
      +-----------+       +-----------+             +-----------+
      |    BGP    |       |    BGP    |             |    BGP    |
      |  Speaker  |       |  Speaker  |    . . .    |  Speaker  |
      +-----------+       +-----------+             +-----------+
            ^                   ^                       ^
            |                   |                       |
           IGP                 IGP                     IGP
```

Figure 1: Link State info collection

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 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).

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 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. Here the SR domain is defined as a single administrative domain that may be comprised of a single AS or multiple ASes under consolidated global SID administration.

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 Attribute. Section 2.4 and Section 2.5 illustrates 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. The corresponding BGP-LS attribute is a Node Attribute, a Link Attribute or a Prefix Attribute. BGP-LS [RFC7752] defines the TLVs that map link-state information to BGP-LS NLRI and 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.

Some of the TLVs defined in this document contain fields (e.g. flags) whose semantics need to be interpreted accordingly to the respective underlying IS-IS, OSPFv2 or OSPFv3 protocol. The receiver of the BGP-LS update for any of the NLRIs MUST check the Protocol-ID of the NLRI and refer to the underlying protocol specification in order to parse such fields. The individual field descriptions in the sub-sections below point to the relevant underlying protocol specifications for such fields.

2.1. Node Attributes TLVs

The following Node Attribute TLVs are defined:

Description	Length	Section
SID/Label	variable	Section 2.1.1
SR Capabilities	variable	Section 2.1.2
SR Algorithm	variable	Section 2.1.3
SR Local Block	variable	Section 2.1.4
SRMS Preference	variable	Section 2.1.5

Table 1: Node Attribute TLVs

These TLVs can ONLY be added to the Node Attribute associated with the Node NLRI that originates the corresponding underlying IGP TLV/ sub-TLV described below.

2.1.1. SID/Label Sub-TLV

The SID/Label TLV is used as sub-TLV by the SR-Capabilities (Section 2.1.2) and SRLB (Section 2.1.4) TLVs and 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            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      SID/Label (variable)                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

where:

Type: TBD, see Section 4.

Length: Variable, 3 or 4.

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).

The receiving router MUST ignore the SID/Label sub-TLV if the length is other then 3 or 4.

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 SR-MPLS forwarding plane. This information is derived from the protocol specific advertisements.

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

- o 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 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    |   Reserved    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

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

Type: TBD, see Section 4.

Length: Variable.

Flags: 1 octet of flags as defined in [I-D.ietf-isis-segment-routing-extensions].

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.

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.

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

- o 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
 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... |  Algorithm N |                |
+-                                                             -+
|                                                               |
+                                                               +
```

where:

Type: TBD, see Section 4.

Length: Variable.

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.

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

o 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:

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

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

Type: TBD, see Section 4.

Length: Variable.

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.

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.

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

- o 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 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            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Preference    |
+-+-+-+-+-+-+-+-+
```

Type: TBD, see Section 4.

Length: 1.

Preference: 1 octet. Unsigned 8 bit SRMS preference.

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 are defined:

Description	Length	Section
Adjacency Segment Identifier (Adj-SID) TLV	variable	Section 2.2.1
LAN Adjacency Segment Identifier (Adj-SID) TLV	variable	Section 2.2.2
L2 Bundle Member TLV	variable	Section 2.2.3

Table 2: Link Attribute TLVs

These TLVs can ONLY be added to the Link Attribute associated with the link whose local node originates the corresponding underlying IGP TLV/sub-TLV described below.

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)[I-D.ietf-isis-segment-routing-extensions]. 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.

2.2.1. Adjacency SID TLV

The Adjacency SID (Adj-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          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   SID/Label/Index (variable)                  |
+---------------------------------------------------------------+
```

where:

Type: TBD, see Section 4.

Length: Variable, 7 or 8 depending on Label or Index encoding of the SID

Flags. 1 octet field of following flags as 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].

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: Label or index value depending on the flags setting as 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].

2.2.2. LAN Adjacency SID TLV

The LAN Adjacency SID (LAN-Adj-SID-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)                 |
+---------------------------------------------------------------+
```

where:

Type: TBD, see Section 4.

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 field of following flags as 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].

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: Label or index value depending on the flags setting as 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].

2.2.3. L2 Bundle Member

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.

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 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               Type            |          Length               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+


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

where:

Type: TBD, see Section 4.

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 L2Bundle Member Attribute TLV. The sub-TLVs are identical to existing BGP-LS TLVs as identified in the table below.

TLV Code Point	Description	Reference Document
1088	Administrative group (color)	[RFC7752]
1089	Maximum link bandwidth	[RFC7752]
1090	Max. reservable link bandwidth	[RFC7752]
1091	Unreserved bandwidth	[RFC7752]
1092	TE default metric	[RFC7752]
1093	Link protection type	[RFC7752]
1099	Adjacency Segment Identifier (Adj-SID) TLV	Section 2.2.1
1100	LAN Adjacency Segment Identifier (Adj-SID) TLV	Section 2.2.2
1104	Unidirectional link delay	[I-D.ietf-idr-te-pm-bgp]
1105	Min/Max Unidirectional link delay	[I-D.ietf-idr-te-pm-bgp]
1106	Min/Max Unidirectional link delay	[I-D.ietf-idr-te-pm-bgp]
1107	Unidirectional packet loss	[I-D.ietf-idr-te-pm-bgp]
1108	Unidirectional residual bandwidth	[I-D.ietf-idr-te-pm-bgp]
1109	Unidirectional available bandwidth	[I-D.ietf-idr-te-pm-bgp]
1110	Unidirectional bandwidth utilization	[I-D.ietf-idr-te-pm-bgp]

Table 3: L2 Bundle Member Link Attribute TLVs

2.3. Prefix Attribute TLVs

The following Prefix Attribute TLVs are defined:

Description	Length	Section
Prefix SID	variable	Section 2.3.1
Range	variable	Section 2.3.4
Prefix Attribute Flags	variable	Section 2.3.2
Source Router-ID	variable	Section 2.3.3

Table 4: Prefix Attribute TLVs

These TLVs can ONLY be added to the Prefix Attribute associated with the prefix whose local node originates the corresponding underlying 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 in:

o IS-IS, as defined by the Prefix-SID TLV in [I-D.ietf-isis-segment-routing-extensions].

o OSPFv2 and OSPFv3, as defined by the Prefix-SID TLV in [I-D.ietf-ospf-segment-routing-extensions] and [I-D.ietf-ospf-ospfv3-segment-routing-extensions] respectively.

The Prefix-SID has the following format:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               Type            |             Length            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Flags     |   Algorithm   |           Reserved            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       SID/Index/Label (variable)              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

where:

Type: TBD, see Section 4.

Length: Variable, 7 or 8 depending on Label or Index encoding of the SID

Flags: 1 octet value which sould 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-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],

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)                      //
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

where:

Type: TBD, see Section 4.

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 are defined in [RFC7794]

* OSPFv2 flags are defined in [RFC7684]

* OSPFv3 flags map to the Prefix Options field defined in [RFC7794] and extended via [RFC8362]

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]. The Source Router-ID TLV may be used to carry the OSPF Router-ID of the prefix originator.

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

where:

Type: TBD, see Section 4.

Length: 4 or 16.

IPv4/IPv6 Address: 4 octet IPv4 address or 16 octet IPv6 address.

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 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]. The Prefix-NLRI to which the Range TLV is attached MUST be advertised as a non-routing prefix where no IGP metric TLV (TLV 1095) is attached.

The format of the Range TLV is as follows:

```
 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      |             Range Size        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
//                          sub-TLVs                           //
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

where:

Figure 2: Range TLV format

Type: TBD, see Section 4.

Length: variable

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].

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:

o The Range TLV is defined in Section 2.3.4.

o The Prefix-SID TLV (used as sub-TLV in this context) is defined in Section 2.3.1.

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 sematic 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.

Description	Length	IS-IS TLV/sub-TLV
SR Capabilities	variable	2 [1]
SR Algorithm	variable	19 [2]
SR Local Block	variable	22 [3]
SRMS Preference	1	19 [4]
Adjacency Segment Identifier (Adj-SID)	variable	31 [5]
LAN Adjacency Segment Identifier (LAN-Adj-SID)	variable	32 [6]
Prefix SID	variable	3 [7]
Range	variable	149 [8]
SID/Label TLV	variable	1 [9]
Prefix Attribute Flags	variable	4 [10]
Source Router ID	variable	11/12 [11]
L2 Bundle Member TLV	variable	25 [12]

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.

Description	Length	OSPFv2 TLV/sub-TLV
SR Capabilities	variable	9 [13]
SR Algorithm	variable	8 [14]
SR Local Block	variable	14 [15]
SRMS Preference	1	15 [16]
Adjacency Segment Identifier (Adj-SID)	variable	2 [17]
LAN Adjacency Segment Identifier (Adj-SID)	variable	3 [18]
Prefix SID	variable	2 [19]
Range	variable	2 [20]
SID/Label TLV	variable	1 [21]
Prefix Attribute Flags	variable	4 [22]

Table 6: OSPF Segment Routing Extensions TLVs/Sub-TLVs

Description	Length	OSPFv3 TLV/sub-TLV
SR Capabilities	variable	9 [23]
SR Algorithm	variable	8 [24]
SR Local Block	variable	14 [25]
SRMS Preference	1	15 [26]
Adjacency Segment Identifier (Adj-SID)	variable	5 [27]
LAN Adjacency Segment Identifier (Adj-SID)	variable	6 [28]
Prefix SID	variable	4 [29]
Range	variable	9 [30]
SID/Label TLV	variable	7 [31]
Prefix Attribute Flags	variable	4 [32]

Table 7: OSPFv3 Segment Routing Extensions TLVs/Sub-TLVs

3. Implementation Status

Note to RFC Editor: Please remove this section prior to publication, as well as the reference to RFC 7942.

This section records the status of known implementations of the protocol defined by this specification at the time of posting of this Internet-Draft, and is based on a proposal described in [RFC7942]. The description of implementations in this section is intended to assist the IETF in its decision processes in progressing drafts to RFCs. Please note that the listing of any individual implementation here does not imply endorsement by the IETF. Furthermore, no effort has been spent to verify the information presented here that was supplied by IETF contributors. This is not intended as, and must not be construed to be, a catalog of available implementations or their features. Readers are advised to note that other implementations may exist.

According to [RFC7942], "this will allow reviewers and working groups to assign due consideration to documents that have the benefit of running code, which may serve as evidence of valuable experimentation and feedback that have made the implemented protocols more mature. It is up to the individual working groups to use this information as they see fit".

Several early implementations exist and will be reported in detail in a forthcoming version of this document. For purposes of early interoperability testing, when no FCFS code point was available, implementations have made use of the values described in Table 8.

It will ease implementation interoperability and deployment if the value could be preserved also due to the large amount of codepoints this draft requires. However, when IANA-assigned values are available, implementations will be updated to use them.

4. IANA Considerations

This document requests assigning code-points from the registry "BGP-LS Node Descriptor, Link Descriptor, Prefix Descriptor, and Attribute TLVs" based on table Table 8. The column "IS-IS TLV/Sub-TLV" defined in the registry does not require any value and should be left empty.

4.1. TLV/Sub-TLV Code Points Summary

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

TLV Code Point	Description	Reference
1034	SR Capabilities	Section 2.1.2
1035	SR Algorithm	Section 2.1.3
1036	SR Local Block	Section 2.1.4
1037	SRMS Preference	Section 2.1.5
1099	Adjacency Segment Identifier (Adj-SID) TLV	Section 2.2.1
1100	LAN Adjacency Segment Identifier (Adj-SID) TLV	Section 2.2.2
1158	Prefix SID	Section 2.3.1
1159	Range	Section 2.3.4
1161	SID/Label TLV	Section 2.1.1
1170	Prefix Attribute Flags	Section 2.3.2
1171	Source Router-ID	Section 2.3.3
1172	L2 Bundle Member TLV	Section 2.2.3

Table 8: Summary Table of TLV/Sub-TLV Codepoints

5. 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 was 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 is retrieving 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 an error in them would result in only that specific attribute being discarded with an error log.

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].

6. 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.

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8. Acknowledgements

The authors would like to thank Jeffrey Haas and Aijun Wang for their review of this document and their comments.

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