Abstract
This document describes protocol extensions and procedures for protecting the ingress node of a Segment Routing (SR) path.

Requirements Language
The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

Status of This Memo
This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on January 7, 2020.
1. Introduction

Fast protection of a transit node of a Segment Routing (SR) path or tunnel is described in [I-D.bashandy-rtgwg-segment-routing-ti-lfa] and [I-D.hu-spring-segment-routing-proxy-forwarding]. However, these documents do not discuss the procedures for fast protection of the ingress node of an SR path or tunnel.

This document fills that void and specifies protocol extensions and procedures for fast protection of the ingress node of an SR path. SR path and SR tunnel, Ingress node and ingress as well as fast protection and protection will be used exchangeably.
2. Terminologies

The following terminologies are used in this document.

SR: Segment Routing
SRv6: SR for IPv6
SRH: Segment Routing Header
SID: Segment Identifier
CE: Customer Edge
PE: Provider Edge
LFA: Loop-Free Alternate
TI-LFA: Topology Independent LFA
TE: Traffic Engineering
BFD: Bidirectional Forwarding Detection
VPN: Virtual Private Network
L3VPN: Layer 3 VPN
FIB: Forwarding Information Base
PLR: Point of Local Repair
BGP: Border Gateway Protocol
IGP: Interior Gateway Protocol
OSPF: Open Shortest Path First
IS-IS: Intermediate System to Intermediate System

3. SR Path Ingress Protection Example

To protect against the failure of the (primary) ingress node of a (primary) SR path, a backup ingress node is configured or selected and is different from the (primary) ingress node. A backup SR path from the backup ingress node is computed and installed. Primary ingress and ingress as well as primary SR path and SR path will be used exchangeably.
Figure 1 shows an example of protecting ingress PE1 of a SR path, which is from ingress PE1 to egress PE3.

```
*******  *******
[PE1]-----[P1]-----[PE3]   PE1 Ingress
/ |        |&&&&&&&& | \
/  |        |&        |  \
[CE1]   |        |&        |   [CE2]      Px Non-Ingress
\ |        |&        | /           *** SR Path
 \ &&&&&&&|&        | /            &&& Backup SR Path
 [PE2]-----[P2]-----[PE4]
```

Figure 1: Protecting Ingress PE1 of SR Path PE1-P1-PE3

In normal operations, CE1 sends the traffic with destination PE3 to ingress PE1, which imports the traffic into the SR path.

When CE1 detects the failure of ingress PE1, it switches the traffic to backup ingress PE2, which imports the traffic from CE1 into a backup SR path. The backup path is from the backup ingress PE2 to the egress PE3. When the traffic is imported into the backup path, it is sent to the egress PE3 along the path.

4. Behavior after Ingress Failure

After the failure of the ingress of an SR path happens, there are a couple of different ways to detect the failure. In each way, there may be some specific behavior for the traffic source (e.g., CE1) and the backup ingress (e.g., PE2).

In one way, the traffic source (e.g., CE1) is responsible for fast detecting the failure of the ingress (e.g., PE1) of an SR path. Fast detecting the failure means detecting the failure in a few or tens of milliseconds. The backup ingress (e.g., PE2) is ready to import the traffic from the traffic source into the backup SR path installed.

In normal operations, the source sends the traffic to the ingress of the SR path. When the source detects the failure of the ingress, it switches the traffic to the backup ingress, which delivers the traffic to the egress of the SR path via the backup SR path.

In another way, the backup ingress is responsible for fast detecting the failure of the ingress of an SR path.

In normal operations, the source (e.g., CE1) sends the traffic to the ingress (e.g., PE1) and may send the traffic to the backup ingress (e.g., PE2). It sends the traffic to the backup ingress (e.g., PE2) after the ingress fails.
The backup ingress does not import any traffic from the source into the backup SR path in normal operations. When it detects the failure of the ingress, it imports the traffic from the source into the backup SR path.

5. Extensions to BGP

For a SR path from a primary ingress node to an egress node, a backup ingress node is selected to protect the failure of the primary ingress node of the SR path. This section describes the extensions to BGP for representing the information for protecting the primary ingress node in a BGP UPDATE message and distributing the information to the backup ingress node. The information includes a SR backup path.

[I-D.ietf-idr-segment-routing-te-policy] specifies a way of representing a SR path in a BGP UPDATE message and distributing the SR path to the ingress node of the SR path.

This is extended to represent the information for protecting the primary ingress by defining a few of new Sub-TLVs.

5.1. SR Path Ingress Protection Sub-TLV

A new Sub-TLV, called SR Path Ingress Protection Sub-TLV, is defined. When a UPDATE message is sent to the backup ingress node for protecting the primary ingress node of a SR path, the message contains this Sub-TLV. Its format is illustrated 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Type (TBD1)   |        Length (variable)      |   Flags    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                                                               ~
~                        Sub-TLVs (optional)                    ~
~                                                               ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 2: SR Path Ingress Protection Sub-TLV

Type: TBD1 is to be assigned by IANA.

Length: Variable.

Flags: 1 octet. One flag is defined.

Flag A: 1 bit. It is set to
1: request a backup ingress to let the forwarding entry for the backup SR path be Active.

0: request a backup ingress to let the forwarding entry for the backup SR path be inactive initially and to make the entry be active after detecting the failure of the primary ingress node of the primary SR path.

A couple types of optional Sub-TLVs are defined, which are Primary Ingress Sub-TLV and Service Sub-TLV.

5.1.1. Primary Ingress Sub-TLV

A Primary Ingress Sub-TLV indicates the IP address of the primary ingress node of a primary SR path. It has two formats: one for primary ingress node IPv4 address and the other for primary ingress node IPv6 address, which are illustrated below.

Type: Its value (1 suggested) is to be assigned by IANA.

Length: 4.

Primary Ingress IPv4 Address: 4 octets. It represents an IPv4 host address of the primary ingress node of a primary SR path.

Type: Its value (2 suggested) is to be assigned by IANA.
Length: 16.

Primary Ingress IPv6 Address: 16 octets. It represents an IPv6 host address of the primary ingress node of a primary SR path.

5.1.2. Service Sub-TLV

A Service Sub-TLV contains a service ID or label to be added into a packet to be carried by a SR path. It has three formats: the first one for the service identified by a label, the second one for the service identified by a service identifier (ID) of 32 bits, and the third one for the service identified by a service identifier (ID) of 128 bits. Their formats are illustrated 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Type (3)   |   Length (4)  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Service Label (20 bits)                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5: Service Label Sub-TLV

Type: Its value (3 suggested) is to be assigned by IANA.

Length: 4.

Service Label: the least significant 20 bits. It represents a label of 20 bits.

```
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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Type (4)   |   Length (4)  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Service ID (4 octets)                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 6: 32 Bits Service ID Sub-TLV

Type: Its value (4 suggested) is to be assigned by IANA.

Length: 4.

Service ID: 4 octets. It represents a Service Identifier (ID) of 32 bits.
6. Backup Ingress Behavior

When a backup ingress node receives a UPDATE message containing the information for protecting the primary ingress node of a SR path, it installs a forwarding entry in its FIB based on the information. The information is encoded in a SR policy of the following structure:

**SR Policy SAFI NLRI:** `<Distinguisher, Policy-Color, Endpoint>`

**Attributes:**
- Tunnel Encaps Attribute (23)
- Tunnel Type (15): SR Policy
  - SR Path Ingress Protection Sub-TLV
  - Primary Ingress Sub-TLV
  - Service Sub-TLV
  - Preference Sub-TLV
  - Binding SID Sub-TLV
  - Explicit NULL Label Policy (ENLP) Sub-TLV
  - Priority Sub-TLV
  - Policy Name Sub-TLV
  - Segment List Sub-TLV
  - Weight Sub-TLV
  - Segment Sub-TLV
  - Segment Sub-TLV
  - ...
  - ...

**Where:**

- SR Policy SAFI NLRI is defined in
  
  [I-D.ietf-idr-segment-routing-te-policy].
o Tunnel Encapsulation Attribute is defined in [I-D.ietf-idr-tunnel-encaps].

o Tunnel Type of SR Policy is defined in [I-D.ietf-idr-segment-routing-te-policy].

o SR Path Ingress Protection, Primary Ingress and Service Sub-TLVs are defined in this document.

o Preference, Binding SID, ENLP, Priority, Policy Name, Segment List, Weight and Segment Sub-TLVs are defined in [I-D.ietf-idr-segment-routing-te-policy].

After receiving a SR policy with a SR Path Ingress Protection Sub-TLV, the backup ingress node will install one or more candidate paths into its "BGP table". Another module such as SRPM will choose one or more paths and install the forwarding entries for them in the data plane.

The forwarding entries for the paths installed in the data plane will be set to be inactive if the flag A in the SR Path Ingress Protection Sub-TLV is zero. When the primary ingress node fails, these forwarding entries are set to be active. The failure of the primary ingress may be detected by the backup ingress node through using a mechanism such as BFD. The IP address of the primary ingress in the Primary Ingress Sub-TLV may be used for detecting the failure of the primary ingress node.

If the flag A in the SR Path Ingress Protection Sub-TLV is one, then the forwarding entries for the paths installed in the data plane will be set to be active.

When there is a Service Sub-TLV in the SR Path Ingress Protection Sub-TLV, the ID or Label in the Service Sub-TLV will be included in the forwarding entries. When a packet is imported into a backup SR path using the forwarding entries, the service ID or Label is pushed first and then the sequence of segments represented in the Segment List Sub-TLV.

7. Security Considerations

Protocol extensions defined in this document do not affect the BGP security other than those as discussed in the Security Considerations section of [RFC5575].
8. Acknowledgements

TBD

9. IANA Considerations

9.1. BGP Tunnel Encapsulation Attribute Sub-TLVs

Under Existing Registry Name: "BGP Tunnel Encapsulation Attribute Sub-TLVs", IANA is requested to assign a new Sub-TLV value for SR Path Ingress Protection as follows:

<table>
<thead>
<tr>
<th>Value</th>
<th>sub-TLV Name</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBD1</td>
<td>SR Path Ingress Protection Sub-TLV</td>
<td>This Document</td>
</tr>
</tbody>
</table>

9.2. Ingress Protection Information Sub-TLVs

A new registry called "Ingress Protection Information Sub-TLVs" is defined in this document. IANA is requested to create and maintain new registry:

- Ingress Protection Information Sub-TLVs

Initial values for the registry are given below. The future assignments are to be made through IETF Review [RFC5226].

<table>
<thead>
<tr>
<th>Value</th>
<th>sub-TLV Name</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Reserved</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Primary Ingress IPv4 Address Sub-TLV</td>
<td>This Document</td>
</tr>
<tr>
<td>2</td>
<td>Primary Ingress IPv6 Address Sub-TLV</td>
<td>This Document</td>
</tr>
<tr>
<td>3</td>
<td>Service Label Sub-TLV</td>
<td>This Document</td>
</tr>
<tr>
<td>4</td>
<td>32 Bits Service ID Sub-TLV</td>
<td>This Document</td>
</tr>
<tr>
<td>5</td>
<td>128 Bits Service ID Sub-TLV</td>
<td>This Document</td>
</tr>
<tr>
<td>6-255</td>
<td>Unassigned</td>
<td></td>
</tr>
</tbody>
</table>

10. References

10.1. Normative References

[I-D.ietf-idr-segment-routing-te-policy]
10.2. Informative References

[I-D.bashandy-rtgwg-segment-routing-ti-lfa]

[I-D.hegde-spring-node-protection-for-sr-te-paths]

[I-D.hu-spring-segment-routing-proxy-forwarding]

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

[I-D.sivabalan-pce-binding-label-sid]


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