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Fast Reroute Procedures For Associated Bidirectional Label  
Switched Paths (LSPs)  
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Abstract

Resource Reservation Protocol (RSVP) association signaling can be used to bind two unidirectional LSPs into an associated bidirectional LSP. When an associated bidirectional LSP is co-routed, the reverse LSP follows the same path as its forward LSP. This document describes Fast Reroute (FRR) procedures for both single-sided and double-sided provisioned associated bidirectional LSPs. The FRR procedures are applicable to co-routed and non co-routed LSPs. For co-routed LSPs, the FRR procedures can ensure that traffic flows on co-routed paths in the forward and reverse directions after a failure event.

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## 1. Introduction

The Resource Reservation Protocol (RSVP) (Extended) ASSOCIATION Object is specified in [RFC6780] which can be used generically to associate (G)Multi-Protocol Label Switching (MPLS) Label Switched Paths (LSPs). [RFC7551] defines mechanisms for binding two point-to-point unidirectional LSPs [RFC3209] into an associated bidirectional LSP. There are two models described in [RFC7551] for provisioning an associated bidirectional LSP, single-sided and double-sided. In both models, the reverse LSP of the bidirectional LSP may or may not be co-routed and follow the same path as its forward LSP.

[GMPLS-FRR] defines Fast Reroute (FRR) procedure for GMPLS signaled LSPs to co-ordinate bypass tunnel assignments in the forward and reverse directions. The mechanisms defined in [GMPLS-FRR] are applicable to FRR of associated bidirectional LSPs.

In packet transport networks, there are requirements where the reverse LSP of a bidirectional LSP needs to follow the same path as its forward LSP [RFC6373]. The MPLS Transport Profile (TP) [RFC6370] architecture facilitates the co-routed bidirectional LSP by using the GMPLS extensions [RFC3473] to achieve congruent paths. However, the RSVP association signaling allows to enable co-routed bidirectional LSPs without having to deploy GMPLS extensions in the existing networks. The association signaling also allows to take advantage of the existing Traffic Engineering (TE) and FRR mechanisms in the network.

This document describes FRR procedures for both single-sided and double-sided provisioned associated bidirectional LSPs. The FRR procedures are applicable to co-routed and non co-routed LSPs. For co-routed LSPs, the FRR procedures can ensure that traffic flows on co-routed paths in the forward and reverse directions after a failure event.

## 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 RFC 2119 [RFC2119].

### 2.2. Terminology

The reader is assumed to be familiar with the terminology in [RFC2205], [RFC3209], [RFC4090] and [RFC7551].

### 2.2.1. Reverse Co-routed Unidirectional LSPs

Two reverse unidirectional point-to-point (P2P) LSPs are setup in the opposite directions between a pair of source and destination nodes to form an associated bidirectional LSP. A reverse unidirectional LSP originates on the same node where the forward unidirectional LSP terminates, and it terminates on the same node where the forward unidirectional LSP originates. A reverse co-routed unidirectional LSP traverses along the same path of the forward direction unidirectional LSP in the opposite direction.

## 3. Overview

As specified in [RFC7551], in the single-sided provisioning case, the RSVP TE tunnel is configured only on one endpoint node of the bidirectional LSP. An LSP for this tunnel is initiated by the originating endpoint with (Extended) ASSOCIATION Object containing Association Type set to "single-sided associated bidirectional LSP" and REVERSE\_LSP Object inserted in the Path message. The remote endpoint then creates the corresponding reverse TE tunnel and signals the reverse LSP in response using the information from the REVERSE\_LSP Object and other objects present in the received Path message. As specified in [RFC7551], in the double-sided provisioning case, the RSVP TE tunnel is configured on both endpoint nodes of the bidirectional LSP. Both forward and reverse LSPs are initiated independently by the two endpoints with (Extended) ASSOCIATION Object containing Association Type set to "double-sided associated bidirectional LSP". In both single-sided and double-sided provisioned bidirectional LSPs, the reverse LSP may or may not be congruent (i.e. co-routed) and follow the same path as its forward LSP.

In the case of single-sided provisioned LSP, the originating LSP with REVERSE\_LSP Object is identified as a forward LSP. In the case of double-sided provisioned LSP, the LSP originating from the higher node address (as source) and terminating on the lower node address (as destination) is identified as a forward LSP. The reverse LSP of the bidirectional LSP traverses in the opposite direction of the forward LSP.

Both single-sided and double-sided associated bidirectional LSPs require solutions to the following issues for fast reroute.

### 3.1. Fast Reroute Bypass Tunnel Assignment

In order to ensure that the traffic flows on a co-routed path after a link or node failure on the protected LSP path, the mid-point Point

of Local Repair (PLR) nodes need to assign matching bidirectional bypass tunnels for fast reroute. Even for a non co-routed bidirectional LSP, it is desired that the same bidirectional bypass tunnel is used in both directions of the protected LSP. Such bypass assignment requires co-ordination between the forward and reverse direction PLR nodes when more than one bypass tunnels are present on a PLR node.

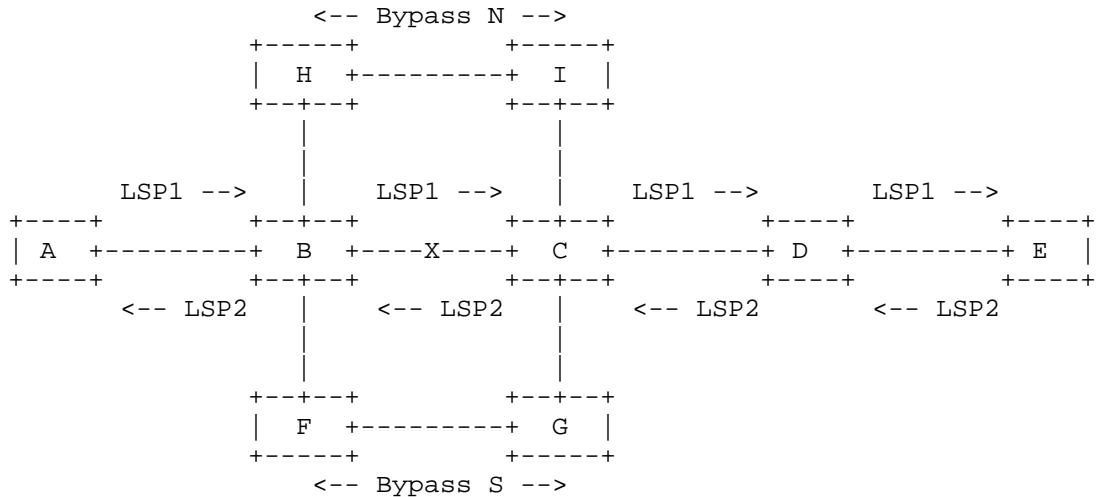


Figure 1: Multiple Bidirectional Bypass Tunnels

As shown in Figure 1, there are two bypass tunnels available, Bypass N on path B-H-I-C and Bypass S on path B-F-G-C. The mid-point PLR nodes B and C need to co-ordinate bypass tunnel assignment to ensure that traffic in both directions flow through either on the Bypass N path B-H-I-C or the Bypass S path B-F-G-C, after the link B-C failure.

### 3.2. Bidirectional LSP Association At Mid-Points

In packet transport networks, a restoration LSP is signaled after a link failure on the protected LSP and the protected LSP may or may not be torn down [GMPLS-REST]. In this case, multiple forward and reverse LSPs of a bidirectional LSP may be present at mid-point nodes with identical (Extended) ASSOCIATION Objects. This creates an ambiguity at mid-point nodes to identify the correct associated LSP pair for fast reroute bypass assignment (e.g. during the recovery phase of RSVP graceful restart procedure).

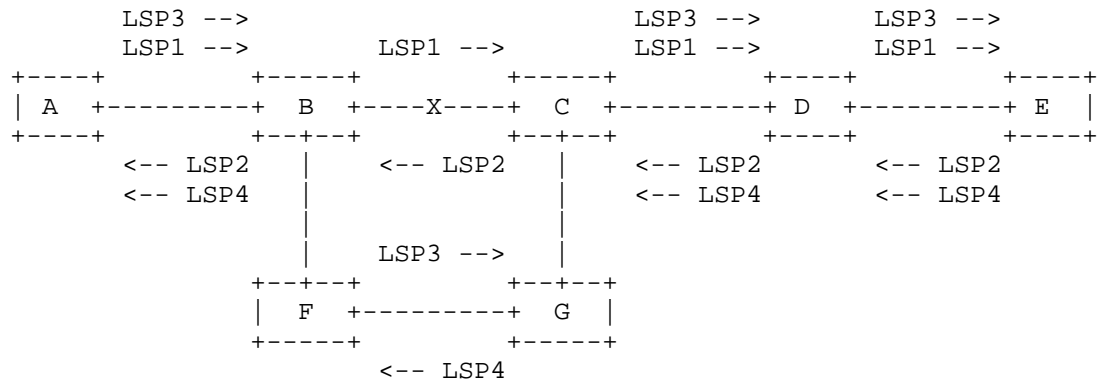


Figure 2: Restoration LSP Set-up After Link Failure

As shown in Figure 2, protected LSPs LSP1 and LSP2 are an associated LSP pair, similarly restoration LSPs LSP3 and LSP4 are an associated LSP pair, both pairs belong to the same associated bidirectional LSP and carry identical (Extended) ASSOCIATION Objects. In this example, mid-point node D may mistakenly associate LSP1 with reverse LSP4 instead of reverse LSP3 due to the matching (Extended) ASSOCIATION Objects. This may cause the bidirectional LSP to become non co-routed. Since a reverse LSP reflects the bypass tunnel assignment received in the forward LSP, this can also lead to undesired bypass tunnel assignments.

#### 4. Signaling Procedure

##### 4.1. Bidirectional LSP Fast Reroute

The mechanisms defined in [GMPLS-FRR] are used for fast reroute of both single-sided and double-sided associated bidirectional LSPs as following.

- o As described in [GMPLS-FRR], BYPASS\_ASSIGNMENT subobject is signaled in the RRO of the Path message to co-ordinate bypass tunnel assignment between the forward and reverse direction PLR nodes. A BYPASS\_ASSIGNMENT subobject MUST be added by the forward direction PLR node in the Path message of the forward LSP to indicate the bypass tunnel assigned.
- o The forward direction PLR node always initiates the bypass tunnel assignment for the forward LSP. The reverse direction PLR (forward direction LSP Merge Point (MP)) node simply reflects the bypass tunnel assignment for the reverse direction LSP.

- o After a link or node failure, the PLR nodes in both forward and reverse directions trigger fast reroute independently using the procedures defined in [RFC4090].
- o When using a node protection bypass tunnel, asymmetry of paths can occur in the forward and reverse directions of the bidirectional LSP after a link failure when using co-routed LSPs [GMPLS-FRR]. This can be corrected using the re-corouting procedure defined in [GMPLS-FRR]. Unlike GMPLS LSPs, the asymmetry of paths in the forward and reverse directions does not result in RSVP soft-state time-out with the associated bidirectional LSPs.

## 4.2. Bidirectional LSP Association At Mid-points

In order to associate the correct LSPs at a mid-point node, an endpoint node MUST signal Extended ASSOCIATION Object and add unique Extended Association ID for each associated forward and reverse LSP pair forming the bidirectional LSP. As an example, an endpoint node MAY set the Extended Association ID to the value specified in Section 5.1 of this document.

- o For single-sided provisioned bidirectional LSPs [RFC7551], the originating endpoint signals the Extended ASSOCIATION Object with a unique Extended Association ID. The remote endpoint copies the contents of the received Extended ASSOCIATION Object including the Extended Association ID in the RSVP Path message of the reverse LSP's Extended ASSOCIATION Object.
- o For double-sided provisioned bidirectional LSPs [RFC7551], both endpoints need to ensure that the bidirectional LSP has a unique Extended ASSOCIATION Object for each forward and reverse LSP pair by provisioning appropriate Extended Association IDs signaled by them.

## 5. Message and Object Definitions

### 5.1. Extended ASSOCIATION Object

The Extended Association ID in the Extended ASSOCIATION Object can be set to the value specified as following to uniquely identify associated forward and reverse LSP pair of a bidirectional LSP.

	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>																					
	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1			
+---	-+	--	+-	-+	--	+-	-+	--	+-	-+	--	+-	-+	--	+-	-+	--	+-	-+	--	+-	-+	--	+-	
	IPv4 LSP Source Address																								

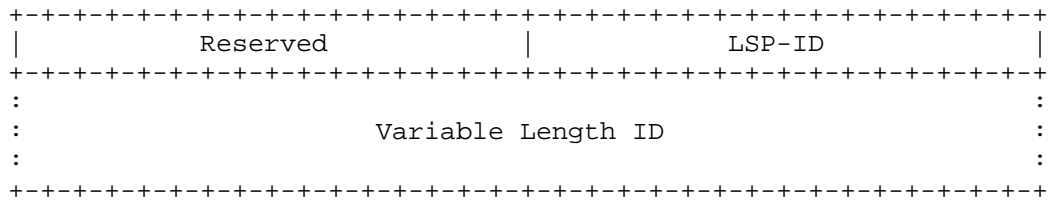


Figure 3: IPv4 Extended Association ID

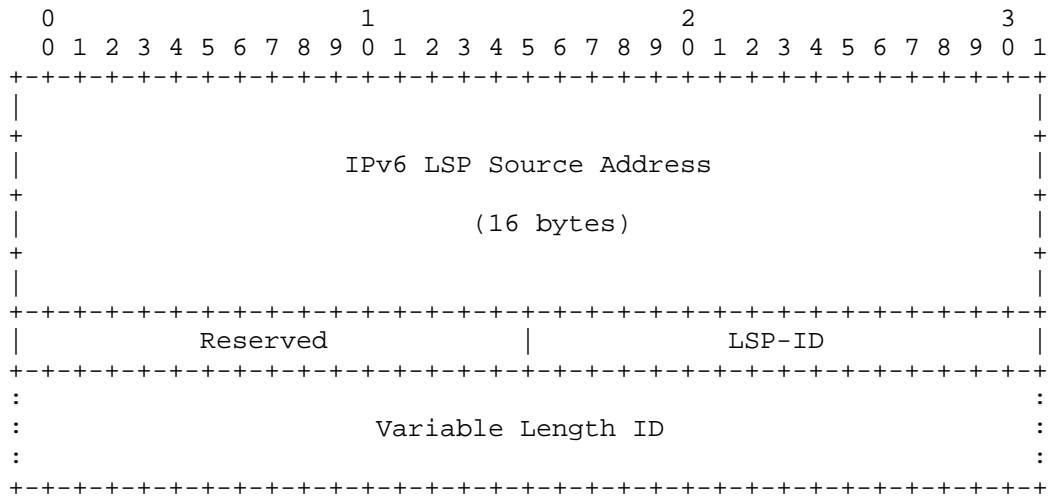


Figure 4: IPv6 Extended Association ID

LSP Source Address

IPv4/IPv6 source address of the forward LSP.

LSP-ID

16-bits LSP-ID of the forward LSP.

Variable Length ID

Variable length ID inserted by the endpoint node of the associated bidirectional LSP [RFC6780].

## 6. Compatibility



This document describes the procedures for fast reroute for associated bidirectional LSPs. Operators wishing to use this function SHOULD ensure that it is supported on the nodes on the LSP path.

## 7. Security Considerations

This document uses signaling mechanisms defined in [RFC7551] and [GMPLS-FRR] and does not introduce any additional security considerations other than already covered in [RFC7551], [GMPLS-FRR] and the MPLS/GMPLS security framework [RFC5920].

## 8. IANA Considerations

This document does not make any request for IANA action.

## 9. References

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