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SR Policy Extensions for Path Segment and Bidirectional Path
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Abstract

BGP SR Policy address-family is used for signaling of individual candidate paths of a Segment Routing Policy. This document specifies extensions for the signaling of a Path Segment Identifier associated with the Segment List(s) of a candidate path. It also specifies extensions for the signaling of the Segment List(s) in the reverse direction when Bidirectional SR Policies are used.

Status of This Memo

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Table of Contents

1. Introduction 2
2. Terminology 3
2.1. Requirements Language 3
3. Overview 3
4. BGP Extensions 5
4.1. SR Path Segment Sub-TLV 5
4.2. Reverse Segment List Sub-TLV 7
5. Operations 8
6. Error Handling and Fault Management 8
7. IANA Considerations 9
7.1. Existing Registry: BGP Tunnel Encapsulation Attribute sub-TLVs 9
8. Security Considerations 9
9. Contributors 9
10. Acknowledgements 10
11. References 11
11.1. Normative References 11
11.2. Informative References 12
Authors' Addresses 12

1. Introduction

Segment Routing (SR) [RFC8402] is a source routing paradigm that explicitly indicates the forwarding path for packets at the ingress node. The ingress node steers packets into a specific path according to the SR Policy as defined in [RFC9256]. BGP SR Policy SAFI [RFC9830] is used for the signaling of SR Policy candidate paths to headend nodes.

In many use cases such as performance measurement, the path to which the packets belong is required to be identified. In some scenarios, (e.g., Mobile backhaul transport networks), there are Requirements to support bidirectional path. This document defines the extensions to BGP SR Policy address-family [RFC9830] to signal Path Segment for individual Segment List and the Reverse Segment List to support instantiation of bidirectional SR Policies.

The Path Segment can be a Path Segment in SR-MPLS [RFC9545] or SRv6 [I-D.ietf-spring-srv6-path-segment].

2. Terminology

This document makes use of the terms defined in [RFC8402], [RFC9256], [RFC9545], and [RFC9830]. Some of terms are listed below for reference.

* SR: Segment Routing.

* SR-MPLS: Segment Routing over MPLS data plane.

* SRv6: Segment Routing over IPv6 data plane.

* PSID: Path Segment Identifier.

* SRPM: SR Policy Module.

2.1. 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.

3. Overview

As defined in [RFC9830], the SR Policy Candidate Path encoding structure is as follows:

```
SR Policy SAFI NLRI: <Distinguisher, Policy-Color, Endpoint>
Attributes:
   Tunnel Encaps Attribute (23)
      Tunnel Type: SR Policy
          Binding SID
          Preference
          Priority
          Policy Name
          Explicit NULL Label Policy (ENLP)
          Segment List
              Weight
              Segment
              Segment
              ...
          ...
```

Figure 1: SR Policy Candidate Path encoding structure

As defined in [RFC9256], a candidate path includes multiple segment list specified by SID list. A Path Segment [RFC9545] [I-D.ietf-spring-srv6-path-segment] can be used for identifying a segment list, candidate path, or SR Policy (depending on its context) at the endpoint (i.e., tail-end) of a SR Policy.

A Segment List Sub-TLV that contains a set of segment Sub-TLVs and other Sub-TLVs as shown in Figure 2. This document defines a new Path Segment Sub-TLV within Segment List Sub-TLV as described in section 3.1.

The new SR Policy encoding structure with Path Segment Sub-TLV is expressed as below:

```
SR Policy SAFI NLRI: <Distinguisher, Policy-Color, Endpoint>
Attributes:
   Tunnel Encaps Attribute (23)
      Tunnel Type: SR Policy
          Binding SID
          Preference
          Priority
          Policy Name
          Explicit NULL Label Policy (ENLP)
          Segment List
              Weight
              Path Segment
              Segment
              Segment
              ...
          Segment List
              Weight
              Path Segment
              Segment
              Segment
              ...
          ...
```

Figure 2: SR Policy encoding structure with Path Segment Sub-TLVs

In some scenariose, for example, mobile backhaul transport network, there are requirements to support bidirectional path. In SR, a bidirectional path can be represented as a binding of two unidirectional SR paths. This document also defines a Reverse Segment List Sub-TLV to describe the reverse path. *When a SR policy includes a bidirectional path, both the forward and reverse segment lists MUST be encoded in the BGP UPDATE message as adjacent Sub-TLVs under the Tunnel Encapsulation attribute.* An SR policy carrying SR bidirectional path information is expressed as below:

```
SR Policy SAFI NLRI: <Distinguisher, Policy-Color, Endpoint>
    Attributes: Tunnel Encaps Attribute (23)
    Tunnel Type: SR Policy
        Binding SID
        Preference
        Priority
        Policy Name
        Explicit NULL Label Policy (ENLP)
        Segment List
            Weight
            Path Segment
            Segment
            Segment
            ...
        Reverse Segment List
            Path Segment
            Segment
            Segment
            ...
```

Figure 3: SR Policy carrying SR bidirectional path information

4. BGP Extensions

4.1. SR Path Segment Sub-TLV

An SR Path Segment Sub-TLV is included in the segment list Sub-TLV to identify an SID list. It has the following format:

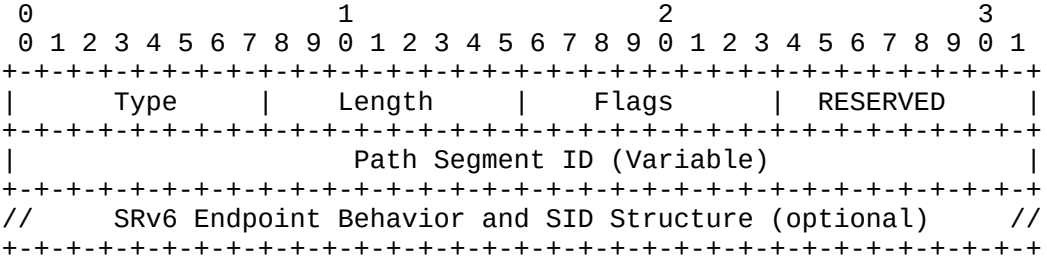


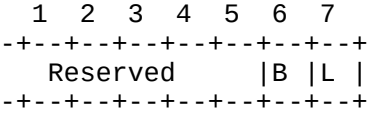
Figure 4: Path Segment Sub-TLV

Where:

* Type (TBA1): SR Path Segment Sub-TLV (to be assigned by IANA).

* Length: the total length of the value field not including Type and Length fields.

* Flags: 8 bits of flags. Following flags are defined:



* - L-Flag: Local flag. Set when the Path Segment has local significance on an SR node.

  - B-Flag: This flag, when set, indicates the presence of the SRv6 Endpoint Behavior and SID Structure encoding specified in Section 2.4.4.2.4. of [RFC9830]. It MUST be ignored when the value of length field is smaller than 18.

  - The rest bits of Flag are reserved and MUST be set to 0 on transmission and MUST be ignored on receipt.

* Path Segment ID: if the length is 2, then no Path Segment ID is present. If the length is 6 then the Path Segment ID is encoded in 4 octets [RFC9545] using the format below. TC, S, TTL (Total of 12 bits) are RESERVED and SHOULD be set to zero and MUST be ignored.

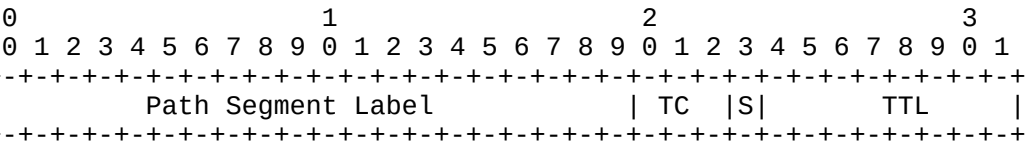


Figure 5: SR-MPLS Path Segment Sub-TLV

If the length is 18 then the Path Segment ID contains a 16-octet SRv6 Path Segment ID [I-D.ietf-spring-srv6-path-segment].

If the length is larger than 18 and B-flag is set, then SRv6 Endpoint Behavior and SID Structure TLVs is included as per Section 2.4.4.2.4. of [RFC9830].

The Path Segment is used to identified an SR path, and it can be used in OAM or IOAM use cases. When all the SID Lists within a candidate path share the same Path Segment ID, the Path Segment can be used to collect the aggregated information of the candidate path. Multiple Path Segment MAY be included in a Segment List for different use cases. In SR-MPLS, one, or some or all of them MAY be inserted into the SID List as the requirement of the use case. However, in SRv6, only one Path Segment ID can be encoded in a SRH. Therefore, an implementation MUST decide how to choose a Path Segment ID from the multiple Path Segment IDs. In order to simplify the implementation, this document suggests to encode only one Path Segment Sub-TLV for a segment list, while the rest Path Segment SHOULD be ignored.

4.2. Reverse Segment List Sub-TLV

A Reverse Segment List Sub-TLV is defined to specify an SR reverse path associated with the path specified by the Segment List, and it has the following format:

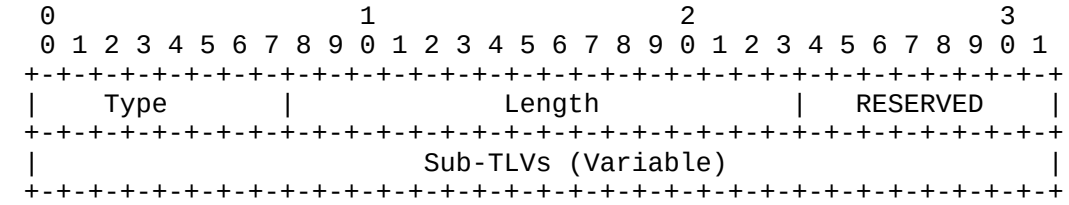


Figure 6: SR Reverse Segment List Sub-TLV

where:

Type (TBA2): Reverse Segment List Sub-TLV (to be assigned by IANA).

Length: the total length of the Sub-TLVs encoded within the Reverse Path Segment List Sub-TLV not including the Type and Length fields.

RESERVED: 1 octet of reserved bits. SHOULD be unset on transmission and MUST be ignored on receipt.

Sub-TLVs, reuse the Sub-TLVs in Segment List defined in [RFC9830] and [RFC9831].

* One or more mandatory SR Path Segment Sub-TLVs that contains the Path Segments of the reverse SR path.

* One or more Segment Sub-TLVs to specify the reverse SR path.

The Segment sub-TLVs in the Reverse Segment List sub-TLV provides the information of the reverse SR path. This Reverse Segment list can be used for directing egress BFD peer to use specific path for the reverse direction of the BFD session [RFC9612] or other applications.

A Reverse Segment List TLV MUST immediately follow its corresponding Segment List TLV in the attribute as this forms the one-to-one correlation of the forward and reverse segment lists. A Reverse Segment List TLV not encoded in the attribute in this manner MUST be considered as malformed. However, a Segment List TLV that is not immediately followed by a Reverse Segment List TLV simply indicates that the forward segment list does not have its corresponding reverse segment list and this condition MUST NOT be considered as an error.

5. Operations

This document defines new Sub-TLVs under the extensions for SR policy defined in [RFC9830], therefore, the description of operations defined in [RFC9830], can apply to this document directly, including advertisement of SR policies and reception of SR policy NLRI.

Typically but not limit to, the unidirectional or bidirectional SR policies carrying path identification infomation are configured by a controller.

After configuration, the unidirectional or bidirectional SR policies carrying path identification infomation will be advertised by BGP update messages. The operation of advertising this SR policy is the same as defined in [RFC9830], as well as the reception.

The consumer of the unidirectional or bidirectional SR policies is not the BGP process, it can be any applications, such as performance measurement [I-D.ietf-spring-stamp-srpm-srv6]. The operation of sending information to consumers is out of scope of this document.

6. Error Handling and Fault Management

This document extends the error handling defined in [RFC9830] for the new TLVs and sub-TLVs introduced herein. In the event of any of the TLVs and sub-TLVs introduced in this document being found to be malformed, the "Treat-as-withdraw" error handling [RFC7606] MUST be performed.

The following conditions MUST be considered as making an UPDATE message malformed:

* *Path Segment Sub-TLV:* The length of the sub-TLV is not 2/6/18/ larger than 18 octets, or the value fields are outside their defined ranges.

* *Reverse Segment List Sub-TLV:* A Reverse Segment List Sub-TLV is present in the Tunnel Encapsulation Attribute but does not immediately follow a Segment List Sub-TLV.

7. IANA Considerations

This document defines new Sub-TLVs in following registries:

7.1. Existing Registry: BGP Tunnel Encapsulation Attribute sub-TLVs

This document defines a new Sub-TLV in the registry "SR Policy Segment List Sub-TLVs" [RFC9830] to be assigned by IANA:

Codepoint	Description	Reference
TBA(17)	Path Segment Sub-TLV	This document

This document also defines a new Sub-TLV in the registry "BGP Tunnel Encapsulation Attribute sub-TLVs" [RFC9830] to be assigned by IANA:

Codepoint	Description	Reference
TBA2	Reverse Segment List Sub-TLV	This document

8. Security Considerations

The security considerations of RFC 9830 apply to this document.

Additionally, specific to the Path Segment ID and Reverse Path Segment, the Path Segment information is critical to the path, and an incorrect Path Segment ID may cause unexpected forwarding actions and results. Implementations must ensure the correctness of the Path Segment ID value, especially in SR-MPLS networks. Furthermore, the distribution of Path Segment information from a controller to an ingress router must be protected. The security considerations outlined in the Path Segment related documents, such as "draft-ietf-spring-srv6-path-segment" and "RFC 9545", apply to this distribution procedure.

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