

Open Shortest Path First IGP
Internet-Draft
Intended status: Standards Track
Expires: February 26, 2018

P. Psenak, Ed.
S. Previdi, Ed.
C. Filsfils
Cisco Systems, Inc.
H. Gredler
RtBrick Inc.
R. Shakir
Google, Inc.
W. Henderickx
Nokia
J. Tantsura
Individual
August 25, 2017

OSPF Extensions for Segment Routing
draft-ietf-ospf-segment-routing-extensions-19

Abstract

Segment Routing (SR) allows 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 OSPF extensions 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 [RFC2119].

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 <http://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 February 26, 2018.

Copyright Notice

Copyright (c) 2017 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to [BCP 78](http://trustee.ietf.org/license-info) and the IETF Trust's Legal Provisions Relating to IETF Documents (<http://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

Table of Contents

1.	Introduction	3
2.	Segment Routing Identifiers	3
2.1.	SID/Label Sub-TLV	3
3.	Segment Routing Capabilities	4
3.1.	SR-Algorithm TLV	4
3.2.	SID/Label Range TLV	6
3.3.	SR Local Block TLV	8
3.4.	SRMS Preference TLV	10
4.	OSPF Extended Prefix Range TLV	11
5.	Prefix SID Sub-TLV	13
6.	Adjacency Segment Identifier (Adj-SID)	16
6.1.	Adj-SID Sub-TLV	16
6.2.	LAN Adj-SID Sub-TLV	18
7.	Elements of Procedure	19
7.1.	Intra-area Segment routing in OSPFv2	19
7.2.	Inter-area Segment routing in OSPFv2	20
7.3.	Segment Routing for External Prefixes	21
7.4.	Advertisement of Adj-SID	21
7.4.1.	Advertisement of Adj-SID on Point-to-Point Links	21
7.4.2.	Adjacency SID on Broadcast or NBMA Interfaces	21
8.	IANA Considerations	22
8.1.	OSPF OSPF Router Information (RI) TLVs Registry	22
8.2.	OSPF Extended Prefix LSA TLV Registry	22
8.3.	OSPF Extended Prefix LSA Sub-TLV Registry	22
8.4.	OSPF Extended Link LSA Sub-TLV Registry	22
9.	Implementation Status	23
10.	Security Considerations	24
11.	Contributors	25
12.	Acknowledgements	25

13.	References	25
13.1.	Normative References	25
13.2.	Informative References	26
	Authors' Addresses	26

[1.](#) Introduction

Segment Routing (SR) allows 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 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 signalling (other than IGP extensions). The IPv6 data plane is out of the scope of this specification - it is not applicable to OSPFv2 which only supports the IPv4 address-family. For example, when used in MPLS networks, SR paths do not require any LDP or RSVP-TE signalling. However, SR can interoperate in the presence of LSPs established with RSVP or LDP.

There are additional segment types, e.g., Binding SID defined in [\[I-D.ietf-spring-segment-routing\]](#).

This draft describes the OSPF extensions required for Segment Routing.

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

Segment Routing use cases are described in [\[RFC7855\]](#).

[2.](#) Segment Routing Identifiers

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

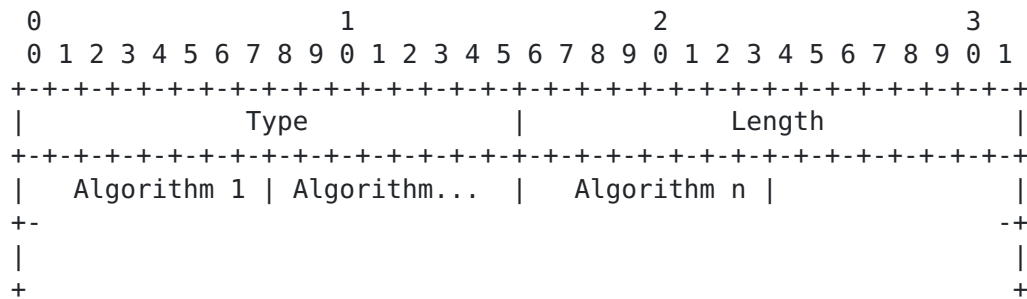
Extended Prefix/Link Opaque LSAs defined in [\[RFC7684\]](#) are used for advertisements of the various SID types.

[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

An SR Router may use various algorithms when calculating reachability to OSPF routers or prefixes in an OSPF area. Examples of these algorithms are metric based Shortest Path First (SPF), various flavors of Constrained SPF, etc. The SR-Algorithm TLV allows a router to advertise the algorithms currently used by the router to

other routers in an OSPF area. The SR-Algorithm TLV has following format:



where:

Type: TBD, suggested value 8

Length: Variable, dependent on number of algorithms advertised.

Algorithm: Single octet identifying the algorithm. The following values are defined by this document:

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. If the SR-Algorithm TLV is advertised, Algorithm 0 MUST be included.

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 support for Algorithm 1 MUST NOT alter the SPF paths computed by Algorithm 1.

When multiple SR-Algorithm TLVs are received from a given router, the receiver SHOULD use the first occurrence of the TLV in the Router Information LSA. If the SR-Algorithm TLV appears in multiple Router Information LSAs that have different flooding scopes, the SR-Algorithm TLV in the Router Information LSA with the area-scoped flooding scope SHOULD be used. If the SR-Algorithm TLV appears in multiple Router Information LSAs that have the same flooding scope, the SR-Algorithm TLV in the Router Information (RI) LSA with the numerically smallest Instance ID SHOULD be used and subsequent instances of the SR-Algorithm TLV SHOULD be ignored.

Multiple occurrences 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 inside the Router Information Opaque LSA. The originating router MUST ensure the order is the 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 a SID index.
- o The originating router MUST NOT advertise overlapping ranges.
- o When a router receives multiple overlapping ranges, it MUST conform to the procedures defined in [\[I-D.ietf-spring-conflict-resolution\]](#).

The following example illustrates the advertisement of multiple ranges:

The originating router advertises the following ranges:

```
Range 1: Range Size: 100   SID/Label Sub-TLV: 100
Range 1: Range Size: 100   SID/Label Sub-TLV: 1000
Range 1: Range Size: 100   SID/Label Sub-TLV: 500
```

The receiving routers concatenate the ranges and build the Segment Routing Global Block (SRGB) 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
...
```

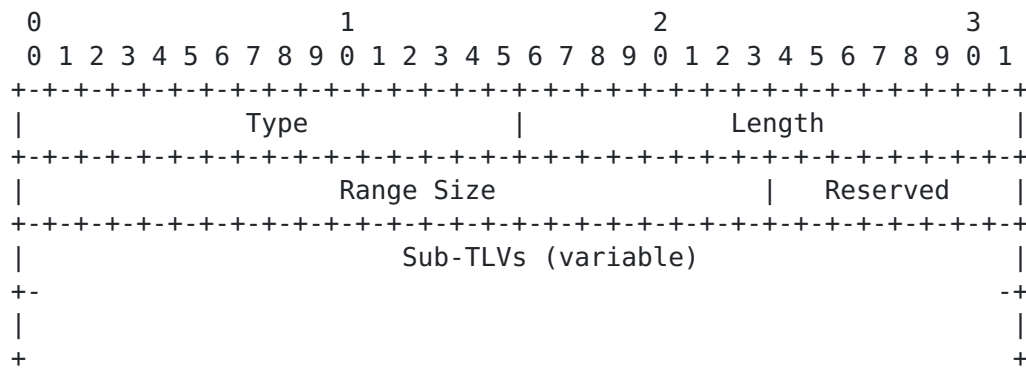
The RI LSA can be advertised at any of the defined flooding scopes (link, area, or autonomous system (AS)). For the purpose of SID/Label Range TLV advertisement, area-scoped flooding is REQUIRED.

3.3. SR Local Block TLV

The SR Local Block TLV (SRLB TLV) contains the range of labels the node has reserved for local SIDs. SIDs from the SRLB MAY be used for Adjacency-SIDs, but also by components other than the OSPF protocol. As an example, an application or a controller may instruct the router to allocate a specific local SID. Some controllers or applications may use the control plane to discover the available set of local SIDs on a particular router. In such cases, the SRLG is advertised in the control plane. The requirement to advertise the SRLB is further described in [[I-D.ietf-spring-segment-routing-mpls](#)]. The SRLB TLV is used to advertise the SRLB.

The SRLB TLV is a top-level TLV of the Router Information Opaque LSA (defined in [[RFC7770](#)]).

The SRLB TLV MAY appear multiple times in the Router Information Opaque LSA and has the following format:



where:

Type: TBD, suggested value 12

Length: Variable, dependent on Sub-TLVs.

Range Size: 3-octet SID/label range size (i.e., the number of SIDs or labels in the range including the first SID/label). It MUST be greater than 0.

Initially, the only supported Sub-TLV is the SID/Label Sub-TLV as defined in [Section 2.1](#). The SID/Label Sub-TLV MUST be included in the SRLB TLV. The SID/Label advertised in the SID/Label Sub-TLV represents the first SID/Label in the advertised range.

Only a single SID/Label Sub-TLV MAY be advertised in the SRLB TLV. If more than one SID/Label Sub-TLVs are present, the SRLB TLV MUST be ignored.

The originating router MUST NOT advertise overlapping ranges.

Each time a SID from the SRLB is allocated, it SHOULD also be reported to all components (e.g., controller or applications) in order for these components to have an up-to-date view of the current SRLB allocation. This is required to avoid collisions between allocation instructions.

Within the context of OSPF, the reporting of local SIDs is done through OSPF Sub-TLVs such as the Adjacency-SID ([Section 6](#)). However, the reporting of allocated local SIDs may also be done through other means and protocols which are outside the scope of this document.

A router advertising the SRLB TLV may also have other label ranges, outside of the SRLB, used for its local allocation purposes which are NOT advertised in the SRLB TLV. For example, it is possible that an

Adjacency-SID is allocated using a local label that is not part of the SRLB.

The RI LSA can be advertised at any of the defined flooding scopes (link, area, or autonomous system (AS)). For the purpose of SRLB TLV advertisement, area-scoped flooding is REQUIRED.

3.4. SRMS Preference TLV

The Segment Routing Mapping Server Preference TLV (SRMS Preference TLV) is used to advertise a preference associated with the node that acts as an SR Mapping Server. The role of an SRMS is described in [[I-D.ietf-spring-segment-routing-ldp-interop](#)]. SRMS preference is defined in [[I-D.ietf-spring-conflict-resolution](#)].

The SRMS Preference TLV is a top-level TLV of the Router Information Opaque LSA (defined in [[RFC7770](#)]).

The SRMS Preference TLV MAY only be advertised once in the Router Information Opaque LSA 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              |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|   Preference   |                                     | Reserved         |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

where:

Type: TBD, suggested value 13

Length: 4 octets

Preference: 1 octet. SRMS preference value from 0 to 255.

When multiple SRMS Preference TLVs are received from a given router, the receiver SHOULD use the first occurrence of the TLV in the Router Information LSA. If the SRMS Preference TLV appears in multiple Router Information LSAs that have different flooding scopes, the SRMS Preference TLV in the Router Information LSA with the narrowest flooding scope SHOULD be used. If the SRMS Preference TLV appears in multiple Router Information LSAs that have the same flooding scope, the SRMS Preference TLV in the Router Information LSA with the numerically smallest Instance ID SHOULD be used and subsequent instances of the SRMS Preference TLV SHOULD be ignored.

The RI LSA can be advertised at any of the defined flooding scopes (link, area, or autonomous system (AS)). For the purpose of the SRMS Preference TLV advertisement, AS-scoped flooding SHOULD be used. This is because SRMS servers can be located in a different area than consumers of the SRMS advertisements. If the SRMS advertisements from the SRMS server are only used inside the SRMS server's area, area-scoped flooding MAY be used.

4. OSPF Extended Prefix Range TLV

In some cases it is useful to advertise attributes for a range of prefixes. The Segment Routing Mapping Server, which is described in [I-D.ietf-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 OSPF Extended Prefix Range TLV, which is a top level TLV of the Extended Prefix LSA described in [RFC7684] is defined for this purpose.

Multiple OSPF Extended Prefix Range TLVs MAY be advertised in each OSPF Extended Prefix Opaque LSA, but all prefix ranges included in a single OSPF Extended Prefix Opaque LSA MUST have the same flooding scope. The OSPF 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 2.

Length: Variable, dependent on Sub-TLVs.

Prefix length: Length of prefix in bits.

AF: Address family for the prefix. Currently, the only supported value is 0 for IPv4 unicast. The inclusion of address family in this TLV allows for future extension.

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 the IPv4 multicast address range (224.0.0.0/3).

Flags: Single 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. An 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 only propagates an inter-area Prefix Range advertisement from the backbone area to connected non-backbone areas if the advertisement is considered to be the best one. The following rules are used to select the best range from the set of advertisements for the same Prefix Range:

An ABR always prefers intra-area Prefix Range advertisements over inter-area advertisements.

An ABR does not consider inter-area Prefix Range advertisements coming from non-backbone areas.

Address Prefix: For the address family IPv4 unicast, the prefix itself is encoded as a 32-bit value. The default route is represented by a prefix of length 0. Prefix encoding for other address families is beyond the scope of this specification.

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.

MT-ID: Multi-Topology ID (as defined in [\[RFC4915\]](#)).

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

A router receiving a Prefix-SID from a remote node and with an algorithm value that such remote node has not advertised in the SR-Algorithm Sub-TLV ([Section 3.1](#)) MUST ignore the Prefix-SID Sub-TLV.

SID/Index/Label: According to the V and L flags, it contains either:

A 32-bit index defining the offset in the SID/Label space advertised by this router.

A 24-bit label where the 20 rightmost bits are used for encoding the label value.

If an OSPF router advertises multiple Prefix-SIDs for the same prefix, topology and algorithm, all of them MUST be ignored.

When calculating the outgoing label for the prefix, the router MUST take into account, as described below, the E, NP and M flags advertised by the next-hop router if that 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 and the E-flag MUST be clear for Prefix-SIDs allocated to inter-area prefixes that are originated by the ABR based on intra-area or inter-area reachability between areas, unless the advertised prefix is directly attached to the ABR.

The NP-Flag (No-PHP) MUST be set and the E-flag MUST be clear for Prefix-SIDs allocated to redistributed prefixes, unless the redistributed prefix is directly attached to the ASBR.

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. If the NP-flag is not set, 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 Area Border Router (prefix propagation from one area to another) or at an AS Boundary 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 an Explicit-NULL label. 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 the M-Flag is set, the NP-flag and the E-flag MUST be ignored at reception.

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 SHOULD be done in following cases:

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

The Prefix is inter-area type and downstream neighbor is an ABR, which is advertising prefix reachability and is also generating the Extended Prefix TLV with the A-flag set for this prefix as described in [section 2.1 of \[RFC7684\]](#).

The Prefix is external type and downstream neighbor is an ASBR, which is advertising prefix reachability and is also generating the Extended Prefix TLV with the A-flag set for this prefix as described in [section 2.1 of \[RFC7684\]](#).

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

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

Router-A: 192.0.2.1/32, Prefix-SID: Index 1
 Router-B: 192.0.2.2/32, Prefix-SID: Index 2
 Router-C: 192.0.2.3/32, Prefix-SID: Index 3
 Router-D: 192.0.2.4/32, Prefix-SID: Index 4

then the Prefix field in the Extended Prefix Range TLV would be set to 192.0.2.1, Prefix Length would be set to 32, 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:

192.0.2.0/30, Prefix-SID: Index 51
 192.0.2.4/30, Prefix-SID: Index 52
 192.0.2.8/30, Prefix-SID: Index 53
 192.0.2.12/30, Prefix-SID: Index 54
 192.0.2.16/30, Prefix-SID: Index 55
 192.0.2.20/30, Prefix-SID: Index 56
 192.0.2.24/30, Prefix-SID: Index 57

then the Prefix field in the Extended Prefix Range TLV would be set to 192.0.2.0, Prefix Length would be set to 30, Range Size would be 7, and the Index value in the Prefix-SID Sub-TLV would be set to 51.

6. Adjacency Segment Identifier (Adj-SID)

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

6.1. Adj-SID Sub-TLV

Adj-SID is an optional Sub-TLV of the Extended Link TLV defined in [RFC7684]. It MAY appear multiple times in the Extended Link TLV. 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                    |      Reserved                |
|                               |      MT-ID                   |
|                               |      Weight                   |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|                               |      SID/Label/Index (variable) |
+-----+-----+-----+-----+-----+-----+-----+-----+

```

where:

Type: TBD, suggested value 2.

Length: 7 or 8 octets, dependent on the V flag.

Flags: Single octet field containing the following flags:

```

0 1 2 3 4 5 6 7
+---+---+---+---+
|B|V|L|G|P|   |
+---+---+---+---+

```

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 G-Flag: Group Flag. When set, the G-Flag indicates that the Adj-SID refers to a group of adjacencies (and therefore MAY be assigned to other adjacencies as well).

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

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

MT-ID: Multi-Topology ID (as defined in [\[RFC4915\]](#)).

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

SID/Index/Label: According to the V and L flags, it contains either:

A 32-bit index defining the offset in the SID/Label space advertised by this router.

A 24-bit label where the 20 rightmost bits are used for encoding the label value.

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](#)].

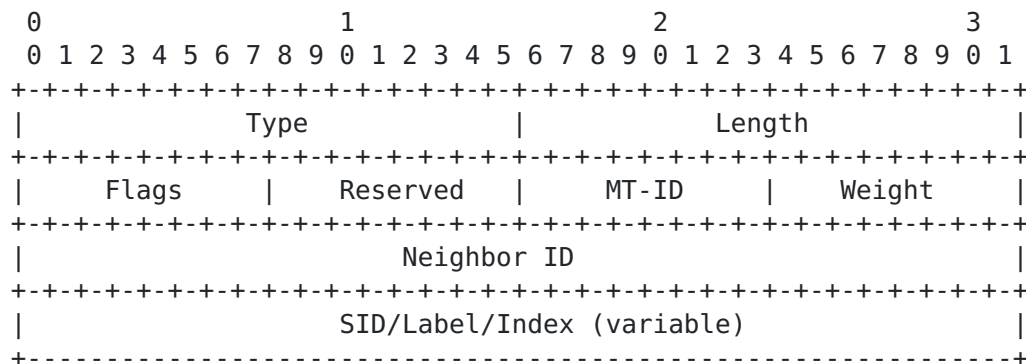
An SR capable router MAY allocate more than one Adj-SID to an adjacency

An SR capable router MAY allocate the same Adj-SID to different adjacencies

When the P-flag is not set, the Adj-SID MAY be persistent. When the P-flag is set, the Adj-SID MUST be persistent.

6.2. LAN Adj-SID Sub-TLV

LAN Adj-SID is an optional Sub-TLV of the Extended Link TLV defined in [[RFC7684](#)]. It MAY appear multiple times in the Extended-Link TLV. It is used to advertise a SID/Label for an adjacency to a non-DR router on a broadcast, NBMA, or hybrid [[RFC6845](#)] network.



where:

Type: TBD, suggested value 3.

Length: 11 or 12 octets, dependent on V-flag.

Flags: same as in [Section 6.1](#)

MT-ID: Multi-Topology ID (as defined in [[RFC4915](#)]).

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

Neighbor ID: The Router ID of the neighbor for which the LAN-Adj-SID is advertised.

SID/Index/Label: According to the V and L flags, it contains either:

A 32-bit index defining the offset in the SID/Label space advertised by this router.

A 24-bit label where the 20 rightmost bits are used for encoding the label value.

When the P-flag is not set, the Adj-SID MAY be persistent. When the P-flag is set, the Adj-SID MUST be persistent.

7. Elements of Procedure

7.1. Intra-area Segment routing in OSPFv2

An OSPFv2 router that supports segment routing MAY advertise Prefix-SIDs for any prefix to which it is advertising reachability (e.g., a loopback IP address as described in [Section 5](#)).

A Prefix-SID can also be advertised by the SR Mapping Servers (as described in [[I-D.ietf-spring-segment-routing-ldp-interop](#)]). A Mapping Server advertises Prefix-SIDs for remote prefixes that exist in the OSPFv2 routing domain. Multiple Mapping Servers can advertise Prefix-SIDs for the same prefix, in which case the same Prefix-SID MUST be advertised by all of them. The flooding scope of the OSPF Extended Prefix Opaque LSA that is generated by the SR Mapping Server could be either area-scoped or AS-scoped and is determined based on the configuration of the SR Mapping Server.

An SR Mapping Server MUST use the 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 an SR Mapping Server. Because the OSPF Extended Prefix Range TLV doesn't include a Route-Type field, as in the OSPF Extended Prefix TLV, it is possible to include adjacent prefixes from different Route-Types in the OSPF Extended Prefix Range TLV.

Area-scoped OSPF Extended Prefix Range TLVs are propagated between areas. Similar to propagation of prefixes between areas, an 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 are described in [Section 4](#).

When propagating an OSPF Extended Prefix Range TLV between areas, ABRs 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](#).

7.2. Inter-area Segment routing in OSPFv2

In order to support SR in a multi-area environment, OSPFv2 must propagate Prefix-SID information between areas. The following procedure is used to propagate Prefix SIDs between areas.

When an OSPF ABR advertises a Type-3 Summary LSA from an intra-area prefix to all its connected areas, it will also originate an Extended Prefix Opaque LSA, as described in [\[RFC7684\]](#). The flooding scope of the Extended Prefix Opaque LSA type will be set to area-local scope. The route-type in the OSPF Extended Prefix TLV is set to inter-area. The Prefix-SID Sub-TLV will be included in this LSA and 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 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 when propagating the Prefix-SID for the prefix to other areas.

When an OSPF ABR advertises Type-3 Summary LSAs from an inter-area route to all its connected areas, it will also originate an Extended Prefix Opaque LSA, as described in [\[RFC7684\]](#). The flooding scope of the Extended Prefix Opaque LSA type will be set to area-local scope. The route-type in OSPF Extended Prefix TLV is set to inter-area. The Prefix-SID Sub-TLV will be included in this LSA and the Prefix-SID will be set as follows:

The ABR will look at its best path to the prefix in the backbone area and find 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 backbone 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 the Prefix-SID for the prefix to other areas.

7.3. Segment Routing for External Prefixes

Type-5 LSAs are flooded domain wide. When an ASBR, which supports SR, generates Type-5 LSAs, it should also originate Extended Prefix Opaque LSAs, as described in [\[RFC7684\]](#). The flooding scope of the Extended Prefix Opaque LSA type is set to AS-wide scope. The route-type in the OSPF Extended Prefix TLV is set to external. The Prefix-SID Sub-TLV is included in this LSA and the Prefix-SID value will be set to the SID that has been reserved for that prefix.

When an NSSA ABR translates Type-7 LSAs into Type-5 LSAs, it should also advertise the Prefix-SID for the prefix. The NSSA ABR determines its best path to the prefix advertised in the translated Type-7 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 for the Type-5 prefix. Otherwise, the Prefix-SID advertised by any other router will be used.

7.4. Advertisement of Adj-SID

The Adjacency Segment Routing Identifier (Adj-SID) is advertised using the Adj-SID Sub-TLV as described in [Section 6](#).

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

An Adj-SID MAY be advertised for any adjacency on a P2P link that is in neighbor 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 than 2-Way, then the Adj-SID advertisement MUST be withdrawn from the area.

7.4.2. Adjacency SID on Broadcast or NBMA Interfaces

Broadcast, NBMA, or hybrid [\[RFC6845\]](#) networks in OSPF are represented by a star topology where the Designated Router (DR) is the central point to which all other routers on the broadcast, NBMA, or hybrid network connect. As a result, routers on the broadcast, NBMA, or hybrid 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 2-Way adjacency state with each other and are directly reachable.

When Segment Routing is used, each router on the broadcast, NBMA, or hybrid network MAY advertise the Adj-SID for its adjacency to the DR using the Adj-SID Sub-TLV as described in [Section 6.1](#).

SR capable routers MAY also advertise a LAN-Adj-SID for other neighbors (e.g., BDR, DR-OTHER) on the broadcast, NBMA, or hybrid network using the LAN-ADJ-SID Sub-TLV as described in [Section 6.2](#).

8. IANA Considerations

This specification updates several existing OSPF registries.

[8.1.](#) OSPF OSPF Router Information (RI) TLVs Registry

- o 8 (IANA Preallocated) - SR-Algorithm TLV
- o 9 (IANA Preallocated) - SID/Label Range TLV
- o 12 - SR Local Block TLV
- o 13 - SRMS Preference TLV

[8.2.](#) OSPF Extended Prefix LSA TLV Registry

Following values are allocated:

- o 2 - OSPF Extended Prefix Range TLV

[8.3.](#) OSPF Extended Prefix LSA Sub-TLV Registry

Following values are allocated:

- o 1 - SID/Label Sub-TLV
- o 2 - Prefix SID Sub-TLV

[8.4.](#) OSPF Extended Link LSA Sub-TLV Registry

Following initial values are allocated:

- o 1 - SID/Label Sub-TLV
- o 2 - Adj-SID Sub-TLV
- o 3 - LAN Adj-SID/Label Sub-TLV

9. Implementation Status

An implementation survey with seven questions related to the implementer's support of OSPFv2 Segment Routing was sent to the OSPF WG list and several known implementers. This section contains responses from three implementers who completed the survey. No external means were used to verify the accuracy of the information submitted by the respondents. The respondents are considered experts on the products they reported on. Additionally, responses were omitted from implementers who indicated that they have not implemented the function yet.

This section will be removed before publication as an RFC.

Responses from Nokia (former Alcatel-Lucent):

Link to a web page describing the implementation:

https://infoproducts.alcatel-lucent.com/cgi-bin/dbaccessfilename.cgi/3HE10799AAAATQZZA01_V1_7450%20ESS%207750%20SR%20and%207950%20XRS%20Unicast%20Routing%20Protocols%20Guide%20R14.0.R1.pdf

The implementation's level of maturity: Production.

Coverage: We have implemented all sections and have support for the latest draft.

Licensing: Part of the software package that needs to be purchased.

Implementation experience: Great spec. We also performed interoperability testing with Cisco's OSPF Segment Routing implementation.

Contact information: wim.henderickx@nokia.com

Responses from Cisco Systems:

Link to a web page describing the implementation:

<http://www.segment-routing.net/home/tutorial>

The implementation's level of maturity: Production.

Coverage: All sections have been implemented according to the latest draft.

Licensing: Part of a commercial software package.

Implementation experience: Many aspects of the draft are result of the actual implementation experience, as the draft evolved from its

initial version to the current one. Interoperability testing with Alcatel-Lucent was performed, which confirmed the draft's ability to serve as a reference for the implementors.

Contact information: ppsenak@cisco.com

Responses from Juniper:

The implementation's name and/or a link to a web page describing the implementation:

Feature name is OSPF SPRING

The implementation's level of maturity: To be released in 16.2 (second half of 2016)

Coverage: All sections implemented except Sections [4](#), and [6](#).

Licensing: JUNOS Licensing needed.

Implementation experience: NA

Contact information: shraddha@juniper.net

[10](#). Security Considerations

With the OSPFv2 segment routing extensions defined herein, OSPFv2 will now program the MPLS data plane [[RFC3031](#)] in addition to the IP data plane. Previously, LDP [[RFC5036](#)] or another label distribution mechanism was required to advertise MPLS labels and program the MPLS data plane.

In general, the same types of attacks that can be carried out on the IP control plane can be carried out on the MPLS control plane resulting in traffic being misrouted in the respective data planes. However, the latter may be more difficult to detect and isolate.

Existing security extensions as described in [[RFC2328](#)] and [[RFC7684](#)] apply to these segment routing extensions. While OSPF is under a single administrative domain, there may be deployments where potential attackers have access to one or more networks in the OSPF routing domain. In these deployments, stronger authentication mechanisms such as those specified in [[RFC7474](#)] SHOULD be used.

Implementations must assure that malformed TLV and Sub-TLV defined in this document are detected and do not provide a vulnerability for attackers to crash the OSPFv2 router or routing process. Reception

of malformed TLV or Sub-TLV SHOULD be counted and/or logged for further analysis.

11. Contributors

The following people gave a substantial contribution to the content of this document: Acee Lindem, Ahmed Bashandy, Martin Horneffer, Bruno Decraene, Stephane Litkowski, Igor Milojevic, Rob Shakir and Saku Ytti.

12. Acknowledgements

We would like to thank Anton Smirnov for his contribution.

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

13. References

13.1. Normative References

- [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>>.
- [RFC4915] Psenak, P., Mirtorabi, S., Roy, A., Nguyen, L., and P. Pillay-Esnault, "Multi-Topology (MT) Routing in OSPF", [RFC 4915](#), DOI 10.17487/RFC4915, June 2007, <<https://www.rfc-editor.org/info/rfc4915>>.
- [RFC6845] Sheth, N., Wang, L., and J. Zhang, "OSPF Hybrid Broadcast and Point-to-Multipoint Interface Type", [RFC 6845](#), DOI 10.17487/RFC6845, January 2013, <<https://www.rfc-editor.org/info/rfc6845>>.
- [RFC7684] Psenak, P., Gredler, H., Shakir, R., Henderickx, W., Tantsura, J., and A. Lindem, "OSPFv2 Prefix/Link Attribute Advertisement", [RFC 7684](#), DOI 10.17487/RFC7684, November 2015, <<https://www.rfc-editor.org/info/rfc7684>>.
- [RFC7770] Lindem, A., Ed., Shen, N., Vasseur, JP., Aggarwal, R., and S. Shaffer, "Extensions to OSPF for Advertising Optional Router Capabilities", [RFC 7770](#), DOI 10.17487/RFC7770, February 2016, <<https://www.rfc-editor.org/info/rfc7770>>.

13.2. Informative References

- [I-D.ietf-spring-conflict-resolution]
Ginsberg, L., Psenak, P., Previdi, S., and M. Pilka,
"Segment Routing MPLS Conflict Resolution", [draft-ietf-spring-conflict-resolution-05](#) (work in progress), July 2017.
- [I-D.ietf-spring-segment-routing]
Filsfils, C., Previdi, S., Decraene, B., Litkowski, S.,
and R. Shakir, "Segment Routing Architecture", [draft-ietf-spring-segment-routing-12](#) (work in progress), June 2017.
- [I-D.ietf-spring-segment-routing-ldp-interop]
Filsfils, C., Previdi, S., Bashandy, A., Decraene, B., and
S. Litkowski, "Segment Routing interworking with LDP",
[draft-ietf-spring-segment-routing-ldp-interop-08](#) (work in progress), June 2017.
- [I-D.ietf-spring-segment-routing-mpls]
Filsfils, C., Previdi, S., Bashandy, A., Decraene, B.,
Litkowski, S., and R. Shakir, "Segment Routing with MPLS
data plane", [draft-ietf-spring-segment-routing-mpls-10](#)
(work in progress), June 2017.
- [RFC2328] Moy, J., "OSPF Version 2", STD 54, [RFC 2328](#),
DOI 10.17487/RFC2328, April 1998, <<https://www.rfc-editor.org/info/rfc2328>>.
- [RFC7474] Bhatia, M., Hartman, S., Zhang, D., and A. Lindem, Ed.,
"Security Extension for OSPFv2 When Using Manual Key
Management", [RFC 7474](#), DOI 10.17487/RFC7474, April 2015,
<<https://www.rfc-editor.org/info/rfc7474>>.
- [RFC7855] Previdi, S., Ed., Filsfils, C., Ed., Decraene, B.,
Litkowski, S., Horneffer, M., and R. Shakir, "Source
Packet Routing in Networking (SPRING) Problem Statement
and Requirements", [RFC 7855](#), DOI 10.17487/RFC7855, May
2016, <<https://www.rfc-editor.org/info/rfc7855>>.

Authors' Addresses

Peter Psenak (editor)
Cisco Systems, Inc.
Apollo Business Center
Mlynske nivy 43
Bratislava 821 09
Slovakia

Email: ppsenak@cisco.com

Stefano Previdi (editor)
Cisco Systems, Inc.
Via Del Serafico, 200
Rome 00142
Italy

Email: stefano@previdi.net

Clarence Filsfils
Cisco Systems, Inc.
Brussels
Belgium

Email: cfilsfil@cisco.com

Hannes Gredler
RtBrick Inc.

Email: hannes@rtbrick.com

Rob Shakir
Google, Inc.
1600 Amphitheatre Parkway
Mountain View, CA 94043
US

Email: robjs@google.com

Wim Henderickx
Nokia
Copernicuslaan 50
Antwerp 2018
BE

Email: wim.henderickx@nokia.com

Jeff Tantsura
Individual
US

Email: jefftant.ietf@gmail.com