RSVP Extensions For Re-optimization of Loosely Routed
Point-to-Multipoint Traffic Engineering Label Switched Paths (LSPs)
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Abstract

   Re-optimization of a Point-to-Multipoint (P2MP) Traffic Engineered
   (TE) Label Switched Path (LSP) may be triggered based on the need to
   re-optimize an individual source-to-leaf (S2L) sub-LSP or a set of
   S2L sub-LSPs, both using Sub-Group-Based Re-optimization method, or
   the entire P2MP-TE LSP tree using the Make-Before-Break (MBB) method.
    This document discusses the application of the existing mechanisms
   for path re-optimization of loosely routed Point-to-Point (P2P) TE
   LSPs to the P2MP-TE LSPs, identifies issues in doing so and defines
   procedures to address them. When re-optimizing a large number of S2L
   sub-LSPs in a tree using the Sub-Group-Based Re-optimization method,
   the S2L sub-LSP descriptor list may need to be semantically
   fragmented. This document defines the notion of a fragment
   identifier to help recipient nodes unambiguously reconstruct the
   fragmented S2L sub-LSP descriptor list.

time. It is inappropriate to use Internet-Drafts as reference
material or to cite them other than as "work in progress."

Table of Contents

1. Introduction

   This document defines Resource Reservation Protocol - Traffic
   Engineering (RSVP-TE) [RFC2205] [RFC3209] signaling extensions for
   re-optimizing loosely routed Point-to-Multipoint (P2MP) Traffic
   Engineered (TE) Label Switched Paths (LSPs) [RFC4875] in a
   Multi-Protocol Label Switching (MPLS) or Generalized MPLS (GMPLS)
   [RFC3473] network.

   A P2MP-TE LSP is comprised of one or more source-to-leaf (S2L)
   sub-LSPs. A loosely routed P2MP-TE S2L sub-LSP is defined as one
   whose path does not contain the full explicit route identifying each
   node along the path to the egress node at the time of its signaling
   by the ingress node. Such an S2L sub-LSP is signaled with no
   Explicit Route Object (ERO) [RFC3209], or with an ERO that contains
   at least one loose next-hop, or with an ERO that contains an abstract
   node which identifies more than one node. This is often the case
   with inter-domain P2MP-TE LSPs where Path Computation Element (PCE)
   is not used [RFC5440].

   As per [RFC4875], an ingress node may re-optimize the entire P2MP-TE
   LSP tree by re-signaling all its S2L sub-LSP(s) using the
   Make-Before-Break (MBB) method or may re-optimize individual S2L sub-
   LSP or a set of S2L sub-LSPs i.e. individual destination or a set of
   destinations, both using the Sub-Group-Based Re-optimization method.

   [RFC4736] defines RSVP signaling procedure for re-optimizing the
   path(s) of loosely routed Point-to-Point (P2P) TE LSP(s). Those
   mechanisms include a method for the ingress node to trigger a new
   path re-evaluation request and a method for the mid-point node to
   notify availability of a preferred path. This document discusses the
   application of those mechanisms to the re-optimization of loosely
   routed P2MP-TE LSPs, identifies issues in doing so and defines
   procedures to address them.

   For re-optimizing a group of S2L sub-LSPs in a tree using the Sub-
   Group-Based Re-optimization method, an S2L sub-LSP descriptor list
   can be used to signal one or more S2L sub-LSPs in an RSVP message.
   This RSVP message may need to be semantically fragmented when large
   number of S2L sub-LSPs are added to the descriptor list. This
   document defines the notion of a fragment identifier to help
   recipient nodes unambiguously reconstruct the fragmented S2L sub-LSP
   descriptor list.

2. Conventions Used in This Document

2.1. Key Word Definitions

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 [RFC2119].

2.2. Abbreviations

ABR: Area Border Router.

AS: Autonomous System.

ERO: Explicit Route Object.

LSR: Label Switching Router.

S2L sub-LSP: Source-to-leaf sub Label Switched Path.

TE LSP: Traffic Engineering Label Switched Path.

TE LSP ingress: Head-end/source node of the TE LSP.

TE LSP egress: Tail-end/destination node of the TE LSP.

2.3. Terminology

The reader is assumed to be familiar with the terminology in [RFC4736] and [RFC4875].

3. Overview

[RFC4736] defines RSVP signaling extensions for re-optimizing loosely routed P2P TE LSPs as follows:

o   A mid-point LSR that expands loose next-hop(s) sends a solicited or unsolicited PathErr with the Notify error code 25 (as defined in [RFC3209]) with sub-code 6 to indicate "Preferable Path Exists" to the ingress node.

o   An ingress node triggers a path re-evaluation request at all mid-point LSR(s) that expands loose next-hop(s) by setting the "Path Re-evaluation Request" flag (0x20) in SESSION_ATTRIBUTES Object in the Path message.

o   The ingress node upon receiving this PathErr with the Notify error code either solicited or unsolicited initiates re-optimization of the LSP using the MBB method with a different LSP-ID.

The following sections discuss the issues that may arise when

applying the mechanisms defined in [RFC4736] for re-optimizing
loosely routed P2MP-TE LSPs.

3.1. Loosely Routed Inter-domain P2MP-TE LSP Tree

An example of a loosely routed inter-domain P2MP-TE LSP tree is shown
in Figure 1. In this example, the P2MP-TE LSP tree consists of 3 S2L
sub-LSPs, to destinations (i.e. leafs) R10, R11 and R12 from the
ingress node (i.e. source) R1. Nodes R2 and R5 are branch nodes and
nodes ABR3, ABR4, ABR7, ABR8 and ABR9 are area border routers. For
the S2L sub-LSP to destination R10, nodes ABR3, ABR7 and R10 are
defined as loose next-hops. For the S2L sub-LSP to destination R11,
nodes ABR3, ABR8 and R11 are defined as loose next-hops. For the S2L
sub-LSP to destination R12, nodes ABR4, ABR9 and R12 are defined as
loose next-hops.

```
        <--area1--><--area0--><-area2->

                           ABR7---R10
                          /
                         /
                ABR3---R5
               /         \
              /           \
         R1---R2           ABR8---R11
              \
               \
                ABR4---R6
                         \
                          \
                           ABR9---R12
```
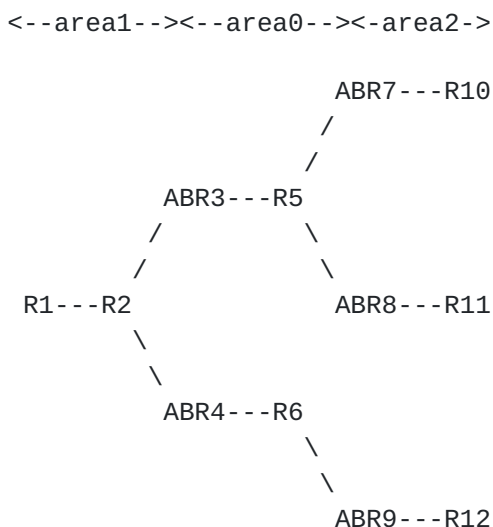
   Figure 1: An Example of Loosely Routed Inter-domain P2MP-TE LSP Tree

3.2. Existing Mechanism For Tree-Based P2MP-TE LSP Re-optimization

Mechanisms defined in [RFC4736] can be easily applied to trigger the
re-optimization of individual or group of S2L sub-LSP(s). However,
to apply these [RFC4736] mechanisms for triggering the
re-optimization of a P2MP-TE LSP tree, an ingress node needs to send
path re-evaluation requests on all (typically 100s of) S2L sub-LSPs
and the mid-point LSR needs to send PathErrs with the Notify error
code for all S2L sub-LSPs. Such mechanisms may lead to the following
issues:

o A mid-point LSR that expands loose next-hop(s) may have to

accumulate the received path re-evaluation request(s) for all S2L
sub-LSPs (e.g. by using a wait timer) and interpret them as a
re-optimization request for the whole P2MP-TE LSP tree.
Otherwise, a mid-point LSR may prematurely notify "Preferable Path
Exists" for one or a sub-set of S2L sub-LSPs.

o Similarly, the ingress node may have to heuristically determine
   when to perform P2MP-TE LSP tree re-optimization and when to
   perform S2L sub-LSP re-optimization. For example, an
   implementation may choose to delay re-optimization long enough to
   allow all PathErr(s) to be received. Such timer-based procedures
   may produce undesired results.

o The ingress node that receives (un)solicited PathErr(s) with the
   Notify error code for individual S2L sub-LSP(s), may prematurely
   start re-optimizing the sub-set of S2L sub-LSPs. However, as
   mentioned in [RFC4875] Section 14.2, such sub-group based re-
   optimization procedure may result in data duplication that can be
   avoided if the entire P2MP-TE LSP tree is re-optimized using the
   Make-Before-Break method with a different LSP-ID, especially if
   the ingress node eventually receives PathErrs with the Notify
   error code for all S2L sub-LSPs of the P2MP-TE LSP tree.

In order to address above mentioned issues and to align
re-optimization of P2MP-TE LSP with P2P LSP [RFC4736], there is a
need for a mechanism to trigger re-optimization of the LSP tree by
re-signaling all S2L sub-LSPs with a different LSP-ID. To meet this
requirement, this document defines RSVP-TE signaling extensions for
the ingress node to trigger the re-evaluation of the P2MP LSP tree on
every hop that has a next-hop defined as a loose or abstract hop for
one or more S2L sub-LSP path, and a mid-point LSR to signal to the
ingress node that a preferable LSP tree exists (compared to the
current path) or that the whole P2MP-TE LSP must be re-optimized
(because of maintenance required on the TE LSP path) (see Section
4.1).

3.3. Existing Mechanism For Sub-Group-Based P2MP-TE LSP Re-optimization

Applying the procedures discussed in RFC4736 in conjunction with the
Sub-Group-Based Re-Optimization procedures ([RFC4875], Section 14.2),
an ingress node MAY trigger path re-evaluation requests for a set of
S2L sub-LSPs in a single Path message using S2L sub-LSP descriptor
list. Similarly, a mid-point LSR may send a PathErr with the Notify
error code 25 and sub-code 6 containing a list of S2L sub-LSPs
transiting through the LSR using an S2L sub-LSP descriptor list to
notify the ingress node. This method can be used for re-optimizing a
sub-group of S2L sub-LSPs within an LSP tree using the same LSP-ID.

This method can alleviate the scale issue associated with sending
RSVP messages for individual S2L sub-LSPs. However, this procedure
can lead to the following issues when used to re-optimize the LSP
tree:

o Path message that is intended to carry the path re-evaluation
   request as defined in [RFC4736] with a full list of S2L sub-LSPs
   in S2L sub-LSPs descriptor list will be decomposed at branching
   LSRs, and only a subset of the S2L sub-LSPs that are routed over
   the same next-hop will be added in the descriptor list of the Path
   message propagated to downstream mid-point LSRs. Consequently,
   when a preferable path exists at such mid-point LSRs, the PathErr
   with the Notify error code can only include the sub-set of S2L
   sub-LSPs traversing the LSR. In this case, at the ingress node
   there is no way to distinguish which mode of re-optimization to
   invoke, i.e. sub-group based re-optimization using the same LSP-ID
   or tree based re-optimization using a different LSP-ID.

o An LSR may semantically fragment a large RSVP message (when a
   combined message may not be large enough to fit all S2L sub-LSPs).
    In this case, the ingress node may receive multiple PathErrs with
   sub-sets of S2L sub-LSPs in each (due to either the combined Path
   message getting fragmented or the combined PathErr message getting
   fragmented) and would require additional logic to determine how to
   re-optimize the LSP tree (for example, waiting for some time to
   aggregate all possible PathErr messages before taking an action).
   When fragmented, RSVP messages may arrive out of order, and the
   receiver has no way of knowing the beginning and end of the S2L
   sub-LSP list.

In order to address the above mentioned issues caused by RSVP message
semantic fragmentation, this document defines new fragment identifier
object for the S2L sub-LSP descriptor list when combining large
number of S2L sub-LSPs in an RSVP message (see Section 4.2).

4. Signaling Extensions For Loosely Routed P2MP-TE LSP Re-optimization

4.1. Tree-Based Re-optimization

To evaluate a P2MP-TE LSP tree on mid-point LSRs that expand loose
next-hop(s), an ingress node MAY send a Path message with "P2MP-TE
Tree Re-evaluation Request (value TBA1)" defined in this document.
The ingress node selects one of the S2L sub-LSPs of the P2MP-TE LSP
tree transiting a mid-point LSR to trigger the re-evaluation request.
 The ingress node MAY send a re-evaluation request to each border LSR
on the path of the LSP tree.

A mid-point LSR that expands loose next-hop(s) for one or more S2L
sub-LSP path(s) does the following upon receiving a Path message with
the "P2MP-TE Tree Re-evaluation Request" flag set:

o   The mid-point LSR MUST check for a preferable P2MP-TE LSP tree by
    re-evaluating all S2L sub-LSP(s) that are expanded paths of the
    loose next-hops of the P2MP-TE LSP.

o   If a preferable P2MP-TE LSP tree is found, the mid-point LSR MUST
    send an RSVP PathErr with the Notify error code 25 defined in
    [RFC3209] and sub-code "Preferable P2MP-TE Tree Exists (value
    TBA2)" defined in this document to the ingress node. The mid-
    point LSR, in turn, SHOULD NOT propagate the "P2MP-TE Tree Re-
    evaluation Request" flag in the subsequent RSVP Path messages sent
    downstream for the re-evaluated P2MP-TE LSP.

o   If no preferable tree for P2MP-TE LSP can be found, the mid-point
    LSR that expands loose next-hop(s) for one or more S2L sub-LSP
    path(s) MUST propagate the request downstream by setting the
    "P2MP-TE Tree Re-evaluation Request" flag in the LSP_ATTRIBUTES
    Object of the RSVP Path message.

A mid-point LSR MAY send an unsolicited PathErr with the Notify error
code and sub-code "Preferable P2MP-TE Tree Exists" to the ingress
node to notify of a preferred P2MP-TE LSP tree when it determines it
exists. In this case, the mid-point LSR that expands loose next-
hop(s) for one or more S2L sub-LSP path(s) selects one of the S2L
sub-LSP(s) of the P2MP-TE LSP tree to send this PathErr message to
the ingress node. The mid-point LSR SHOULD consider how frequently
it chooses to send such a PathErr - considering both that a PathErr
may be lost on its transit to the ingress node and that the ingress
node may choose not to re-optimize the LSP when such a PathErr is
received.

The sending of an RSVP PathErr with the Notify error code and
"Preferable P2MP-TE Tree Exists" sub-code to the ingress node
notifies the ingress node of the existence of a preferable P2MP-TE
LSP tree and upon receiving this PathErr, the ingress node SHOULD
trigger re-optimization of the LSP using the MBB method with a
different LSP-ID.

4.2. Sub-Group-Based Re-optimization Using Fragment Identifier

It might be preferable, as per [RFC4875], to re-optimize the entire
P2MP-TE LSP by re-signaling all of its S2L sub-LSP(s) (Section 14.1,
"Make-before-Break") or to re-optimize individual or group of S2L
sub-LSP(s) i.e. individual or group of destination(s) (Section 14.2

"Sub-Group-Based Re-Optimization" in [RFC4875]), both using the same
LSP-ID. For loosely routed S2L sub-LSPs, this can be achieved by
using the procedures defined in [RFC4736] to re-optimize one or more
S2L sub-LSP(s) of the P2MP-TE LSP.

An ingress node may trigger path re-evaluation requests using the
procedures defined in [RFC4736] for a set of S2L sub-LSPs by
combining multiple Path messages using an S2L sub-LSP descriptor list
[RFC4875]. An S2L sub-LSP descriptor list is created using a series
of S2L_SUB_LSP Objects as defined in [RFC4875]. Similarly, a mid-
point LSR may send a PathErr with the Notify error code (value 25)
and "Preferable Path Exists" (sub-code 6) containing a list of S2L
sub-LSPs transiting through the LSR using an S2L sub-LSP descriptor
list to notify the ingress node of preferable paths available.

As per [RFC4875] (Section 5.2.3, "Transit Fragmentation of Path State
Information"), when a Path message is not large enough to fit all S2L
sub-LSPs in the descriptor list, an LSR may semantically fragment the
message. In this case, the LSR MUST add the S2L_SUB_LSP_FRAG Object
defined in this document in the S2L sub-LSP descriptor to be able to
rebuild the list from the received fragments that may arrive out of
order.

The S2L_SUB_LSP_FRAG Object defined in this document is optional.
However, a node MUST add the S2L_SUB_LSP_FRAG Object for each
fragment in S2L sub-LSP descriptor when the RSVP message needs to be
fragmented.

A mid-point LSR SHOULD wait to accumulate all S2L sub-LSPs before
attempting to re-evaluate preferable path when a Path message for
"Path Re-evaluation Request" is received with S2L_SUB_LSP_FRAG
Object. If a mid-point LSR does not receive all fragments of the
Path message (for example, when fragments are lost) within a
configurable time interval, it SHOULD trigger re-evaluation of all
S2L sub-LSPs of the P2MP-TE LSP transiting on the node. A mid-point
LSR MUST receive at least one fragment of the Path message to trigger
this behaviour.

An ingress node SHOULD wait to accumulate all S2L sub-LSPs before
attempting to trigger re-optimization when a PathErr with Notify
error code and "Preferable Path Exists" sub-code is received with a
S2L_SUB_LSP_FRAG Object. If an ingress node does not receive all
fragments of the PathErr message (for example, when fragments are
lost) within a configurable time interval, it SHOULD trigger re-
optimization of all S2L sub-LSPs of the P2MP-TE LSP transiting on the
mid-point node that had sent the PathErr message. An ingress node
MUST receive at least one fragment of the PathErr message to trigger
this behaviour.

The S2L_SUB_LSP_FRAG Object defined in this document has a wider
applicability in addition to the P2MP-TE LSP re-optimization. It can
also be used (in Path and Resv messages) to setup a new P2MP-TE LSP,
send other PathErr messages as well as Path Tear and Resv Tear
messages for a set of S2L sub-LSPs. This is outside the scope of
this document.

5. Message and Object Definitions

5.1. P2MP-TE Tree Re-evaluation Request Flag

In order to trigger a tree re-evaluation request, a new flag is
defined in Attributes Flags TLV of the LSP_ATTRIBUTES Object
[RFC5420] as follows:

    Bit Number (TBA1, to be assigned by IANA): P2MP-TE Tree
        Re-evaluation Request flag

The "P2MP-TE Tree Re-evaluation Request" flag is meaningful in a Path
message of a P2MP-TE S2L sub-LSP and is inserted by the ingress node
using the message format defined in [RFC6510].

5.2. Preferable P2MP-TE Tree Exists Path Error Sub-code

In order to indicate to an ingress node that a preferable P2MP-TE LSP
tree exists, the following new sub-code for PathErr with Notify error
code 25 [RFC3209] is defined:

    Sub-code (TBA2, to be assigned by IANA): Preferable P2MP-TE Tree
        Exists sub-code

When a preferable path for P2MP-TE LSP tree exists, the mid-point LSR
sends a solicited or unsolicited "Preferable P2MP-TE Tree Exists"
sub-code with PathErr with Notify error code 25 to the ingress node
of the P2MP-TE LSP.

5.3. Fragment Identifier For S2L sub-LSP Descriptor

The S2L_SUB_LSP Object [RFC4875] identifies a particular S2L sub-LSP
belonging to the P2MP-TE LSP. An S2L sub-LSP descriptor list is
created using a series of S2L_SUB_LSP Objects as defined in
[RFC4875]. The RSVP message may need to be semantically fragmented
[RFC4875] due to large number of S2L sub-LSPs added in the descriptor
list, and such fragments may be received our of order. To be able to
rebuild the fragmented S2L sub-LSP descriptor list correctly, the

following Object is defined to identify the fragments.

S2L_SUB_LSP_FRAG: Class-Num TBA3 by IANA

```
+---------------+--------------+--------------+--------------+
|         Length (8 bytes)     | Class-Num TBA3|   C-Type 1   |
+---------------+--------------+--------------+--------------+
|           Fragment ID        | Fragments Tot | Fragment Num |
+---------------+--------------+--------------+--------------+
```

Fragment ID: 16-bit integer in the range of 1 to 65535.

   This value is incremented for each new RSVP message that needs to
   be semantically fragmented. The fragment ID is reset to 1 when it
   reaches the maximum value of 65535. The scope of the fragment ID
   is limited to the RSVP message type (e.g. Path) carrying the
   fragment. In other words, fragment IDs do not have any
   correlation between different RSVP message types (e.g. Path and
   PathErr). The receiver does not check to ensure if the
   consecutive new RSVP messages (e.g. Path messages) are received
   with fragment IDs incremented by 1.

Fragments Total: 8-bit integer in the range of 1 to 255.

  This value indicates the number of fragments sent for the given
  RSVP message. This value MUST be the same in all fragmented RSVP
  messages with a common Fragment ID.

Fragment Number: 8-bit integer in the range of 1 to 255.

   This value indicates the position of this fragment in the given
   RSVP message.

The format of an S2L sub-LSP descriptor message is as follows:

```
   <S2L sub-LSP descriptor> ::=
                 [ <S2L_SUB_LSP_FRAG> ]
                   <S2L_SUB_LSP>
                 [ <P2MP SECONDARY_EXPLICIT_ROUTE> ]
```


The S2L_SUB_LSP_FRAG Object is added before adding the S2L_SUB_LSP
Object in the semantically fragmented RSVP message.

6. Compatibility

The LSP_ATTRIBUTES Object has been defined in [RFC5420] and its
message formats in [RFC6510] with class numbers in the form 11bbbbbb,
which ensures compatibility with non-supporting nodes. Per
[RFC2205], nodes not supporting this extension will ignore the new
flag defined for this Object in this document but forward it without
modification.

The S2L_SUB_LSP_FRAG Object has been defined with class numbers in
the form 11bbbbbb, which ensures compatibility with non-supporting
nodes. Per [RFC2205], nodes not supporting this Object will ignore
the Object but forward it without modification.

7. IANA Considerations

IANA is requested to administer assignment of new values for
namespace defined in this document and summarized in this section.

7.1. P2MP-TE Tree Re-evaluation Request Flag

IANA maintains a name space for RSVP-TE TE parameters "Resource
Reservation Protocol-Traffic Engineering (RSVP-TE) Parameters" (see
http://www.iana.org/assignments/rsvp-te-parameters). From the
registries in this name space "Attribute Flags", allocation of new
flag is requested (Section 5.1).

The following new flag is defined for the Attributes Flags TLV in the
LSP_ATTRIBUTES Object [RFC5420]. The numeric value is to be assigned
by IANA.

o P2MP-TE Tree Re-evaluation Request Flag:

```
+--------+--------------+---------+---------+---------+-----------+
| Bit No | Attribute    | Carried | Carried | Carried | Reference |
|        | Flag Name    | in Path | in Resv | in RRO  |           |
|        |              |         |         | or ERO  |           |
+--------+--------------+---------+---------+---------+-----------+
| TBA1 by| P2MP-TE Tree | Yes     | No      | No      | This      |
| IANA   | Re-evaluation|         |         |         | document  |
+--------+--------------+---------+---------+---------+-----------+
```

7.2. Preferable P2MP-TE Tree Exists Path Error Sub-code

IANA maintains a name space for RSVP protocol parameters "Resource
Reservation Protocol (RSVP) Parameters" (see
http://www.iana.org/assignments/rsvp-parameters). From the
sub-registry "Sub-Codes - 25 Notify Error" in registry "Error Codes

   and Globally-Defined Error Value Sub-Codes", allocation of a new
   error code is requested (Section 5.2).

   As defined in [RFC3209], the Error Code 25 in the ERROR SPEC Object
   corresponds to PathErr with Notify error. This document adds a new
   sub-code for this PathErr as follows:

   o Preferable P2MP-TE Tree Exists sub-code:

```
+----------+--------------------+---------+---------+-----------+
| Sub-code | Sub-code           | PathErr | PathErr | Reference |
| value    | Description        | Code    | Name    |           |
+----------+--------------------+---------+---------+-----------+
| TBA2 by  | Preferable P2MP-TE | 25      | Notify  | This      |
| IANA     | Tree Exists        |         | Error   | document  |
+----------+--------------------+---------+---------+-----------+
```

7.3. Fragment Identifier For S2L sub-LSP Descriptor

   IANA maintains a name space for RSVP protocol parameters "Resource
   Reservation Protocol (RSVP) Parameters" (see
   http://www.iana.org/assignments/rsvp-parameters). From the registry
   "Class Names, Class Numbers, and Class Types", allocation of new
   Class-Num is requested (Section 5.3).

   o S2L_SUB_LSP_FRAG Object:

```
+-----------------+---------------------------+-----------------+
| Class-Num value | Description               | Reference       |
+-----------------+---------------------------+-----------------+
| TBA3 by IANA    | S2L_SUB_LSP_FRAG          | This document    |
+-----------------+---------------------------+-----------------+
```

8. Security Considerations

   This document defines RSVP-TE signaling extensions to allow an
   ingress node of a P2MP-TE LSP to request the re-evaluation of the LSP
   tree downstream of a node, and for a mid-point LSR to notify the
   ingress node of the existence of a preferable tree by sending a
   PathErr. As per [RFC4736], in the case of a P2MP-TE LSP S2L sub-LSP
   spanning multiple domains, it may be desirable for a mid-point LSR to
   modify the RSVP PathErr message defined in this document to preserve
   confidentiality across domains.

   This document also defines fragment identifier for the S2L sub-LSP
   descriptor when combining large number of S2L sub-LSPs in an RSVP

message and the message needs to be semantically fragmented. The
introduction of the fragment identifier, by itself, introduces no
additional information to signaling. For a general discussion on
MPLS and GMPLS related security issues, see the MPLS/GMPLS security
framework [RFC5920].

9. References

9.1. Normative References

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           and G. Swallow, "RSVP-TE: Extensions to RSVP for LSP
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