Segment Routing for unicast traffic has been proposed to cope with the use cases in traffic engineering, fast re-reroute, service chain, etc. The document generalizes more use cases based on segment and proposes the concept of Segment Path Programming. In the field of Segment Path Programming: 1. The Segment used in the programmed segment path is not only used in the forwarding plane, but also used in the control plane. 2. The programmed segment path is not only used in the transport layer, but also used in the service layer. Accordingly this document proposes use cases, architecture and protocol extension requirements for the Segment Path Programming (SPP).

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 April 19, 2016.
1. Introduction

Segment Routing [I-D.ietf-spring-segment-routing] for unicast traffic has been proposed to cope with the usecases in traffic engineering, fast re-reroute, service chain, etc. The document generalizes more use cases based on segment and proposes the concept of Segment Path Programming. In the field of Segment Path Programming: 1. The Segment used in the programmed segment path is not only used in the...
forwarding plane, but also used in the control plane. 2. The programmed segment path is not only used in the transport layer, but also in the service layer. Accordingly this document proposes use cases, architecture and protocol extension requirements for the Segment Path Programming (SPP).

2. Terminology

BGP: Border Gateway Protocol
L2VPN: Layer 2 VPN
L3VPN: Layer 3 VPN
SPP: Segment Path Programming
SR-path: Segment Routing Path
SRGB: SR Global Block

3. Redefinition of Segment

3.1. Application of Segment in Control Plane and Forwarding Plane

In the existing segment routing, the segment will be applied to the MPLS forwarding plane directly. In the MPLS architecture, the global segment such as node segment will be mapped to MPLS label since SRGB will be defined as the set of local labels reserved for global segments and the local segment will be a local label outside the SRGB.

In fact, the segment can be only used in the control plane instead of mapping to the forwarding plane. In the usecase, the segment is just an indicator for specific process which can be used for the application of Segment Path Programming.

For example, node segment in the Segment Routing mapped in the control plane and forwarding plane in the MPLS architecture is shown in the following figure.
In the Segment Path Programming, the node segment can be enhanced to support following mapping in the control plane and forwarding plane even in the MPLS architecture.

Control Plane:

```
+---------+              +------------+
| Segment |              |            |
|         |      =       |   Label    |
|   ID    |              |            |
+---------+              +------------+
```

Forwarding Plane:

```
+--------+------------+      +------------+-------------------------+
|        | Forwarding | -->  | Forwarding | Forwarding Information  |
| Label  |            |      |            |        to               |
|        |   Index    |      |   Index    |   Specified Node        |
+--------+------------+      +------------+-------------------------+
```

Figure 1: Node Segment in Segment Routing

In this mapping, the Segment ID can map to the forwarding entry to specific node. But it is only an indicator in the control plane which can be used for possible applications. When receive the mapping information between the application and the Segment ID, the network node will install additional forwarding entry as follows which map the application information to the forwarding information specified by the segment ID.

```
+------------+-------------------------+
| Forwarding | Forwarding Information  |
|            |        to               |
|   Index    |   Specified Node        |
+------------+-------------------------+
```

Figure 2: Enhanced Node Segment in Segment Path Programming
Control Plane:

Mapping Information

<table>
<thead>
<tr>
<th>App</th>
<th>Segment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Info</td>
<td>ID</td>
</tr>
</tbody>
</table>

Forwarding Plane:

<table>
<thead>
<tr>
<th>App Info</th>
<th>Forwarding</th>
<th>--&gt;</th>
<th>Forwarding</th>
<th>Forwarding Information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Index</td>
<td></td>
<td>Index</td>
<td>Specified Node</td>
</tr>
</tbody>
</table>

Figure 3: Mapping App to Segment in Segment Path Programming

The application information in the forwarding entry should be derived from the packet received by the network nodes such as the destination IP/MAC address, the source IP/MAC address, the port number, the protocol number, etc. It can also be the MPLS label.

In order to support the enhanced segment in the Segment Programming Path, whether to map the Segment to MPLS label can be determined by the local policy of the network node. Protocol extensions can also be introduced to specify if the Segment maps to the MPLS label when advertised the information of SRGBs or all kinds of Segments.

3.2. Application of Segment in Reachability and Service Process

In the existing Segment Routing, in the MPLS architecture the segment will be mapped to the label which is always the indicator of reachability to the specific node, the specific agency, etc. More types of Segments which indicates the reachability can be introduced according to existing MPLS forwarding plane. Since these segments represent reachability in the network, they can be used for traffic steering. These segments includes:

-- Node Segment
-- Agency Segment
-- AS (Autonomous System) Segment
-- Anycast Segment
-- Multicast Segment
As the development of Segment Routing, the service segment is introduced to represent the specific service process. It can be used for some new application scenarios such as the Service Function Chain (SFC). For the service process in the traditional IP/MPLS forwarding plane, it can also be indicated by different types of segments. This provides the possibility to flexibly combine these segments to set up a Segment Path to represent a series of service processes in the network on the specific flow instead of only steering traffic. These segments can represent different service processes in the forwarding plane as follows:

-- Tunnel Segment
-- VPN Segment
-- etc.

4. Definition of Segment Path Programming Path

Owing to more types of segments and flexible application of segment in the control plane and the forwarding plane, there will be powerful capability to combine these segments which can be used to steering traffic or provide flexible service process to satisfy different service requirements for specific flows in the network. We call such combination of segments as Segment Path and the flexible combining of segments as Segment Path Programming.

Segment Routing ([I-D.ietf-spring-segment-routing]) is a typical example of Segment Path Programming. There can be multiple layers for Segment Path Programming which are shown in the following figure:
5. Usecases of Segment Path Programming

5.1. Flexible Service Process Combination

The following figure shows the usecase of Segment Path Programming to combine service segments according to the service requirements on the traffic which can be specified by the traditional BGP VPN prefix. The combination of these service segments represent the required ECMP, QoS and OAM process.
Traditional Label Binding for VPN Prefix:

<table>
<thead>
<tr>
<th>VPN Prefix</th>
<th>VPN Prefix</th>
<th>Label</th>
</tr>
</thead>
</table>

Additional Segment Path Information:

<table>
<thead>
<tr>
<th>ECMP</th>
<th>QoS</th>
<th>OAM</th>
<th>Segment</th>
<th>Segment</th>
<th>Segment</th>
</tr>
</thead>
</table>

If the network node maps the corresponding segment to MPLS label, the forwarding entry can be as follows:

<table>
<thead>
<tr>
<th>VPN Prefix</th>
<th>Entropy</th>
<th>QoS</th>
<th>OAM</th>
<th>VPN Prefix</th>
<th>Transport Tunnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>---&gt; Label</td>
<td>Label</td>
<td>Label</td>
<td>Label</td>
<td>Label</td>
<td>---&gt; determined by BGP Nexthop</td>
</tr>
</tbody>
</table>

5.2. Node Segment for Synonymous Flow Label

Synonymous flow label has been proposed by [I-D.bryant-mpls-synonymous-flow-labels] to solve the issue of the measurement of packet loss for multipoint-to-point LSP. Node segment advertised in the Segment Routing can be used as the flow label. In the scenario of performance measurement the flow label can only be interpreted by network node to identify the source of the flow other than set up the MPLS forwarding entry for the node segment in the scenario of segment routing. So when advertise the node segment information on the usage of the node segment can also be carried or the local policy can be introduced to determine the application of the node segment. Then the segment path can be set up based on such node segment for the purpose of performance measurement.

5.3. Steering Traffic without Mapping Segment to Label

The following figure shows the usecase of Segment Path Programming to steer traffic which can be specified by the traditional BGP prefix.
Traditional BGP Prefix:

```
+----------+
|   BGP    |
|  Prefix  |
+----------+
```

Additional Segment Path Information:

```
+----------+----------+
|  Agency  |   Node   |
|  Segment |  Segment |
+----------+----------+
```

If these segments are not applied in the MPLS forwarding plane, the Segment Path will be explained as steering traffic specified by the BGP prefix to reach specific node (determined by the Node Segment) through specific local link (determined by the Agency Segment). The corresponding forwarding entry will be as follows:

```
+----------+------------+      +------------+---------------+--------------------+
|    BGP   | Forwarding |      | Forwarding |   Next Hop    | Outgoing Interface |
|          |            | -->  |            | determined by |    determine by    |
|   Prefix |   Index    |      |   Index    |  Node Segment |    Link Segment    |
+----------+------------+      +------------+---------------+--------------------+
```

5.4. Centralized Mapping Service to Tunnels

In the transport layers, there can be multiple tunnels with different constraints to one specific destination. In the traditional way, the tunnel is set up by the distributed forwarding nodes. As the PCE-initiated LSP setup [I-D.ietf-pce-pce-initiated-lsp] is introduced, the tunnel setup can be triggered by the central controlled way. In order to satisfy the different service requirements, it is necessary to provide the capability to flexibly map the service to different tunnels. Since the central control point has enough information based on the whole network view, it can be an effective way to map the service to the tunnel by the central point and advertise the mapping information to the end-points of the service to guide the mapping in the forwarding node.

The method to implement mapping service to tunnels can directly introduce the tunnel attribute to specify the tunnel proposed by [I-D.li-idr-mpls-path-programming]. [I-D.li-spring-tunnel-segment] proposes one new type of segment, Tunnel Segment, which can provide an alternative way to implement mapping service to tunnels. In the following figure, the central controller can trigger to set up the MPLS TE tunnels through PCE-initiated LSP and allocate Segment ID for the tunnel in the Node-1.
Without applying the segment to MPLS label the Node-1 can set up the following mapping for the tunnel segment:

Control Plane:

<table>
<thead>
<tr>
<th>Segment ID</th>
<th>--&gt;</th>
<th>Forwarding</th>
<th>Index</th>
</tr>
</thead>
</table>

Forwarding Plane:

<table>
<thead>
<tr>
<th>Forwarding</th>
<th>Tunnel Forwarding</th>
<th>Index</th>
<th>Information</th>
</tr>
</thead>
</table>

Figure 6: Enhanced Node Segment in Segment Path Programming

Then the central controller can advertise following Segment Path information for the flow which can be specified by the traditional BGP prefix.
Traditional BGP Prefix:

```
+----------+
|   BGP    |
|  Prefix  |
+----------+
```

Additional Segment Path Information:

```
+----------+
|  Tunnel  |
|  Segment |
+----------+
```

Then the following forwarding entry can be set up for the specified BGP prefix to steer traffic to specific tunnel in the Node-1.

```
+----------+------------+      +------------+----------------------+
|    BGP   | Forwarding |      | Forwarding |   Tunnel Forwarding  |
|          |            | -->  |            |                      |
|   Prefix |   Index    |      |   Index    |     Information      |
+----------+------------+      +------------+----------------------+
```

6. Framework of Service-Oriented MPLS Path Programming

6.1. Central Control for MPLS Path Programming

Central control plays an important role in Segment Path Programming shown in the figure 7. There are two important functionalities for the central controller:

1. Central controlled Segment allocation/collection: Segment can be allocated centrally for specific usage. Or central controller can collect the segment binding information from the network nodes. BGP/PCEP/IGP extensions can be introduced to distribute or collect the segment binding information.

2. Central controlled Segment Path Programming: Central controller can calculate path in a global network view and implement the Segment Path Programming based on the collected information of segments to satisfy different requirements of service flows. BGP/PCEP extensions can be introduced to download the Segment Path for the Service/Network layer or Transport/Link layer.
6.2. Protocol Extensions Requirements

REQ 01: BGP/PCEP/IGP extensions should be introduced to distribute Segment binding for specific usage from the central controller to other client nodes.

REQ 02: BGP/PCEP/IGP extensions should be introduced to collect Segment binding for specific usage from the client nodes to the central controller.

REQ 03: BGP extensions should be introduced to download Segment (stack) for Segment Path of the service/network layer.

REQ 04: PCE extensions should be introduced to download Segment (stack) for Segment Path of the transport layer.

REQ 05: Protocol extensions should be introduced to specify the application of SRGB or Segment which means if the segment is applied to MPLS forwarding plane.

7. IANA Considerations

This document makes no request of IANA.
8. Security Considerations

TBD.

9. References

9.1. Normative References


9.2. Informative References

[I-D.bryant-mpls-synonymous-flow-labels]

[I-D.ietf-pce-pce-initiated-lsp]

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

[I-D.li-idr-mpls-path-programming]
Li, Z., "BGP Extensions for Service-Oriented MPLS Path Programming (MPP)", draft-li-idr-mpls-path-programming-01 (work in progress), March 2015.

[I-D.li-spring-tunnel-segment]
Li, Z. and N. Wu, "Tunnel Segment in Segment Routing", draft-li-spring-tunnel-segment-00 (work in progress), September 2015.

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