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H. Chen, Ed.  
Huawei Technologies  
R. Torvi, Ed.  
Juniper Networks  
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**Extensions to RSVP-TE for LSP Ingress Local Protection**  
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Abstract

This document describes extensions to Resource Reservation Protocol - Traffic Engineering (RSVP-TE) for locally protecting the ingress node of a Traffic Engineered (TE) Label Switched Path (LSP) in a Multi-Protocol Label Switching (MPLS) and Generalized MPLS (GMPLS) network.

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## 1. Co-authors

Ning So, Autumn Liu, Alia Atlas, Yimin Shen, Tarek Saad, Fengman Xu, Mehmet Toy, Lei Liu

## 2. Introduction

For MPLS LSPs it is important to have a fast-reroute method for protecting its ingress node as well as transit nodes. This is not covered either in the fast-reroute method defined in [RFC4090] or in the P2MP fast-reroute extensions to fast-reroute in [RFC4875].

An alternate approach to local protection (fast-reroute) is to use global protection and set up a second backup LSP (whether P2MP or P2P) from a backup ingress to the egresses. The main disadvantage of this is that the backup LSP may reserve additional network bandwidth.

This specification defines a simple extension to RSVP-TE for local protection of the ingress node of a P2MP or P2P LSP.

### 2.1. An Example of Ingress Local Protection

Figure 1 shows an example of using a backup P2MP LSP to locally protect the ingress of a primary P2MP LSP, which is from ingress R1 to three egresses: L1, L2 and L3. The backup LSP is from backup ingress Ra to the next hops R2 and R4 of ingress R1.

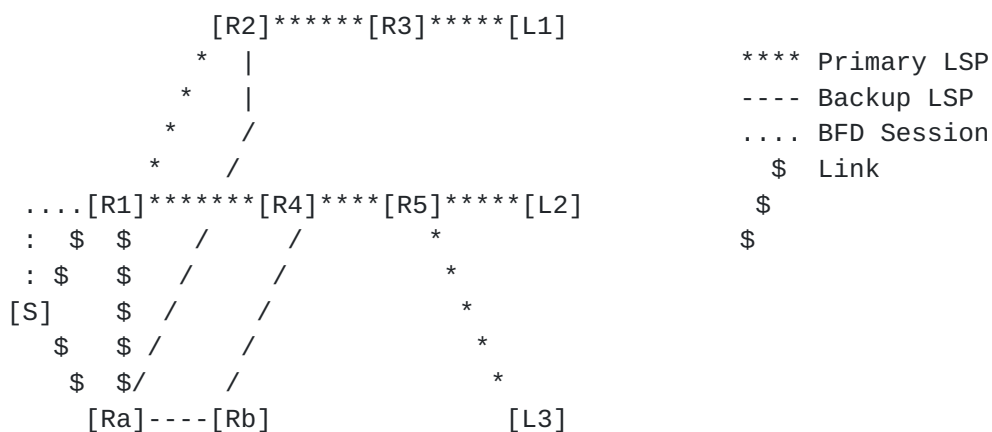


Figure 1: Backup P2MP LSP for Locally Protecting Ingress

In normal operations, source S sends the traffic to primary ingress R1. R1 imports the traffic into the primary LSP.

When source S detects the failure of R1, it switches the traffic to



backup ingress Ra, which imports the traffic from S into the backup LSP to R1's next hops R2 and R4, where the traffic is merged into the primary LSP, and then sent to egresses L1, L2 and L3.

Source S should be able to detect the failure of R1 and switch the traffic within 10s of ms.

Note that the backup ingress must be one logical hop away from the ingress. A logical hop is a direct link or a tunnel such as a GRE tunnel, over which RSVP-TE messages may be exchanged.

## **2.2. Ingress Local Protection with FRR**

Through using the ingress local protection and the FRR, we can locally protect the ingress, all the links and the transit nodes of an LSP. The traffic switchover time is within 10s of ms whenever the ingress, any of the links and the transit nodes of the LSP fails.

The ingress node of the LSP can be locally protected through using the ingress local protection. All the links and all the transit nodes of the LSP can be locally protected through using the FRR.

## **3. Ingress Failure Detection**

Exactly how to detect the failure of the ingress is out of scope. However, it is necessary to discuss different modes for detecting the failure because they determine what is the required behavior for the source and backup ingress.

### **3.1. Source Detects Failure**

Source Detects Failure or Source-Detect for short means that the source is responsible for fast detecting the failure of the primary ingress of an LSP. The backup ingress is ready to import the traffic from the source into the backup LSP after the backup LSP is up.

In normal operations, the source sends the traffic to the primary ingress. When the source detects the failure of the primary ingress, it switches the traffic to the backup ingress, which delivers the traffic to the next hops of the primary ingress through the backup LSP, where the traffic is merged into the primary LSP.

For a P2P LSP, after the primary ingress fails, the backup ingress must use a method to reliably detect the failure of the primary ingress before the PATH message for the LSP expires at the next hop of the primary ingress. After reliably detecting the failure, the backup ingress sends/refreshes the PATH message to the next hop



through the backup LSP as needed.

After the primary ingress fails, it will not be reachable after routing convergence. Thus checking whether the primary ingress (address) is reachable is a possible method.

### **3.2. Backup and Source Detect Failure**

Backup and Source Detect Failure or Backup-Source-Detect for short means that both the backup ingress and the source are concurrently responsible for fast detecting the failure of the primary ingress.

In normal operations, the source sends the traffic to the primary ingress. It switches the traffic to the backup ingress when it detects the failure of the primary ingress.

The backup ingress does not import any traffic from the source into the backup LSP in normal operations. When it detects the failure of the primary ingress, it imports the traffic from the source into the backup LSP to the next hops of the primary ingress, where the traffic is merged into the primary LSP.

The source-detect is preferred. It is simpler than the backup-source-detect, which needs both the source and the backup ingress detect the ingress failure quickly.

## **4. Backup Forwarding State**

Before the primary ingress fails, the backup ingress is responsible for creating the necessary backup LSPs. These LSPs might be multiple bypass P2P LSPs that avoid the ingress. Alternately, the backup ingress could choose to use a single backup P2MP LSP as a bypass or detour to protect the primary ingress of a primary P2MP LSP.

The backup ingress may be off-path or on-path of an LSP. If a backup ingress is not any node of the LSP, we call it is off-path. If a backup ingress is a next-hop of the primary ingress of the LSP, we call it is on-path. If it is on-path, the primary forwarding state associated with the primary LSP SHOULD be clearly separated from the backup LSP(s) state.

### **4.1. Forwarding State for Backup LSP**

A forwarding entry for a backup LSP is created on the backup ingress after the LSP is set up. Depending on the failure-detection mode (e.g., source-detect), it may be used to forward received traffic or simply be inactive (e.g., backup-source-detect) until required. In





either case, when the primary ingress fails, this entry is used to import the traffic into the backup LSP to the next hops of the primary ingress, where the traffic is merged into the primary LSP.

The forwarding entry for a backup LSP is a local implementation issue. In one device, it may have an inactive flag. This inactive forwarding entry is not used to forward any traffic normally. When the primary ingress fails, it is changed to active, and thus the traffic from the source is imported into the backup LSP.

## 5. Protocol Extensions

A new object INGRESS\_PROTECTION is defined for signaling ingress local protection. It is backward compatible.

### 5.1. INGRESS\_PROTECTION Object

The INGRESS\_PROTECTION object with the FAST\_REROUTE object in a PATH message is used to control the backup for protecting the primary ingress of a primary LSP. The primary ingress MUST insert this object into the PATH message to be sent to the backup ingress for protecting the primary ingress. It has the following format:

```

Class-Num = TBD      C-Type = TBD
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
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|          Length (bytes)          |   Class-Num   |   C-Type   |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|   Secondary LSP ID   |   Flags   |   Options   |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
~                               (Subobjects)                               ~
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

#### Flags

```

0x01   Ingress local protection available
0x02   Ingress local protection in use
0x04   Bandwidth protection

```

#### Options

```

0x01   Revert to Ingress
0x02   P2MP Backup

```

The Secondary LSP ID in the object is an LSP ID that the primary ingress has allocated for a protected LSP tunnel. The backup ingress may use this LSP ID to set up a new LSP from the backup ingress to



the destinations of the protected LSP tunnel. This allows the new LSP to share resources with the old one.

The flags are used to communicate status information from the backup ingress to the primary ingress.

- o Ingress local protection available: The backup ingress sets this flag after backup LSPs are up and ready for locally protecting the primary ingress. The backup ingress sends this to the primary ingress to indicate that the primary ingress is locally protected.
- o Ingress local protection in use: The backup ingress sets this flag when it detects a failure in the primary ingress. The backup ingress keeps it and does not send it to the primary ingress since the primary ingress is down.
- o Bandwidth protection: The backup ingress sets this flag if the backup LSPs guarantee to provide desired bandwidth for the protected LSP against the primary ingress failure.

The options are used by the primary ingress to specify the desired behavior to the backup ingress.

- o Revert to Ingress: The primary ingress sets this option indicating that the traffic for the primary LSP successfully re-signaled will be switched back to the primary ingress from the backup ingress when the primary ingress is restored.
- o P2MP Backup: This option is set to ask for the backup ingress to use P2MP backup LSP to protect the primary ingress. Note that one spare bit of the flags in the FAST-REROUTE object can be used to indicate whether P2MP or P2P backup LSP is desired for protecting an ingress and transit node.

The INGRESS\_PROTECTION object may contain some sub objects below.

#### **5.1.1. Subobject: Backup Ingress IPv4/IPv6 Address**

When the primary ingress of a protected LSP sends a PATH message with an INGRESS\_PROTECTION object to the backup ingress, the object may have a Backup Ingress IPv4/IPv6 Address sub object containing an IPv4/IPv6 address belonging to the backup ingress. The Type of the sub object is TBD-1/TBD-2 for Backup Ingress IPv4/IPv6 Address. The body of the sub object is given below:



```

      0               1               2               3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
|                               IPv4/IPv6 address (4/16 bytes)       |
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

```

IPv4/IPv6 address: A 32/128-bit unicast, host address.

### 5.1.2. Subobject: Ingress IPv4/IPv6 Address

The INGRESS\_PROTECTION object may have an Ingress IPv4/IPv6 Address sub object containing an IPv4/IPv6 address belonging to the primary ingress. The Type of the sub object is TBD-3/TBD-4 for Ingress IPv4/IPv6 Address. The sub object has the following body:

```

      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
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
|                               IPv4/IPv6 address (4/16 bytes)       |
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

```

IPv4/IPv6 address: A 32/128-bit unicast, host address.

### 5.1.3. Subobject: Traffic Descriptor

The INGRESS\_PROTECTION object may have a Traffic Descriptor sub object describing the traffic to be mapped to the backup LSP on the backup ingress for locally protecting the primary ingress. The Type of the sub object is TBD-5/TBD-6/TBD-7 for Interface/IPv4/6 Prefix respectively. The sub object has the following body:

```

      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
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
|                               Traffic Element 1                   |
~
|                               Traffic Element n                   |
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

```

The Traffic Descriptor sub object may contain multiple Traffic Elements of same type as follows:



- o Interface Traffic (Type TBD-5): Each of the Traffic Elements is a 32 bit index of an interface, from which the traffic is imported into the backup LSP.
- o IPv4/6 Prefix Traffic (Type TBD-6/TBD-7): Each of the Traffic Elements is an IPv4/6 prefix, containing an 8-bit prefix length followed by an IPv4/6 address prefix, whose length, in bits, was specified by the prefix length, padded to a byte boundary.

#### **5.1.4. Subobject: Label-Routes**

The INGRESS\_PROTECTION object in a PATH message from the primary ingress to the backup ingress will have a Label-Routes sub object containing the labels and routes that the next hops of the ingress use. The Type of the sub object is TBD-8. The sub object has the following body:

```

      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
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
~                                     Subobjects                             ~
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

The Subobjects in the Label-Routes are copied from those in the RECORD\_ROUTE objects in the RESV messages that the primary ingress receives from its next hops for the primary LSP. They MUST contain the first hops of the LSP, each of which is paired with its label.

## **6. Behavior of Ingress Protection**

### **6.1. Overview**

There are four parts of ingress protection: 1) setting up the necessary backup LSP forwarding state; 2) identifying the failure and providing the fast repair (as discussed in Sections [3](#) and [4](#)); 3) maintaining the RSVP-TE control plane state until a global repair can be done; and 4) performing the global repair(see [Section 6.4](#)).

### **6.2. Ingress Behavior**

The primary ingress must be configured with a couple of pieces of information for ingress protection.





- o Backup Ingress Address: The primary ingress must know an IP address for it to be included in the INGRESS\_PROTECTION object.
- o Application Traffic Identifier: The primary ingress and backup ingress must both know what application traffic should be directed into the LSP. If a list of prefixes in the Traffic Descriptor sub-object will not suffice, then a commonly understood Application Traffic Identifier can be sent between the primary ingress and backup ingress. The exact meaning of the identifier should be configured similarly at both the primary ingress and backup ingress. The Application Traffic Identifier is understood within the unique context of the primary ingress and backup ingress.

With this additional information, the primary ingress can create and signal the necessary RSVP extensions to support ingress protection.

The primary ingress relays the information for ingress protection of an LSP to the backup ingress via PATH messages. Once the LSP is created, the ingress of the LSP sends the backup ingress a PATH message with an INGRESS\_PROTECTION object with Label-Routes subobject, which is populated with the next-hops and labels. This provides sufficient information for the backup ingress to create the appropriate forwarding state and backup LSP(s).

The ingress also sends the backup ingress all the other PATH messages for the LSP with an empty INGRESS\_PROTECTION object. Thus, the backup ingress has access to all the PATH messages needed for modification to refresh control-plane state after a failure.

To protect the ingress of an LSP, the ingress does the following after the LSP is up.

1. Select a PATH message.
2. If the backup ingress is off-path, then send it a PATH message with the content from the selected PATH message and an INGRESS\_PROTECTION object; else (the backup ingress is a next hop, i.e., on-path case) add an INGRESS\_PROTECTION object into the existing PATH message to the backup ingress (i.e., the next hop). The object contains the Traffic-Descriptor sub-object, the Backup Ingress Address sub-object and the Label-Routes sub-object. The flags is set to indicate whether a Backup P2MP LSP is desired. A second LSP-ID is allocated (if it is not allocated yet) and used in the object. The Label-Routes sub-object contains the next-hops of the ingress and their labels.



3. For each of the other PATH messages, send the backup ingress a PATH message with the content copied from the message and an empty INGRESS\_PROTECTION object, which is an object without any Traffic-Descriptor sub-object.

### **6.3. Backup Ingress Behavior**

An LER determines that the ingress local protection is requested for an LSP if the INGRESS\_PROTECTION object is included in the PATH message it receives for the LSP. The LER can further determine that it is the backup ingress if one of its addresses is in the Backup Ingress Address sub-object of the INGRESS\_PROTECTION object. The LER as the backup ingress will assume full responsibility of the ingress after the primary ingress fails. In addition, the LER determines that it is off-path if it is not a next hop of the primary ingress.

#### **6.3.1. Backup Ingress Behavior in Off-path Case**

The backup ingress considers itself as a PLR and the primary ingress as its next hop and provides a local protection for the primary ingress. It behaves very similarly to a PLR providing fast-reroute where the primary ingress is considered as the failure-point to protect. Where not otherwise specified, the behavior given in [\[RFC4090\]](#) for a PLR should apply.

The backup ingress SHOULD follow the control-options specified in the INGRESS\_PROTECTION object and the flags and specifications in the FAST-REROUTE object. This applies to providing a P2MP backup if the "P2MP backup" is set, a one-to-one backup if "one-to-one desired" is set, facility backup if the "facility backup desired" is set, and backup paths that support the desired bandwidth, and administrative-colors that are requested.

If multiple non empty INGRESS\_PROTECTION objects have been received via multiple PATH messages for the same LSP, then the most recent one MUST be the one used.

The backup ingress creates the appropriate forwarding state for the backup LSP tunnel(s) to the merge point(s).

When the backup ingress sends a RESV message to the primary ingress, it should add an INGRESS\_PROTECTION object into the message. It SHOULD set or clear the flags in the object to report "Ingress local protection available", "Ingress local protection in use", and "bandwidth protection".

If the backup ingress doesn't have a backup LSP tunnel to all the merge points, it SHOULD clear "Ingress local protection available".



[Editor Note: It is possible to indicate the number or which are unprotected via a sub-object if desired.]

When the primary ingress fails, the backup ingress redirects the traffic from a source into the backup P2P LSPs or the backup P2MP LSP transmitting the traffic to the next hops of the primary ingress, where the traffic is merged into the protected LSP.

In this case, the backup ingress keeps the PATH message with the INGRESS\_PROTECTION object received from the primary ingress and the RESV message with the INGRESS\_PROTECTION object to be sent to the primary ingress. The backup ingress sets the "local protection in use" flag in the RESV message, indicating that the backup ingress is actively redirecting the traffic into the backup P2P LSPs or the backup P2MP LSP for locally protecting the primary ingress failure.

Note that the RESV message with this piece of information will not be sent to the primary ingress because the primary ingress has failed.

If the backup ingress has not received any PATH message from the primary ingress for an extended period of time (e.g., a cleanup timeout interval) and a confirmed primary ingress failure did not occur, then the standard RSVP soft-state removal SHOULD occur. The backup ingress SHALL remove the state for the PATH message from the primary ingress, and tear down the one-to-one backup LSPs for protecting the primary ingress if one-to-one backup is used or unbind the facility backup LSPs if facility backup is used.

When the backup ingress receives a PATH message from the primary ingress for locally protecting the primary ingress of a protected LSP, it checks to see if any critical information has been changed. If the next hops of the primary ingress are changed, the backup ingress SHALL update its backup LSP(s) accordingly.

When the backup ingress receives a PATH message with a non empty INGRESS\_PROTECTION object, it examines the object to learn what traffic associated with the LSP. It determines the next-hops to be merged to by examining the Label-Routes sub-object in the object.

The backup ingress stores the PATH message received from the primary ingress, but does NOT forward it.

The backup ingress responds with a RESV to the PATH message received from the primary ingress. If the INGRESS\_PROTECTION object is not "empty", the backup ingress SHALL send the RESV message with the state indicating protection is available after the backup LSP(s) are successfully established.



### **6.3.2. Backup Ingress Behavior in On-path Case**

An LER as the backup ingress determines that it is on-path if one of its addresses is a next hop of the primary ingress. The LER on-path sends the corresponding PATH messages without any INGRESS\_PROTECTION object to its next hops. It creates a number of backup P2P LSPs or a backup P2MP LSP from itself to the other next hops (i.e., the next hops other than the backup ingress) of the primary ingress. The other next hops are from the Label-Routes sub object.

It also creates a forwarding entry, which sends/multicasts the traffic from the source to the next hops of the backup ingress along the protected LSP when the primary ingress fails. The traffic is described by the Traffic-Descriptor.

After the forwarding entry is created, all the backup P2P LSPs or the backup P2MP LSP is up and associated with the protected LSP, the backup ingress sends the primary ingress the RESV message with the INGRESS\_PROTECTION object containing the state of the local protection such as "local protection available" flag set to one, which indicates that the primary ingress is locally protected.

When the primary ingress fails, the backup ingress sends/multicasts the traffic from the source to its next hops along the protected LSP and imports the traffic into each of the backup P2P LSPs or the backup P2MP LSP transmitting the traffic to the other next hops of the primary ingress, where the traffic is merged into protected LSP.

During the local repair, the backup ingress continues to send the PATH messages to its next hops as before, keeps the PATH message with the INGRESS\_PROTECTION object received from the primary ingress and the RESV message with the INGRESS\_PROTECTION object to be sent to the primary ingress. It sets the "local protection in use" flag in the RESV message.

### **6.3.3. Failure Detection and Refresh PATH Messages**

As described in [[RFC4090](#)], it is necessary to refresh the PATH messages via the backup LSP(s). The Backup Ingress MUST wait to refresh the PATH messages until it can accurately detect that the ingress node has failed. An example of such an accurate detection would be that the IGP has no bi-directional links to the ingress node and the last change was long enough in the past that changes should have been received (i.e., an IGP network convergence time or approximately 2-3 seconds) or a BFD session to the primary ingress' loopback address has failed and stayed failed after the network has reconverged.





As described in [RFC4090 [Section 6.4.3](#)], the backup ingress, acting as PLR, SHOULD modify and send any saved PATH messages associated with the primary LSP to the corresponding next hops through backup LSP(s). Any PATH message sent will not contain any INGRESS\_PROTECTION object. The RSVP\_HOP object in the message contains an IP source address belonging to the backup ingress. The sender template object has the backup ingress address as its tunnel sender address.

#### **[6.4.](#) Revertive Behavior**

Upon a failure event in the (primary) ingress of a protected LSP, the protected LSP is locally repaired by the backup ingress. There are a couple of basic strategies for restoring the LSP to a full working path.

- Revert to Primary Ingress: When the primary ingress is restored, it re-signals each of the LSPs that start from the primary ingress. The traffic for every LSP successfully re-signaled is switched back to the primary ingress from the backup ingress.
- Global Repair by Backup Ingress: After determining that the primary ingress of an LSP has failed, the backup ingress computes a new optimal path, signals a new LSP along the new path, and switches the traffic to the new LSP.

##### **[6.4.1.](#) Revert to Primary Ingress**

If "Revert to Primary Ingress" is desired for a protected LSP, the (primary) ingress of the LSP re-signals the LSP that starts from the primary ingress after the primary ingress restores. After the LSP is re-signaled successfully, the traffic can be switched back to the primary ingress from the backup ingress on the source node and redirected into the LSP starting from the primary ingress.

The primary ingress can specify the "Revert to Ingress" control-option in the INGRESS\_PROTECTION object in the PATH messages to the backup ingress. After receiving the "Revert to Ingress" control-option, the backup ingress stops sending/refreshing PATH messages for the protected LSP.

##### **[6.4.2.](#) Global Repair by Backup Ingress**

When the backup ingress has determined that the primary ingress of the protected LSP has failed (e.g., via the IGP), it can compute a new path and signal a new LSP along the new path so that it no longer relies upon local repair. To do this, the backup ingress uses the same tunnel sender address in the Sender Template Object and uses the



previously allocated second LSP-ID in the INGRESS\_PROTECTION object of the PATH message as the LSP-ID of the new LSP. This allows the new LSP to share resources with the old LSP. In addition, if the Ingress recovers, the Backup Ingress SHOULD send it RESVs with the INGRESS\_PROTECTION object where the "Revert to Ingress" is specified. The Secondary LSP ID should be the unused LSP ID - while the LSP ID signaled in the RESV will be that currently active. The Ingress can learn from the RESVs what to signal. Even if the Ingress does not take over, the RESVs notify it that the particular LSP IDs are in use. The Backup Ingress can reoptimize the new LSP as necessary until the Ingress recovers. Alternately, the Backup Ingress can create a new LSP with no bandwidth reservation that duplicates the path(s) of the protected LSP, move traffic to the new LSP, delete the protected LSP, and then resignal the new LSP with bandwidth.

## **7. Security Considerations**

In principle this document does not introduce new security issues. The security considerations pertaining to [RFC 4090](#), [RFC 4875](#) and other RSVP protocols remain relevant.

## **8. IANA Considerations**

TBD

## **9. Contributors**

Renwei Li  
Huawei Technologies  
2330 Central Expressway  
Santa Clara, CA 95050  
USA  
Email: renwei.li@huawei.com

Quintin Zhao  
Huawei Technologies  
Boston, MA  
USA  
Email: quintin.zhao@huawei.com



Zhenbin Li  
Huawei Technologies  
2330 Central Expressway  
Santa Clara, CA 95050  
USA  
Email: zhenbin.li@huawei.com

Boris Zhang  
Telus Communications  
200 Consilium Pl Floor 15  
Toronto, ON M1H 3J3  
Canada  
Email: Boris.Zhang@telus.com

Markus Jork  
Juniper Networks  
10 Technology Park Drive  
Westford, MA 01886  
USA  
Email: mjork@juniper.net

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### **Appendix A. Authors' Addresses**





Huaimo Chen  
Huawei Technologies  
Boston, MA  
USA  
Email: huaimo.chen@huawei.com

Raveendra Torvi  
Juniper Networks  
10 Technology Park Drive  
Westford, MA 01886  
USA  
Email: rtorvi@juniper.net

Ning So  
Tata Communications  
2613 Fairbourne Cir.  
Plano, TX 75082  
USA  
Email: ningso01@gmail.com

Autumn Liu  
Ericsson  
300 Holger Way  
San Jose, CA 95134  
USA  
Email: autumn.liu@ericsson.com

Alia Atlas  
Juniper Networks  
10 Technology Park Drive  
Westford, MA 01886  
USA  
Email: akatlas@juniper.net



Yimin Shen  
Juniper Networks  
10 Technology Park Drive  
Westford, MA 01886  
USA  
Email: yshen@juniper.net

Tarek Saad  
Cisco Systems  
Email: tsaad@cisco.com

Fengman Xu  
Verizon  
2400 N. Glenville Dr  
Richardson, TX 75082  
USA  
Email: fengman.xu@verizon.com

Mehmet Toy  
Comcast  
1800 Bishops Gate Blvd.  
Mount Laurel, NJ 08054  
USA  
Email: mehmet\_toy@cable.comcast.com

Lei Liu  
UC Davis  
USA  
Email: liulei.kddi@gmail.com

