                     BGP Link State Extensions for SRv6
                      draft-ietf-idr-bgpls-srv6-ext-00

Abstract

   Segment Routing 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". These
   segments are advertised by the various protocols such as BGP, ISIS
   and OSPFv3.

   BGP Link-state (BGP-LS) address-family solution for SRv6 is similar
   to BGP-LS for SR for MPLS dataplane. This draft defines extensions
   to the BGP-LS to advertise SRv6 Segments along with their functions
   and other attributes via BGP.

Requirements Language

   The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
   "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and
   "OPTIONAL" in this document are to be interpreted as described in BCP
   14 [RFC2119] [RFC8174] when, and only when, they appear in all
   capitals, as shown here.

Status of This Memo

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

   Internet-Drafts are working documents of the Internet Engineering
   Task Force (IETF). Note that other groups may also distribute
   working documents as Internet-Drafts. The list of current Internet-
   Drafts is at https://datatracker.ietf.org/drafts/current/.

   Internet-Drafts are draft documents valid for a maximum of six months
   and may be updated, replaced, or obsoleted by other documents at any
   time. It is inappropriate to use Internet-Drafts as reference
   material or to cite them other than as "work in progress."

   This Internet-Draft will expire on December 2, 2019.

Copyright Notice

Table of Contents

1. Introduction

SRv6 refers to Segment Routing instantiated on the IPv6 dataplane
[RFC8402]. Segment Identifier (SID) is often used as a shorter
reference for "SRv6 Segment".

The network programming paradigm
[I-D.filsfils-spring-srv6-network-programming] is central to SRv6.
It describes how different functions can be bound to their SIDs and
how a network program can be expressed as a combination of SIDs.

An SRv6-capable node N maintains a "My SID Table" (refer
[I-D.filsfils-spring-srv6-network-programming]). This table contains
all the SRv6 segments explicitly instantiated at node N.

The IS-IS [I-D.bashandy-isis-srv6-extensions] and OSPFv3
[I-D.li-ospf-ospfv3-srv6-extensions] link-state routing protocols
have been extended to advertise some of these SRv6 SIDs and
SRv6-related information. BGP ([I-D.dawra-idr-srv6-vpn]) has been
extended to advertise some of these SRv6 SIDs for VPN services.
Certain other SRv6 SIDs may be instantiated on a node via other
mechanisms for topological or service functionalities.

The advertisement of SR related information along with the topology
for the MPLS dataplane instantiation is specified in
[I-D.ietf-idr-bgp-ls-segment-routing-ext] and for the BGP Egress Peer
Engineering (EPE) is specified in
[I-D.ietf-idr-bgpls-segment-routing-epe]. On the similar lines,
introducing the SRv6 related information in BGP-LS allows it's
consumer applications that require topological visibility to also
receive the "My SID Table" from nodes across a domain or even across
Autonomous Systems (AS), as required. This allows applications to
leverage the SRv6 capabilities for network programming.

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 [RFC7752].

This document describes extensions to BGP-LS to advertise the SRv6
"My SID Table" and other SRv6 information from all the SRv6 capable
nodes in the domain when sourced from link-state routing protocols

and directly from individual SRv6 capable nodes when sourced from
BGP.

2. BGP-LS Extensions for SRv6

BGP-LS[RFC7752] defines the BGP Node, Link and Prefix attributes.
All non-VPN link, node, and prefix information SHALL be encoded using
AFI 16388 / SAFI 71. VPN link, node, and prefix information SHALL be
encoded using AFI 16388 / SAFI 72.

The SRv6 information pertaining to a node is advertised via the BGP-
LS Node NLRI and using the BGP-LS Attribute TLVs as follows:

o SRv6 Capabilities of the node is advertised via a new SRv6
   Capabilities TLV

o New MSD types introduced for SRv6 are advertised as new sub-TLVs
   of the Node MSD TLV specified in
   [I-D.ietf-idr-bgp-ls-segment-routing-msd].

o Algorithm support for SRv6 is advertised via the existing SR
   Algorithm TLV specified in
   [I-D.ietf-idr-bgp-ls-segment-routing-ext].

The SRv6 information pertaining to a link is advertised via the BGP-
LS Link NLRI and using the BGP-LS Attribute TLVs as follows:

o SRv6 End.X SID of the link state routing adjacency or the BGP EPE
   Peer Adjacency is advertised via a new SRv6 End.X SID TLV

o SRv6 LAN End.X SID of the link state routing adjacency to a non-
   DR/DIS router is advertised via a new SRv6 LAN End.X SID TLV

o New MSD types introduced for SRv6 are advertised as new sub-TLVs
   of the Link MSD TLV specified in
   [I-D.ietf-idr-bgp-ls-segment-routing-msd].

The SRv6 Locator information of a node is advertised via the BGP-LS
Prefix NLRI using the new SRv6 Locator TLV in the BGP-LS Attribute.

The SRv6 SIDs associated with the node from its "My SID Table" are
advertised as a newly introduce BGP-LS SRv6 SID NLRI. This enables
the BGP-LS encoding to scale to cover a potentially large set of SRv6
SIDs instantiated on a node with the granularity of individual SIDs
and without affecting the size and scalability of the BGP-LS updates.
New BGP-LS Attribute TLVs are introduced for the SRv6 SID NLRI as
follows:

   o The endpoint function of the SRv6 SID is advertised via a new SRv6
      Endpoint Function TLV

   o The BGP EPE Peer Node and Peer Set SID context is advertised via a
      new SRv6 BGP EPE Peer Node SID TLV

   When the BGP-LS router is advertising topology information that it
   sources from the underlying link-state routing protocol, then it maps
   the corresponding SRv6 information from the SRv6 extensions for IS-IS
   [I-D.bashandy-isis-srv6-extensions] and OSPFv3
   [I-D.li-ospf-ospfv3-srv6-extensions] protocols to their BGP-LS TLVs/
   sub-TLVs for all SRv6 capable nodes in that routing protocol domain.
   When the BGP-LS router is advertising topology information from the
   BGP routing protocol [I-D.ietf-idr-bgpls-segment-routing-epe], then
   it advertises the SRv6 information from the local node alone (e.g.
   BGP EPE topology information or in the case of a data center network
   running BGP as the only routing protocol).

   Subsequent sections of this document specify the encoding of the
   newly defined extensions.

3. SRv6 Node Attributes

   SRv6 attributes of a node are advertised using the new BGP-LS
   Attribute TLVs defined in this section and associated with the BGP-LS
   Node NLRI.

3.1. SRv6 Capabilities TLV

   This BGP-LS Attribute TLV 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. A single instance of this TLV MUST be included
   in the BGP-LS attribute for each SRv6 capable node. This TLV maps to
   the SRv6 Capabilities sub-TLV and the SRv6 Capabilities TLV of the
   IS-IS and OSPFv3 protocol SRv6 extensions respectively.

```
     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            |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
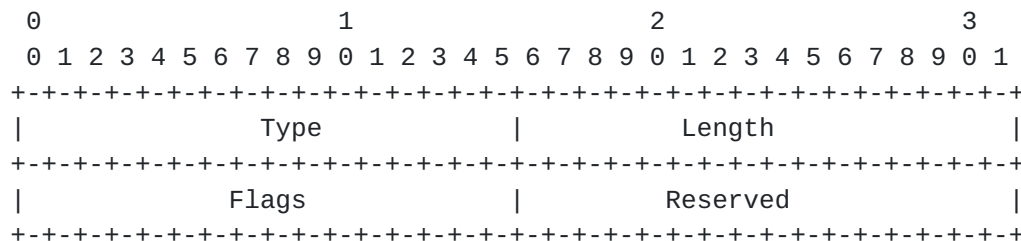
                   Figure 1: SRv6 Capabilities TLV Format

   Where:

o Type: 2 octet field with value TBD, see Section 8.

o Length : 2 octet field with value set to 4.

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

                Figure 2: SRv6 Capability TLV Flags Format

   * O-flag: If set, then router is capable of supporting SRH O-bit
      Flags, as specified in [I-D.ali-spring-srv6-oam].

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

3.2. SRv6 Node MSD Types

The Node MSD TLV [I-D.ietf-idr-bgp-ls-segment-routing-msd] of the
BGP-LS Attribute of the Node NLRI is also used to advertise the
limits and the supported Segment Routing Header (SRH)
[I-D.ietf-6man-segment-routing-header] operations supported by the
SRv6 capable node. The SRv6 MSD Types specified in
[I-D.bashandy-isis-srv6-extensions] are also used with the BGP-LS
Node MSD TLV as these codepoints are shared between IS-IS, OSPF and
BGP-LS protocols. The description and semantics of these new MSD
types for BGP-LS are identical as specified
[I-D.bashandy-isis-srv6-extensions] and summarized in the table
below:

```
   +----------+-----------------------------+
   | MSD Type |    Description               |
   +----------+-----------------------------+
   |   TBD    | Maximum Segments Left        |
   |   TBD    | Maximum End Pop              |
   |   TBD    | Maximum T.Insert             |
   |   TBD    | Maximum T.Encaps             |
   |   TBD    | Maximum End D                |
   +----------+-----------------------------+
```

                   Figure 3: SRv6 Node MSD Types

Each MSD type is encoded as a one octet type followed by a one octet
value.

4. SRv6 Link Attributes

SRv6 attributes and SIDs associated with a link or adjacency are
advertised using the new BGP-LS Attribute TLVs defined in this
section and associated with the BGP-LS Link NLRI.

4.1. SRv6 End.X SID TLV

The SRv6 End.X SID TLV is used to advertise the SRv6 End.X SIDs that
correspond to a point-to-point or point-to-multipoint link or
adjacency of the local node for IS-IS and OSPFv3 protocols. This TLV
can also be used to advertise the End.X function SRv6 SID
corresponding to the underlying layer-2 member links for a layer-3
bundle interface using L2 Bundle Member Attribute TLV as specified in
[I-D.ietf-idr-bgp-ls-segment-routing-ext] .

For the nodes running BGP routing protocol, this TLV is used to
advertise the BGP EPE Peer Adjacency SID for SRv6 on the same lines
as specified for SR/MPLS in [I-D.ietf-idr-bgpls-segment-routing-epe].
The SRv6 End.X SID for the BGP Peer Adjacency indicates the cross-
connect to a specific layer-3 link to the specific BGP session peer
(neighbor).

The 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            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     SRv6 Endpoint Function    |     Flags     |   Algorithm   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Weight    |    Reserved   |  SID (16 octets) ...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     SID (cont ...)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     SID (cont ...)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     SID (cont ...)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     SID (cont ...)              | Sub-TLVs (variable) . . .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
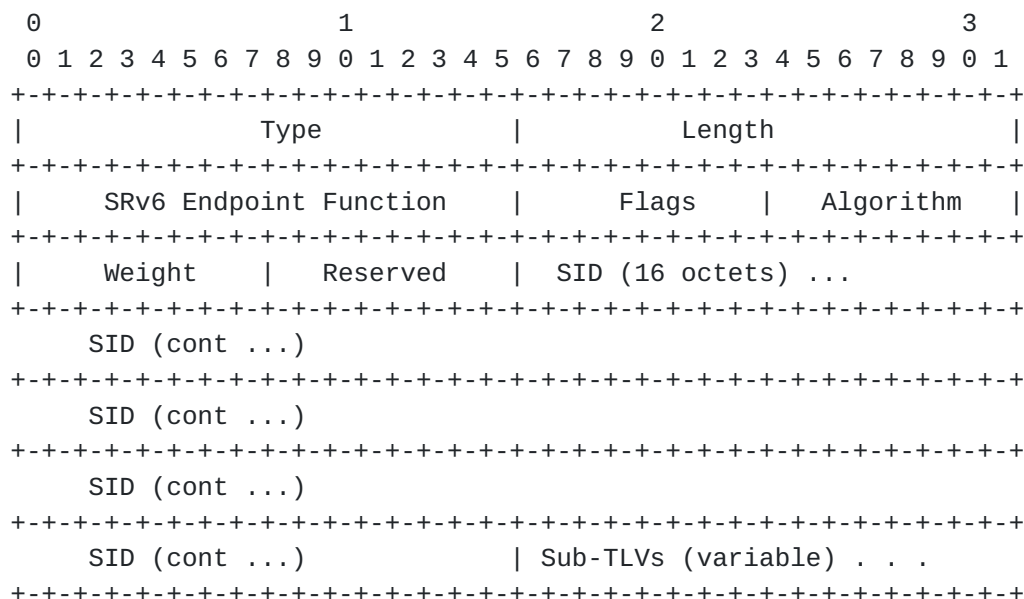
Figure 4: SRv6 End.X TLV Format

Where:

   Type: 2 octet field with value TBD, see Section 8.

   Length: 2 octet field with the total length of the value portion
   of the TLV.

   Function Code: 2 octet field. The Endpoint Function code point
   for this SRv6 SID as defined in
   [I-D.filsfils-spring-srv6-network-programming].

   Flags: 1 octet of flags with the following definition:

```
 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+
|B|S|P|  Rsvd   |
+-+-+-+-+-+-+-+-+
```

                  Figure 5: SRv6 End.X SID TLV Flags Format

   * B-Flag: Backup Flag. If set, the SID is eligible for
      protection (e.g. using IPFRR) as described in [RFC8355].

   * S-Flag: Set Flag. When set, the S-Flag indicates that the SID
      refers to a set of adjacencies (and therefore MAY be assigned
      to other adjacencies as well).

   * P-Flag: Persistent Flag: When set, the P-Flag indicates that
      the SID is persistently allocated, i.e., the value remains
      consistent across router restart and/or interface flap.

   * Rsvd bits: Reserved for future use and MUST be zero when
      originated and ignored when received.

   Algorithm: 1 octet field. Algorithm associated with the SID.
   Algorithm values are defined in the IGP Algorithm Type registry.

   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 SHOULD be set to 0 and MUST be
   ignored on receipt.

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

      Sub-TLVs : currently none defined. Used to advertise sub-TLVs
      that provide additional attributes for the given SRv6 End.X SID.

4.2. SRv6 LAN End.X SID TLV

   For a LAN interface, normally a node only announces its adjacency to
   the IS-IS pseudo-node (or the equivalent OSPF Designated Router).
   The SRv6 LAN End.X SID TLV allows a node to announce SRv6 SID
   corresponding to functions like END.X for its adjacencies to all
   other (i.e. non-DIS or non-DR) 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 SRv6 End.X SID TLVs
   for these neighbor adjacencies.

   The IS-IS and OSPFv3 SRv6 LAN End.X SID TLVs have 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             |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |     SRv6 Endpoint Function    |     Flags     |   Algorithm   |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |    Weight     |   Reserved    |    ISIS System-ID (6 octets)  |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+                                   |
   | or OSPFv3 Router-ID (4 octets) of the neighbor               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |    SID (16 octets) ...
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
       SID (cont ...)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
       SID (cont ...)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
       SID (cont ...)                                             |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Sub-TLVs (variable) . . .
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
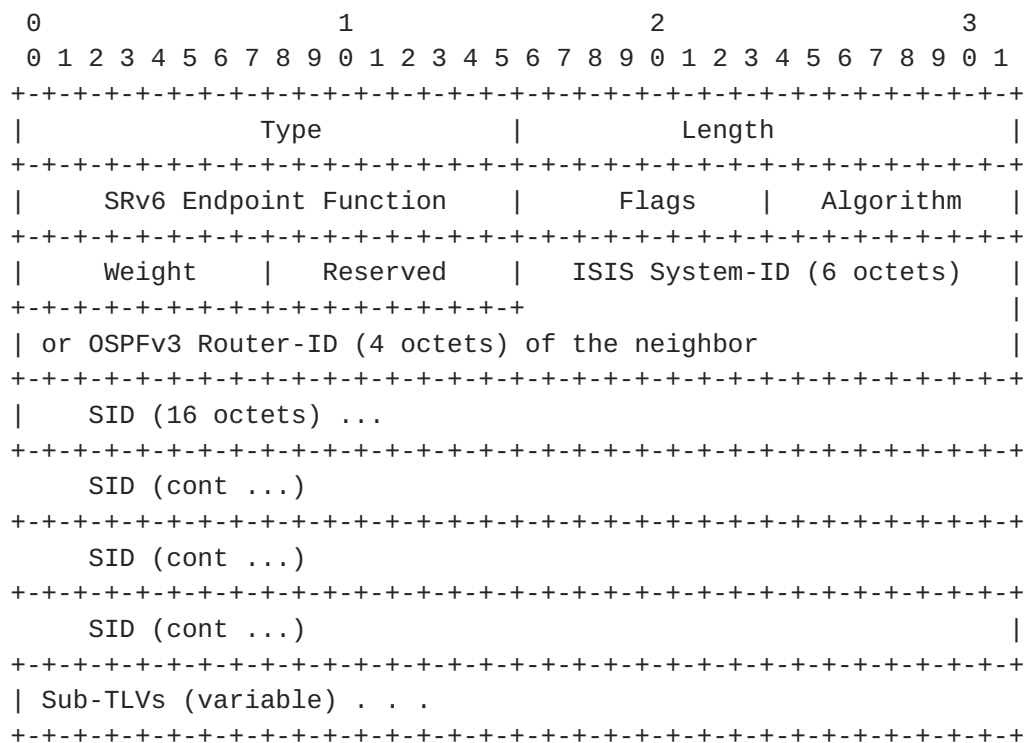
                   Figure 6: SRv6 LAN End.X SID TLV Format

   Where:

   o Type: 2 octet field with value TBD in case of IS-IS and TBD in
      case of OSPFv3, see Section 8.

o Length: 2 octet field with the total length of the value portion
   of the TLV.

o Function Code: 2 octet field. The Endpoint Function code point
   for this SRv6 SID as defined in
   [I-D.filsfils-spring-srv6-network-programming].

o Flags: 1 octet of flags with the following definition:

```
 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+
|B|S|P|  Rsvd   |
+-+-+-+-+-+-+-+-+
```

             Figure 7: SRv6 LAN End.X SID TLV Flags Format

   * B-Flag: Backup Flag. If set, the SID is eligible for
      protection (e.g. using IPFRR) as described in [RFC8355].

   * S-Flag: Set Flag. When set, the S-Flag indicates that the SID
      refers to a set of adjacencies (and therefore MAY be assigned
      to other adjacencies as well).

   * P-Flag: Persistent Flag: When set, the P-Flag indicates that
      the SID is persistently allocated, i.e., the value remains
      consistent across router restart and/or interface flap.

   * Rsvd bits: Reserved for future use and MUST be zero when
      originated and ignored when received.

o Algorithm: 1 octet field. Algorithm associated with the SID.
   Algorithm values are defined in the IGP Algorithm Type registry.

o 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].

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

o Neighbor ID : 6 octets of ISIS System ID of the neighbor for the
   ISIS SRv6 LAN End.X SID TLV and 4 octets of OSPFv3 Router-id of
   the neighbor for the OSPFv3 SRv6 LAN End.X SID TLV.

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

o Sub-TLVs : currently none defined. Used to advertise sub-TLVs
   that provide additional attributes for the given SRv6 LAN End.X
   SID.

4.3. SRv6 Link MSD Types

The Link MSD TLV [I-D.ietf-idr-bgp-ls-segment-routing-msd] of the
BGP-LS Attribute of the Link NLRI is also used to advertise the
limits and the supported Segment Routing Header (SRH) operations
supported on the specific link by the SRv6 capable node. The SRv6
MSD Types specified in [I-D.bashandy-isis-srv6-extensions] are also
used with the BGP-LS Link MSD TLV as these codepoints are shared
between IS-IS, OSPF and BGP-LS protocols. The description and
semantics of these new MSD types for BGP-LS are identical as
specified [I-D.bashandy-isis-srv6-extensions] and summarized in the
table below:

```
+----------+-----------------------------+
| MSD Type |    Description              |
+----------+-----------------------------+
|   TBD    | Maximum Segments Left       |
|   TBD    | Maximum End Pop             |
|   TBD    | Maximum T.Insert            |
|   TBD    | Maximum T.Encaps            |
|   TBD    | Maximum End D               |
+----------+-----------------------------+
```

Figure 8: SRv6 Link MSD Types

Each MSD type is encoded as a one octet type followed by a one octet
value.

5. SRv6 Prefix Attributes

SRv6 attributes with an IPv6 prefix are advertised using the new BGP-
LS Attribute TLVs defined in this section and associated with the
BGP-LS Prefix NLRI.

5.1. SRv6 Locator TLV

As described in [I-D.filsfils-spring-srv6-network-programming], an
SRv6 SID is 128 bits and represented as

LOC:FUNCT

where LOC (the locator portion) is the L most significant bits and
FUNCT is the 128-L least significant bits. L is called the locator

length and is flexible. 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. These Locators are
advertised as BGP-LS Prefix NLRI objects along with the SRv6 Locator
TLV in its BGP-LS Attribute.

The IPv6 Prefix matching the Locator MAY be also advertised as a
prefix reachability by the underlying routing protocol. In this
case, the Prefix NLRI would be also associated with the Prefix Metric
TLV that carries the routing metric for this prefix. When the
Locator prefix is not being advertised as a prefix reachability, then
the Prefix NLRI would have the SRv6 Locator TLV associated with it
but no Prefix Metric TLV. In the absence of Prefix Metric TLV, the
consumer of the BGP-LS topology information MUST NOT interpret the
Locator prefix as a prefix reachability routing advertisement.

The SRv6 Locator 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     |   Algorithm   |           Reserved            |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                            Metric                             |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |   Sub-TLVs (variable) . . .
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 9: SRv6 Locator TLV Format

Where:

   Type: 2 octet field with value TBD, see Section 8.

   Length: 2 octet field with the total length of the value portion
   of the TLV.

   Flags: 1 octet of flags with the following definition:

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

Figure 10: SRv6 Locator TLV Flags Format

   * D-Flag: Indicates that the locator has been leaked into the IGP
      domain when set. IS-IS operations for this are discussed in
      [I-D.bashandy-isis-srv6-extensions].

   * A-Flag: When the Locator is associated with anycast
      destinations, the A flag SHOULD be set. Otherwise, this bit
      MUST be clear.

   * Reserved bits: Reserved for future use and MUST be zero when
      originated and ignored when received.

   Algorithm: 1 octet field. Algorithm associated with the SID.
   Algorithm values are defined in the IGP Algorithm Type registry.

   Reserved: 2 octet field. The value MUST be zero when originated
   and ignored when received.

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

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

6. SRv6 SID NLRI

   SRv6 SID information is advertised in BGP UPDATE messages using the
   MP_REACH_NLRI and MP_UNREACH_NLRI attributes [RFC4760]. The "Link-
   State NLRI" defined in [RFC7752] is extended to carry the SRv6 SID
   information.

   A new "Link-State NLRI Type" is defined for SRv6 SID information as
   following:

   o Link-State NLRI Type: SRv6 SID NLRI (value TBD see IANA
      Considerations Section 8.1).

   The format of this new NLRI type is as shown in the following figure:

```
  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
  +-+-+-+-+-+-+-+-+
  |  Protocol-ID  |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                          Identifier                          |
  |                          (64 bits)                           |
  ++-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
  |                 Local Node Descriptors (variable)           //
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                 SRv6 SID Descriptors (variable)             //
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
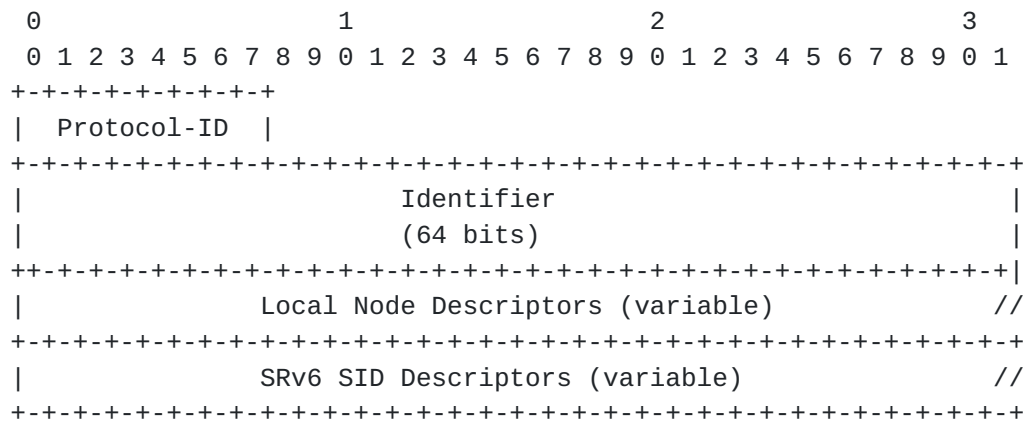
                  Figure 11: SRv6 SID NLRI Format

   Where:

   o Protocol-ID: 1 octet field that specifies the protocol component
      through which BGP-LS learns the SRv6 SIDs of the node. The
      following Protocol-IDs apply to the SRv6 SID NLRI:

   +-------------+---------------------------------+
   | Protocol-ID | NLRI information source protocol |
   +-------------+---------------------------------+
1	IS-IS Level 1
2	IS-IS Level 2
4	Direct
5	Static configuration
6	OSPFv3
7	BGP
   +-------------+---------------------------------+

                 Figure 12: Protocol IDs for SRv6 SID NLRI

   o Identifier: 8 octet value as defined in [RFC7752].

   o Local Node Descriptors TLV: as defined in [RFC7752] for IGPs,
      local and static configuration and as defined in
      [I-D.ietf-idr-bgpls-segment-routing-epe] for BGP protocol.

   o SRv6 SID Descriptors: MUST include the SRv6 SID Information TLV
      defined in Section 6.1 and optionally MAY include the Multi-
      Topology Identifier TLV as defined in [RFC7752].

   New TLVs carried in the BGP Link State Attribute defined in [RFC7752]
   are also defined in order to carry the attributes of a SRv6 SID in
   Section 7.

6.1. SRv6 SID Information TLV

A SRv6 SID is a 128 bit value
[I-D.filsfils-spring-srv6-network-programming] and is encoded using
the SRv6 SID Information TLV.

The 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            |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |     SID (16 octets) ...
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      SID (cont ...)
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      SID (cont ...)
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      SID (cont ...)                                             |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
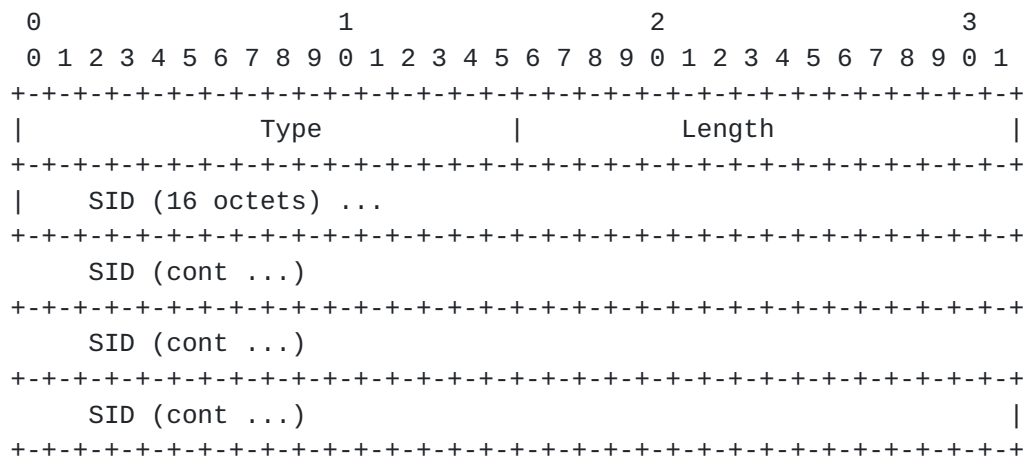
Figure 13: SRv6 SID Information TLV Format

Where:

Type: 2 octet field with value TBD, see Section 8.

Length: 2 octet field with value set to 16.

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

7. SRv6 SID Attributes

This section specifies the new TLVs to be carried in the BGP Link
State Attribute associated with the BGP-LS SRv6 SID NLRI.

7.1. SRv6 Endpoint Function TLV

Each SRv6 SID instantiated in the "My SID Table" of an SRv6 capable
node has a specific instruction bound to it. A set of well-known
functions that can be associated with a SID are defined in
[I-D.filsfils-spring-srv6-network-programming].

The SRv6 Endpoint Function TLV is a mandatory TLV that MUST be
included in the BGP-LS Attribute associated with the BGP-LS SRv6 SID
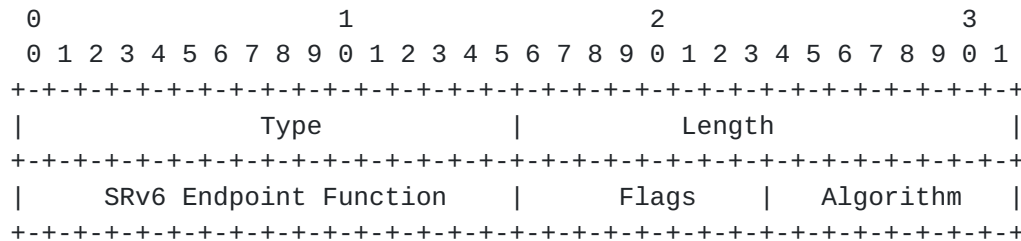NLRI. The TLV has the following format:

```
  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            |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |      SRv6 Endpoint Function   |     Flags     |   Algorithm   |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 14: SRv6 Endpoint Function TLV

Where:

   Type: 2 octet field with value TBD, see Section 8.

   Length: 2 octet field with the value 4.

   Function Code: 2 octet field. The Endpoint Function code point
   for this SRv6 SID as defined in
   [I-D.filsfils-spring-srv6-network-programming].

   Flags: 1 octet of flags with the none defined currently. Reserved
   for future use and MUST be zero when originated and ignored when
   received.

   Algorithm: 1 octet field. Algorithm associated with the SID.
   Algorithm values are defined in the IGP Algorithm Type registry.

7.2. SRv6 BGP Peer Node SID TLV

The BGP Peer Node SID and Peer Set SID for SR with MPLS dataplane are
specified in [I-D.ietf-idr-bgpls-segment-routing-epe]. The similar
Peer Node and Peer Set SID functionality can be realized with SRv6
using the END.X SRv6 SID. The SRv6 BGP Peer Node SID TLV is an
optional TLV for use in the BGP-LS Attribute for an SRv6 SID NLRI
corresponding to BGP protocol. This TLV MUST be included along with
SRv6 End.X SID that is associated with the BGP Peer Node or Peer Set
functionality.

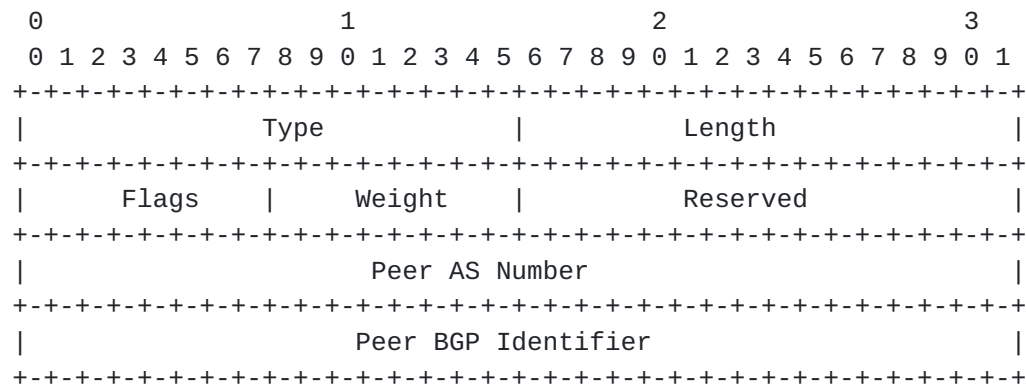The TLV has the following format:

```
 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           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Peer AS Number                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Peer BGP Identifier                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 15: SRv6 BGP Peer Node SID TLV Format

Where:

o Type: 2 octet field with value TBD, see Section 8.

o Length: 2 octet field with the value 12.

o Flags: 1 octet of flags with the following definition:

```
 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+
|B|S|P|  Rsvd   |
+-+-+-+-+-+-+-+-+
```
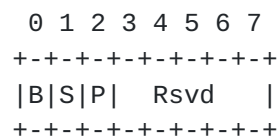
Figure 16: SRv6 BGP Peer End.X SID TLV Flags Format

  * B-Flag: Backup Flag. If set, the SID is eligible for
     protection (e.g. using IPFRR) as described in [RFC8355].

  * S-Flag: Set Flag. When set, the S-Flag indicates that the SID
     refers to a set of BGP peering sessions (i.e. BGP Peer Set SID
     functionality) and therefore MAY be assigned to one or more
     End.X SIDs associated with BGP peer sessions.

  * P-Flag: Persistent Flag: When set, the P-Flag indicates that
     the SID is persistently allocated, i.e., the value remains
     consistent across router restart and/or session flap.

  * Rsvd bits: Reserved for future use and MUST be zero when
     originated and ignored when received.

o 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].

o Peer AS Number : 4 octets of BGP AS number of the peer router.

o Peer BGP Identifier : 4 octets of the BGP Identifier (BGP Router-
   ID) of the peer router.

For a SRv6 BGP EPE Peer Node SID, one instance of this TLV is
associated with the SRv6 SID. For SRv6 BGP EPE Peer Set SID,
multiple instances of this TLV (one for each peer in the "peer set")
are associated with the SRv6 SID and the S (set/group) flag is SET.

8. IANA Considerations

This document requests assigning code-points from the IANA "Border
Gateway Protocol - Link State (BGP-LS) Parameters" registry as
described in the sub-sections below.

8.1. BGP-LS NLRI-Types

The following codepoints is suggested (to be assigned by IANA) from
within the sub-registry called "BGP-LS NLRI-Types":

```
+------+----------------------------+---------------+
| Type | NLRI Type                  |   Reference   |
+------+----------------------------+---------------+
|  TBD | SRv6 SID                   | this document |
+------+----------------------------+---------------+
```

Figure 17: SRv6 SID NLRI Type Codepoint

8.2. BGP-LS TLVs

The following TLV codepoints are suggested (to be assigned by IANA)
from within the sub-registry called "BGP-LS Node Descriptor, Link
Descriptor, Prefix Descriptor, and Attribute TLVs":

```
+----------+----------------------------------+--------------+
| TLV Code |             Description          | Value defined |
|  Point   |                                  |      in      |
+----------+----------------------------------+--------------+
|   TBD    |   SRv6 Capabilities TLV          | this document |
|   TBD    |   SRv6 End.X SID TLV             | this document |
|   TBD    |   IS-IS SRv6 LAN End.X SID TLV   | this document |
|   TBD    |   OSPFv3 SRv6 LAN End.X SID TLV  | this document |
|   TBD    |   SRv6 Locator TLV               | this document |
|   TBD    |   SRv6 SID Information TLV        | this document |
|   TBD    |   SRv6 Endpoint Function TLV     | this document |
|   TBD    |   SRv6 BGP Peer Node SID TLV     | this document |
+----------+----------------------------------+--------------+
```

Figure 18: SRv6 BGP-LS Attribute TLV Codepoints

9. Manageability Considerations

This section is structured as recommended in[RFC5706]

10. Operational Considerations

10.1. Operations

Existing BGP and BGP-LS operational procedures apply. No additional
operation procedures are defined in this document.

11. Security Considerations

Procedures and protocol extensions defined in this document do not
affect the BGP security model. See the 'Security Considerations'
section of [RFC4271] for a discussion of BGP security. Also refer
to[RFC4272] and [RFC6952] for analysis of security issues for BGP.

12. Contributors

James Uttaro
AT&T
USA
Email: ju1738@att.com

Hani Elmalky
Ericsson
USA
Email: hani.elmalky@gmail.com

   Arjun Sreekantiah
   Individual
   USA
   Email: arjunhrs@gmail.com

   Les Ginsberg
   Cisco Systems
   USA
   Email: ginsberg@cisco.com

   Shunwan Zhuang
   Huawei
   China
   Email: zhuangshunwan@huawei.com

13. Acknowledgements

14. References

14.1. Normative References

   [I-D.ali-spring-srv6-oam]
              Ali, Z., Filsfils, C., Kumar, N., Pignataro, C.,
              faiqbal@cisco.com, f., Gandhi, R., Leddy, J., Matsushima,
              S., Raszuk, R., daniel.voyer@bell.ca, d., Dawra, G.,
              Peirens, B., Chen, M., and G. Naik, "Operations,
              Administration, and Maintenance (OAM) in Segment Routing
              Networks with IPv6 Data plane (SRv6)", draft-ali-spring-
              srv6-oam-02 (work in progress), October 2018.

   [I-D.bashandy-isis-srv6-extensions]
              Psenak, P., Filsfils, C., Bashandy, A., Decraene, B., and
              Z. Hu, "IS-IS Extensions to Support Routing over IPv6
              Dataplane", draft-bashandy-isis-srv6-extensions-05 (work
              in progress), March 2019.

   [I-D.dawra-idr-srv6-vpn]
              Dawra, G., Filsfils, C., Dukes, D., Brissette, P.,
              Camarillo, P., Leddy, J., daniel.voyer@bell.ca, d.,
              daniel.bernier@bell.ca, d., Steinberg, D., Raszuk, R.,
              Decraene, B., Matsushima, S., and S. Zhuang, "BGP
              Signaling for SRv6 based Services.", draft-dawra-idr-
              srv6-vpn-05 (work in progress), October 2018.

   [I-D.filsfils-spring-srv6-network-programming]
             Filsfils, C., Camarillo, P., Leddy, J.,
             daniel.voyer@bell.ca, d., Matsushima, S., and Z. Li, "SRv6
             Network Programming", draft-filsfils-spring-srv6-network-
             programming-07 (work in progress), February 2019.

   [I-D.ietf-6man-segment-routing-header]
             Filsfils, C., Dukes, D., Previdi, S., Leddy, J.,
             Matsushima, S., and d. daniel.voyer@bell.ca, "IPv6 Segment
             Routing Header (SRH)", draft-ietf-6man-segment-routing-
             header-19 (work in progress), May 2019.

   [I-D.ietf-idr-bgp-ls-segment-routing-ext]
             Previdi, S., Talaulikar, K., Filsfils, C., Gredler, H.,
             and M. Chen, "BGP Link-State extensions for Segment
             Routing", draft-ietf-idr-bgp-ls-segment-routing-ext-15
             (work in progress), May 2019.

   [I-D.ietf-idr-bgp-ls-segment-routing-msd]
             Tantsura, J., Chunduri, U., Mirsky, G., Sivabalan, S., and
             N. Triantafillis, "Signaling MSD (Maximum SID Depth) using
             Border Gateway Protocol Link-State", draft-ietf-idr-bgp-
             ls-segment-routing-msd-04 (work in progress), February
             2019.

   [I-D.ietf-idr-bgpls-segment-routing-epe]
             Previdi, S., Talaulikar, K., Filsfils, C., Patel, K., Ray,
             S., and J. Dong, "BGP-LS extensions for Segment Routing
             BGP Egress Peer Engineering", draft-ietf-idr-bgpls-
             segment-routing-epe-19 (work in progress), May 2019.

   [I-D.li-ospf-ospfv3-srv6-extensions]
             Li, Z., Hu, Z., Cheng, D., Talaulikar, K., and P. Psenak,
             "OSPFv3 Extensions for SRv6", draft-li-ospf-
             ospfv3-srv6-extensions-03 (work in progress), March 2019.

   [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate
             Requirement Levels", BCP 14, RFC 2119,
             DOI 10.17487/RFC2119, March 1997,
             <https://www.rfc-editor.org/info/rfc2119>.

   [RFC7752] Gredler, H., Ed., Medved, J., Previdi, S., Farrel, A., and
             S. Ray, "North-Bound Distribution of Link-State and
             Traffic Engineering (TE) Information Using BGP", RFC 7752,
             DOI 10.17487/RFC7752, March 2016,
             <https://www.rfc-editor.org/info/rfc7752>.

   [RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC
              2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174,
              May 2017, <https://www.rfc-editor.org/info/rfc8174>.

   [RFC8402] Filsfils, C., Ed., Previdi, S., Ed., Ginsberg, L.,
              Decraene, B., Litkowski, S., and R. Shakir, "Segment
              Routing Architecture", RFC 8402, DOI 10.17487/RFC8402,
              July 2018, <https://www.rfc-editor.org/info/rfc8402>.

14.2. Informative References

   [RFC4271] Rekhter, Y., Ed., Li, T., Ed., and S. Hares, Ed., "A
              Border Gateway Protocol 4 (BGP-4)", RFC 4271,
              DOI 10.17487/RFC4271, January 2006,
              <https://www.rfc-editor.org/info/rfc4271>.

   [RFC4272] Murphy, S., "BGP Security Vulnerabilities Analysis",
              RFC 4272, DOI 10.17487/RFC4272, January 2006,
              <https://www.rfc-editor.org/info/rfc4272>.

   [RFC4760] Bates, T., Chandra, R., Katz, D., and Y. Rekhter,
              "Multiprotocol Extensions for BGP-4", RFC 4760,
              DOI 10.17487/RFC4760, January 2007,
              <https://www.rfc-editor.org/info/rfc4760>.

   [RFC5706] Harrington, D., "Guidelines for Considering Operations and
              Management of New Protocols and Protocol Extensions",
              RFC 5706, DOI 10.17487/RFC5706, November 2009,
              <https://www.rfc-editor.org/info/rfc5706>.

   [RFC6952] Jethanandani, M., Patel, K., and L. Zheng, "Analysis of
              BGP, LDP, PCEP, and MSDP Issues According to the Keying
              and Authentication for Routing Protocols (KARP) Design
              Guide", RFC 6952, DOI 10.17487/RFC6952, May 2013,
              <https://www.rfc-editor.org/info/rfc6952>.

   [RFC8355] Filsfils, C., Ed., Previdi, S., Ed., Decraene, B., and R.
              Shakir, "Resiliency Use Cases in Source Packet Routing in
              Networking (SPRING) Networks", RFC 8355,
              DOI 10.17487/RFC8355, March 2018,
              <https://www.rfc-editor.org/info/rfc8355>.

Authors' Addresses

   Gaurav Dawra (editor)
   LinkedIn
   USA

   Email: gdawra.ietf@gmail.com

   Clarence Filsfils
   Cisco Systems
   Belgium

   Email: cfilsfil@cisco.com

   Ketan Talaulikar (editor)
   Cisco Systems
   India

   Email: ketant@cisco.com

   Mach Chen
   Huawei
   China

   Email: mach.chen@huawei.com

   Daniel Bernier
   Bell Canada
   Canada

   Email: daniel.bernier@bell.ca

   Bruno Decraene
   Orange
   France

   Email: bruno.decraene@orange.com