       RSVP-TE Signaling Extension for LSP Handover from the Management Plane
            to the Control Plane in a GMPLS-Enabled Transport Network

Abstract

   In a transport network scenario, Data Plane connections controlled by
   either a Generalized Multiprotocol Label Switching (GMPLS) Control
   Plane (Soft Permanent Connections - SPC) or a Management System
   (Permanent Connections - PC) may independently coexist. The ability
   of transforming an existing PC into an SPC and vice versa -- without
   actually affecting Data Plane traffic being carried over it -- is a
   requirement. The requirements for the conversion between permanent
   connections and switched connections in a GMPLS Network are defined
   in RFC 5493.

   This memo describes an extension to GMPLS Resource Reservation
   Protocol - Traffic Engineering (RSVP-TE) signaling that enables the
   transfer of connection ownership between the Management and the
   Control Planes. Such a transfer is referred to as a Handover. This
   document defines all Handover-related procedures. This includes the
   handling of failure conditions and subsequent reversion to original
   state. A basic premise of the extension is that the Handover
   procedures must never impact an already established Data Plane
   connection.

Status of This Memo

   This is an Internet Standards Track document.

   This document is a product of the Internet Engineering Task Force
   (IETF). It represents the consensus of the IETF community. It has
   received public review and has been approved for publication by the
   Internet Engineering Steering Group (IESG). Further information on
   Internet Standards is available in Section 2 of RFC 5741.

   Information about the current status of this document, any errata,
   and how to provide feedback on it may be obtained at
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1. Introduction

   In a typical traditional transport network scenario, Data Plane (DP)
   connections between two endpoints are controlled by means of a
   Network Management System (NMS) operating within the Management Plane
   (MP). NMS/MP is the owner of such transport connections, being
   responsible for their setup, teardown, and maintenance.

   The adoption of a Generalized MPLS (GMPLS) [RFC3945] Control Plane
   (CP) in a network that is already in service -- controlled by the NMS
   at the MP level -- introduces the need for a procedure able to
   coordinate a controlled Handover of a Data Plane connection from the
   MP to the CP.

   In addition, the control Handover in the opposite direction, from CP
   to MP should be possible as well. The procedures described in this
   memo can be applied to a Label Switched Path (LSP) in any DP
   switching technology and any network architecture.

   This memo describes an extension to GMPLS Resource reSerVation
   Protocol - Traffic Engineering (RSVP-TE) [RFC3471] [RFC3473]
   signaling that enables the Handover of connection ownership between
   the Management and the Control Planes. All Handover-related
   procedures are defined below. This includes the handling of failure
   conditions and subsequent reversion to original state. A basic
   premise of the extension is that the Handover procedures must never
   impact the exchange of user data on LSPs that are already established
   in the DP.

1.1. Dedication

   We would like to dedicate this work to our friend and colleague Dino
   Bramanti, who passed away at the early age of 38. Dino has been
   involved in this work since its beginning.

2. Terminology

   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].

3. Motivation

   The main motivation behind this work is the definition of a simple
   and very low-impact procedure that satisfies the requirements defined
   in [RFC5493]. Such a procedure is aimed at giving the transport
   network operators the chance to hand over the ownership of existing
   LSPs provisioned by NMS from the MP to the CP without disrupting user

traffic flowing on them. Handover from the MP to the CP (i.e., when
existing DP connection ownership and control is passed from the MP to
the CP) has been defined as a mandatory requirement, while the
opposite operation, CP-to-MP Handover, has been considered as a nice-
to-have feature that can be seen as an emergency procedure to disable
the CP and take manual control of the LSP. For more details on
requirements and motivations, please refer to [RFC5493].

4. Procedures

   The modification defined in this document refers only to the
   ADMIN_STATUS Object, that is, the message flow is left unmodified for
   both LSP setup and deletion. Moreover, a new Error Value is defined
   to identify the failure of a Handover procedure.

   The following paragraphs give detailed description of the "MP-to-CP
   Handover" and "CP-to-MP Handover" procedures, based on the use of a
   newly defined bit called "H bit".

   Just as when setting up an LSP using the CP [RFC3473], the Path
   message may contain full information about the explicit route
   including the links and labels traversed by the LSP. This
   information is encoded in the Explicit Route Object (ERO), and must
   be supplied by the MP using details recorded when the LSP was
   provisioned, or collected by the MP by inspecting the nodes along the
   path.

   Alternatively, and also just as when setting up an LSP using the CP
   [RFC3473], the ERO may include less information such that the details
   of the next hop have to be determined by each node along the LSP as
   it processes the Path message. This approach may be desirable when
   the full information is not available to the MP or cannot be passed
   to the head-end node when initiating the Handover from the MP to the
   CP.

   This section (Section 4) describes the general procedures and
   protocol extensions for MP-to-CP Handover, and it uses the case of a
   fully detailed ERO to describe the mechanism. Section 5 describes
   how each node behaves in the case of a limited amount of information
   in the ERO.

   Note that when Handover is being performed for a bidirectional LSP
   and the ERO contains full information including labels, the ERO
   SHOULD include both upstream and downstream labels. Per Section
   5.1.1 of [RFC3473], the labels are indicated on an output basis; this
   means that the labels are used by the upstream node to create the
   LABEL_SET Object and, for bidirectional LSPs, the UPSTREAM_LABEL
   Object used in the outgoing Path message.

4.1. MP-to-CP Handover: LSP Ownership Transfer from Management Plane to
      Control Plane

   The MP-to-CP Handover procedure MUST create an RSVP-TE session along
   the path of the LSP to be moved from the MP to the CP, associating it
   with the existing cross-connected resources owned by the MP (e.g.,
   lambdas, time slots, or reserved bandwidth) and at the same time
   transferring their ownership to the CP.

   The operator instructs the ingress node to hand over control of the
   LSP from the MP to the CP. In this Handover mode, it supplies the
   exact path of the LSP including any resource reservation and label
   information.

   The ingress MUST check that no corresponding Path state exists and
   that corresponding Data Plane state does exist. If there is an
   error, this MUST be reported to the operator and further protocol
   action MUST NOT be taken.

   The ingress signals the LSP using a Path message with the H bit and R
   bit set in the ADMIN_STATUS Object. In this mode of Handover, the
   Path message also carries an ERO that includes Label subobjects
   indicating the labels used by the LSP at each hop. The ingress MUST
   start the Expiration timer (see Section 4.2.1.2 for expiration of
   this timer). Such a timer SHOULD be configurable per LSP and have a
   default value of 30 seconds.

   Each Label Switching Router (LSR) that receives a Path message with
   the H bit set checks to see whether there is any matching Path state.

   o If matching Path state is found with the H bit set, this is a Path
      refresh and should be treated accordingly [RFC3473].

   o If matching Path state is found with the H bit clear, this is an
      error and MUST be treated according to the error case description
      in Section 4.2.1.1.

   o If no Path state is found, the LSR goes on to check whether there
      is any matching Data Plane state.

   o If no matching Data Plane state is found (including only partially
      matching Data Plane state), this is an error or a race condition.
      It MUST be handled according to the description in Section
      4.2.1.1.

o If matching Data Plane state is found, the LSR MUST save the Path
   state (including the set H bit), and it MUST forward the Path
   message to the egress. The LSR MUST retain any MP state
   associated with the LSP at this point.

An egress LSR MUST act as any other LSR, except that there is no
downstream node to which to forward the Path message. If all checks
are passed, the egress MUST respond with a Resv with the H bit set.

A transit LSR MUST process each Resv according to the normal rules of
[RFC3473].

When an ingress LSR receives a Resv message carrying the H bit set,
it checks the Expiration timer.

o If the timer is not running, the Resv is treated as a refresh and
   no special action is taken [RFC3473].

o If the timer is running, the ingress MUST cancel the timer and
   SHOULD notify the operator that the first stage of Handover is
   complete. The ingress MUST send a Path message that is no
   different from the previous message except that the H bit MUST be
   clear.

The Path message with the H bit clear will travel the length of the
LSP and will result in the return of a Resv with the H bit clear
according to normal processing [RFC3473]. As a result, the H bit
will be cleared in the stored Path state at each transit LSR and at
the egress LSR. Each LSR SHOULD release any associated MP state
associated with the LSP when it receives the Path message with H bit
clear, but MAY retain the information according to local policy for
use in future MP processing.

When the ingress receives a Resv with the H bit clear, the Handover
is completed. The ingress SHOULD notify the operator that the
Handover is correctly completed.

4.2. MP-to-CP Handover Procedure Failure Handling

In the case of MP-to-CP Handover, two different failure scenarios can
happen: Path Failure and Resv Failure. Moreover, each failure can be
due to two different causes: DP Failure or Communication Failure. In
any case, the LSP ownership MUST be immediately rolled back to the
one previous to the Handover procedure. A section for each
combination will be analyzed in the following.

4.2.1. MP-to-CP Handover Failure - Path Failure

4.2.1.1. MP-to-CP Handover Failure - Path Message and Data Plane
          Failure

   In the following paragraph, we will analyze the case where the
   Handover procedure fails during the Path message processing.

```
   |         Path      |                 |                 |
   |--------------->|        Path      |                 |
   |                   |---------------X|                 |
   |                   |      PathErr    |                 |
   |      PathErr      |<--------------|                 |
   |<--------------|                   |                 |
   |                   |                 |                 |
   Ingress LER       LSR A           LSR B         Egress LER
```
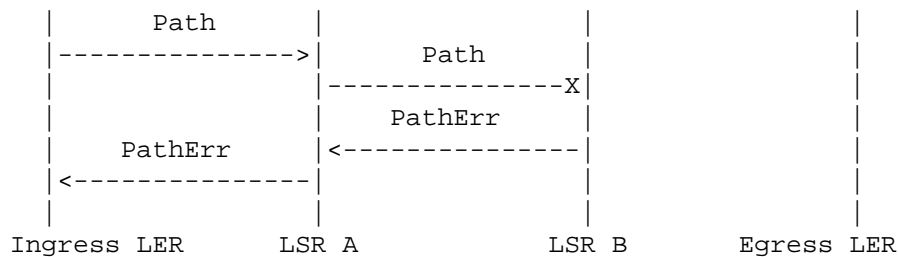
              Figure 1: MP2CP - Path Msg and DP Failure

   If an error occurs, the node detecting the error MUST respond to the
   received Path message with a PathErr message, and MUST abort the
   Handover procedure. The PathErr message SHOULD have the
   Path_State_Removed flag set [RFC3473], but implementations MAY retain
   their local state and wait for Path state timeout as per normal RSVP
   processing.

   Nodes receiving a PathErr message MUST follow standard PathErr
   message processing and the associated DP resources MUST NOT be
   impacted. If the local CP state indicates that a Handover is in
   progress (based on the H bit in the Path message), the LSR MUST
   revert the LSP ownership to the MP.

4.2.1.2. MP-to-CP Handover Failure - Path Message and Communication
          Failure

   Other possible scenarios are shown in the following figures and are
   based on the inability to reach a node along the path of the LSP.

   The below scenario postulates the use of a reliable message delivery
   based on the mechanism defined in [RFC2961].

```
      |        Path       |                   |                   |
      |---------------->|        Path       |                   |
      |                   |---------------X|                   |
      |                   |---------------X|                   |
      |                   |       ...         |                   |
      |                   |---------------X|                   |
      |                   |                   |                   |
   Ingress LER       LSR A               LSR B          Egress LER
```
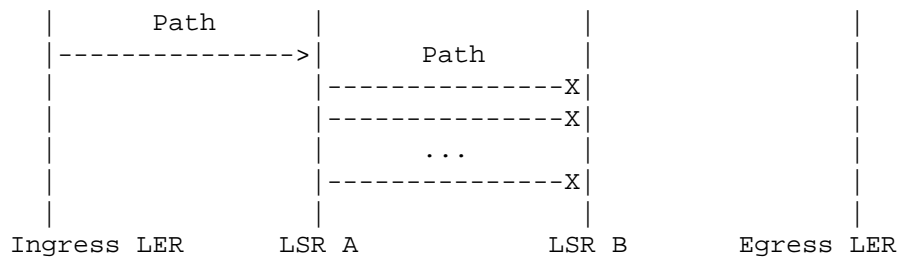
                  Figure 2: MP2CP - Path Msg and Communication Failure
                              (Reliable Delivery)

   The Path message sent from LSR A towards LSR B is lost or does not
   reach the destination for any reason. As a reliable delivery
   mechanism is implemented, LSR A retransmits the Path message for a
   configurable number of times, and if no ack is received, the Handover
   procedure will be aborted (via the Expiration timer).

   In the next scenario RSVP-TE messages are sent without reliable
   message delivery, that is, no [RFC2961] MessageID procedure is used.

```
      |        Path       |                   |                   |
      |---------------->|        Path       |                   |
      |                   |----------X     |                   |
      |                   |                   |                   |
   TIMER EXPIRES         |                   |                   |
      |     Path Tear     |    Path Tear     |    Path Tear     |
      |---------------->|---------------->|---------------->|
      |                   |                   |                   |
   Ingress LER       LSR A               LSR B          Egress LER
```
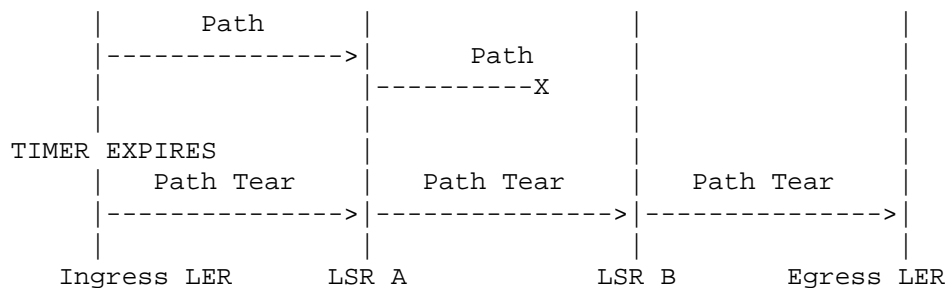
                  Figure 3: MP2CP - Path Msg and Communication Failure
                            (No Reliable Delivery)

   If the Resv message is not received before the expiration of the
   Expiration timer, the Handover procedure is aborted as described in
   Section 4.2.1.1. Please note that any node that has forwarded a Path
   (LSR A), i.e., has installed local path state, will send a PathTear
   when that state is removed (according to [RFC2205]).

4.2.2. MP-to-CP Handover Failure - Resv Error

4.2.2.1. MP-to-CP Handover Failure - Resv Error and Data Plane Failure

   In the case of a failure occurrence during the Resv message
   processing (in case there has been any change in the Data Plane
   during the signaling), the node MUST send a PathErr message [RFC2205]
   in the upstream direction. The PathErr message is constructed and

processed as defined above in Section 4.2.1.1. The failure detection
node MUST also send a PathTear message downstream. The PathTear
message is constructed and processed as defined above in
Section 4.2.1.1.

```
       |       Path      |       Path      |       Path      |
       |--------------->|--------------->|--------------->|
       |                 |                 |      Resv       |
       |                 |                 |<--------------|
       |                 |       Resv      |                 |
       |                 |X--------------|                 |
       |     PathErr     |    PathTear     |    PathTear     |
       |<--------------|--------------->|--------------->|
       |                 |                 |                 |
    Ingress LER       LSR A            LSR B       Egress LER
```
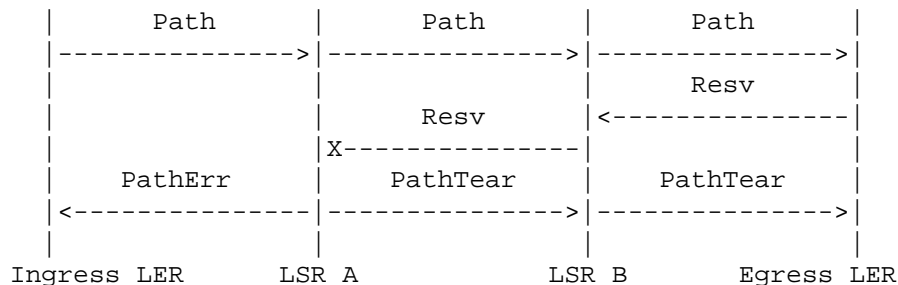
                Figure 4: MP2CP - Resv Error and DP Failure

   In the case shown in Figure 4, the failure occurs in LSR A. A
   PathTear message is sent towards B and a PathErr message (with
   ErrorCode set to "Handover Procedure Failure") is sent in the
   upstream direction. The PathErr and PathTear messages remove the
   Path state established by the Path messages along the nodes of the
   LSP and abort the Handover procedure.

   Please note that the failure occurred after the Handover procedure
   was successfully completed in LSR B, but Handover state will still be
   maintained locally as, per Section 4.1, a Path message with the H bit
   clear will have not yet been sent or received. A node that receives
   a PathTear when it has Path state with the H bit set MUST remove Path
   state, but MUST NOT change Data Plane state. It MUST return LSP
   ownership to the MP.

4.2.2.2. MP-to-CP Handover Failure - Resv Error and Communication
          Failure

   When a Resv message cannot reach one or more of the upstream nodes,
   the procedure is quite similar to the one previously seen about the
   Path message. Even in this case, it is possible to distinguish two
   different scenarios.

   In the first scenario we consider the utilization of a reliable
   message delivery based on the mechanism defined in [RFC2961]. After
   a correct forwarding of the Path message along the nodes of the LSP,
   the Egress LSR sends a Resv message in the opposite direction. It
   might happen that the Resv message does not reach the ingress Label
   Edge Router (LER) or an LSR, say LSR A. LSR B MUST send a Resv
   message again for a configurable number of times and then, if the
   delivery does not succeed, the adoption procedure will be aborted
   (via the Expiration timer).

```
   |        Path        |        Path        |        Path        |
   |--------------->|--------------->|--------------->|
   |                |                |        Resv        |
   |                |        Resv        |<---------------|
   |                |        X---------|                |
   |                |        X---------|                |
   |                |        ...        |                |
   |                |        X---------|                |
   |                |                |                |
   Ingress
        LSR A            LSR B      Egress LER
```
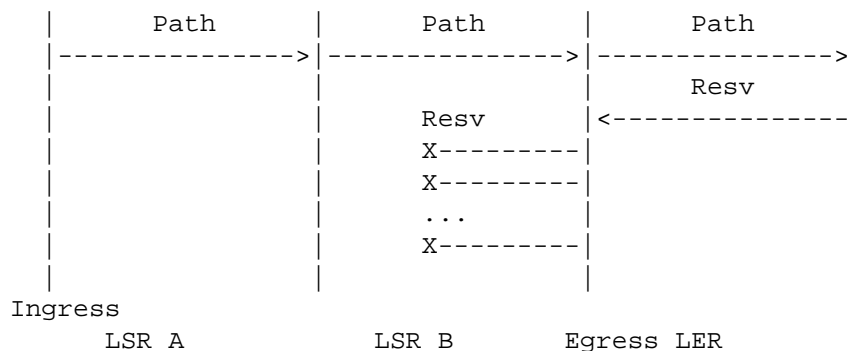
            Figure 5: MP2CP - Resv Error and Communication Failure
                            (Reliable Delivery)

   Considering that the Resv message did not manage to reach LSR A, it
   is highly probable that the PathErr would fail too. Due to this
   fact, the Expiration timer is used on the ingress LER after sending
   the path and on LSR A after forwarding it. When the timer expires,
   if no Resv or PathErr message is received, the Handover procedure is
   aborted as described in Section 4.2.1.1 and the LSP ownership is
   returned to the Management Plane.

   Figure 6, on the other hand, shows the scenario in which no reliable
   delivery mechanism is implemented.

```
          |      Path      |      Path      |      Path      |
          |--------------->|--------------->|--------------->|
          |                |                |      Resv      |
          |                |                |<---------------|
          |                |      Resv      |                |
          |                |      X---------|                |
       TIMER EXPIRES       |                |                |
          |    Path Tear   |    Path Tear   |    Path Tear   |
          |--------------->|--------------->|--------------->|
          |                |                |                |
       Ingress LER     LSR A            LSR B       Egress LER
```
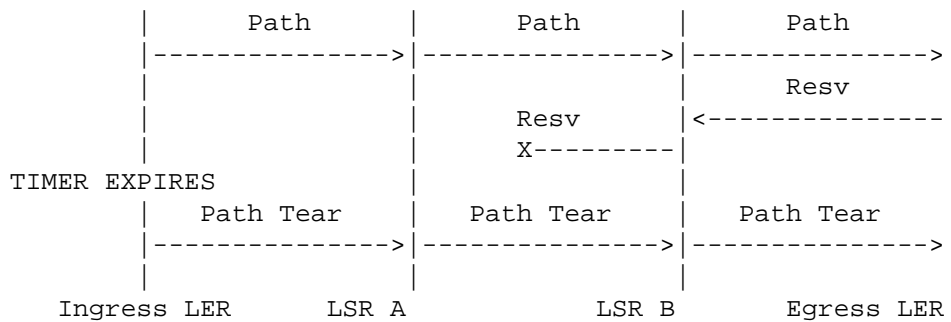
            Figure 6: MP2CP - Resv Error and Communication Failure
                          (No Reliable Delivery)

   If no Resv message is received before the Expiration timer expires,
   the ingress LER follows the same procedure defined in Section 4.1.

4.2.2.3. MP-to-CP Handover Failure - Node Graceful Restart

   If node restart and graceful restart are enabled, then one of the
   following scenarios will happen.

   Case I - Finite Restart Time

   In this case, the Restart Time (see [RFC3473]) is finite, i.e., not a
   value of 0xffffffff. In the sequence diagram below, assume LSR A
   restarts. If the ingress LER does not receive the Resv message in
   time, it MUST abort the Handover process by generating a PathTear
   message downstream. Also, if LSR A does not complete the restart
   process within the restart time interval, then LSR B MUST start
   tearing down all LSPs between LSR A and LSR B and this includes the
   LSP that is being used to carry out the Handover of MP resources to
   the CP. LSP B MUST generate a PathTear message downstream and a
   PathErr message upstream. Both LSR B and the egress LER MUST NOT
   release the DP resources because, in both nodes, the H bit is set in
   the local Path state.

```
 |       Path       |       Path       |       Path       |
 |---------------->|---------------->|---------------->|
 |                 |                 |       Resv       |
 |                 |                 |<----------------|
 |                 |       Resv       |                 |
 |             X    X---------|       |                 |
 |   PathTear       |                 |                 |
 |-------X          Restart Timer    |                 |
 |                      Expires       |                 |
 |                 PathErr  |   PathTear       |
 |                      X--------|---------------->|
 |                 |                 |                 |
 |             X    |                 |                 |
 |                 |                 |                 |
Ingress LER     LSR A           LSR B        Egress LER
```

               Figure 7: MP2CP - Node Graceful Restart - Case I
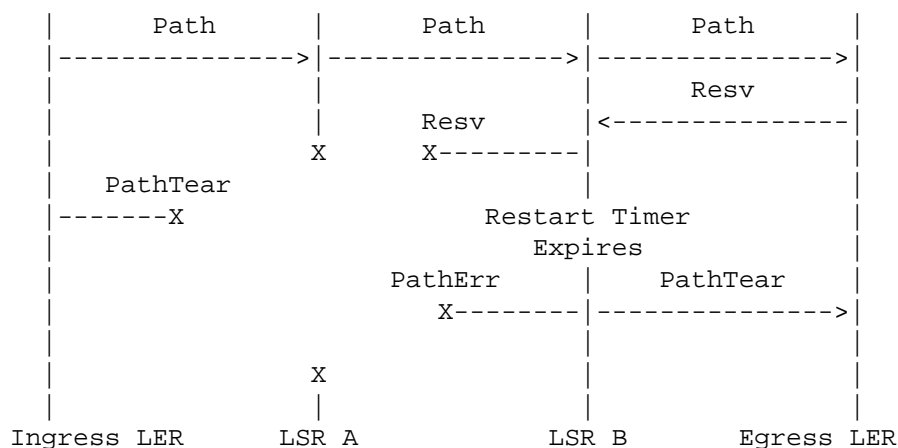
   Case II - Infinite Restart Time

   In this case, the Restart Time (see [RFC3473]) indicates that the
   restart of the sender's Control Plane may occur over an indeterminate
   interval, i.e., is 0xffffffff. The sequence is quite similar to the
   previous one. In this sequence, the restart timer will not expire in
   LSR B since it is run infinitely. Instead, after LSR A restarts, LSR
   B MUST start the recovery timer. The recovery timer will expire
   since there will be no Path message with the RECOVERY LABEL received
   from LSR A given the ingress node had already removed the local Path
   state after it aborts the Handover process. Thus, LSR B MUST tear
   down the specific LSP that is being used to convert the MP resources
   to CP by generating a PathTear message downstream and PathErr message
   upstream. Similarly to the previous case, both LSR B and the egress
   LER MUST NOT release the DP resources because the H bit is set in the
   local Path state.

```
|       Path        |       Path        |       Path        |
|--------------->|--------------->|--------------->|
|                   |                   |       Resv        |
|                   |                   |<---------------|
|                   |       Resv        |                   |
|                   X       X---------|                   |
|     PathTear      |                   |                   |
|-------X           |                   |                   |
|                   |                   |                   |
|                   X                   |                   |
|                   |                   |                   |
|                   |      Recovery Timer                   |
|                   |         Expires   |                   |
|      PathErr      |      PathErr      |     PathTear      |
|<---------------|<---------------|--------------->|
|                   |                   |                   |
Ingress LER      LSR A            LSR B        Egress LER
```
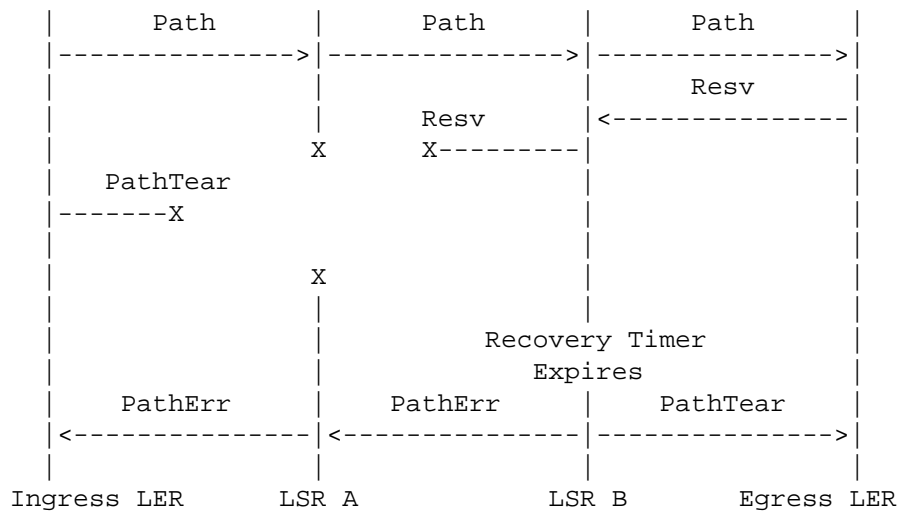
            Figure 8: MP2CP - Node Graceful Restart - Case II

   Case III

   In this case, the ingress LER does not abort the Handover process.
   When LSR A restarts, the ingress LER detects the restart and MUST
   re-generate the Path message with the H bit set in order to restart
   the Handover.

   When LSR B receives the Path message, it sees the H-bit set on the
   message and also sees that it has the H-bit set in its own state and
   that it has sent the Resv. But it is also aware that LSR A has
   restarted and could have sent a Path message with a RECOVERY LABEL
   object. LSR B may attempt to resume the Handover process or may
   abort the Handover. This choice is made according to local policy.

   If resuming the Handover, LSR B MUST treat the received Path message
   as a retransmission, and MUST retransmit its Resv. If aborting
   Handover, LSR B MUST return a PathErr and MUST send a PathTear
   downstream. In both cases, LSR B MUST NOT modify the DP state.

```
|       Path       |       Path       |       Path       |
|--------------->|--------------->|--------------->|
|                |                |       Resv       |
|                |                |<---------------|
|                |       Resv       |                |
|              X       X---------|                |
|                |                |                |
|              X                 |                |
|                |                |                |
|       Path       |       Path       |                |
|--------------->|--------------->|                |
|     PathErr      |     PathErr      |     PathTear     |
|<---------------|<---------------|--------------->|
|                |                |                |
Ingress LER       LSR A            LSR B       Egress LER
```
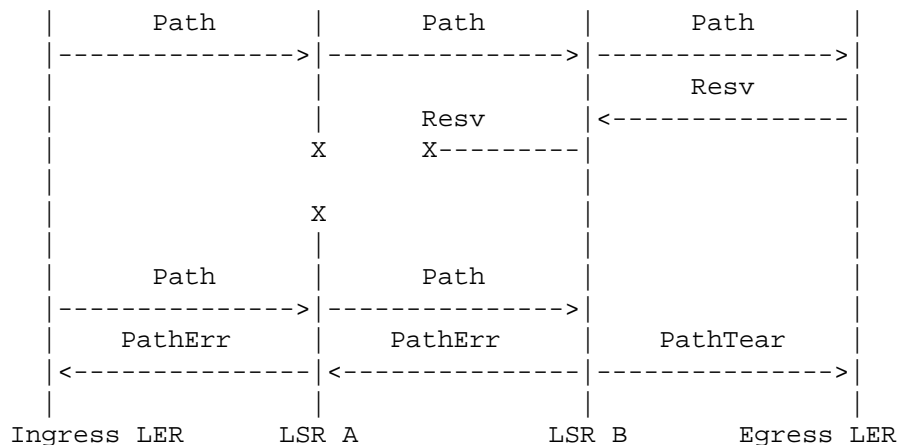
               Figure 9: MP2CP - Node Graceful Restart - Case III

4.3. CP-to-MP Handover: LSP Ownership Transfer from Control Plane to
      Management Plane

   Let's now consider the case of LSP ownership transfer from Control
   Plane to Management Plane. Also in this section, we will analyze the
   Handover procedure success and failure.

   The scenario is still a DP connection between two nodes acting as
   ingress and egress for a LSP, but in this case, the CP has the
   ownership and control of the LSP. The CP-to-MP Handover procedure
   MUST delete the existing RSVP-TE session information and MUST NOT
   affect the cross-connected resources, but just move their ownership
   to the MP.

   In other words, after LSP ownership transfer from CP to MP, the LSP
   is no longer under the control of RSVP-TE, which is no more able to
   "see" the LSP itself. The CP-to-MP Handover procedure MUST be a
   standard LSP deletion procedure as described in Section 7.2.1 of
   [RFC3473]. The procedure is initiated at the ingress node of the LSP
   by an MP entity. The ingress node and MP exchange the relevant
   information for this task and then propagate it over CP by means of
   RSVP-TE tear down signaling as described below.

   The ingress node MUST send a Path message in the downstream direction
   with Handover and Reflect bits set in the ADMIN_STATUS Object. No
   action is taken over the DP and transit LSRs must forward such
   message towards the egress node. All of the nodes MUST keep track of
   the procedure storing the H bit in their local Path and Resv states.
   Then, every node waits for the H bit to be received within the
   related Resv message. After the Resv message is received by the
   ingress LER, it MUST send a PathTear message in order to clear the

whole LSP information recorded on the RSVP-TE data structures of the
nodes. Downstream nodes processing a PathTear message that follows a
Path message with the H bit set, MUST NOT remove any associated Data
Plane state. In other words, a normal LSP tear down signaling is
exchanged between nodes traversed by the LSP, but the H bit set in
the Path message indicates that no DP action has to correspond to CP
signaling.

4.4. CP-to-MP Handover Procedure Failure

Failures during CP-to-MP Handover procedure MUST NOT result in the
removal of any associated Data Plane state. To that end, when a Resv
message containing an ADMIN_STATUS Object with the H bit not received
during the period of time described in Section 7.2.2. of [RFC3473]
different processing is required. While the H bit is set in the Path
state, a node MUST NOT send a PathTear when a failure is detected.
Instead, the failure is reported upstream using a PathErr. The only
node that can send a PathTear is the ingress node, and it can only do
this as a step in the procedures specified in this document. This
applies to both MP-to-CP and CP-to-MP Handover. The ingress node MAY
choose to report the failure in the CP-to-MP Handover procedure via
the MP.

The CP-to-MP Handover procedure can also fail due to two causes:
PathTear lost or node down. In the former case, if the LSP is not
under MP control after the Expiration timer elapses, a manual
intervention from the network operator is requested, while in the
latter case, different scenarios may happen:
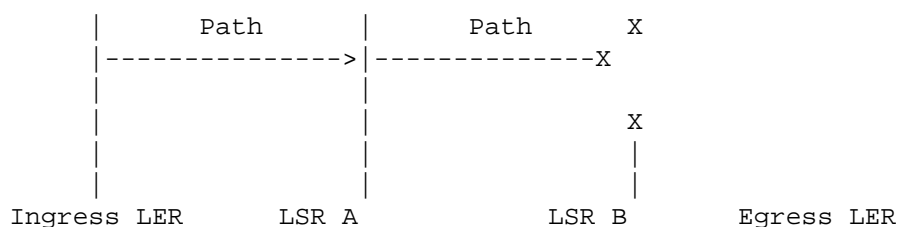
- CASE I - Path message and node down

```
        |      Path     |      Path     X              |
        |-------------->|--------------X               |
        |               |                              |
        |               |              X               |
        |               |              |               |
        |               |              |               |
    Ingress LER      LSR A          LSR B         Egress LER
```

              Figure 10: Case I - Path Message and Node Down

Per [RFC3473], Section 7.2.2, the ingress node should wait for a
configurable amount of time (30 seconds by default) and then send a
PathTear message. In this case, the normal deletion procedure MUST

NOT be followed. When the Expiration timer elapses, a manual
intervention from network operator is requested and normal, i.e.,
pre-CP-to-MP Handover, LSP processing continues.

- CASE II - Resv message and node down

```
          |       Path      |      Path      |      Path      |
          |--------------->|--------------->|--------------->|
          |                |                |      Resv      |
          |                |      Resv      |<---------------|
          |            X       X---------|                |
          |                |                |                |
          |            X       |                |                |
          |                |                |                |
       Ingress LER      LSR A            LSR B        Egress LER
```
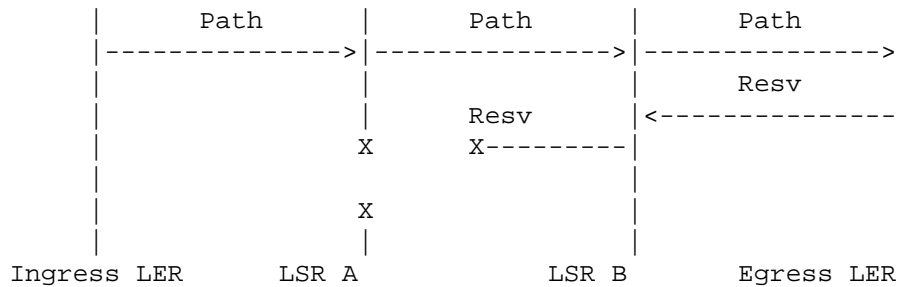
          Figure 11: Case II - Resv Message and Node Down

The procedure to be followed is the same depicted in CASE I. The
network operator can ask for the automatic CP-to-MP procedure again
after the failed node comes back up. Per [RFC3473], section 7.2, the
nodes will forward the new Path and Resv messages correctly.

- CASE III - PathTear message and node down

```
          |       Path      |      Path      |      Path      |
          |--------------->|--------------->|--------------->|
          |       Resv      |      Resv      |      Resv      |
          |<---------------|<---------------|<---------------|
          |    PathTear     |                |                |
          |--------------->|    PathTear    X               |
          |                |------------X               |
          |                |                X               |
          |                |                |                |
       Ingress LER      LSR A            LSR B        Egress LER
```
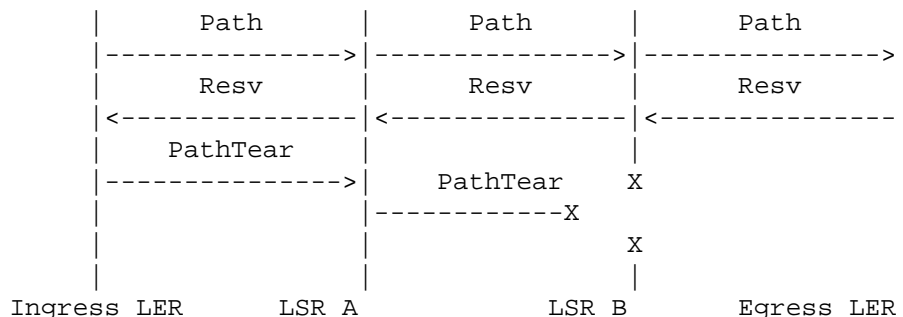
          Figure 12: Case III - PathTear Message and Node Down

This scenario can be managed as a normal PathTear lost described
above in this section.

5. Minimum Information for MP-to-CP Handover

As described in Section 4, it is also possible for the ERO to contain
less than the full set of path information for the LSP being handed
over. This arises when only a minimal set of information is handed

to the CP by the MP at the LSP's head-end. Instead of collecting all
of the LSP information (including the labels) and formatting it into
an ERO, as described in Section 4, it is possible to start with a
minimum amount of information. The full ERO method and the
partial/no ERO method are not mutually exclusive; support of both
methods is required.

At the ingress node, the information needed to specify the LSP is the
outgoing interface ID, upstream label, and downstream label of this
interface and egress node ID. The remaining information about an
existing LSP can then be collected hop by hop, as the signaling is
going on, by looking up the cross-connection table in the DP at each
node along the LSP path.

Starting from the information available at the ingress LER about the
outgoing interface ID of that ingress node, the incoming interface ID
of the next hop can be found by looking up the link resource table/
database in the LER itself.

The Path message is hence built with the LABEL_SET Object ([RFC3473])
and the UPSTREAM_LABEL Object ([RFC3473]), where the upstream label
and downstream label of ingress outgoing interface of the LSP are
included in these two objects. In addition to the above mentioned
objects, the Path message MUST include the ADMIN_STATUS Object with
the H bit set, as already defined in previous chapters for the
detailed ERO-based way of proceeding. Such a Handover Path is sent
to the incoming interface of the next hop. When this Path message
reaches the second node along the LSP, the information about incoming
interface ID and the upstream and downstream labels of this interface
is extracted from it, and it is used to find next hop outgoing
interface ID and the upstream/downstream labels by looking up the DP
cross-connection table.

After having determined, in this way, the parameters describing the
LSPs next hop, the outgoing Path message to be sent is built
replacing the LABEL_SET Object and UPSTREAM_LABEL Object content with
the looked-up values of upstream and downstream labels.

By repeating this procedure for each transit node along the LSP, it
is possible to make the Handover Path message reach the egress node,
exactly following the LSP that is in place over DP. The ERO MAY, in
this case, be included in the Path message as an optional object, and
MAY be filled with the LSP-relevant information down to either the
port level with the interface ID or the label level with upstream and
downstream labels. The ERO can be used to check the consistency of
resource in the DP down to the port level or label level at each
intermediate node along the LSP.

Where the DP path continues beyond the egress, by indicating the
Egress label at the head-end of an LSP, the traffic can be directed
to the right destination. The GMPLS signaling procedure for egress
control is described in [RFC4003]

6. RSVP Message Formats

This memo does not introduce any modification in RSVP messages object
composition.

7. Objects Modification

The modifications required concern two RSVP objects: the ADMIN_STATUS
and ERROR_SPEC Objects.

7.1. Administrative Status Object

This memo introduces a new flag into the ADMIN_STATUS Object. The
ADMIN_STATUS Object is defined in [RFC3473]. This document uses the
H bit of the ADMIN_STATUS Object. The bit is bit number 25.

7.2. Error Spec Object

It is possible that a failure, such as the loss of the Data
Communication Network (DCN) connection or the restart of a node,
occurs during the LSP ownership handing over. In this case, the LSP
Handover procedure is interrupted, the ownership of the LSP must
remain with the ownership prior to the initiation of the Handover
procedure. It is important that the transaction failure not affect
the DP. The LSP is kept in place and no traffic hit occurs.

The failure is signaled by a PathErr message in the upstream
direction and PathTear messages in the downstream direction. The
PathErr messages include an ERROR_SPEC Object specifying the causes
of the failure.

This memo introduces a new Error Code (with different Error Values)
into the ERROR_SPEC Object, defined in [RFC2205].

The defined Error Code is "Handover Procedure Failure", and its value
is 35. For this Error Code, the following Error Value sub-codes are
defined:

    1 = Cross-connection mismatch

    2 = Other failure

8. Compatibility

   The main requirement for the Handover procedure to work is that all
   nodes along the path MUST support the extension defined in this
   document. This requirement translates to an administrative
   requirement as it is not enforced at the protocol level. As defined,
   non-supporting nodes will simply propagate the H bit without setting
   local state. This may result in an impact on data traffic during the
   Handover procedure.

9. Security Considerations

   The procedures described in this document rely completely on RSVP-TE
   messages and mechanism. The use of the H bit being set in the
   ADMIN_STATUS Object basically informs the receiving entity that no
   operations are to be done over the DP as a consequence of such
   special signaling flow. Using specially flagged signaling messages,
   we want to limit the function of setup and teardown messages to the
   CP, making them ineffective over related DP resource usage.

   However, the Handover procedures allow the Control Plane to be used
   to take an LSP out of the control of the Management Plane. This
   could cause considerable disruption and could introduce a new
   security concern. As a consequence, the use of GMPLS security
   techniques is more important. For RSVP-TE security, please refer to
   [RFC3473], for the GMPLS security framework, please refer to
   [sec-fwk].

10. IANA Considerations

   IANA manages the bit allocations for the ADMIN_STATUS Object
   ([RFC3473]). This document requires the allocation of the Handover
   bit: the H bit. IANA has allocated a bit for this purpose.

   Bit Number Hex Value   Name   Reference
   ---------- ----------- -------------------------------- ---------
   25   0x00000040   Handover (H)   [RFC5852]

   IANA has also allocated a new Error Code:

     35 Handover failure

         This Error Code has the following globally defined Error
         Value sub-codes:

             1 = Cross-connection mismatch
             2 = Other failure

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