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**PCEP Extensions for Associated Bidirectional Label Switched
Paths (LSPs) with Stateful PCE
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Abstract

The Path Computation Element Communication Protocol (PCEP) provides mechanisms for Path Computation Elements (PCEs) to perform path computations in response to Path Computation Clients (PCCs) requests.

The Stateful PCE extensions allow stateful control of Multi-Protocol Label Switching (MPLS) Traffic Engineering (TE) Label Switched Paths (LSPs) using PCEP. The Resource Reservation Protocol (RSVP) is used to signal the LSP in the network.

This document defines PCEP extensions for binding two reverse unidirectional RSVP TE LSPs into an Associated Bidirectional Label Switched Path (LSP) when using Stateful PCE for both PCE-Initiated and PCC-Initiated LSPs.

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Table of Contents

1.	Introduction	3
2.	Conventions Used in This Document	4
2.1.	Key Word Definitions	4
2.2.	Terminology	4
3.	Overview	4
3.1.	Single-sided Initiation	4
3.2.	Double-sided Initiation	5
3.3.	Co-routed Associated Bidirectional LSP	5
4.	Protocol Extensions	5
4.1.	Association Object	6
4.2.	Bidirectional LSP Association Group TLV	6
5.	PCEP Procedure	7
5.1.	PCE Initiated LSPs	7
5.2.	PCC Initiated LSPs	7
5.3.	State Synchronization	8
5.4.	Error Handling	8
6.	Security Considerations	8
7.	Manageability Considerations	8
7.1.	Control of Function and Policy	8
7.2.	Information and Data Models	8
7.3.	Liveness Detection and Monitoring	9
7.4.	Verify Correct Operations	9
7.5.	Requirements On Other Protocols	9
7.6.	Impact On Network Operations	9
8.	IANA Considerations	9
8.1.	Association Types	9
8.2.	Bidirectional LSP Association Group TLV	9
8.2.1.	Flag Fields in Bidirectional LSP Association Group TLV	10
8.3.	PCEP Errors	10
9.	Acknowledgments	10
10.	References	11
10.1.	Normative References	11

10.2. Informative References	11
Authors' Addresses	12

1. Introduction

[RFC5440] describes the Path Computation Element Protocol (PCEP) as a communication mechanism between a Path Computation Client (PCC) and a Path Control Element (PCE), or between PCE and PCC, that enables computation of Multi-Protocol Label Switching (MPLS) Traffic Engineering (TE) Label Switched Paths (LSPs).

[I-D.ietf-pce-stateful-pce] specifies extensions to PCEP to enable stateful control of MPLS TE LSPs. It describes two modes of operation - Passive Stateful PCE and Active Stateful PCE. In [I-D.ietf-pce-stateful-pce], the focus is on Active Stateful PCE where LSPs are provisioned on the PCC and control over them is delegated to a PCE. Further [[I-D.ietf-pce-pce-initiated-lsp](#)] describes the setup, maintenance and teardown of PCE-Initiated LSPs for the Stateful PCE model.

[I-D.ietf-pce-association] introduces a generic mechanism to create a grouping of LSPs which can then be used to define associations between a set of LSPs and/or a set of attributes, for example primary and secondary LSP associations, and is equally applicable to the active and passive modes of a Stateful PCE [I-D.ietf-pce-stateful-pce] or a stateless PCE [[RFC5440](#)].

The MPLS Transport Profile (MPLS-TP) requirements document [[RFC5654](#)] specifies that MPLS-TP MUST support associated bidirectional point-to-point LSPs. [[RFC7551](#)] specifies RSVP signaling extensions for binding two reverse unidirectional LSPs into an associated bidirectional LSP.

This document specifies PCEP extensions for binding two reverse unidirectional RSVP-TE LSPs into an Associated Bidirectional LSP for both single-sided and double-sided initiation cases when using Stateful PCE. The PCEP extensions cover the following cases:

- o The forward or reverse LSP of an bidirectional LSP is initiated on a PCC by a Stateful PCE which retains the control of the LSP. The PCE is responsible for computing the path of the LSP and updating the PCC with the information about the path.
- o A PCC initiates the forward or reverse LSP of a bidirectional LSP and retains the control of the LSP. The PCC computes the path and updates the PCE with the information about the path (as long as it controls the LSP).

- o A PCC initiates the forward or reverse LSP of a bidirectional LSP and delegates the control of the LSP to a Stateful PCE. The PCE may compute the path for the LSP and update the PCC with the information about the path (as long as it controls the LSP).

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 [\[RFC2119\]](#).

2.2. Terminology

The reader is assumed to be familiar with the terminology defined in [\[RFC5440\]](#) and [\[RFC7551\]](#).

3. Overview

As shown in Figure 1, two reverse unidirectional LSPs can be associated to form an associated bidirectional LSP. There are two methods of initiating the bidirectional LSP association, single-sided and double-sided as described in the following sections.

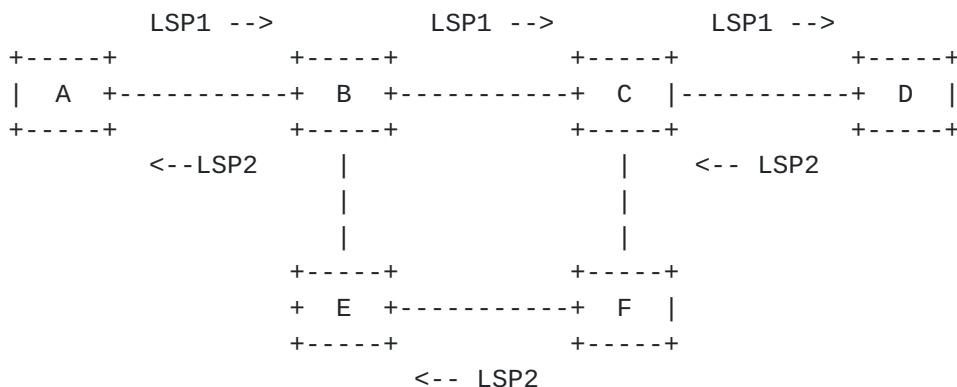


Figure 1: An Example of Associated Bidirectional LSP

3.1. Single-sided Initiation

As specified in [\[RFC7551\]](#), in the single-sided initiation case, the bidirectional tunnel is signaled only on one ingress endpoint node (PCC) of a LSP tunnel. Both forward and reverse LSPs are initiated by the Stateful PCE with the Association Type set to "Single-sided Bidirectional LSP Association" on the originating endpoint node

(PCC). The originating PCC identifies the forward and reverse LSPs in the TLV of the Association Objects.

The originating endpoint node uses the properties for the reverse LSP in the RSVP REVERSE_LSP Object [RFC7551] of the forward LSP Path message. The remote endpoint then creates the corresponding reverse tunnel and signals the reverse LSP in response to the received RSVP Path message. The two unidirectional reverse LSPs on the originating endpoint node are bound together using the PCEP signaled Association Objects and on the remote endpoint node by the RSVP signaled Association Objects.

As shown in Figure 1, the forward LSP LSP1 and the reverse LSP LSP2 are initiated on the originating endpoint node A by the PCE. The creation of reverse LSP2 on the remote endpoint node D is triggered by the RSVP signaled LSP1.

3.2. Double-sided Initiation

As specified in [RFC7551], in the double-sided initiation case, the bidirectional LSP is signaled by both endpoint nodes (PCCs) of the tunnel. The forward and reverse LSPs for this tunnel are initiated by the Stateful PCE with Association Type set to "Double-sided Bidirectional LSP Association" on both ingress PCCs. The two reverse unidirectional LSPs on both PCCs are bound together by using the PCEP signaled Association Objects.

As shown in Figure 1, LSP1 is initiated on the endpoint node A and LSP2 is initiated on the endpoint node D, both by the PCE.

3.3. Co-routed Associated Bidirectional LSP

In both single-sided and double-sided initiation cases, forward and reverse LSPs may be co-routed as shown in Figure 2, where both forward and reverse LSPs follow the same congruent path.

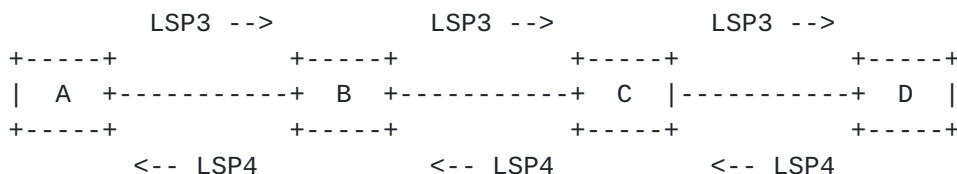


Figure 2: An Example of Co-routed Associated Bidirectional LSP

4. Protocol Extensions

4.1. Association Object

As per [[I-D.ietf-pce-association](#)], LSPs are associated by adding them to a common association group. This document defines new Bidirectional LSP Association Groups to be used by the associated bidirectional LSPs. A member of the Bidirectional LSP Association Group can take the role of a forward or reverse LSP. The reverse LSP source address MUST be the destination address of the forward LSP and destination address MUST be the source address of the forward LSP within a bidirectional LSP association group.

This document defines two new Association Types for the Association Object as follows:

- o Association Type (TBD1) = Single-sided Bidirectional LSP Association Group
- o Association Type (TBD2) = Double-sided Bidirectional LSP Association Group

The Association ID, Association Source, optional Global Association Source and optional Extended Association ID in the Bidirectional LSP Association Group Object are initiated by the Stateful PCE using the procedures defined in [[RFC7551](#)].

4.2. Bidirectional LSP Association Group TLV

The Bidirectional LSP Association Group TLV is an optional TLV for use with the Bidirectional LSP Association Object Type.

- o The Bidirectional LSP Association Group TLV follows the PCEP TLV format from [[RFC5440](#)].
- o The type (16 bits) of the TLV is TBD3, to be assigned by IANA.
- o The length is 4 Bytes.
- o The value comprises of a single field, the Bidirectional LSP Association Flags (32 bits), where each bit represents a flag option.
- o If the Bidirectional LSP Association Group TLV is missing, it means the LSP is the forward LSP.
- o The Bidirectional LSP Association Group TLV MUST NOT be present more than once. If it appears more than once, only the first occurrence is processed and any others MUST be ignored.

The format of the Bidirectional LSP Association Group TLV is shown in Figure 3:

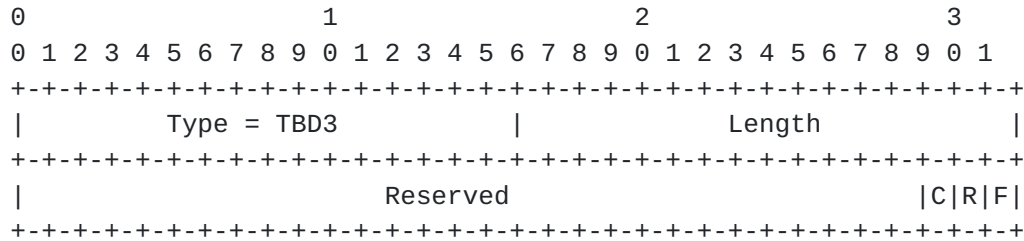


Figure 3: Bidirectional LSP Association Group TLV format

Bidirectional LSP Association Flags are defined as following.

F (Forward LSP, 1 bit) - Indicates whether the LSP associated is the forward LSP of the bidirectional LSP. If this flag is set, the LSP is a forward LSP.

R (Reverse LSP, 1 bit) - Indicates whether the LSP associated is the reverse LSP of the bidirectional LSP. If this flag is set, the LSP is a reverse LSP.

C (Co-routed LSP, 1 bit) - Indicates whether the bidirectional LSP is co-routed. If this flag is set, the associated bidirectional LSP is co-routed.

The Reserved flags MUST be set to 0 when sent and ignore when received.

When an associated bidirectional LSP is delegated to a Stateful PCE, the C flag is used by the PCE to compute paths of the forward and reverse LSPs those are co-routed.

5. PCEP Procedure

5.1. PCE Initiated LSPs

As specified in [[I-D.ietf-pce-association](#)], Association Groups can be created by both PCE and PCC.

A PCE can create and update the forward and reverse LSPs independently for both Single-sided and Double-sided bidirectional LSP association groups.

5.2. PCC Initiated LSPs

A PCC can associate or remove an LSP under its control from the bidirectional LSP association group. The PCC must report the change in association to PCE(s) via PCRpt message.

5.3. State Synchronization

During state synchronization, a PCC MUST report all the existing bidirectional LSP association groups to PCE(s). Following the state synchronization, the PCE MUST remove all stale associations.

5.4. Error Handling

The reverse LSP in the bidirectional LSP association group MUST have the source address matching the destination address of the forward LSP and destination address matching the source address of the forward LSP. If a PCE attempts to add an LSP to a bidirectional LSP association group not complying to this rule, the PCC for the single-sided initiation case MUST send PCErr with Error-Type= TBD4 (Bidirectional LSP Association Error) and Error-Value = 1 (Endpoints mismatch). Similarly, if a PCC attempt to add an LSP to a bidirectional LSP association group at PCE not complying to this rule, the PCE for both single-sided and double-sided initiated bidirectional LSPs MUST send this PCErr.

6. Security Considerations

This document introduces two new Association Types for the Association Object, Double-sided Bidirectional LSP Association Group and Single-sided Associated Bidirectional LSP Group. These types, by themselves, introduce no additional security concerns beyond those discussed in [\[RFC5440\]](#), [\[I-D.ietf-pce-stateful-pce\]](#) and [\[I-D.ietf-pce-association\]](#).

7. Manageability Considerations

7.1. Control of Function and Policy

An operator MUST be allowed to provision the bidirectional LSP association parameters at PCEP peers.

7.2. Information and Data Models

A Management Information Base (MIB) module for modeling PCEP is described in [\[RFC7420\]](#). However, one may prefer the mechanism for configuration using YANG data model [\[I-D.pce-pcep-yang\]](#). These SHOULD be enhanced to provide controls and indicators for support of

the associated bidirectional LSP feature. Support for various configuration knobs as well as counters of messages sent/received containing the TLVs (defined in this document) SHOULD be added.

7.3. Liveness Detection and Monitoring

Mechanisms defined in this document do not imply any new liveness detection and monitoring requirements in addition to those already listed in [[RFC5440](#)].

7.4. Verify Correct Operations

Mechanisms defined in this document do not imply any new operation verification requirements in addition to those already listed in [[RFC5440](#)].

7.5. Requirements On Other Protocols

Mechanisms defined in this document do not add any new requirements on other protocols.

7.6. Impact On Network Operations

Mechanisms defined in this document do not have any new impact on network operations.

8. IANA Considerations

8.1. Association Types

This document defines the following Association Types for the Association Object defined [[I-D.ietf-pce-association](#)].

Value	Name	Reference

TBD1	Single-sided Bidirectional LSP Association Group	[This I.D.]
TBD2	Double-sided Bidirectional LSP Association Group	[This I.D.]

8.2. Bidirectional LSP Association Group TLV

This document defines a new TLV for carrying additional LSP information for the Bidirectional LSP Association Group TLV as following:

TLV-Type	Name	Reference

TBD3	Bidirectional LSP Association Group TLV	[This I.D.]

8.2.1. Flag Fields in Bidirectional LSP Association Group TLV

This document requests that a new sub-registry, named "Bidirectional LSP Association Group TLV Flag Field", is created within the "Path Computation Element Protocol (PCEP) Numbers" registry to manage the Flag field in the Bidirectional LSP Association Group TLV.

New values are to be assigned by Standards Action [[RFC5226](#)]. Each bit should be tracked with the following qualities:

- o Bit number (counting from bit 0 as the most significant bit)
- o Capability description
- o Defining RFC

The following values are defined in this document for the Flag field.

Bit	Description	Reference

31	F - Forward LSP	[This I.D.]
30	R - Reverse LSP	[This I.D.]
29	C - Co-routed LSP	[This I.D.]

8.3. PCEP Errors

This document defines new Error-Type and Error-Value related to bidirectional LSP association as following.

Error-Type	Description	Reference

TBD4	Bidirectional LSP Association Error	[This I.D.]
	Error-value=1: Endpoints mismatch	[This I.D.]

9. Acknowledgments

TBA.

10. References

10.1. Normative References

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