

Open Shortest Path First IGP
Internet-Draft
Intended status: Standards Track
Expires: October 22, 2018

P. Psenak, Ed.
C. Filsfils
Cisco Systems, Inc.
S. Previdi, Ed.
Individual
H. Gredler
RtBrick Inc.
R. Shakir
Google, Inc.
W. Henderickx
Nokia
J. Tantsura
Nuage Networks
April 20, 2018

OSPFv3 Extensions for Segment Routing
draft-ietf-ospf-ospfv3-segment-routing-extensions-12

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 OSPFv3 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 <https://datatracker.ietf.org/drafts/current/>.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any

Internet-Draft OSPFv3 Extensions for Segment Routing

April 2018

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 October 22, 2018.

Copyright Notice

Copyright (c) 2018 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to [BCP 78](#) and the IETF Trust's Legal Provisions Relating to IETF Documents (<https://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.	OSPFv3 Extended Prefix Range TLV	11
5.	Prefix SID Sub-TLV	14
6.	Adjacency Segment Identifier (Adj-SID)	17
6.1.	Adj-SID Sub-TLV	17
6.2.	LAN Adj-SID Sub-TLV	19
7.	Elements of Procedure	20
7.1.	Intra-area Segment routing in OSPFv3	20
7.2.	Inter-area Segment routing in OSPFv3	22
7.3.	Segment Routing for External Prefixes	23
7.4.	Advertisement of Adj-SID	23
7.4.1.	Advertisement of Adj-SID on Point-to-Point Links	23
7.4.2.	Adjacency SID on Broadcast or NBMA Interfaces	23
8.	IANA Considerations	24

8.1.	OSPFv3 Extend-LSA TLV Registry	24
8.2.	OSPFv3 Extend-LSA Sub-TLV registry	24
9.	Security Considerations	24
10.	Contributors	25
11.	Acknowledgements	25

12.	References	25
12.1.	Normative References	25
12.2.	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 - OSPFv3 extension for SR with IPv6 data plane will be specified in a separate document. 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 OSPFv3 extensions required for Segment Routing with MPLS data plane.

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

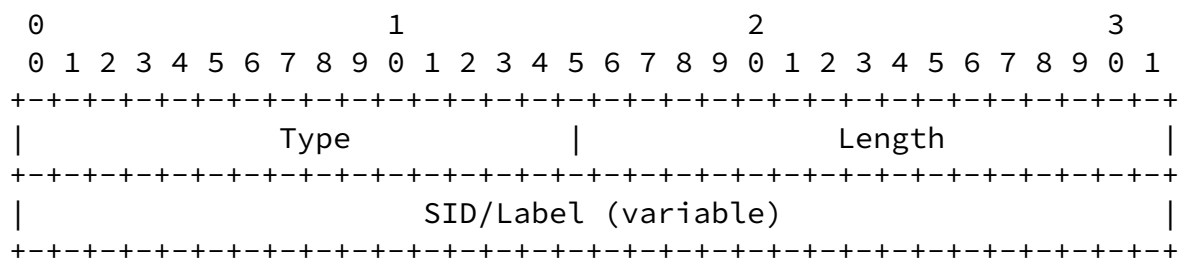
Segment Routing use cases are described in [\[RFC7855\]](#).

[2.](#) Segment Routing Identifiers

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

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 Sub-TLV has following format:



where:

Type: 7

Length: Variable, 3 or 4 octets

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 than 3 or 4.

3. Segment Routing Capabilities

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

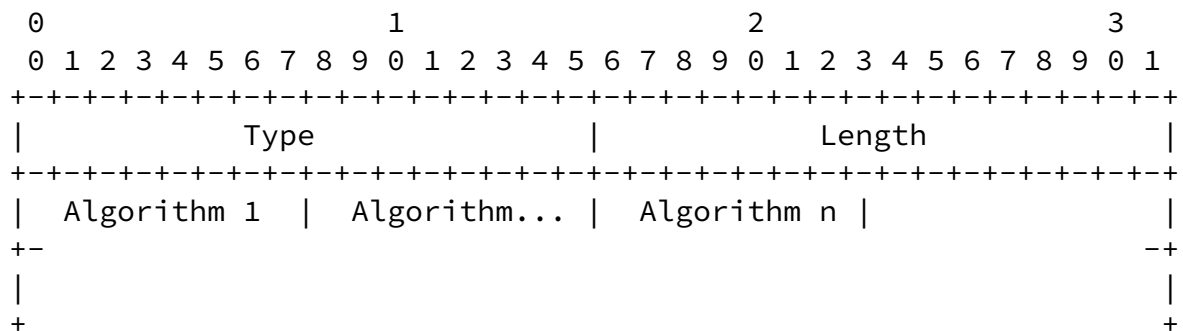
These SR capabilities are advertised in the OSPFv3 Router Information Opaque LSA (defined in [RFC7770]).

3.1. SR-Algorithm TLV

The SR-Algorithm TLV is a top-level TLV of the OSPFv3 Router Information Opaque LSA (defined in [RFC7770]).

The SR-Algorithm TLV is optional. It SHOULD only be advertised once in the OSPFv3 Router Information Opaque LSA. If the SR-Algorithm TLV is not advertised by the node, such node is considered as not being segment routing capable.

An SR router can use various algorithms when calculating reachability to OSPFv3 routers or prefixes in an OSPFv3 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 OSPFv3 area. The SR-Algorithm TLV has following format:



where:

Type: 8

Length: Variable, in octets, 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

OSPFv3 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 MUST use the first occurrence of the TLV in the OSPFV3 Router Information Opaque LSA. If the SR-Algorithm TLV appears in multiple OSPFv3 Router Information Opaque LSAs that have different flooding scopes, the SR-Algorithm TLV in the OSPFv3 Router Information Opaque LSA with the area-scoped flooding scope MUST be used. If the SR-Algorithm TLV appears in multiple OSPFv3 Router Information Opaque LSAs that have the same flooding scope, the SR-Algorithm TLV in the OSPFv3 Router Information Opaque LSA with the numerically smallest Instance ID MUST be used and subsequent instances of the SR-Algorithm TLV MUST be ignored.

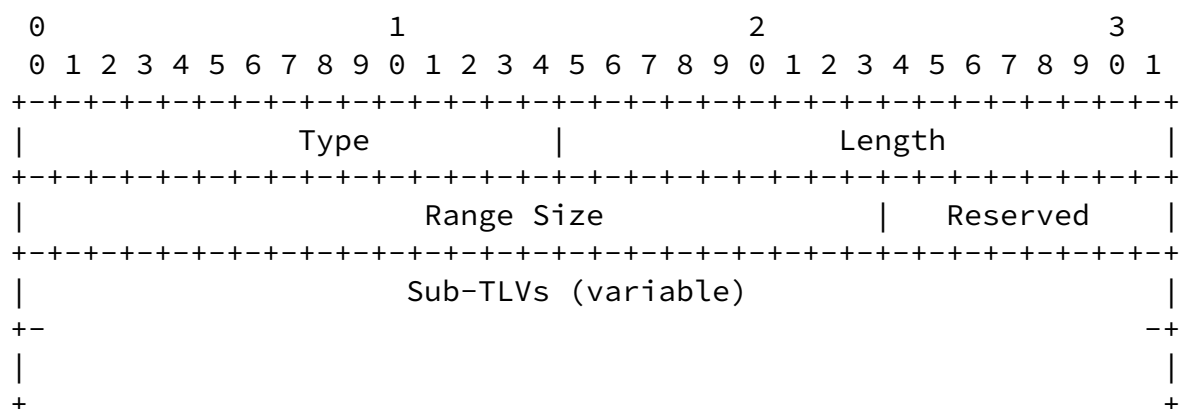
The OSPFv3 Router Information Opaque LSA can be advertised at any of the defined opaque flooding scopes (link, area, or Autonomous System (AS)). For the purpose of SR-Algorithm TLV advertisement, area-scoped flooding is REQUIRED.

[3.2.](#) SID/Label Range TLV

Prefix SIDs MAY be advertised in a form of an index as described in [Section 5](#). Such index defines the offset in the SID/Label space advertised by the router. The SID/Label Range TLV is used to advertise such SID/Label space.

The SID/Label Range TLV is a top-level TLV of the OSPFv3 Router Information Opaque LSA (defined in [[RFC7770](#)]).

The SID/Label Range TLV MAY appear multiple times and has the following format:



where:

Type: 9

Length: Variable, in octets, 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.

Reserved: SHOULD be set to 0 on transmission and MUST be ignored on reception.

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 SID/Label Range 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 SID/Label Range TLV. If more than one SID/Label Sub-TLVs are present, the SID/Label Range TLV MUST 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 [\[I-D.ietf-spring-segment-routing-mpls\]](#).

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
...
```

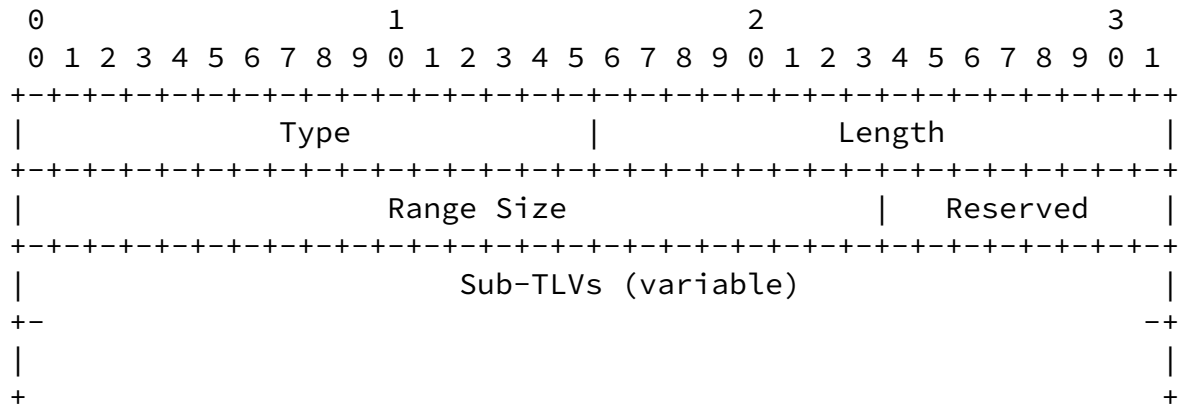
The OSPFv3 Router Information Opaque LSA can be advertised at any of the defined flooding scopes (link, area, or autonomous system (AS)). For the purpose of SID/Label Range TLV advertisement, area-scoped flooding is REQUIRED.

[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 OSPFv3 protocol. As an example, an application or a controller can instruct the router to allocate a specific local SID. Some controllers or applications can use the control plane to discover the available set of local SIDs on a particular router. In such cases, the SRLB 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 OSPFv3 Router Information Opaque LSA (defined in [[RFC7770](#)]).

The SRLB TLV MAY appear multiple times in the OSPFv3 Router Information Opaque LSA and has the following format:



where:

Type: 14

Length: Variable, in octets, 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.

Reserved: SHOULD be set to 0 on transmission and MUST be ignored on reception.

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 OSPFv3, the reporting of local SIDs is done through OSPFv3 Sub-TLVs such as the Adjacency-SID ([Section 6](#)). However, the reporting of allocated local SIDs can also be done through other means and protocols which are outside the scope of this

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.

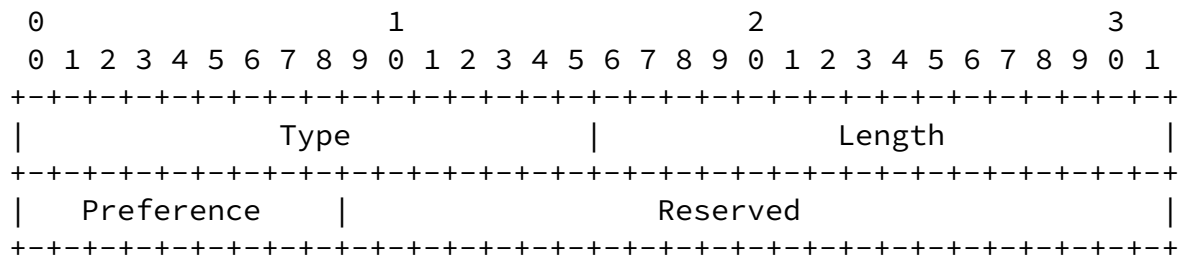
The OSPFv3 Router Information Opaque LSA can be advertised at any of the defined flooding scopes (link, area, or autonomous system (AS)). For the purpose of SRLB TLV advertisement, area-scoped flooding is REQUIRED.

[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-segment-routing-ldp-interop](#)].

The SRMS Preference TLV is a top-level TLV of the OSPFv3 Router Information Opaque LSA (defined in [[RFC7770](#)]).

The SRMS Preference TLV MAY only be advertised once in the OSPFv3 Router Information Opaque LSA and has the following format:



where:

Type: 15

Length: 4 octets

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

Reserved: SHOULD be set to 0 on transmission and MUST be ignored on reception.

When multiple SRMS Preference TLVs are received from a given router, the receiver MUST use the first occurrence of the TLV in the OSPFv3 Router Information Opaque LSA. If the SRMS Preference TLV appears in multiple OSPFv3 Router Information Opaque LSAs that have different

flooding scopes, the SRMS Preference TLV in the OSPFv3 Router Information Opaque LSA with the narrowest flooding scope MUST be used. If the SRMS Preference TLV appears in multiple OSPFv3 Router Information Opaque LSAs that have the same flooding scope, the SRMS Preference TLV in the OSPFv3 Router Information Opaque LSA with the numerically smallest Instance ID MUST be used and subsequent instances of the SRMS Preference TLV MUST be ignored.

The OSPFv3 Router Information Opaque 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.](#) OSPFv3 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 OSPFv3 Extended Prefix Range TLV, is defined for this purpose.

The OSPFv3 Extended Prefix Range TLV is a 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 each LSA mentioned above. The OSPFv3 Extended Prefix Range TLV has the following format:

Psenak, et al.

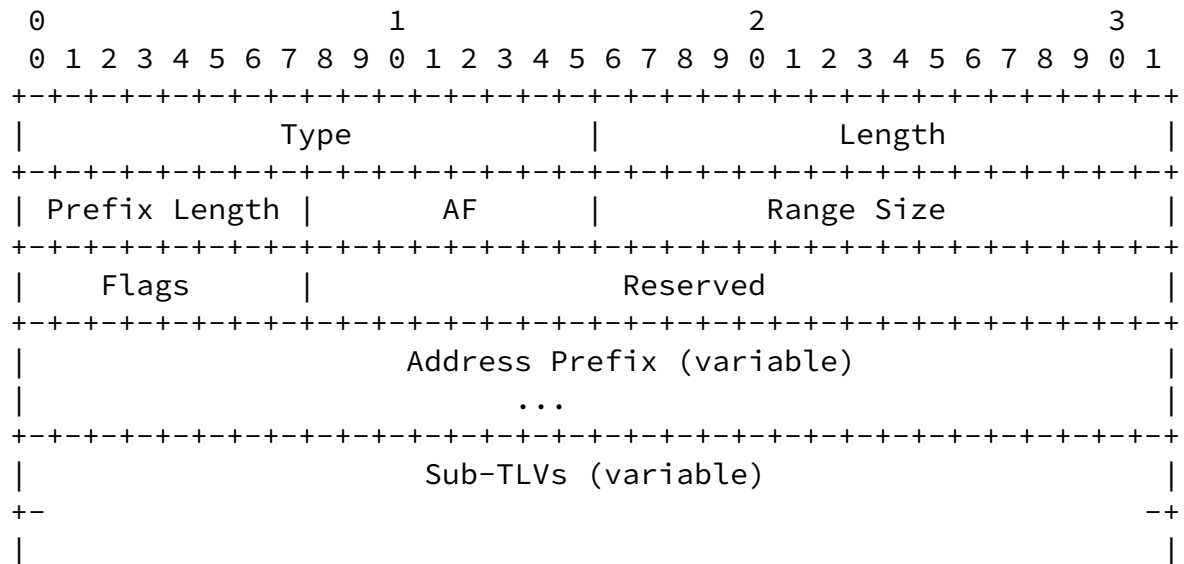
Expires October 22, 2018

[Page 11]

Internet-Draft

OSPFv3 Extensions for Segment Routing

April 2018



where:

Type: 9

Length: Variable, in octets, dependent on Sub-TLVs.

Prefix length: Length of prefix in bits.

AF: Address family for the prefix.

AF: 0 - IPv4 unicast

AF: 1 - 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:

IPv4 multicast address range (224.0.0.0/3), if the AF is IPv4 unicast

addresses from other than the IPv6 unicast address class, if the AF is IPv6 unicast

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 OSPFv3 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.

Reserved: SHOULD be set to 0 on transmission and MUST be ignored on reception.

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.

For the address family IPv6 unicast, the prefix, encoded as an even multiple of 32-bit words, padded with zeroed bits as necessary. This encoding consumes $((\text{PrefixLength} + 31) / 32)$ 32-bit words.

Prefix encoding for other address families is beyond the scope of this specification.

[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](#):

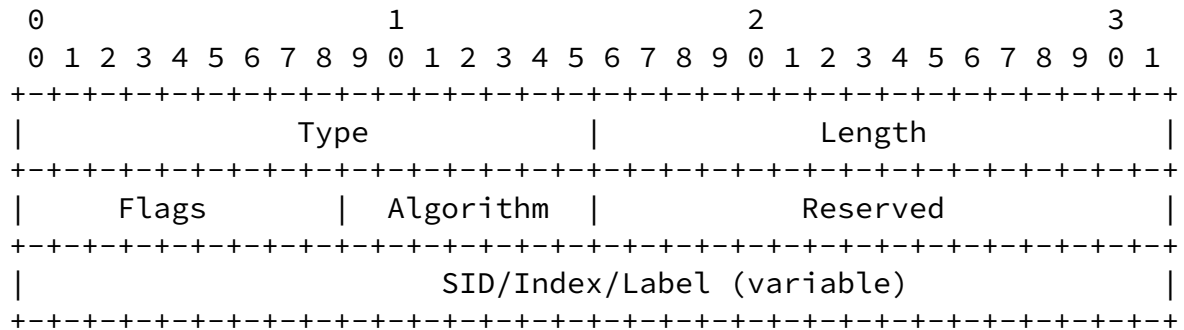
Intra-Area Prefix TLV

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:

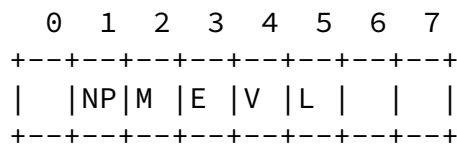


where:

Type: 4

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

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



where:

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

M-Flag: Mapping Server Flag. If set, the SID was advertised by a Segment Routing Mapping Server as described in [\[I-D.ietf-spring-segment-routing-ldp-interop\]](#).

E-Flag: Explicit-Null Flag. If set, any upstream neighbor of the Prefix-SID originator MUST replace the Prefix-SID with the Explicit-NULl label (0 for IPv4, 2 for IPv6) before forwarding the packet.

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.

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.

Reserved: SHOULD be set to 0 on transmission and MUST be ignored on reception.

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 OSPFv3 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 need to 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 setting LA-bit in the Prefix Options as described in [\[I-D.ietf-ospf-ospfv3-lsa-extend\]](#).

The Prefix is external type and downstream neighbor is an ASBR, which is advertising prefix reachability and is setting LA-bit in

the Prefix Options as described in
[\[I-D.ietf-ospf-ospfv3-lsa-extend\]](#).

When a Prefix-SID is advertised in the OSPFv3 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: 2001:DB8::1/128, Prefix-SID: Index 1
Router-B: 2001:DB8::2/128, Prefix-SID: Index 2
Router-C: 2001:DB8::3/128, Prefix-SID: Index 3
Router-D: 2001:DB8::4/128, Prefix-SID: Index 4
```

then the Address Prefix field in the OSPFv3 Extended Prefix Range TLV would be set to 2001:DB8::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:

```
2001:DB8:1::0/120, Prefix-SID: Index 51
2001:DB8:1::100/120, Prefix-SID: Index 52
2001:DB8:1::200/120, Prefix-SID: Index 53
2001:DB8:1::300/120, Prefix-SID: Index 54
2001:DB8:1::400/120, Prefix-SID: Index 55
2001:DB8:1::500/120, Prefix-SID: Index 56
2001:DB8:1::600/120, Prefix-SID: Index 57
```

then the Prefix field in the OSPFv3 Extended Prefix Range TLV would be set to 2001:DB8:1::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.](#) 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 Router-Link TLV as defined in [\[I-D.ietf-ospf-ospfv3-lsa-extend\]](#). It MAY appear multiple times in the Router-Link TLV. The Adj-SID Sub-TLV has the following format:

Psenak, et al.

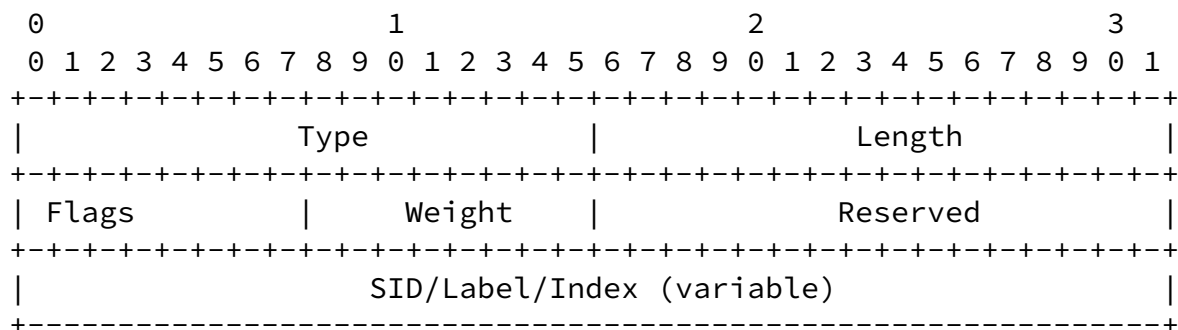
Expires October 22, 2018

[Page 17]

Internet-Draft

OSPFv3 Extensions for Segment Routing

April 2018

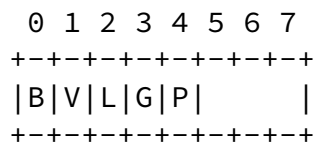


where:

Type: 5

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

Flags: Single octet field containing the following flags:



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.

Reserved: SHOULD be set to 0 on transmission and MUST be ignored on reception.

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 [[I-D.ietf-spring-segment-routing](#)].

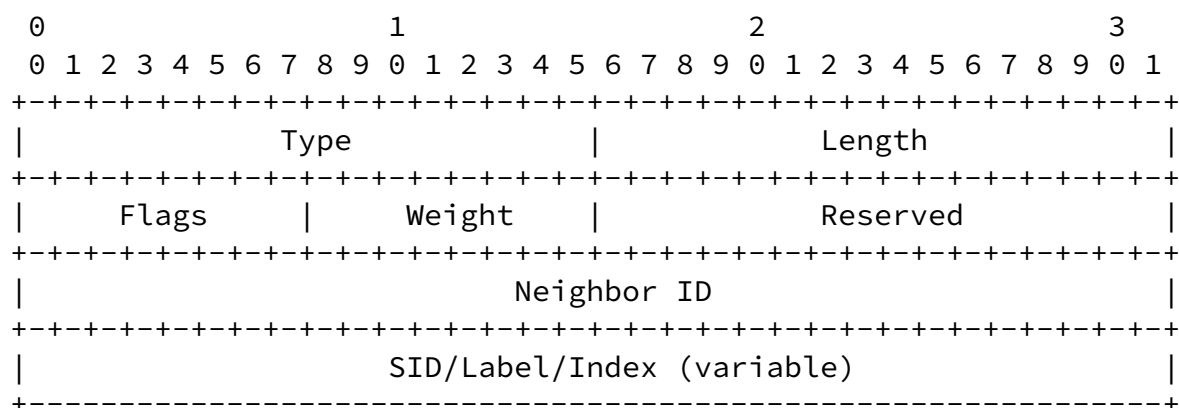
An SR capable router MAY allocate more than one Adj-SID to an adjacency

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 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 router on a broadcast, NBMA, or hybrid [RFC6845] network.



where:

Type: 6

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

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

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

Reserved: SHOULD be set to 0 on transmission and MUST be ignored on reception.

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 OSPFv3

An OSPFv3 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 OSPFv3 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 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 OSPFv3 LSA type 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 the prefix reachability.

An SR Mapping Server MUST use the OSPFv3 Extended Prefix Range TLVs when advertising SIDs for prefixes. Prefixes of different route-types can be combined in a single OSPFv3 Extended Prefix Range TLV advertised by an SR Mapping Server.

Area-scoped OSPFv3 Extended Prefix Range TLVs are propagated between areas. Similar to propagation of prefixes between areas, an ABR only propagates the OSPFv3 Extended Prefix Range TLV that it considers to be the best from the set it received. The rules used to pick the best OSPFv3 Extended Prefix Range TLV are described in [Section 4](#).

When propagating an OSPFv3 Extended Prefix Range TLV between areas, ABRs MUST set the IA-Flag, that is used to prevent redundant flooding of the OSPFv3 Extended Prefix Range TLV between areas as described in [Section 4](#).

[7.2](#). 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 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 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 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 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

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 [[RFC3101](#)] ABR 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 for the E-AS-External-LSA. 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 OSPFv3 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 OSPFv3 registries.

[8.1.](#) OSPFv3 Extend-LSA TLV Registry

Following values are allocated:

- o suggested value 9 - OSPFv3 Extended Prefix Range TLV

[8.2.](#) OSPFv3 Extend-LSA Sub-TLV registry

- o 4 - Prefix SID Sub-TLV
- o 5 - Adj-SID Sub-TLV
- o 6 - LAN Adj-SID Sub-TLV
- o 7 - SID/Label Sub-TLV

[9.](#) Security Considerations

With the OSPFv3 segment routing extensions defined herein, OSPFv3 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 can be more difficult to detect and isolate.

Existing security extensions as described in [[RFC5340](#)] and [[I-D.ietf-ospf-ospfv3-lsa-extend](#)] apply to these segment routing extensions. While OSPFv3 is under a single administrative domain, there can be deployments where potential attackers have access to one or more networks in the OSPFv3 routing domain. In these deployments, stronger authentication mechanisms such as those specified in [[RFC4552](#)] 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 OSPFv3 router or routing process. Reception of malformed TLV or Sub-TLV SHOULD be counted and/or logged for further analysis. Logging of malformed TLVs and Sub-TLVs SHOULD be rate-limited to prevent a Denial of Service (DoS) attack (distributed or otherwise) from overloading the OSPFv3 control plane.

[10.](#) Contributors

Acee Lindem gave a substantial contribution to the content of this document.

[11.](#) Acknowledgements

We would like to thank Anton Smirnov for his contribution.

[12.](#) References

[12.1.](#) Normative References

[I-D.ietf-ospf-ospfv3-lsa-extend]

Lindem, A., Roy, A., Goethals, D., Vallem, V., and F. Baker, "OSPFv3 LSA Extendibility", [draft-ietf-ospf-ospfv3-lsa-extend-23](#) (work in progress), January 2018.

[I-D.ietf-spring-segment-routing]

Filsfils, C., Previdi, S., Ginsberg, L., Decraene, B., Litkowski, S., and R. Shakir, "Segment Routing Architecture", [draft-ietf-spring-segment-routing-15](#) (work in progress), January 2018.

[I-D.ietf-spring-segment-routing-ldp-interop]

Bashandy, A., Filsfils, C., Previdi, S., Decraene, B., and S. Litkowski, "Segment Routing interworking with LDP", [draft-ietf-spring-segment-routing-ldp-interop-11](#) (work in progress), April 2018.

[I-D.ietf-spring-segment-routing-mpls]

Bashandy, A., Filsfils, C., Previdi, S., Decraene, B., Litkowski, S., and R. Shakir, "Segment Routing with MPLS data plane", [draft-ietf-spring-segment-routing-mpls-13](#) (work in progress), April 2018.

- [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>>.
- [RFC3031] Rosen, E., Viswanathan, A., and R. Callon, "Multiprotocol Label Switching Architecture", [RFC 3031](#), DOI 10.17487/RFC3031, January 2001, <<https://www.rfc-editor.org/info/rfc3031>>.

Psenak, et al.

Expires October 22, 2018

[Page 25]

Internet-Draft

OSPFv3 Extensions for Segment Routing

April 2018

- [RFC3101] Murphy, P., "The OSPF Not-So-Stubby Area (NSSA) Option", [RFC 3101](#), DOI 10.17487/RFC3101, January 2003, <<https://www.rfc-editor.org/info/rfc3101>>.
- [RFC5036] Andersson, L., Ed., Minei, I., Ed., and B. Thomas, Ed., "LDP Specification", [RFC 5036](#), DOI 10.17487/RFC5036, October 2007, <<https://www.rfc-editor.org/info/rfc5036>>.
- [RFC5340] Coltun, R., Ferguson, D., Moy, J., and A. Lindem, "OSPF for IPv6", [RFC 5340](#), DOI 10.17487/RFC5340, July 2008, <<https://www.rfc-editor.org/info/rfc5340>>.
- [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>>.
- [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>>.
- [RFC8126] Cotton, M., Leiba, B., and T. Narten, "Guidelines for Writing an IANA Considerations Section in RFCs", [BCP 26](#), [RFC 8126](#), DOI 10.17487/RFC8126, June 2017, <<https://www.rfc-editor.org/info/rfc8126>>.

[12.2](#). Informative References

- [RFC4552] Gupta, M. and N. Melam, "Authentication/Confidentiality for OSPFv3", [RFC 4552](#), DOI 10.17487/RFC4552, June 2006, <<https://www.rfc-editor.org/info/rfc4552>>.
- [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

Psenak, et al.

Expires October 22, 2018

[Page 26]

Internet-Draft OSPFv3 Extensions for Segment Routing

April 2018

Peter Psenak (editor)
Cisco Systems, Inc.
Eurovea Centre, Central 3
Pribinova Street 10
Bratislava 81109
Slovakia

Email: ppsenak@cisco.com

Clarence Filsfils
Cisco Systems, Inc.
Brussels
Belgium

Email: cfilsfil@cisco.com

Stefano Previdi (editor)
Individual

Email: stefano.previdi@net

Hannes Gredler
RtBrick Inc.
Austria

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

Psenak, et al.

Expires October 22, 2018

[Page 27]

Internet-Draft

OSPFv3 Extensions for Segment Routing

April 2018

Jeff Tantsura
Nuage Networks
US

Email: jefftant.ietf@gmail.com

