Abstract

Segment Routing (SR) allows for a flexible definition of end-to-end paths by encoding paths as sequences of sub-paths, called "segments". Segment routing architecture can be implemented over IPv6 data plane, called SRv6. In some use-cases such as end-to-end SR Path Protection and Performance Measurement (PM), SRv6 path need to be identified. This document defines the encoding and processing of Path Segment in SRv6 networks.

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1. Introduction

Segment routing (SR) [RFC8402] is a source routing paradigm that explicitly indicates the forwarding path for packets at the ingress node by inserting an ordered list of instructions, called segments.

When segment routing is deployed on IPv6 dataplane, it is called SRv6 [I-D.ietf-6man-segment-routing-header], and it uses the a new IPv6 [RFC8200] Extension Header (EH) called the IPv6 Segment Routing Header (SRH) [I-D.ietf-6man-segment-routing-header] to construct SRv6 path. As per [I-D.ietf-spring-srv6-network-programming], an SRv6 segment is a 128-bit value, which can be represented as LOC:FUNCT, where LOC is the L most significant bits and FUNCT is the 128-L least significant bits. Most often the LOC part of the SID is routable and leads to the node which instantiates that SID. The FUNCT part of the SID is an opaque identification of a local function bound to the SID.

In several use cases, such as binding bidirectional path [I-D.li-pce-sr-bidir-path] and end-to-end performance measurement [I-D.gandhi-spring-twamp-srpm], the ability to implement path identification is a pre-requisite. In SRv6, an SRv6 path can be identified by the content of the segment list. However, the segment
list may not be a good key to identify an SRv6 path, since the length of segment list is too long and flexible according to the number of SIDs. Therefore, [I-D.li-spring-srv6-path-segment] defines SRv6 Path Segment in order to identify an SRv6 path.

This document defines the encoding and processing of SRv6 Path Segment in SRv6 networks.

1.1. Requirements Language

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

1.2. Terminology

PM: Performance Measurement.
SID: Segment ID.
SL: Segment List.
SR: Segment Routing.
SRH: Segment Routing Header.
PSID: Path Segment Identifier.
PSP: Penultimate Segment Popping.

Further, this document makes use of the terms defined in [RFC8402] and [I-D.ietf-spring-srv6-network-programming].

2. Encoding of SRv6 Path Segment

This section will describe the encoding of SRv6 Path Segment [I-D.li-spring-srv6-path-segment] in SRH. As per [I-D.li-spring-srv6-path-segment], an SRv6 Path Segment is a 128-bits value, which identifies an SRv6 path. Depending on the use case, an SRv6 Path Segment can identify:

- an SRv6 path within an SRv6 domain
- an SRv6 Policy
o a Candidate-paths or a SID-List in a SRv6 Policy
  [I-D.ietf-spring-segment-routing-policy].

2.1. Encapsulation of SRv6 Path Segment

The SRv6 Path Segment MUST appear only once in a SID list, and it
MUST appear at the last entry, so the SRv6 Path Segment MUST NOT be
copied to the IPv6 destination address. The format of the SRv6 Path
Segment follows the format described in section 2.2.

In order to indicate the existence of Path Segment in the SRH, this
document defines a P-bit in SRH flag field. The encapsulation of
SRv6 Path Segment is shown below.

```
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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Next Header  |  Hdr Ext Len  |  Routing Type |  Segments Left |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Last Entry   |   Flags     |  P |  Tag          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Segment List[0] (128 bits IPv6 address) |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| ...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Segment List[n-1] (128 bits IPv6 address) |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| SRv6 Path Segment (Segment List[n],128 bits IPv6 value) |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
//
// Optional Type Length Value objects (variable) //
//
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1. SRv6 Path Segment in SID List
2.2. Format of SRv6 Path Segment

This document proposes two types of SRv6 Path Segment format.

Editor’s Note: Authors would like to request comments of these encoding mechanisms of SRv6 Path Segment. The appropriate encoding will be maintained while the rest will be deleted in the future version of this document.

2.2.1. SRv6 Path Segment: Locator and Local ID

As per [I-D.ietf-spring-srv6-network-programming], an SRv6 segment is a 128-bit value, which can be represented as LOC:FUNCT, where LOC is the L most significant bits and FUNCT is the 128-L least significant bits. L is called the locator length and is flexible. Each operator is free to use the locator length it chooses. Most often the LOC part of the SID is routable and leads to the node which instantiates that SID. The FUNCT part of the SID is an opaque identification of a local function bound to the SID. The FUNCT value zero is invalid.

SRv6 Path Segment can follow the format, where the LOC part identifies the egress node that allocates the Path Segment, and the FUNCT part is an unique local ID to identify an SRv6 Path towards to the egress on the egress.

The Function Type of SRv6 Path Segment is END.PSID (End Function with Path Segment Identifier, to be allocated by IANA).

The proposed P bit can be used to identify that the last SID is an SRv6 Path Segment.

+--------------------------------------------------------------+
| Locator              |        Function ID                   |
+--------------------------------------------------------------+
|<-------------------------128 bits--------------------------->|

Figure 2. PSID in Format LOC:FUNCT

2.2.2. SRv6 Path Segment: Global ID

An SRv6 Path Segment ID can be a Global ID, and its format depends on the use case.
The SRv6 Path Segment will not be copied to the IPv6 Destination Address, so the SRv6 Path Segment ID can be allocated from an independent 128-bits ID Space. In this case, a new table should be maintained at the node for SRv6 Path Segment. The proposed P bit can be used to identify that the last SID is an SRv6 Path Segment and need to be looked up in the SRv6 Path Segment table.

```
+--------------------------------------------------------------+
|                         Global ID/PSID                       |
+--------------------------------------------------------------+
|<-------------------------128 bits--------------------------->|
```

Figure 3. A Global ID as an PSID

3. Processing of SRv6 Path Segment

As per [I-D.li-spring-srv6-path-segment], an SRv6 Path Segment is a local segment allocated by an egress node. An SRv6 Path Segment can be allocated through several ways, such as CLI, BGP [I-D.li-idr-sr-policy-path-segment-distribution], PCEP [I-D.li-pce-sr-path-segment] or other means. The mechanisms through which an SRv6 Path Segment is allocated is out of scope of this document.

When the SRv6 Path Segment is allocated by the egress, it MUST be distributed to the ingress node. In this case, only the egress will process the SRv6 Path Segment, and other nodes specified by SIDs in the SID list do not know how to process the SRv6 Path Segment.

An SRv6 Path Segment may be distributed to the SRv6 nodes along the SRv6 path. In this case, the SRv6 nodes that learn SRv6 Path Segment may process the SRv6 Path Segment depending on the use case.

When the SRv6 Path Segment is used, the following rules apply:

- The SRv6 Path Segment MUST appear only once in a SID list, and it MUST appear at the last entry. Only the one that appears at the last entry in the SID list will be processed. SRv6 Path Segment appears at other location in the SID list will be treated as an error.

- When an SRv6 Path Segment is inserted, the SL MUST be initiated to be less than the value of Last Entry, and will not point to SRv6 Path Segment. For instance, when the Last entry is 4, the SID List[4] is the SRv6 Path Segment, so the SL MUST be set to 3 or other numbers less than Last entry.
The SRv6 Path Segment MUST NOT be copied to the IPv6 destination address.

Penultimate Segment Popping (PSP, as defined in [I-D.ietf-spring-srv6-network-programming]) MUST be disabled.

The ingress needs to set the P-bit when an SRv6 Path Segment is inserted in the SID List. Nodes that supporting SRv6 Path Segment processing will inspect the last entry to process SRv6 Path Segment when the P-bit is set. When the P-bit is unset, the nodes will not inspect the last entry.

The specific SRv6 Path Segment processing depends on use cases, and it is out of scope of this document.

4. IANA Considerations
TBA

5. Security Considerations
TBA

6. Acknowledgements
TBA

7. References

7.1. Normative References

[I-D.ietf-6man-segment-routing-header]

[I-D.ietf-spring-srv6-network-programming]

[I-D.li-spring-srv6-path-segment]
7.2. Informative References

[I-D.gandhi-spring-twamp-srpm]

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

[I-D.li-idr-sr-policy-path-segment-distribution]

[I-D.li-pce-sr-bidir-path]

Authors’ Addresses

Cheng Li
Huawei Technologies
Email: chengli3@huawei.com

Weiqiang Cheng
China Mobile
Email: chengweiqiang@chinamobile.com

Zhenbin Li
Huawei Technologies
Huawei Campus, No. 156 Beiqing Rd.
Beijing  100095
China
Email: lizhenbin@huawei.com

Dhruv Dhody
Huawei Technologies
Divyashree Techno Park, Whitefield
Bangalore  560066
India
Email: dhruv.ietf@gmail.com