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**Include Routes - Extension to
Resource ReserVation Protocol-Traffic Engineering (RSVP-TE)
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Abstract

There are scenarios that require two or more LSPs or segments of
LSPs to follow same route in the network. This document specifies
methods to communicate route inclusions along the loose hops during
path setup using the Resource ReserVation Protocol-Traffic
Engineering (RSVP-TE) protocol.

Conventions used in this document

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].

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1. Introduction

   There are scenarios that require two or more Label Switched
   Paths (LSPs) to follow same route in the network. E.g., many
   deployments require member LSPs of a bundle/ aggregated link (or
   Forwarding Adjacency (FA))) follow the same route. Possible
   reasons for two or more LSPs to follow the same end-to-end or
   partial route include, but are not limited to:

   . Fate sharing: an application may require that two or more
      LSPs fail together. In the example of bundle link this would

mean that if one component goes down, the entire bundle goes
down.

. Homogeneous Attributes: it is often required that two or more
LSPs have the same TE metrics like latency, latency variation,
etc. In the example of a bundle/ aggregated link this would
meet the requirement that all component links (FAs) of a
bundle should have same latency and latency variation. As
noted in [OSPF-TE-METRIC] and [ISIS-TE-METRIC], in certain
networks, such as financial information networks, network
performance (e.g. latency and latency variation) is becoming
critical and hence having bundles with component links (FAs)
with homogeneous latency and latency variation is important.

The RSVP-TE specification [RFC3209] and GMPLS extensions to
RSVP-TE [RFC3473] allow abstract nodes and resources to be
explicitly included in a path setup, e.g., using IPv4 prefix ERO
subobject [RFC3209], IPv6 prefix ERO subobject [RFC3209] and
Unnumbered Interface ID ERO subobject [RFC3477], etc. However,
such inclusion may not be possible in the following scenarios:

. Inclusion of an LSP path which, while known at the source
node of the to-be-signaled LSP, where the required detail of
the route is incomplete or unavailable, e.g. due to
confidentiality of the path attributes. Such cases are likely
to arise in Inter-domain and GMPLS overlay networks.

These use-cases require the relevant path-inclusion information
to be communicated to the route expanding nodes. This document
defines the necessary information, encodings, and procedures.

This document assumes that node expanding the route is normally a
hop of the included LSP. However, there is a race condition in
which included LSP is yet to be signaled. This draft addresses
this race condition, as detailed in Section 2.2.

2. RSVP-TE signaling extensions

New IPv4 and IPv6 Point-to-Point (P2P) Path ERO subobject types
are defined in this document. These ERO subobjects are used to
communicate path inclusion requirements to the ERO expanding
node(s). For this purpose, the subobjects carry RSVP-TE
Forwarding Equivalence Class (FEC) of the reference LSP who's
Path is be used to expand the loose hop of the LSP being
signaled.

2.1. **IPv4 Point-to-Point Path ERO subobject**

   The IPv4 Point-to-Point Path ERO subobject is defined as
   follows:
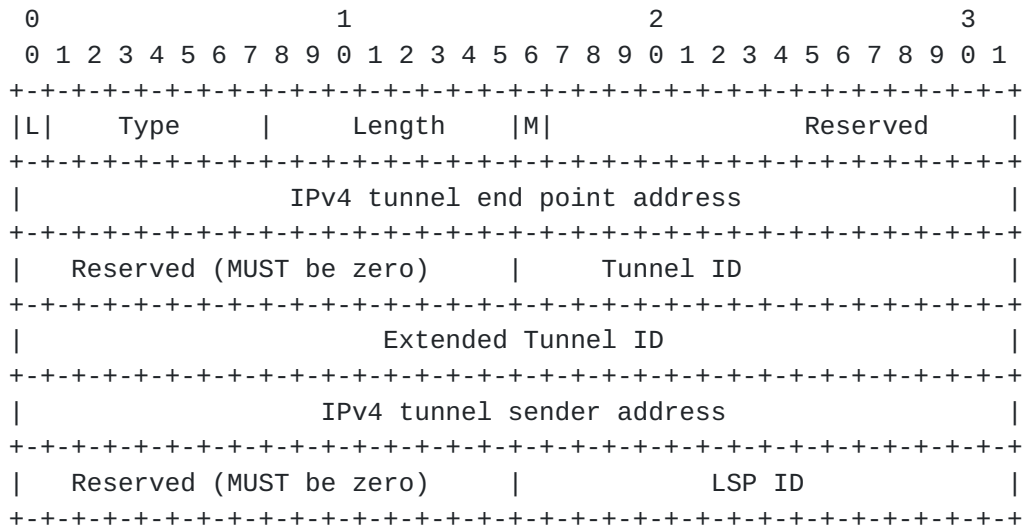
```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|L|   Type     |    Length     |M|                Reserved      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                 IPv4 tunnel end point address                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Reserved (MUST be zero)     |        Tunnel ID             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Extended Tunnel ID                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   IPv4 tunnel sender address                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Reserved (MUST be zero)     |            LSP ID            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```


   L

        The L bit is an attribute of the subobject. The L bit is
        set if the subobject represents a loose hop in the ERO.
        If the bit is not set, the subobject represents a strict
        hop in the explicit route.

        This document only defines the use of the subobject in
        loose hopes in the ERO, i.e., L bit MUST of set to 1.

   Type

        IPv4 Point-to-Point Path ERO subobject
        (to be assigned by IANA; suggested value: 38).

   Length

        The length contains the total length of the subobject in
        bytes, including the type and length fields. The length is
        always 24.

   M bit: When "mandatory inclusion" bit is set, the route of the
   LSP being signaled MUST follow the path specified by the Path
   ERO subobject. When mandatory inclusion is not set, the route

of the LSP being signaled SHOULD follow the path specified by
the Path ERO subobject.

The remaining fields are used to specify RSVP-TE FEC of the
reference LSP who's Path is be used to expand the route of the
LSP being signaled. Specifically,

Tunnel ID

    Tunnel ID of the reference LSP who's Path is be used to
    expand the route of the LSP being signaled.

Extended Tunnel ID

    Extended Tunnel ID of the reference LSP who's Path is be
    used to expand the route of the LSP being signaled.

IPv4 tunnel sender address

    IPv4 tunnel sender address of the reference LSP who's
    path is be used to expand the route of the LSP being
    signaled.

LSP ID

    LSP ID of the reference LSP who's Path is be used to
    expand the route of the LSP being signaled.

2.2. IPv6 Point-to-Point Path ERO subobject

The IPv6 Point-to-Point Path ERO subobject is defined as
follows:

```
 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 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|L|   Type    |    Length     |M|            Reserved           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                 IPv6 tunnel end point address                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              IPv6 tunnel end point address (cont.)            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              IPv6 tunnel end point address (cont.)            |
```

```
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              IPv6 tunnel end point address (cont.)           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Must Be Zero         |           Tunnel ID          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Extended Tunnel ID                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Extended Tunnel ID (cont.)                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Extended Tunnel ID (cont.)                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Extended Tunnel ID (cont.)                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    IPv4 tunnel sender address                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                 IPv4 tunnel sender address (cont.)           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                 IPv4 tunnel sender address (cont.)           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                 IPv4 tunnel sender address (cont.)           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Reserved (MUST be zero)      |              LSP ID          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   L

        The L bit is an attribute of the subobject. The L bit is
        set if the subobject represents a loose hop in the ERO.
        If the bit is not set, the subobject represents a strict
        hop in the explicit route.

        This document only defines the use of the subobject in
        loose hopes in the ERO, i.e., L bit MUST of set to 1.

   Type

        IPv6 Point-to-Point Path ERO subobject
        (to be assigned by IANA; suggested value: 39).

   Length

        The length contains the total length of the subobject in
        bytes, including the type and length fields. The length is
        always 48.

M bit: The M bit usage is as defined for the M bit of IPv4
Point-to-Point Path ERO subobject.

The remaining fields are used to specific RSVP-TE FEC of the
reference LSP who's Path is be used to expand the route of the
LSP being signaled, as detailed in Section 2.1.

2.3. Processing rules for Path ERO subobjects

The basic processing rules of an ERO are not altered. Please
refer to [RFC3209] for details.

If an LSR strips all local subobjects from an ERO carried in a
Path message (according to the procedures in [RFC3209]) and
finds that the next subobject is an IPv4 P2P Path ERO subobject
or IPv6 P2P LSP subject, it MUST attempt to resolve the Path ERO
subobject as described in the following.

If the L bit of the Path ERO subobject is not set, i.e., the
subobject represents a strict hop in the explicit route, the
processing node MUST respond with a PathErr message with the
error code "Routing Problem" (24) and the error value "Bad
initial subobject" (4).

If the M bit is set, the processing node follows the following
procedure:

- If the path taken by the LSP referenced in the Path ERO
   subobject is known to the processing node and the path
   contains the loose abstract node in the ERO hop, the
   processing node MUST ensure that loose hop expansion to the
   next abstract node follows the referenced path.

- If the path taken by the LSP referenced in the Path ERO
   subobject does not contain the loose abstract node in the ERO
   hop, the processing node MUST sent a PathErr message with the
   error code "Routing Problem" (24) and the new error value
   "unknown or inconsistent LSP suboject" (value to be assigned
   by IANA) for the signaled LSP.

- If the path referenced in the LSP subobject is unknown to the
   processing node, the processing node SHOULD ignore the Path
   ERO subobject and SHOULD proceed with the signaling request.
   After sending the Resv for the signaled LSP, the processing
   node SHOULD return a PathErr with the error code "Notify

Error" (25) and error sub-code "TBD" (value to be assigned by
IANA, suggested value: TBD) for the signaled LSP.

If the M bit is not set, the processing node follows the
following procedure:

- If the path taken by the LSP referenced in the Path ERO
   subobject is known to the processing node and the path
   contains the loose abstract node in the ERO hop, the
   processing node SHOULD ensure that loose hop expansion to the
   next abstract node follows the referenced path.

- If the path taken by the LSP referenced in the Path ERO
   subobject is unknown to the processing node and/ or the
   referenced path does not contain the loose abstract node in
   the ERO hop, the processing node SHOULD ignore the route
   inclusion specified in the Path ERO subobject and SHOULD
   compute a suitable path to the loose abstract node in the ERO
   hop and proceed with the signaling request. After sending the
   Resv for the signaled LSP, the processing node SHOULD return a
   PathErr with the error code "Notify Error" (25) and error sub-
   code " unknown or inconsistent LSP suboject" (value to be
   assigned by IANA) for the signaled LSP.

3. Security Considerations

This document does not introduce any additional security issues
above those identified in [RFC5920], [RFC2205], [RFC3209], and
[RFC3473] and [RFC4874].

4. IANA Considerations

4.1. New ERO subobject types

This document adds the following new subobject of the existing
entry for ERO (20, EXPLICIT_ROUTE):

Value	Description
TBA subobject	IPv4 Point-to-Point Path ERO
TBA subobject	IPv6 Point-to-Point Path ERO

These subobject may be present in the Explicit Route Object, but
not in the Route Record Object.

4.2. New RSVP error sub-codes

IANA registry: RSVP PARAMETERS
Subsection: Error Codes and Globally-Defined Error Value Sub-
Codes

For Error Code "Routing Problem" (24) (see [RFC3209]) the
following sub-codes are defined.

```
Sub-code                         Value
--------                         -----
```

Unknown or inconsistent LSP suboject   To be assigned by IANA.

For Error Code "Notify Error" (25) (see [RFC3209]) the following
sub-codes are defined.

```
Sub-code                         Value
--------                         -----
```

Unknown or inconsistent LSP suboject   To be assigned by IANA.

5. Acknowledgments

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Fang and Walid Wakim for their review comments.

6. References

6.1. Normative References

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6.2. Informative References

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