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F. Zhang, Ed.
ZTE
R. Jing
China Telecom
R. Gandhi, Ed.
Cisco Systems

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# RSVP-TE Extensions for Associated Bidirectional LSPs
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## Abstract

This document describes Resource reSerVation Protocol (RSVP) extensions to bind two point-to-point unidirectional Label Switched Paths (LSPs) into an associated bidirectional LSP. The association is achieved by defining the new Association Types in (Extended) ASSOCIATION object. In addition, RSVP extensions allow asymmetric upstream and downstream bandwidths for the bidirectional LSP.

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## 1. Introduction

The MPLS Transport Profile (MPLS-TP) requirements document [RFC5654] specifies that MPLS-TP MUST support associated bidirectional point-to-point Label Switched Paths (LSPs). These requirements are given in Section 2.1 (General Requirements), and are repeated below:

7. MPLS-TP MUST support associated bidirectional point-to-point LSPs.

11. The end points of an associated bidirectional LSP MUST be aware of the pairing relationship of the forward and reverse LSPs used to support the bidirectional service.

12. Nodes on the LSP of an associated bidirectional LSP where both the forward and backward directions transit the same node in the same (sub)layer as the LSP SHOULD be aware of the pairing relationship of the forward and the backward directions of the LSP.

14. MPLS-TP MUST support bidirectional LSPs with asymmetric bandwidth requirements, i.e., the amount of reserved bandwidth differs between the forward and backward directions.

50. The MPLS-TP control plane MUST support establishing associated bidirectional P2P LSP including configuration of protection functions and any associated maintenance functions.

The above requirements are also repeated in [RFC6373].

Furthermore, an associated bidirectional LSP is also useful for protection switching for Operations, Administrations and Maintenance (OAM) messages that require a return path.

A variety of applications, such as Internet services and the return paths of OAM messages, exist and which may have different upstream and downstream bandwidth requirements. [RFC5654] specifies an asymmetric bandwidth requirement in Section 2.1 (General Requirements), and is repeated below:

14. MPLS-TP MUST support bidirectional LSPs with asymmetric bandwidth requirements, i.e., the amount of reserved bandwidth differs between the forward and backward directions.

The approach for supporting asymmetric bandwidth co-routed bidirectional LSPs is defined in [RFC6387].

The method of association and the corresponding Resource reSerVation Protocol (RSVP) ASSOCIATION object are defined in [RFC4872],

[RFC4873] and [RFC6689]. In that context, the ASSOCIATION object is used to associate a recovery LSP with the LSP it is protecting. This object also has broader applicability as a mechanism to associate RSVP states. [RFC6780] defines an Extended ASSOCIATION object that can be more generally applied for this purpose.

This document specifies mechanisms for binding two reverse unidirectional LSPs into an associated bidirectional LSP. The association is achieved by defining new Association Types in the (Extended) ASSOCIATION object. RSVP extensions allow asymmetric upstream and downstream bandwidths for the bidirectional LSP.

## 2. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

## 3. Overview

### 3.1. Provisioning Model Overview

This section provides an overview of the models for provisioning bidirectional LSPs.

The associated bidirectional LSP's forward and reverse unidirectional LSPs are established, monitored, and protected independently as specified by [RFC5654]. Configuration information regarding the LSPs can be provided at one or both endpoints of the associated bidirectional LSP. Depending on the method chosen, there are two models of creating an associated bidirectional LSP; single sided provisioning, and double sided provisioning.

#### 3.1.1. Single Sided Provisioning

For the single sided provisioning, the TE tunnel is configured only on one side. An LSP for this tunnel is initiated by the initiating endpoint with the (Extended) ASSOCIATION object inserted in the Path message. The other endpoint then creates the corresponding reverse TE tunnel and signals the reverse LSP in response to this.

#### 3.1.2. Double Sided Provisioning

For the double sided provisioning, two unidirectional TE tunnels are configured independently on both sides. The LSPs for the tunnels are signaled with (Extended) ASSOCIATION objects inserted in the Path message by both sides to indicate that the two LSPs are to be associated to form a bidirectional LSP.

### 3.2. Association Signaling Overview

This section provides an overview of the association signaling methods for the bidirectional LSPs.

Three scenarios exist for binding two unidirectional LSPs together to form an associated bidirectional LSP. These are: 1) Neither unidirectional LSP exists, and both must be established. 2) Both unidirectional LSPs exist, but the association must be established. 3) One LSP exists, but the reverse associated LSP must be established.

In each of the situations described above, both provisioning models are applicable.

Path Computation Element (PCE)-based approaches [RFC4655], may be used for path computation of an associated bidirectional LSP. However, these approaches are outside the scope of this document.

Consider the topology described in Figure 1 (an example of associated bidirectional LSP). LSP1 from A to B, takes the path A,D,B and LSP2 from B to A takes the path B,D,C,A. These two LSPs, once established and associated, form an associated bidirectional LSP between node A and node B.

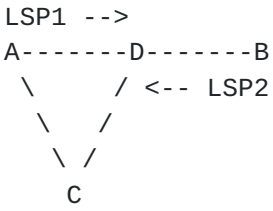



Figure 1: An example of associated bidirectional LSP

#### 3.2.1. Single Sided Provisioning

For the single sided provisioning model, creation of reverse LSP1 is triggered by LSP2 or creation of reverse LSP2 is triggered by LSP1. When creation of reverse LSP2 is triggered by LSP1, LSP1 is provisioned first (or refreshed if LSP1 already exists) at node A. LSP1 is then signaled with an (Extended) ASSOCIATION object inserted in the Path message, in which the Association Type indicating single sided provisioning. Upon receiving this Path message for LSP1, node B establishes reverse LSP2. The (Extended) ASSOCIATION object inserted in LSP2's Path message is the same as that received in LSP1's Path message.

A similar procedure is used if LSP2 is provisioned first at node B and the creation of reverse LSP1 is triggered by LSP2. In both cases, the two unidirectional LSPs are bound together to form an associated bidirectional LSP based on identical (Extended) ASSOCIATION objects in the two LSPs' Path messages.

### 3.2.2. Double Sided Provisioning

For the double sided provisioning model, both LSP1 and LSP2 are signaled independently with (Extended) ASSOCIATION object inserted in the Path message, in which the Association Type indicating double sided provisioning. In this case, the two unidirectional LSPs are bound together to form an associated bidirectional LSP based on identical (Extended) ASSOCIATION objects in the two LSPs' Path messages.

## 3.3. Asymmetric Bandwidth Signaling Overview

This section provides an overview of the methods for signaling asymmetric upstream and downstream bandwidths for the associated bidirectional LSPs.

### 3.3.1. Single Sided Provisioning

New REVERSE_LSP object applicable to the single sided provisioning model is defined in this document, in Section 5.3. When the single sided provisioning model is used, the existing SENDER_TSPEC object is added in the REVERSE_LSP object as a subobject in the initiating LSP's Path message to specify the reverse LSP's traffic parameters. As described in Section 5.3, addition of the REVERSE_LSP object also allows the initiating node to control the reverse LSP.

Consider again the topology described in Figure 1, where the creation of reverse LSP2 is triggered by LSP1. Node A signals LSP1 with the (Extended) ASSOCIATION object with Association Type indicating single sided provisioning and inserts SENDER_TSPEC subobject in the REVERSE_LSP object in the Path message. Node B then establishes the LSP2 in the reverse direction using the asymmetric bandwidth thus specified by LSP1 and allows node A to control the reverse LSP2.

### 3.3.2. Double Sided Provisioning

When the double sided provisioning model is used, the two unidirectional LSPs are established with asymmetric bandwidths independently. However, these LSPs are associated purely based on the identical contents of their (Extended) ASSOCIATION objects.

### 3.4. Recovery LSP Overview

Consider again the topology described in Figure 1, where LSP1 and LSP2 form an associated bidirectional LSP. Under a recovery scenario, a third LSP (LSP3) may be used to protect LSP1 on node A. LSP3 may be established before or after the failure occurs. LSP3 in this case belongs to the same TE tunnel as LSP1 on node A.

When node A detects that LSP1 has failed or needs to be reoptimized, LSP3 is initialized or refreshed with the (Extended) ASSOCIATION object (including the Association Type) inherited from LSP1's Path message. If LSP3 is the protecting LSP [RFC4872], the PROTECTION object [RFC4872] is also inherited from LSP1. In any case, LSP2 and LSP3 are associated to form an associated bidirectional LSP based on the identical (Extended) ASSOCIATION objects in their Path messages.

#### 3.4.1. Single Sided Provisioning

When the single sided provisioning model is used, recovery LSP3 on node A triggers the creation of reverse recovery LSP4 on node B as described in Section 3.2.1 of this document. However, node A and node B perform LSP recovery actions independently [RFC5654].

#### 3.4.2. Double Sided Provisioning

When the double sided provisioning model is used, recovery LSP3 on node A may or may not have associated reverse recovery LSP4 on node B. In any case, node A and node B perform LSP recovery actions independently [RFC5654].

### 3.5. Provisioning For Mesh-Groups

TE mesh-groups are defined in [RFC4972]. In order to enable unambiguous association of the mesh-group's bidirectional LSPs, the information carried in the (Extended) ASSOCIATION object, specifically the contents of the Association Source and Identifier fields are provisioned for the mesh-groups using the models specified in Section 3.1.1 and 3.1.2 of this document, namely, single sided and double sided provisioning.

## 4. Processing Rules

In general, the processing rules for the ASSOCIATION object are as specified in [RFC4872] and Extended ASSOCIATION object are specified in [RFC6780]. Following sections describe the rules for processing (Extended) ASSOCIATION and REVERSE_LSP objects for associated bidirectional LSPs.

### 4.1. ASSOCIATION Object

The ASSOCIATION object is populated using the rules defined below for associating two reverse unidirectional LSPs to form a bidirectional LSP.

Association Types:

In order to bind two reverse unidirectional LSPs to be an associated bidirectional LSP, the Association Type MUST be set to indicate either single sided or double sided LSPs.

The new Association Types are defined as follows:

| Value | Type |
|---|---|
| 4 (TBD) | Double Sided Associated Bidirectional LSPs (D) |
| 5 (TBD) | Single Sided Associated Bidirectional LSPs (A) |

Association ID:

For both single sided and double sided provisioning, Association ID MUST be set to a value assigned by the node that originates the association for the bidirectional LSP.

Association Source:

For double sided provisioning, Association Source MUST be set to an address selected by the node that originates the association for the bidirectional LSP (which may be a management entity.)

For single sided provisioning, Association Source MUST be set to an address assigned to the node that originates the LSP.

### 4.2. Extended ASSOCIATION Object

The Extended ASSOCIATION object is populated using the rules defined below for associating two reverse unidirectional LSPs to form a bidirectional LSP.

The Association Type, Association ID and Association Source MUST be set as defined for the ASSOCIATION object in Section 4.1.

Global Association Source:

For both single sided and double sided provisioning, Global

Association Source, when used, MUST be set to the Global_ID [RFC6370] of the node that originates the association for the bidirectional LSP.

Extended Association ID:

For both single sided and double sided provisioning, Extended Association ID, when used, MUST be set to a value selected by the node that originates the association for the bidirectional LSP.

### 4.3. Rules For ASSOCIATION Object

The ASSOCIATION object is inserted in the Path message of the LSP using the rules defined in this document for associating two reverse unidirectional LSPs to form an associated bidirectional LSP.

For associating two unidirectional LSPs to form a bidirectional LSP, if either Global Association Source or Extended Association Address is required, then an Extended ASSOCIATION object [RFC6780] is inserted in the Path message of the LSP instead of the ASSOCIATION object.

Association Type in the (Extended) ASSOCIATION object MUST be set to the "Single Sided Associated Bidirectional LSPs" or "Double Sided Associated Bidirectional LSPs" based on the single sided or double sided provisioning model used for the LSPs. ASSOCIATION or Extended ASSOCIATION objects with both single sided and double sided Association Types MUST NOT be added in the same Path message.

As described in [RFC6780], association of the LSPs is based on matching ASSOCIATION objects in Path or Resv. Upstream initialized association is represented in (Extended) ASSOCIATION object carried in the Path message and downstream initialized association is represented in (Extended) ASSOCIATION object carried in the Resv message. The new Association Types defined in this document are only used in upstream initialized association. Thus they can appear in the (Extended) ASSOCIATION object in Path message only.

The procedures associated with the processing of the (Extended) ASSOCIATION objects are discussed in [RFC6780]. [RFC6780] specifies that in the absence of Association Type-specific rule for identifying association, the included (Extended) ASSOCIATION objects in the LSPs MUST be identical in order for an association to be formed. This document adds no specific rules for the new Association Types defined, and the determination of LSP association therefore proceeds as specified in [RFC6780].

LSP recovery as defined in [RFC4872] and [RFC4873] is not impacted by

this document. The recovery mechanisms defined in [RFC4872] and [RFC4873] rely on the use of ASSOCIATION objects, but use a different value for Association Type; multiple ASSOCIATION objects MAY exist in the LSP Path message and MAY coexist with the procedures defined in this document.

As specified in [RFC4872], an endpoint node that does not support the new Association Types defined in this document MUST return a PathErr message with the error code "LSP Admission Failure" (value 01 as defined in [RFC2205]) and the sub-code "Bad Association Type" (value 5 as defined in [RFC4872]).

### 4.3.1. Teardown of Associated LSPs

Associated bidirectional LSP teardown follows the standard procedures defined in [RFC3209] and [RFC3473] either without or with the administrative status. Note that teardown procedures of the unidirectional LSPs forming an associated bidirectional LSP are independent of each other, so it is possible that while one LSP follows graceful teardown with administrative status, the reverse LSP is torn down without administrative status (using PathTear/ResvTear/PathErr with state removal).

For the single sided provisioning where the REVERSE_LSP object is not signaled, the teardown of the initiating LSP SHOULD trigger the teardown of the reverse LSP, however, teardown of the reverse LSP MAY NOT trigger the teardown of the initiating LSP (which may depend on the local policy).

For the double sided provisioning, the teardown of one unidirectional LSP SHOULD not trigger teardown of the reverse LSP.

### 4.3.2. Compatibility For ASSOCIATION Object

The ASSOCIATION object has been defined in [RFC4872] and the Extended ASSOCIATION object has been defined in [RFC6780], both with class numbers in the form 11bbbbbb, which ensures compatibility with non-supporting nodes. Per [RFC2205], such nodes will ignore the object but forward it without modification.

Operators wishing to use a function supported by a particular association type SHOULD ensure that the type is supported on any node that is expected to act on the association [RFC6780].

## 4.4. Rules For REVERSE_LSP Object

A node initiating a Path message containing an ASSOCIATION or Extended ASSOCIATION object with the Association Type set to "Single

Sided Associated Bidirectional LSPs" MAY include a REVERSE_LSP object in the Path message of the LSP when it wishes to control the reverse LSP on the other endpoint node and to specify the reverse LSP's traffic parameters.

The REVERSE_LSP subobject MAY contain any of the specified subobjects which the initiating node desires to have included in the Path message for the associated reverse LSP. A REVERSE_LSP object MUST contain at least one subobject.

A node receiving a valid Path message containing a REVERSE_LSP object that is not the endpoint node for the LSP being signaled MUST forward the REVERSE_LSP object unchanged in the outgoing Path message.

The endpoint node upon receiving a Path message containing a REVERSE_LSP object triggers to establish the reverse LSP according to the received parameters in the REVERSE_LSP object. The receiver endpoint node MUST convert the subobjects of the REVERSE_LSP object into the corresponding objects to be carried in the reverse LSP's Path message.

A Path message that does not contain an ASSOCIATION or Extended ASSOCIATION object with the Association Type set to "Single Sided Associated Bidirectional LSPs" MUST NOT contain a REVERSE_LSP object.

### 4.4.1. Teardown of Associated LSPs

If initiating node controlling the reverse LSP using the procedure defined in this document, wishes to tear down the associated bidirectional LSP, the initiating node sends a PathTear message to the other endpoint, the other endpoint MUST trigger to tear down the reverse associated LSP.

### 4.4.2. Compatibility For REVERSE_LSP Object

The REVERSE_LSP object is defined with class numbers in the form 11bbbbbb, which ensures compatibility with non-supporting nodes. Per [RFC2205], such nodes will ignore the object but forward it without modification.

Per [RFC2205], an endpoint node that does not support the REVERSE_LSP C-Type MAY generate an "Unknown object C-Type" error. This error will propagate to the initiating node for standard error processing.

# 5. Message and Object Definitions

## 5.1. RSVP Message Formats

This section presents the RSVP message-related formats as modified by this document. Unmodified RSVP message formats are not listed.

The format of a Path message is as follows:

```
<Path Message> ::= <Common Header> [ <INTEGRITY> ]
                   [ [<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ... ]
                   [ <MESSAGE_ID> ]
                   <SESSION> <RSVP_HOP>
                   <TIME_VALUES>
                   [ <EXPLICIT_ROUTE> ]
                   <LABEL_REQUEST>
                   [ <PROTECTION> ]
                   [ <LABEL_SET> ... ]
                   [ <SESSION_ATTRIBUTE> ]
                   [ <NOTIFY_REQUEST> ... ]
                   [ <ADMIN_STATUS> ]
                   [ <ASSOCIATION> ... ]
                   [ <REVERSE_LSP]
                   [ <POLICY_DATA> ... ]
                   <sender descriptor>
```

The format of the <sender descriptor> is not modified by this document.

## 5.2. ASSOCIATION Object Definition

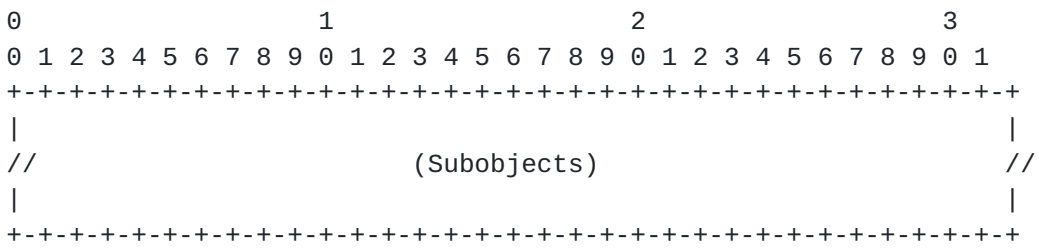
The ASSOCIATION object is defined in [RFC4872]. The Extended ASSOCIATION object is defined in [RFC6780]. Other than the two new Association Types defined in this document, the (Extended) ASSOCIATION object definition is not modified by this document.

## 5.3. REVERSE_LSP Object Definition

### 5.3.1. REVERSE_LSP Object Format

The information of the reverse LSP is specified via the REVERSE_LSP object. This is an optional object carried in a Path message with class numbers in the form 11bbbbbb and has the following format:

Class = TBD (of the form 11bbbbbb), C_Type =  (TBD)




### 5.3.2. REVERSE_LSP Subobjects

The contents of a REVERSE_LSP object is a variable length series of subobjects. The subobjects permitted in the REVERSE_LSP object are previously defined as Path message subobjects, and have the same format and order in the REVERSE_LSP object.

Examples of the Path message subobjects carried in the REVERSE_LSP object are (but not limited to):

- SENDER_TSPEC [RFC2205]
- EXPLICIT_ROUTE object (ERO) [RFC3209]
- SESSION_ATTRIBUTE object [RFC3209]
- ADMIN_STATUS object [RFC3473]
- LSP_ATTRIBUTES object [RFC5420]
- LSP_REQUIRED_ATTRIBUTES object [RFC5420]
- PROTECTION object [RFC3473] [RFC4872]

## 6. IANA Considerations

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

### 6.1. Association Types

New Association Types for ASSOCIATION and Extended ASSOCIATION objects are defined in this document as follows:

| Value | Type |
|---|---|
| 4 (TBD) | Double Sided Associated Bidirectional LSPs (D) |
| 5 (TBD) | Single Sided Associated Bidirectional LSPs (A) |

### 6.2. REVERSE_LSP Object

A new class type for REVERSE_LSP has been requested in the 11bbbbbb range (TBD) with the following definition:

Class Types or C-types (TBD), Value (TBD): REVERSE_LSP Object

There are no other IANA considerations introduced by this document.

## 7. Security Considerations

This document introduces two new Association Types, however, no new security issues relating to the (Extended) ASSOCIATION object are introduced.

The procedures defined in this document result in an increased state information carried in signaling messages. The presence of the REVERSE_LSP object necessarily provides more information about the LSPs. Thus, in the event of the interception of a signaling message, slightly more information about the state of the network could be deduced than was previously the case. This is judged to be a very minor security risk as this information is already available via routing.

Otherwise, this document introduces no additional security considerations. For a general discussion on MPLS and GMPLS related security issues, see the MPLS/GMPLS security framework [RFC5920].

## 8. Acknowledgement

The authors would like to thank Lou Berger and George Swallow for their great guidance in this work, Jie Dong for the discussion of recovery, Lamberto Sterling for his valuable comments on the section of asymmetric bandwidths, Daniel King for the review of the document, Attila Takacs for the discussion of the provisioning model. At the same time, the authors would also like to acknowledge the contributions of Bo Wu, Xihua Fu, Lizhong Jin for the initial discussions, and Wenjuan He for the prototype implementation. The authors would also like to thank Siva Sivabalan, Eric Osborne and Robert Sawaya for the discussions on the ASSOCIATION object. The authors would like to thank Matt Hartley for providing useful suggestions on the document.

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## Authors' Addresses

Fei Zhang (editor)
ZTE

Email: zhang.fei3@zte.com.cn

Ruiquan Jing
China Telecom

Email: jingrq@ctbri.com.cn

Fan Yang
ZTE

Email: yang.fan240347@gmail.com

Weilian Jiang
ZTE

Email: jiang.weilian@gmail.com

Rakesh Gandhi (editor)
Cisco Systems

Email: rgandhi@cisco.com