               OSPFv3 Extensions for Segment Routing
          draft-ietf-ospf-ospfv3-segment-routing-extensions-03

Abstract

   Segment Routing (SR) allows for a flexible definition of end-to-end
   paths within IGP topologies by encoding paths as sequences of
   topological sub-paths, called "segments". These segments are
   advertised by the link-state routing protocols (IS-IS and OSPF).

   This draft describes the OSPFv3 extensions that are required for
   Segment Routing.

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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1. Introduction

   Segment Routing (SR) allows for a flexible definition of end-to-end
   paths within IGP topologies by encoding paths as sequences of
   topological sub-paths, called "segments". These segments are
   advertised by the link-state routing protocols (IS-IS and OSPF).
   Prefix segments represent an ecmp-aware shortest-path to a prefix (or
   a node), 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. SR's
   control-plane can be applied to both IPv6 and MPLS data-planes, and
   does not require any additional signaling (other than the regular
   IGP). For example, when used in MPLS networks, SR paths do not
   require any LDP or RSVP-TE signaling. Still, SR can interoperate in
   the presence of LSPs established with RSVP or LDP.

   This draft describes the OSPFv3 extensions required for segment
   routing.

   Segment Routing architecture is described in
   [I-D.ietf-spring-segment-routing].

   Segment Routing use cases are described in
   [I-D.filsfils-spring-segment-routing-use-cases].

2. Segment Routing Identifiers

   Segment Routing defines various types of Segment Identifiers (SIDs):
   Prefix-SID, Adjacency-SID, LAN Adjacency SID and Binding SID.

2.1. SID/Label Sub-TLV

   The SID/Label Sub-TLV appears in multiple TLVs or Sub-TLVs defined
   later in this document. It is used to advertise the SID or label
   associated with a prefix or adjacency. The SID/Label 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            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      SID/Label (variable)                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

where:

   Type: TBD, suggested value 3

   Length: variable, 3 or 4 bytes

   SID/Label: if length is set to 3, then the 20 rightmost bits
   represent a label. If length is set to 4, then the value
   represents a 32 bit SID.

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

3. Segment Routing Capabilities

   Segment Routing requires some additional capabilities of the router
   to be advertised to other routers in the area.

   These SR capabilities are advertised in OSPFv3 Router Information LSA
   (defined in [RFC4970]).

3.1. SR-Algorithm TLV

   The SR-Algorithm TLV is a TLV of the OSPFv3 Router Information LSA
   (defined in [RFC4970]).

   The SR-Algorithm TLV is optional. It MAY only be advertised once in
   the OSPFv3 Router Information LSA. If the SID/Label Range TLV, as
   defined in Section 3.2, is advertised, then the SR-Algorithm TLV MUST
   also be advertised.

   An OSPFv3 router may use various algorithms when calculating
   reachability to other nodes in area or to prefixes attached to these
   nodes. Examples of these algorithms are metric based Shortest Path
   First (SPF), various sorts of Constrained SPF, etc. The SR-Algorithm
   TLV allows a router to advertise the algorithms that the router is
   currently using to other routers in an area. The SR-Algorithm TLV
   has following structure:

```
 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, suggested value 8

> Length: variable

> Algorithm: Single octet identifying the algorithm. The following
> value has been defined:

>> 0: Shortest Path First (SPF) algorithm based on link metric.
>> This is the standard shortest path algorithm as computed by the
>> OSPF protocol. Consistent with the deployed practice for link-
>> state protocols, Algorithm 0 permits any node to overwrite the
>> SPF path with a different path based on its local policy.

>> 1: Strict Shortest Path First (SPF) algorithm based on link
>> metric. The algorithm is identical to Algorithm 0 but
>> Algorithm 1 requires that all nodes along the path will honor
>> the SPF routing decision. Local policy at the node claiming
>> the support of Algorithm 1 MUST NOT alter the forwarding
>> decision computed by Algorithm 1.

The RI LSA can be advertised at any of the defined flooding scopes
(link, area, or autonomous system (AS)). For the purpose of the SR-
Algorithm TLV propagation, area scope flooding is required.

3.2. SID/Label Range TLV

The SID/Label Range TLV is a TLV of the OSPFv3 Router Information LSA
(defined in [RFC4970]).

The SID/Label Sub-TLV MAY appear multiple times and 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            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                 Range Size                |    Reserved      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Sub-TLVs (variable)                     |
+-                                                            -+
|                                                              |
+                                                              +
```

where:

    Type: TBD, suggested value 9

    Length: variable

    Range Size: 3 octets of SID/label range

Initially, the only supported Sub-TLV is the SID/Label TLV as defined
in Section 2.1. The SID/Label advertised in the SID/Label TLV
represents the first SID/Label in the advertised range.

Multiple occurrence of the SID/Label Range TLV MAY be advertised, in
order to advertise multiple ranges. In such case:

o The originating router MUST encode each range into a different
   SID/Label Range TLV.

o The originating router decides the order in which the set of SID/
   Label Range TLVs are advertised in the OSPFv3 Router Information
   LSA. The originating router MUST ensure the order is same after a
   graceful restart (using checkpointing, non-volatile storage or any
   other mechanism) in order to assure the SID/label range and SID
   index correspondence is preserved across graceful restarts.

o The receiving router must adhere to the order in which the ranges
   are advertised when calculating a SID/label from the SID index.

o A router not supporting multiple occurrences of the SID/Label
   Range TLV MUST use first advertised SID/Label Range TLV.

The following example illustrates the advertisement of multiple
ranges:

   The originating router advertises the following ranges:
      Range 1: [100, 199]
      Range 2: [1000, 1099]
      Range 3: [500, 599]

   The receiving routers concatenate the ranges and build the Segment Routing
Global Block
   (SRGB) is as follows:

   SRGB = [100, 199]
          [1000, 1099]
          [500, 599]

   The indexes span multiple ranges:

      index=0 means label 100
      ...
      index 99 means label 199
      index 100 means label 1000
      index 199 means label 1099
      ...
      index 200 means label 500
      ...

   The RI LSA can be advertised at any of the defined flooding scopes
   (link, area, or autonomous system (AS)). For the purpose of the SR-
   Capability TLV propagation, area scope flooding is required.

3.3. SR-Forwarding Capabilities

   OSPFv3 router supporting Segment Routing needs to advertise its SR
   data-plane capabilities. Data-plane capabilities are advertised in
   OSPF Router Informational Capabilities TLV, which is defined in
   section 2.3 of RFC 4970 [RFC4970].

   Two new bits are allocated in the OSPF Router Informational
   Capability Bits as follows:

      Bit-6 - MPLS IPv6 flag. If set, then the router is capable of
      processing SR MPLS encapsulated IPv6 packets on all interfaces.

      Bit-7 - If set, then the router is capable of processing the IPv6
      Segment Routing Header on all interfaces as defined in
      [I-D.previdi-6man-segment-routing-header].

   For the purpose of the SR-Forwarding Capabilities propagation, area
   scope flooding is required.

4. OSPFv3 Extended Prefix Range TLV

In some cases it is useful to advertise attributes for a range of
prefixes. Segment Routing Mapping Server, which is described in
[I-D.filsfils-spring-segment-routing-ldp-interop], is an example
where we need a single advertisement to advertise SIDs for multiple
prefixes from a contiguous address range. The OSPFv3 Extended Prefix
Range TLV is defined for this purpose.

The OSPFv3 Extended Prefix Range TLV is a new top level TLV of the
following LSAs defined in [I-D.ietf-ospf-ospfv3-lsa-extend]:

      E-Intra-Area-Prefix-LSA

      E-Inter-Area-Prefix-LSA

      E-AS-External-LSA

      E-Type-7-LSA

Multiple OSPFv3 Extended Prefix Range TLVs MAY be advertised in these
extended LSAs. The OSPFv3 Extended Prefix Range 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             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Prefix Length |      AF       |           Range Size          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Flags      |                   Reserved                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Address Prefix (variable)                 |
|                          ...                                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Sub-TLVs (variable)                       |
+-                                                             -+
|                                                               |
```
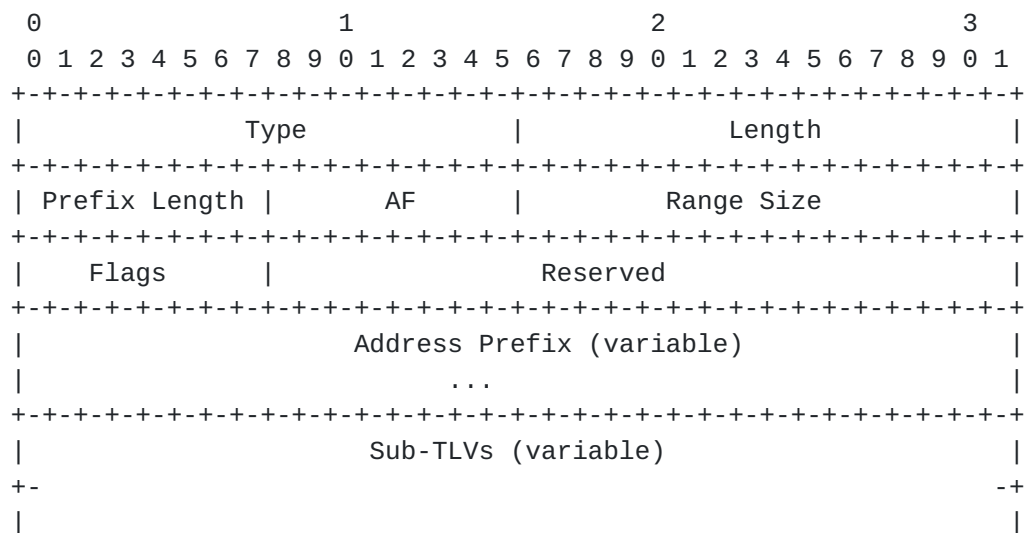
where:

      Type: TBD, suggested value 9.

      Length: variable

      Prefix length: length of the prefix

AF: 0 - IPv6 unicast

Range size: represents the number of prefixes that are covered by
the advertisement. The Range Size MUST NOT exceed the number of
prefixes that could be satisfied by the prefix length without
including addresses from other than the IPv6 unicast address
class.

Flags: 1 octet field. The following flags are defined:


```
   0  1  2  3  4  5  6  7
 +--+--+--+--+--+--+--+--+
 |IA|  |  |  |  |  |  |  |
 +--+--+--+--+--+--+--+--+
```

where:

> IA-Flag: Inter-Area flag. If set, advertisement is of inter-
> area type. ABR that is advertising the OSPF Extended Prefix
> Range TLV between areas MUST set this bit.
>
> This bit is used to prevent redundant flooding of Prefix Range
> TLVs between areas as follows:
>
> > An ABR always prefers intra-area Prefix Range advertisement
> > over inter-area one.
> >
> > An ABR does not consider inter-area Prefix Range
> > advertisements coming from non backbone area.
> >
> > An ABR propagates inter-area Prefix Range advertisement from
> > backbone area to connected non backbone areas only if such
> > advertisement is considered to be the best one.

Address Prefix: the prefix, encoded as an even multiple of 32-bit
words, padded with zeroed bits as necessary. This encoding
consumes ((PrefixLength + 31) / 32) 32-bit words. The Address
Prefix represents the first prefix in the prefix range.

5. Prefix SID Sub-TLV

The Prefix SID Sub-TLV is a Sub-TLV of the following OSPFv3 TLVs as
defined in [I-D.ietf-ospf-ospfv3-lsa-extend] and in Section 4:

Intra-Area Prefix TLV

Inter-Area Prefix TLV

External Prefix TLV

OSPFv3 Extended Prefix Range TLV

It MAY appear more than once in the parent TLV 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            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Flags     |  Algorithm    |            Reserved           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      SID/Index/Label (variable)               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

where:

   Type: TBD, suggested value 4.

   Length: variable

   Flags: 1 octet field. The following flags are defined:


```
   0  1  2  3  4  5  6  7
 +--+--+--+--+--+--+--+--+
 |  |NP|M |E |V |L |  |  |
 +--+--+--+--+--+--+--+--+
```

where:

      NP-Flag: No-PHP flag. If set, then the penultimate hop MUST
      NOT pop the Prefix-SID before delivering the packet to the node
      that advertised the Prefix-SID.

      M-Flag: Mapping Server Flag. If set, the SID is advertised
      from the Segment Routing Mapping Server functionality as
      described in [I-D.filsfils-spring-segment-routing-ldp-interop].

      E-Flag: Explicit-Null Flag. If set, any upstream neighbor of
      the Prefix-SID originator MUST replace the Prefix-SID with a
      Prefix-SID having an Explicit-NULL value (0 for IPv4) before
      forwarding the packet.

The V-Flag: Value/Index Flag. If set, then the Prefix-SID
carries an absolute value. If not set, then the Prefix-SID
carries an index.

The L-Flag: Local/Global Flag. If set, then the value/index
carried by the Prefix-SID has local significance. If not set,
then the value/index carried by this Sub-TLV has global
significance.

Other bits: Reserved. These MUST be zero when sent and are
ignored when received.

Algorithm: one octet identifying the algorithm the Prefix-SID is
associated with as defined in [Section 3.1](#).

SID/Index/Label: label or index value depending on the V-bit
setting.

Examples:

A 32 bit global index defining the offset in the SID/Label
space advertised by this router - in this case the V and L
flags MUST NOT be set.

A 24 bit local label where the 20 rightmost bits are used
for encoding the label value - in this case the V and L
flags MUST be set.

If multiple Prefix-SIDs are advertised for the same prefix, the
receiving router MUST use the first encoded SID and MAY use the
subsequent SIDs.

When propagating Prefix-SIDs between areas, if multiple prefix-SIDs
are advertised for a prefix, an implementation SHOULD preserve the
original order when advertising prefix-SIDs to other areas. This
allows implementations that only support a single Prefix-SID to have
a consistent view across areas.

When calculating the outgoing label for the prefix, the router MUST
take into account E and P flags advertised by the next-hop router, if
next-hop router advertised the SID for the prefix. This MUST be done
regardless of whether the next-hop router contributes to the best
path to the prefix.

The NP-Flag (No-PHP) MUST be set for Prefix-SIDs allocated to inter-
area prefixes that are originated by the ABR based on intra-area or
inter-area reachability between areas. When the inter-area prefix is

generated based on a prefix which is directly attached to the ABR,
NP-Flag SHOULD NOT be set

The NP-Flag (No-PHP) MUST be set on the Prefix-SIDs allocated to
redistributed prefixes, unless the redistributed prefix is directly
attached to ASBR, in which case the NP-Flag SHOULD NOT be set.

If the NP-Flag is not set then any upstream neighbor of the Prefix-
SID originator MUST pop the Prefix-SID. This is equivalent to the
penultimate hop popping mechanism used in the MPLS dataplane. In
such case, MPLS EXP bits of the Prefix-SID are not preserved for the
final destination (the Prefix-SID being removed). If the NP-Flag is
clear then the received E-flag is ignored.

If the NP-Flag is set then:

   If the E-flag is not set then any upstream neighbor of the Prefix-
   SID originator MUST keep the Prefix-SID on top of the stack. This
   is useful when the originator of the Prefix-SID must stitch the
   incoming packet into a continuing MPLS LSP to the final
   destination. This could occur at an inter-area border router
   (prefix propagation from one area to another) or at an inter-
   domain border router (prefix propagation from one domain to
   another).

   If the E-flag is set then any upstream neighbor of the Prefix-SID
   originator MUST replace the Prefix-SID with a Prefix-SID having an
   Explicit-NULL value. This is useful, e.g., when the originator of
   the Prefix-SID is the final destination for the related prefix and
   the originator wishes to receive the packet with the original EXP
   bits.

When M-Flag is set, NP-Flag MUST be set and E-bit MUST NOT be set.

As the Mapping Server does not specify the originator of a prefix
advertisement it is not possible to determine PHP behavior solely
based on the Mapping Server advertisement. However, PHP behavior may
safely be done in following cases:

   Prefix is of intra-area type and the downstream neighbor is the
   originator of the prefix.

   Prefix is of inter-area type and downstream neighbor is an ABR,
   which is advertising the prefix reachability and is setting LA-bit
   in the Prefix Options as described in section 3.1 of
   [I-D.ietf-ospf-ospfv3-lsa-extend].

Prefix is of external type and downstream neighbor is an ASBR,
which is advertising the prefix reachability and is setting LA-bit
in the Prefix Options as described in section 3.1 of
[I-D.ietf-ospf-ospfv3-lsa-extend].

When a Prefix-SID is advertised in an Extended Prefix Range TLV, then
the value advertised in Prefix SID Sub-TLV is interpreted as a
starting SID value.

Example 1: if the following router addresses (loopback addresses)
need to be mapped into the corresponding Prefix SID indexes:

        Router-A: 192::1/128, Prefix-SID: Index 1
        Router-B: 192::2/128, Prefix-SID: Index 2
        Router-C: 192::3/128, Prefix-SID: Index 3
        Router-D: 192::4/128, Prefix-SID: Index 4

then the Address Prefix field in the OSPFv3 Extended Prefix Range TLV
is set to 192::1, Prefix Length would be set to 128, Range Size would
be set to 4 and the Index value in the Prefix-SID Sub-TLV would be
set to 1.

Example 2: If the following prefixes need to be mapped into the
corresponding Prefix-SID indexes:

        10:1:1::0/120,   Prefix-SID: Index 51
        10:1:1::100/120, Prefix-SID: Index 52
        10:1:1::200/120, Prefix-SID: Index 53
        10:1:1::300/120, Prefix-SID: Index 54
        10:1:1::400/120, Prefix-SID: Index 55
        10:1:1::500/120, Prefix-SID: Index 56
        10:1:1::600/120, Prefix-SID: Index 57

then the Address Prefix field in the OSPFv3 Extended Prefix Range TLV
is set to 10:1:1::0, Prefix Length would be set to 120, Range Size
would be set to 7 and the Index value in the Prefix-SID Sub-TLV would
be set to 51.

6. SID/Label Binding Sub-TLV

The SID/Label Binding Sub-TLV is used to advertise SID/Label mapping
for a path to the prefix.

The SID/Label Binding TLV MAY be originated by any router in an
OSPFv3 domain. The router may advertise a SID/Label binding to a FEC
along with at least a single 'nexthop style' anchor. The protocol
supports more than one 'nexthop style' anchor to be attached to a
SID/Label binding, which results into a simple path description

language. In analogy to RSVP the terminology for this is called an
'Explicit Route Object' (ERO). Since ERO style path notation allows
anchoring SID/label bindings to both link and node IP addresses, any
Label Switched Path (LSP) can be described. Furthermore, SID/Label
Bindings from external protocols can also be re-advertised.

The SID/Label Binding TLV may be used for advertising SID/Label
Bindings and their associated Primary and Backup paths. In one
single TLV, either a primary ERO Path, backup ERO Path, or both are
advertised. If a router wants to advertise multiple parallel paths,
then it can generate several TLVs for the same Prefix/FEC. Each
occurrence of a Binding TLV for a given FEC Prefix will add a new
path.

SID/Label Binding Sub-TLV is a Sub-TLV of the following OSPFv3 TLVs,
as defined in [I-D.ietf-ospf-ospfv3-lsa-extend] and in Section 4:

   Intra-Area Prefix TLV

   Inter-Area Prefix TLV

   External Prefix TLV

   OSPFv3 Extended Prefix Range TLV

Multiple SID/Label Binding Sub-TLVs can be present in these TLVs.
The SID/Label Binding Sub-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      |    Weight     |            Reserved           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Sub-TLVs (variable)                     |
+-                                                             -+
|                                                               |
```

where:

   Type: TBD, suggested value 7

   Length: variable

   Flags: 1 octet field of following flags:

```
 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+
|M|             |
+-+-+-+-+-+-+-+-+
```

where:

M-bit - When the bit is set the binding represents the
mirroring context as defined in
[I-D.minto-rsvp-lsp-egress-fast-protection].

Weight: weight used for load-balancing purposes. The use of the
weight is defined in section 3.5.1 of
[I-D.ietf-spring-segment-routing].

SID/Label Binding Sub-TLV currently supports following Sub-TLVs:

SID/Label Sub-TLV as described in Section 2.1. This Sub-TLV MUST
appear in the SID/Label Binding Sub-TLV and it MUST only appear
once.

ERO Metric Sub-TLV as defined in Section 6.1.

ERO Sub-TLVs as defined in Section 6.2.

6.1. ERO Metric Sub-TLV

The ERO Metric Sub-TLV is a Sub-TLV of the SID/Label Binding TLV.

The ERO Metric Sub-TLV advertises the cost of an ERO path. It is
used to compare the cost of a given source/destination path. A
router SHOULD advertise the ERO Metric Sub-TLV in an advertised ERO
TLV. The cost of the ERO Metric Sub-TLV SHOULD be set to the
cumulative IGP or TE path cost of the advertised ERO. Since
manipulation of the Metric field may attract or repel traffic to and
from the advertised segment, it MAY be manually overridden.

```
 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            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Metric (4 octets)                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                    ERO Metric Sub-TLV format

where:

Type: TBD, suggested value 8

Length: Always 4

Metric: A 4 octet metric representing the aggregate IGP or TE path
cost.

6.2. ERO Sub-TLVs

All 'ERO' information represents an ordered set which describes the
segments of a path. The first ERO Sub-TLV describes the first
segment of a path. Similiarly, the last ERO Sub-TLV describes the
segment closest to the egress point. If a router extends or stitches
a path, it MUST prepend the new segment's path information to the ERO
list. This applies equally to advertised backup EROs.

All ERO Sub-TLVs must immediately follow the (SID)/Label Sub-TLV.

All Backup ERO Sub-TLVs must immediately follow the last ERO Sub-TLV.

6.2.1. IPv4 ERO Sub-TLV

IPv4 ERO Sub-TLV is a Sub-TLV of the SID/Label Binding Sub-TLV.

The IPv4 ERO Sub-TLV describes a path segment using IPv4 Address
style of encoding. Its semantics have been borrowed from [RFC3209].

```
 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                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   IPv4 Address (4 octets)                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
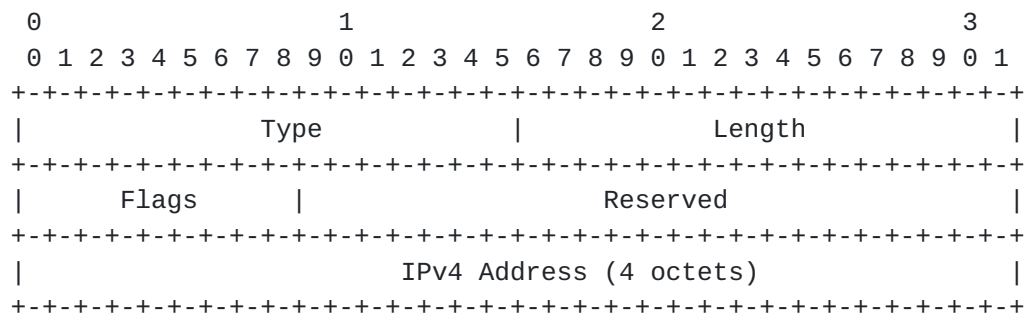
                     IPv4 ERO Sub-TLV format

where:

Type: TBD, suggested value 9

Length: 8 bytes

Flags: 1 octet field of following flags:

```
  0 1 2 3 4 5 6 7
 +-+-+-+-+-+-+-+-+
 |L|             |
 +-+-+-+-+-+-+-+-+
```

   where:

      L-bit - If the L-bit is set, then the segment path is
      designated as 'loose'. Otherwise, the segment path is
      designated as 'strict'.

   IPv4 Address - the address of the explicit route hop.

6.2.2. IPv6 ERO Sub-TLV

   IPv6 ERO Sub-TLV is a Sub-TLV of the SID/Label Binding Sub-TLV.

   The IPv6 ERO Sub-TLV (Type TBA) describes a path segment using IPv6
   Address style of encoding. Its semantics have been borrowed from
   [RFC3209].

```
    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                       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                               |
   +-                                                             -+
   |                                                               |
   +-                        IPv6 Address                         -+
   |                                                               |
   +-                                                             -+
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                       IPv6 ERO Sub-TLV format

   where:

   Type: TBD, suggested value 10

   Length: 8 bytes

   Flags: 1 octet field of following flags:

```
    0 1 2 3 4 5 6 7
   +-+-+-+-+-+-+-+-+
   |L|             |
   +-+-+-+-+-+-+-+-+
```

   where:

      L-bit - If the L-bit is set, then the segment path is
      designated as 'loose'. Otherwise, the segment path is
      designated as 'strict'.

   IPv6 Address - the address of the explicit route hop.

6.2.3. Unnumbered Interface ID ERO Sub-TLV

   The Unnumbered Interface ID ERO Sub-TLV is a Sub-TLV of the SID/Label
   Binding Sub-TLV.

   The appearance and semantics of the 'Unnumbered Interface ID' have
   been borrowed from [RFC3477].

   The Unnumbered Interface-ID ERO Sub-TLV describes a path segment that
   spans over an unnumbered interface. Unnumbered interfaces are
   referenced using the interface index. Interface indices are assigned
   local to the router and therefore not unique within a domain. All
   elements in an ERO path need to be unique within a domain and hence
   need to be disambiguated using a domain unique Router-ID.

```
    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                       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                          Router ID                            |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                         Interface ID                          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   where:

            Unnumbered Interface ID ERO Sub-TLV format

   Type: TBD, suggested value 11

   Length: 12 bytes

Flags: 1 octet field of following flags:

```
 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+
|L|             |
+-+-+-+-+-+-+-+-+
```

where:

L-bit - If the L-bit is set, then the segment path is
designated as 'loose'. Otherwise, the segment path is
designated as 'strict'.

Router-ID: Router-ID of the next-hop.

Interface ID: is the identifier assigned to the link by the router
specified by the Router-ID.

6.2.4. IPv4 Backup ERO Sub-TLV

IPv4 Prefix Backup ERO Sub-TLV is a Sub-TLV of the SID/Label Binding
Sub-TLV.

The IPv4 Backup ERO Sub-TLV describes a path segment using IPv4
Address style of encoding. Its semantics have been borrowed from
[RFC3209].

```
 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                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   IPv4 Address (4 octets)                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                   IPv4 Backup ERO Sub-TLV format

where:

Type: TBD, suggested value 12

Length: 8 bytes

Flags: 1 octet field of following flags:

```
 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+
|L|             |
+-+-+-+-+-+-+-+-+
```

where:

> L-bit - If the L-bit is set, then the segment path is
> designated as 'loose'. Otherwise, the segment path is
> designated as 'strict'.'

IPv4 Address - the address of the explicit route hop.

6.2.5. IPv6 Backup ERO Sub-TLV

The IPv6 ERO Sub-TLV is a Sub-TLV of the SID/Label Binding Sub-TLV.

The IPv6 Backup ERO Sub-TLV describes a Backup path segment using
IPv6 Address style of encoding. Its appearance and semantics have
been borrowed from [RFC3209].

The 'L' bit in the Flags is a one-bit attribute. If the L bit is
set, then the value of the attribute is 'loose.' Otherwise, the
value of the attribute is 'strict.'

```
    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                     |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                              |
   +-                                                            -+
   |                                                              |
   +-                       IPv6 Address                         -+
   |                                                              |
   +-                                                            -+
   |                                                              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                    IPv6 Backup ERO Sub-TLV format

where:

Type: TBD, suggested value 13

Length: 8 bytes

Flags: 1 octet field of following flags:

```
 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+
|L|             |
+-+-+-+-+-+-+-+-+
```

where:

L-bit - If the L-bit is set, then the segment path is
designated as 'loose'. Otherwise, the segment path is
designated as 'strict'.

IPv6 Address - the address of the explicit route hop.

6.2.6. Unnumbered Interface ID Backup ERO Sub-TLV

The Unnumbered Interface ID Backup Sub-TLV is a Sub-TLV of the SID/
Label Binding Sub-TLV.

The appearance and semantics of the 'Unnumbered Interface ID' have
been borrowed from [RFC3477].

The Unnumbered Interface-ID Backup ERO Sub-TLV describes a path
segment that spans over an unnumbered interface. Unnumbered
interfaces are referenced using the interface index. Interface
indices are assigned local to the router and are therefore not unique
within a domain. All elements in an ERO path need to be unique
within a domain and hence need to be disambiguated with specification
of the unique Router-ID.

```
 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                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Router ID                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Interface ID                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Unnumbered Interface ID Backup ERO Sub-TLV format

where:

Type: TBD, suggested value 14

Length: 12 bytes

Flags: 1 octet field of following flags:

```
 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+
|L|             |
+-+-+-+-+-+-+-+-+
```

where:

L-bit - If the L-bit is set, then the segment path is
designated as 'loose'. Otherwise, the segment path is
designated as 'strict'.

Router-ID: Router-ID of the next-hop.

Interface ID: is the identifier assigned to the link by the router
specified by the Router-ID.

7. Adjacency Segment Identifier (Adj-SID)

An Adjacency Segment Identifier (Adj-SID) represents a router
adjacency in Segment Routing.

7.1. Adj-SID Sub-TLV

The extended OSPFv3 LSAs, as defined in
[I-D.ietf-ospf-ospfv3-lsa-extend], are used to advertise prefix SID
in OSPFv3

The Adj-SID Sub-TLV is an optional Sub-TLV of the Router-Link TLV as
defined in [I-D.ietf-ospf-ospfv3-lsa-extend]. It MAY appear multiple
times in Router-Link TLV. Examples where more than one Adj-SID may
be used per neighbor are described in section 4 of
[I-D.filsfils-spring-segment-routing-use-cases]. The Adj-SID Sub-TLV
has the following format:

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

where:

   Type: TBD, suggested value 5.

   Length: variable.

   Flags. 1 octet field of following flags:

```
 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+
|B|V|L|S|       |
+-+-+-+-+-+-+-+-+
```

where:

      B-Flag: Backup-flag. If set, the Adj-SID refers to an
      adjacency that is eligible for protection (e.g.: using IPFRR or
      MPLS-FRR) as described in section 3.5 of
      [I-D.ietf-spring-segment-routing].

      The V-Flag: Value/Index Flag. If set, then the Adj-SID carries
      an absolute value. If not set, then the Adj-SID carries an
      index.

      The L-Flag: Local/Global Flag. If set, then the value/index
      carried by the Adj-SID has local significance. If not set,
      then the value/index carried by this Sub-TLV has global
      significance.

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

      Other bits: Reserved. These MUST be zero when sent and are
      ignored when received.

Weight: weight used for load-balancing purposes. The use of the
weight is defined in section 3.5.1 of
[I-D.ietf-spring-segment-routing].

SID/Index/Label: label or index value depending on the V-bit
setting.

Examples:

A 32 bit global index defining the offset in the SID/Label
space advertised by this router - in this case the V and L
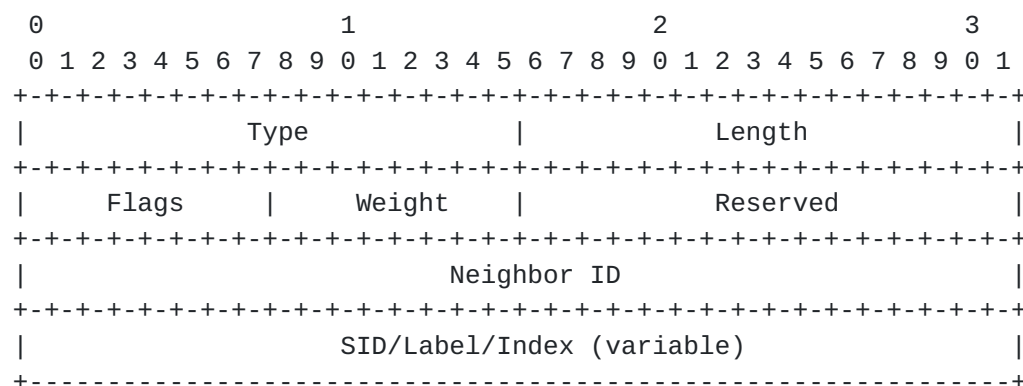flags MUST NOT be set.

A 24 bit local label where the 20 rightmost bits are used
for encoding the label value - in this case the V and L
flags MUST be set.

16 octet IPv6 address - in this case the V-flag MUST be set.
The L-flag MUST be set for link-local IPv6 address and MUST
NOT be set for IPv6 global unicast address.

An SR capable router MAY allocate an Adj-SID for each of its
adjacencies and set the B-Flag when the adjacency is eligible for
protection by an FRR mechanism (IP or MPLS) as described in section
3.5 of [I-D.ietf-spring-segment-routing].

7.2. LAN Adj-SID Sub-TLV

The LAN Adj-SID is an optional Sub-TLV of the Router-Link TLV. It
MAY appear multiple times in the Router-Link TLV. It is used to
advertise a SID/Label for an adjacency to a non-DR neighbor on a
broadcast or NBMA network.

```
 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           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Neighbor ID                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     SID/Label/Index (variable)                |
+---------------------------------------------------------------+
```

where:

Type: TBD, suggested value 6.

Length: variable.

Flags. 1 octet field of following flags:

```
 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+
|B|V|L|S|       |
+-+-+-+-+-+-+-+-+
```

where:

> B-Flag: Backup-flag: set if the LAN-Adj-SID refer to an
> adjacency that is eligible for protection (e.g.: using IPFRR or
> MPLS-FRR) as described in section 3.1 of
> [I-D.filsfils-spring-segment-routing-use-cases].

> The V-Flag: Value/Index Flag. If set, then the LAN Adj-SID
> carries an absolute value. If not set, then the LAN Adj-SID
> carries an index.

> The L-Flag: Local/Global Flag. If set, then the value/index
> carried by the LAN Adj-SID has local significance. If not set,
> then the value/index carried by this subTLV has global
> significance.

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

> Other bits: Reserved. These MUST be zero when sent and are
> ignored when received.

Weight: weight used for load-balancing purposes. The use of the
weight is defined in section 3.5.1 of
[I-D.ietf-spring-segment-routing].

SID/Index/Label: label or index value depending on the V-bit
setting.

> Examples:

>> A 32 bit global index defining the offset in the SID/Label
>> space advertised by this router - in this case the V and L
>> flags MUST NOT be set.

>> A 24 bit local label where the 20 rightmost bits are used
>> for encoding the label value - in this case the V and L
>> flags MUST be set.

16 octet IPv6 address - in this case the V-flag MUST be set.
The L-flag MUST be set for link-local IPv6 address and MUST
NOT be set for IPv6 global unicast address.

8. Elements of Procedure

8.1. Intra-area Segment routing in OSPFv3

An OSPFv3 router that supports segment routing MAY advertise Prefix-
SIDs for any prefix that it is advertising reachability for (e.g.,
loopback IP address) as described in Section 5.

If multiple routers advertise a Prefix-SID for the same prefix, then
the Prefix-SID MUST be the same. This is required in order to allow
traffic load-balancing when multiple equal cost paths to the
destination exist in the network.

The Prefix-SID can also be advertised by the SR Mapping Servers (as
described in [I-D.filsfils-spring-segment-routing-ldp-interop]). The
Mapping Server advertises Prefix-SID for remote prefixes that exist
in the network. Multiple Mapping Servers can advertise Prefix-SID
for the same prefix, in which case the same Prefix-SID MUST be
advertised by all of them. The SR Mapping Server could use either
area scope or autonomous system flooding scope when advertising
Prefix SID for prefixes, based on the configuration of the SR Mapping
Server. Depending on the flooding scope used, the SR Mapping Server
chooses the LSA that will be used. If the area flooding scope is
needed, E-Intra-Area-Prefix-LSA ([I-D.ietf-ospf-ospfv3-lsa-extend])
is used. If autonomous system flooding scope is needed, E-AS-
External-LSA ([I-D.ietf-ospf-ospfv3-lsa-extend]) is used.

When a Prefix-SID is advertised by the Mapping Server, which is
indicated by the M-flag in the Prefix-SID Sub-TLV (Section 5), the
route type as implied by the LSA type is ignored and the Prefix-SID
is bound to the corresponding prefix independent of the route type.

Advertisement of the Prefix-SID by the Mapping Server using Inter-
Area Prefix TLV, External-Prefix TLV or Intra-Area-Prefix TLV
([I-D.ietf-ospf-ospfv3-lsa-extend]) does not itself contribute to the
prefix reachability. The NU-bit MUST be set in the PrefixOptions
field of the LSA which is used by the Mapping Server to advertise SID
or SID range, which prevents the advertisement to contribute to
prefix reachability.

SR Mapping Server MUST use OSPF Extended Prefix Range TLV when
advertising SIDs for prefixes. Prefixes of different route-types can
be combined in a single OSPF Extended Prefix Range TLV advertised by
the SR Mapping Server.

Area scoped OSPF Extended Prefix Range TLV are propagated between
areas. Similar to propagation of prefixes between areas, ABR only
propagates the OSPF Extended Prefix Range TLV that it considers to be
the best from the set it received. The rules used to pick the best
OSPF Extended Prefix Range TLV is described in Section 4.

When propagating OSPF Extended Prefix Range TLV between areas, ABR
MUST set the IA-Flag, that is used to prevent redundant flooding of
the OSPF Extended Prefix Range TLV between areas as described in
Section 4.

If the Prefix-SID that is advertised in Prefix SID Sub-TLV is also
covered by the OSPF Extended Prefix Range TLV, the Prefix-SID
advertised in Prefix SID Sub-TLV MUST be preferred.

8.2. Inter-area Segment routing in OSPFv3

In order to support SR in a multi-area environment, OSPFv3 must
propagate Prefix-SID information between areas. The following
procedure is used in order to propagate Prefix SIDs between areas.

When an OSPFv3 ABR advertises a Inter-Area-Prefix-LSA from an intra-
area prefix to all its connected areas, it will also include Prefix-
SID Sub-TLV, as described in Section 5. The Prefix-SID value will be
set as follows:

   The ABR will look at its best path to the prefix in the source
   area and find out the advertising router associated with the best
   path to that prefix.

   The ABR will then determine if such router advertised a Prefix-SID
   for the prefix and use it when advertising the Prefix-SID to other
   connected areas.

   If no Prefix-SID was advertised for the prefix in the source area
   by the router that contributes to the best path to the prefix, the
   originating ABR will use the Prefix-SID advertised by any other
   router (e.g.: a Prefix-SID coming from an SR Mapping Server as
   defined in [I-D.filsfils-spring-segment-routing-ldp-interop]) when
   propagating Prefix-SID for the prefix to other areas.

When an OSPFv3 ABR advertises Inter-Area-Prefix-LSA LSAs from an
inter-area route to all its connected areas it will also include
Prefix-SID Sub-TLV, as described in Section 5. The Prefix-SID value
will be set as follows:

   The ABR will look at its best path to the prefix in the source
   area and find out the advertising router associated with the best
   path to that prefix.

   The ABR will then look if such router advertised a Prefix-SID for
   the prefix and use it when advertising the Prefix-SID to other
   connected areas.

   If no Prefix-SID was advertised for the prefix in the source area
   by the ABR that contributes to the best path to the prefix, the
   originating ABR will use the Prefix-SID advertised by any other
   router when propagating Prefix-SID for the prefix to other areas.

8.3. SID for External Prefixes

   AS-External-LSAs are flooded domain wide. When an ASBR, which
   supports SR, generates E-AS-External-LSA, it should also include
   Prefix-SID Sub-TLV, as described in Section 5. The Prefix-SID value
   will be set to the SID that has been reserved for that prefix.

   When an NSSA ASBR translates an E-NSSA-LSA into an E-AS-External-LSA,
   it should also advertise the Prefix-SID for the prefix. The NSSA ABR
   determines its best path to the prefix advertised in the translated
   E-NSSA-LSA and finds the advertising router associated with that
   path. If the advertising router has advertised a Prefix-SID for the
   prefix, then the NSSA ABR uses it when advertising the Prefix-SID in
   the E-AS-External-LSA. Otherwise the Prefix-SID advertised by any
   other router will be used.

8.4. Advertisement of Adj-SID

   The Adjacency Segment Routing Identifier (Adj-SID) is advertised
   using the Adj-SID Sub-TLV as described in Section 7.

8.4.1. Advertisement of Adj-SID on Point-to-Point Links

   An Adj-SID MAY be advertised for any adjacency on p2p link that is in
   a state 2-Way or higher. If the adjacency on a p2p link transitions
   from the FULL state, then the Adj-SID for that adjacency MAY be
   removed from the area. If the adjacency transitions to a state lower
   then 2-Way, then the Adj-SID advertisement MUST be removed from the
   area.

8.4.2. Adjacency SID on Broadcast or NBMA Interfaces

   Broadcast or NBMA networks in OSPFv3 are represented by a star
   topology where the Designated Router (DR) is the central point to
   which all other routers on the broadcast or NBMA network connect. As

a result, routers on the broadcast or NBMA network advertise only
their adjacency to the DR. Routers that do not act as DR do not form
or advertise adjacencies with each other. They do, however, maintain
a 2-Way adjacency state with each other and are directly reachable.

When Segment Routing is used, each router on the broadcast or NBMA
network MAY advertise the Adj-SID for its adjacency to the DR using
Adj-SID Sub-TLV as described in Section 7.1.

SR capable routers MAY also advertise an Adj-SID for other neighbors
(e.g. BDR, DR-OTHER) on the broadcast or NBMA network using the LAN
ADJ-SID Sub-TLV as described in Section 7.2.

9. IANA Considerations

This specification updates several existing OSPF registries.

9.1. OSPF Router Information (RI) TLVs Registry

o 8 (IANA Preallocated) - SR-Algorithm TLV

o 9 (IANA Preallocated) - SID/Label Range TLV

9.2. OSPFv3 Extend-LSA TLV Registry

Following values are allocated:

o suggested value 9 - OSPF Extended Prefix Range TLV

9.3. OSPFv3 Extend-LSA Sub-TLV registry

o suggested value 3 - SID/Label Sub-TLV

o suggested value 4 - Prefix SID Sub-TLV

o suggested value 5 - Adj-SID Sub-TLV

o suggested value 6 - LAN Adj-SID Sub-TLV

o suggested value 7 - SID/Label Binding Sub-TLV

o suggested value 8 - ERO Metric Sub-TLV

o suggested value 9 - IPv4 ERO Sub-TLV

o suggested value 10 - IPv6 ERO Sub-TLV

o suggested value 11 - Unnumbered Interface ID ERO Sub-TLV

o suggested value 12 - IPv4 Backup ERO Sub-TLV

o suggested value 13 - IPv6 Backup ERO Sub-TLV

o suggested value 14 - Unnumbered Interface ID Backup ERO Sub-TLV

10. Security Considerations

Implementations must assure that malformed permutations of the newly defined sub-TLvs do not result in errors which cause hard OSPFv3 failures.

11. Acknowledgements

Thanks to Acee Lindem for the detail review of the draft, corrections, as well as discussion about details of the encoding.

We would like to thank Anton Smirnov for his contribution.

Many thanks to Yakov Rekhter, John Drake and Shraddha Hedge for their contribution on earlier incarnations of the "Binding / MPLS Label TLV" in [I-D.gredler-ospf-label-advertisement].

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