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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 new Association Types for use in ASSOCIATION and in Extended ASSOCIATION Objects. One of these types enables independent provisioning of the associated bidirectional LSPs on both sides, while the other enables single sided provisioning. The REVERSE_LSP Object is also defined to enable a single endpoint to specify all the parameters of an associated LSP in the single sided provisioning case.

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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.

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 the Extended ASSOCIATION Objects that can be more generally applied for this purpose. This document refers to the [RFC4872] defined ASSOCIATION Objects and the [RFC6780] defined the Extended ASSOCIATION Objects collectively as the (Extended) ASSOCIATION Objects.

This document specifies mechanisms for binding two reverse unidirectional LSPs into an associated bidirectional LSP. The association is achieved by defining new Association Types for use in (Extended) ASSOCIATION Objects. One of these types enables independent provisioning of the associated bidirectional LSPs, while the other enables single sided provisioning. The REVERSE_LSP Object is also defined to enable a single endpoint to specify all the parameters of an associated LSP in the single sided provisioning case. For example, the REVERSE_LSP Object allow asymmetric upstream and downstream bandwidths for the associated 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].

2.1. Definitions

2.1.1. Reverse Unidirectional LSPs

Two reverse unidirectional 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.

2.1.2. Message Formats

This document uses the Routing Backus-Naur Form (RBNF) to define message formats as defined in [RFC5511].

3. Overview

3.1. Provisioning Model Overview

This section provides an overview and definition of the models for provisioning associated 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 Traffic Engineering (TE) tunnel is configured only on one endpoint. 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 using information from the REVERSE_LSP Object if present.

3.1.2. Double Sided Provisioning

For the double sided provisioning, two unidirectional TE tunnels are configured independently, one on each endpoint. The LSPs for the tunnels are signaled with (Extended) ASSOCIATION Objects inserted in the Path message by both endpoints 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 associated 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.

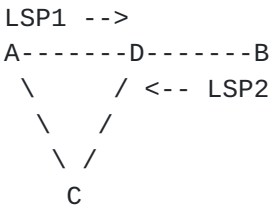


Figure 1: An example of associated bidirectional LSP

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 is included. 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 is included. 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. The LSPs to be selected for the association are provisioned by the management action applied at both endpoints.

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

A new REVERSE_LSP Object for use in the single sided provisioning model is defined in this document, in Section 4.4. When the single sided provisioning model is used, a SENDER_TSPEC object can be added in the REVERSE_LSP Object as a subobject in the initiating LSP's Path message to specify a different bandwidth for the reverse LSP. As described in Section 4.4, addition of the REVERSE_LSP Object also allows the initiating node to control other aspects of the reverse LSP (such as its path) by including other existing objects in a REVERSE_LSP Object.

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 a SENDER_TSPEC subobject for use by LSP2 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 separate bandwidths, which may or may not be identical. However, these LSPs are associated purely based on the identical contents of their (Extended) ASSOCIATION Objects.

3.4. Recovery LSP Overview

Recovery of each unidirectional LSP forming the bidirectional LSP is independent [RFC5654] and is based on the parameters signaled in their respective RSVP Path messages.

Recovery LSP association is based on the identical content of the (Extended) ASSOCIATION Objects signaled in their Path messages during the initial LSP setup for both single sided and double sided provisioning. As defined, see [RFC6780], multiple ASSOCIATION

objects may be present in the signaling of a single LSP.

4. Message and Object Definitions

4.1. 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.

4.2. ASSOCIATION Object

The ASSOCIATION Object is populated using the rules defined below for associating two reverse unidirectional LSPs to form an associated 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
3	Double Sided Associated Bidirectional LSP (D)
4	Single Sided Associated Bidirectional LSP (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:

Association Source MUST be set to an address selected by the node that originates the association for the bidirectional LSP. For example, this may be a management entity, or in the case of single sided provisioning, an address assigned to the node that originates the LSP.

4.3. 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.

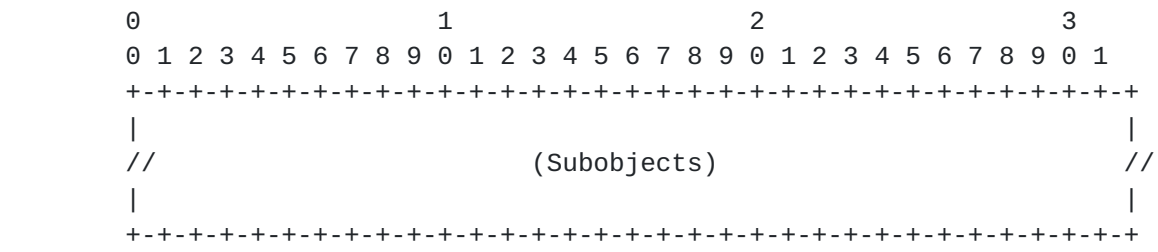
4.4. REVERSE_LSP Object Definition

4.4.1. 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 Number in the form 11bbbbbb and has the following format:

Class_Num = 203, C_Type = 1.



4.4.2. REVERSE_LSP Subobjects

The contents of a REVERSE_LSP Object is a variable length series of subobjects and have the same format as RSVP Objects, see Section 3.1.2 of [RFC2205]. The subobjects permitted in the REVERSE_LSP Object are previously defined as Path message Objects, and have the same order in the REVERSE_LSP Object.

Examples of the Path message objects 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_REQUIRED_ATTRIBUTES Object [RFC5420]
- PROTECTION Object [RFC3473] [RFC4872]

5. 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.

5.1. Rules For ASSOCIATION Object

This section defines the processing for the association of two unidirectional LSPs to form an associated bidirectional LSP. Such association is based on the use of an (Extended) ASSOCIATION Object.

The procedures related to the actual identification of associations between LSPs based on (Extended) ASSOCIATION Objects are defined 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 exist. This document adds no specific rules for the new Association Types defined, and the identification of LSP association therefore proceeds as specified in [RFC6780].

As described in [RFC6780], association of LSPs can be upstream or downstream initiated, as indicated by (Extended) ASSOCIATION Objects in Path or Resv Messages. The association of bidirectional LSPs is always upstream initialized, therefore the Association Types defined in this document are only to be interpreted in Path Messages. These types SHOULD NOT be used in ASSOCIATION Objects carried in Resv messages and SHOULD be ignored if present.

To indicate an associated bidirectional LSP, an ingress node MUST insert an (Extended) ASSOCIATION Object into the Path message of the unidirectional LSP that is part of the associated bidirectional LSP it initiates. If either Global Association Source or Extended Association Address is required, then an Extended ASSOCIATION Object [RFC6780] MUST be inserted in the Path message. Otherwise, an ASSOCIATION Object MAY be used. Only one (Extended) ASSOCIATION Object with the Association Types defined in this document SHOULD be included by an ingress node in an outgoing Path message. (Extended) ASSOCIATION Objects with both single sided and double sided Association Types MUST NOT be added in the same Path message.

The ingress node MUST set the Association Type field in the (Extended) ASSOCIATION Object to "Single Sided Associated Bidirectional LSP" when single sided provisioning is used, and to "Double Sided Associated Bidirectional LSP" when double sided provisioning is used.

A transit node MAY identify the unidirectional LSPs of an associated bidirectional LSP based on (Extended) ASSOCIATION Objects, with the Association Type values defined in this document, carried in Path messages. Clearly, such associations are only possible when the LSPs transit the node. As mentioned above, such associations are made per the rules defined in [RFC6780].

Egress nodes which support the Association Types defined in this document identify the unidirectional LSPs of an associated bidirectional LSP based on (Extended) ASSOCIATION Objects carried in Path messages. Note that an ingress node will normally be the ingress for one of the unidirectional LSPs that make up an associated bidirectional LSP. When an egress node receives a Path message

containing an (Extended) ASSOCIATION Object with one of the Association Types defined in this document, it MUST attempt to identify other LSPs (including ones for which it is an ingress node) with which the LSP being processed is associated. As defined above, such associations are made per the rules defined in [RFC6780]. If the egress node does not support the Association Types defined in this document, it MUST return a PathErr with Error Code "Admission Control Failure (01) [RFC2205]" and Sub-code "Bad Association Type (5) [RFC4872]". An LSP not being associated at the time of signaling (for example, during rerouting or re-optimization) on an egress node is not necessarily considered an error condition.

Associated bidirectional LSP teardown follows the standard procedures defined in [RFC3209] and [RFC3473] either without or with the administrative status. Generally, the 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). See Section 5.3 below for additional rules related to LSPs established using single sided provisioning.

When an LSP signaled with a Path message containing an (Extended) ASSOCIATION Object with an Association Type defined in this document is torn down, the processing node SHALL remove the binding of the LSP to any previously identified associated bidirectional LSP.

No additional processing is needed for Path messages with an (Extended) ASSOCIATION Object containing an Association Type field of Double Sided Associated Bidirectional LSP.

5.1.1. 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].

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 the (Extended) ASSOCIATION Objects, but use a different value for Association Type; multiple ASSOCIATION

Objects can be present in the LSP Path message and can coexist with the procedures defined in this document.

5.2. 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 LSP" MUST include a REVERSE_LSP Object in the Path message of the LSP when it wishes to control the reverse LSP originating on the other endpoint node.

The REVERSE_LSP subobject MAY contain any of the specified objects 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. If there is no subobject to be added in the REVERSE_LSP Object, then the REVERSE_LSP Object MUST NOT be added in the Path message. The REVERSE_LSP Object MUST NOT be included in a REVERSE_LSP Object.

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

An egress node, upon receiving a Path message containing an REVERSE_LSP Object MUST verify that the Path message contains an ASSOCIATION or Extended ASSOCIATION object with the Association Type set to "Single Sided Associated Bidirectional LSP". If it does not, the Path message MUST NOT trigger a reverse LSP. This verification failure SHOULD NOT trigger any RSVP message but can be logged locally, and perhaps reported through network management mechanisms.

Once validated, the egress node MUST use the subobjects contained in any present REVERSE_LSP Objects in the management of the reverse LSP described in the previous section. Note that the contents of a REVERSE_LSP Object may change over the life of an LSP and such changes MUST result in corresponding changes in the reverse LSP. An addition or removal of the REVERSE_LSP Object in the received Path message may cause an egress node to teardown and reestablish a new reverse LSP, or trigger re-optimization or in-place modification of the LSP (which may depend on the local policy).

5.2.1. 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.

5.3. Single Sided Associated Bidirectional LSP Setup and Teardown

An egress node, upon receiving a Path message containing an ASSOCIATION or Extended ASSOCIATION Object with Association Type set to "Single Sided Associated Bidirectional LSP" MUST create an LSP in the reverse direction or reject the Path message. If the creation of a reverse LSP fails, the egress node MUST return a PathErr with Error code "Admission Control Failure (01) [RFC2205]" and Sub-code "Reverse LSP Failure" defined in this document.

If REVERSE_LSP Object is not present in the received Path message of the LSP, the egress node SHOULD use the LSP properties from the received LSP Path message to signal the LSP in the reverse direction (which may depend on the local policy). The teardown of the initiating LSP SHOULD trigger the teardown of the reverse associated LSP, however, teardown of the reverse LSP SHOULD NOT trigger the teardown of the initiating LSP (which may depend on the local policy).

If REVERSE_LSP Object is present in the received Path message of the LSP, the egress node follows the procedure defined in Section 5.2 to setup the reverse LSP. If initiating node controlling the reverse LSP, wishes to teardown the associated bidirectional LSP, the initiating node sends a PathTear message to the egress node, the egress node MUST trigger to teardown the reverse associated LSP, however, teardown of the reverse LSP SHOULD NOT trigger the teardown of the initiating LSP (which may depend on the local policy).

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

IANA maintains the "Generalized Multi-Protocol Label Switching (GMPLS) Signaling Parameters" registry (see http://www.iana.org/assignments/gmpls-sig-parameters). "Association Type" subregistry is included in this registry.

This registry will be updated by new Association Types for ASSOCIATION and Extended ASSOCIATION Objects defined in this document as follows:

Value	Name	Reference
3	Double Sided Associated Bidirectional LSP (D)	Section 4.2
4	Single Sided Associated Bidirectional LSP (A)	Section 4.2

Specified Association Type values are temporary early allocations as per RFC7120.

6.2. REVERSE_LSP Object

IANA maintains the "RSVP Parameters" registry (see http://www.iana.org/assignments/rsvp-parameters/rsvp-parameters.xml). Class Names, Class Numbers, and Class Types subregistry is included in this registry.

This registry will be extended for new Class Number (Class-Num) and Class Type (C-type) for RSVP REVERSE_LSP Object requested in the 11bbbbbb range defined in this document as follows:

Class Number	Class Name	Reference
203	REVERSE_LSP	Section 4.4

- REVERSE_LSP : Class Type or C-type = 1

Specified REVERSE_LSP Class Number and Class Type values are temporary early allocations as per RFC7120.

6.3. Reverse LSP Failure PathErr Sub-code

IANA maintains the "RSVP Parameters" registry (see http://www.iana.org/assignments/rsvp-parameters/rsvp-parameters.xml). Error Codes and Globally-Defined Error Value Sub-Codes subregistry is included in this registry.

This registry will be extended for the new PathErr Sub-code defined in this document as follows:

Error Code = 01: "Admission Control Failure" (see [RFC2205])

- "Admission Control Failure/Reverse LSP Failure" (TBA)

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

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