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PCEP Extension for Segment Routing (SR) Bi-directional Associated Paths  
[draft-li-pce-sr-bidir-path-01](#)

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 Multiprotocol Label Switching (MPLS) Traffic Engineering (TE) Label Switched Paths (LSPs) using PCEP. Furthermore, PCEP can be used for computing paths in SR networks.

This document defines PCEP extensions for grouping two reverse unidirectional SR Paths into an Associated Bidirectional SR path when using a Stateful PCE for both PCE-Initiated and PCC-Initiated LSPs as well as when using a Stateless PCE.

Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [BCP 14](#) [[RFC2119](#)] [[RFC8174](#)] when, and only when, they appear in all capitals, as shown here.

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## **1. Introduction**

Segment routing (SR) [[RFC8402](#)] leverages the source routing and tunneling paradigms. SR supports to steer packets into an explicit forwarding path at the ingress node.

[RFC5440] describes the Path Computation Element (PCE) Communication Protocol (PCEP). PCEP enables the communication between a Path Computation Client (PCC) and a PCE, or between PCE and PCE, for the purpose of computation of Multiprotocol Label Switching (MPLS) as well as Generalized MPLS (GMPLS) Traffic Engineering Label Switched Path (TE LSP) characteristics.

[RFC8231] specifies a set of extensions to PCEP to enable stateful control of TE LSPs within and across PCEP sessions in compliance with [[RFC4657](#)]. It includes mechanisms to effect LSP State Synchronization between PCCs and PCEs, delegation of control over LSPs to PCEs, and PCE control of timing and sequence of path computations within and across PCEP sessions. The model of operation where LSPs are initiated from the PCE is described in [[RFC8281](#)].

[I-D.ietf-pce-segment-routing] specifies extensions to the Path Computation Element Protocol (PCEP) [[RFC5440](#)] for SR networks, that allow a stateful PCE to compute and initiate SR-TE paths, as well as a PCC to request, report or delegate SR paths.

[[I-D.negi-pce-segment-routing-ipv6](#)] extend PCEP to support SR for IPv6 data plane.

[I-D.ietf-pce-association-group] 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 [[RFC8231](#)] or a stateless PCE [[RFC5440](#)].

Currently, SR network only supports uni-directional path, but the bidirectional SR path is required in some scenarios, for example, mobile backhaul transport network. The requirement of SR bidirectional path is specified in [[I-D.cheng-spring-mpls-path-segment](#)].

[I-D.ietf-pce-association-bidir] defines PCEP extensions for grouping two reverse unidirectional MPLS TE LSPs into an Associated Bidirectional LSP when using a Stateful PCE for both PCE-Initiated and PCC-Initiated LSPs as well as when using a Stateless PCE.



This document extends the bidirectional association to segment routing by specifying PCEP extensions for grouping two reverse unidirectional SR paths into a bi-directional SR path.

[I-D.ietf-pce-association-bidir] specify the Double-sided Bidirectional procedure, where the PCE creates the association and provisions at the both ends, the RSVP-TE does the signaling to the egress the status of the forward LSP and the ingress about the reverse LSP. Thus the both ends learn both the LSPs forming the bi-directional association. In case of SR, to support the bi-directional use-case, this is done via the PCEP protocol itself as described in [Section 3.1](#). This is done so that both ends are aware of the path segment/ID used by each of the uni-directional LSP, as well as the status, the ERO etc.

[I-D.li-pce-sr-path-segment] defines a procedure for path ID in PCEP for SR by defining the PATH-ID TLV. The path ID can be a path segment in SR-MPLS [[I-D.cheng-spring-mpls-path-segment](#)], or a path ID in SRv6 [[I-D.li-spring-passive-pm-for-srv6-np](#)], or other IDs that can identify an SR path. The PATH-ID SHOULD be included for associated bidirectional SR paths.

## 2. Terminology

This memo makes use of the terms defined in [[I-D.ietf-pce-segment-routing](#)]. The reader is assumed to be familiar with the terminology defined in [[RFC5440](#)], [[RFC8231](#)], [[RFC8281](#)], [[I-D.ietf-pce-association-group](#)] and [[I-D.ietf-pce-association-bidir](#)].

## 3. PCEP Extension for Bi-directional SR Path

As per [[I-D.ietf-pce-association-group](#)], LSPs are associated by adding them to a common association group.

[[I-D.ietf-pce-association-bidir](#)] specifies PCEP extensions for grouping two reverse unidirectional MPLS-TE LSPs into an Associated Bidirectional LSP for both single-sided and double-sided initiation cases by defining two new Bidirectional LSP Association Groups.

This document extends the procedure for SR bidirectional associated paths by defining a new bidirectional association type (i.e. Double-sided Bi-directional SR Path Association Group). The document further describe the mechanism of associating two unidirectional SR path into a bidirectional SR path. [[I-D.li-pce-sr-path-segment](#)] defines a procedure for path ID in PCEP for SR by defining the PATH-ID TLV. The bidirectional SR path MUST also use the PATH-ID TLV.



Note that a new association type is created by this document to create new procedures applicable to SR-path (and are quite different to the RSVP-TE bi-directional association groups).

### **3.1. Double-sided Bidirectional SR Path Association Group Object**

As defined in [[I-D.ietf-pce-association-bidir](#)], two LSPs are associated as a bi-directional MPLS-TE LSP by a common bi-directional LSP association group. For associating two SR paths, this document defines a new association group called 'Double-sided Bidirectional SR Path Association Group' as follows:

- o Association Type (TBD1 to be assigned by IANA) = Double-sided Bidirectional SR Path Association Group

Similar to other bidirectional associations, this Association Type is operator-configured in nature and statically created by the operator on the PCEP peers. The paths belonging to this association is conveyed via PCEP messages to the PCEP peer. Operator-configured Association Range TLV [[I-D.ietf-pce-association-group](#)] MUST NOT be sent for these Association Types, and MUST be ignored, so that the entire range of association ID can be used for them. The handling of the Association ID, Association Source, optional Global Association Source and optional Extended Association ID in this association are set in the same way as [[I-D.ietf-pce-association-bidir](#)].

A member of the Double-sided Bi-directional SR Path Association Group can take the role of a forward or reverse SR path and follows the rules similar to the rules defined in [[I-D.ietf-pce-association-bidir](#)] for LSPs.

- o An SR path (forward or reverse) can not be part of more than one Double-sided Bi-directional SR Path Association Group.
- o The endpoints of the SR paths in this associations cannot be different.

For describing the SR paths in this association group, such as direction and co-routed information, this association group reuses the Bi-directional LSP Association Group TLV defined in [[I-D.ietf-pce-association-bidir](#)]. All fields and processing rules are as per [[I-D.ietf-pce-association-bidir](#)].

## **4. Bi-directional Flag**

As defined in [[RFC5440](#)], the B-flag in RP object MUST be set when the PCC specifies that the path computation request relates to a bi-directional TE LSP. In this document, the B-flag also MUST be set





when the PCC specifies that the path computation request relates to a bi-directional SR path. When a stateful PCE initiates or updates a bi-directional SR paths including LSPs and SR paths, the B-flag in SRP object [[I-D.ietf-pce-pcep-stateful-pce-gmpls](#)] may be set as well.

## **5. Procedures of Bi-directional Path Computation**

Two uni-directional SR paths can be associated by the association group object as specified in [[I-D.ietf-pce-association-group](#)]. A bidirectional LSP association group object is defined in [[I-D.ietf-pce-association-bidir](#)] (for MPLS-TE). This documents extends the mechanism for bidirectional SR paths. Two SR paths can be associated together by including the Bi-directional SR Path Association Group in the PCEP messages. The PATH-ID TLV [[I-D.li-pce-sr-path-segment](#)] SHOULD also be included in the LSP object for these SR paths.

There is also a need to include the reverse direction path in the PCEP messages, to do this the PCE SHOULD inform the reverse SR path to the ingress PCC and vice versa. To achieve this a PCInitiate message for the reverse SR path is sent to the ingress PCC and a PCInitiate message for the forward SR path is sent to the egress PCC (with the same association group). These PCInitiate message MUST NOT trigger initiation of SR paths. The information of reverse direction path can be used for several scenarios, such as directed BFD [[I-D.ietf-mpls-bfd-directed](#)].

### **5.1. PCE Initiated SR Paths**

As specified in [[I-D.ietf-pce-association-group](#)] Bidirectional SR Association Group can be created by a Stateful PCE.

- o Stateful PCE can create and update the forward and reverse SR path independently for Double-sided Bi-directional SR Path Association Groups.
- o Stateful PCE can establish and remove the association relationship on a per SR path basis.
- o Stateful PCE can create and update the SR path and the association on a PCC via PCInitiate and PCUpd messages, respectively, using the procedures described in [[I-D.ietf-pce-association-group](#)].
- o The Path-ID TLV SHOULD be included for each SR path in the LSP object.



- o The opposite direction SR path (LSP2(R) at S, LSP1(F) at D ) SHOULD be informed via PCInitiate message with the matching association group.

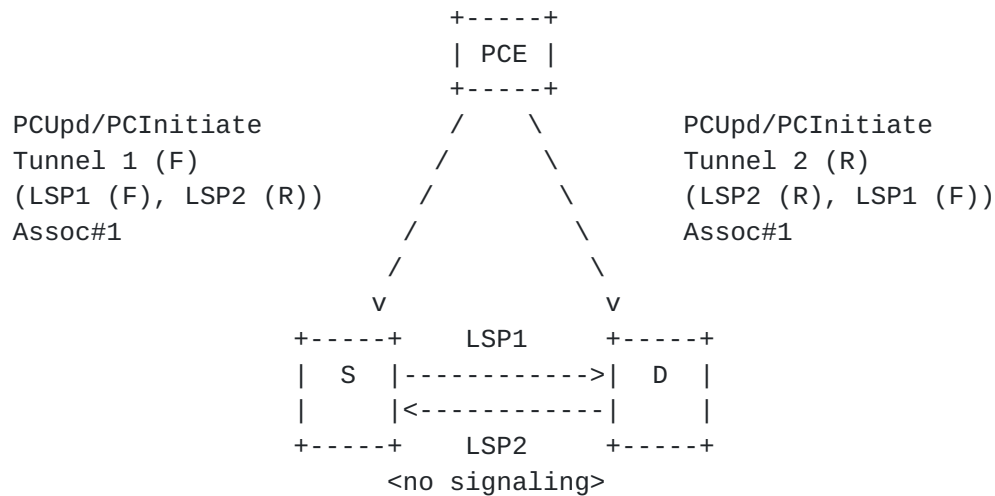


Figure 1: PCE-Initiated Double-sided Bidirectional SR Path

## 5.2. PCC Initiated SR Paths

As specified in [[I-D.ietf-pce-association-group](#)] Bidirectional SR Association Group can also be created by a PCC.

- o PCC can create and update the forward and reverse SR paths independently for Double-sided Bi-directional SR Path Association Groups.
- o PCC can establish and remove the association relationship on a per SR path basis.
- o PCC MUST report the change in the association group of an SR path to PCE(s) via PCRpt message.
- o PCC can report the forward and reverse SR paths independently to PCE(s) via PCRpt message.
- o PCC can delegate the forward and reverse SR paths independently to a Stateful PCE, where PCE would control the SR paths.
- o Stateful PCE can update the SR paths in the Double-sided Bi-directional SR Path Association Group via PCUpd message, using the procedures described in [[I-D.ietf-pce-association-group](#)].



- o The Path-ID TLV MUST be handled as defined in [\[I-D.li-pce-sr-path-segment\]](#).
- o The opposite direction SR path (LSP2(R) at S, LSP1(F) at D ) SHOULD be informed via PCInitiate message with the matching association group.

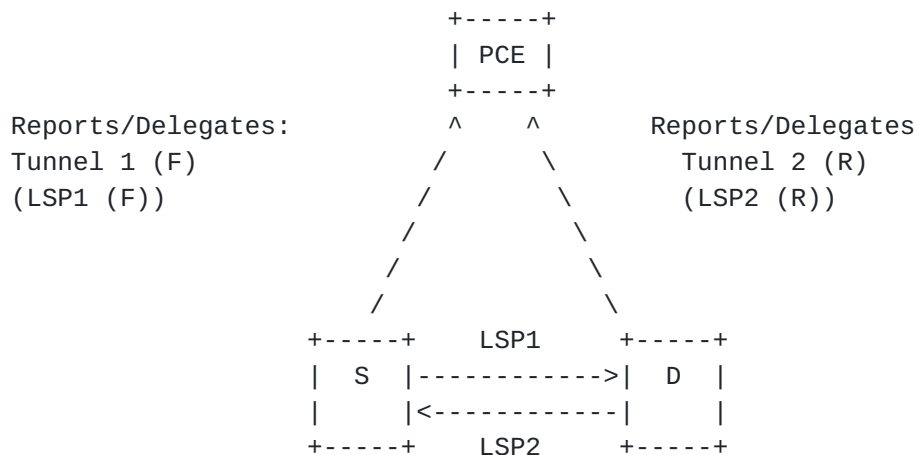


Figure 2a: PCC-Initiated Double-sided Bidirectional SR Path

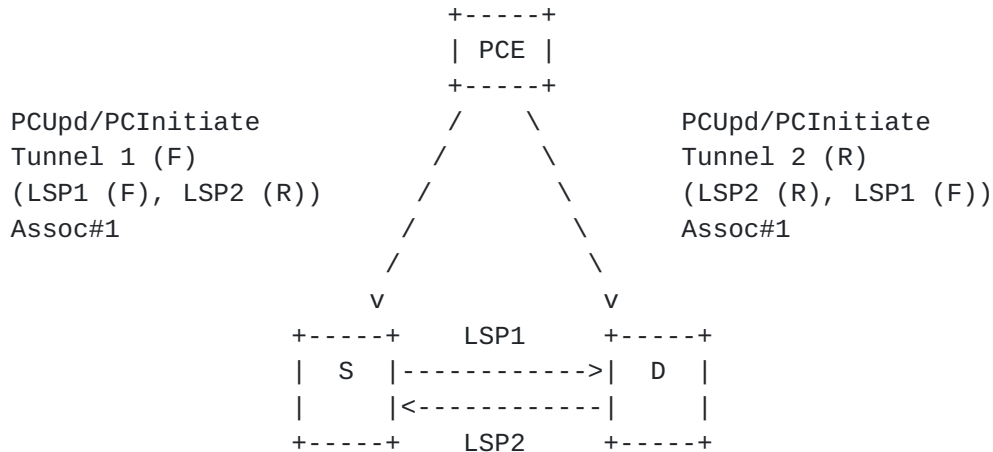


Figure 2b: PCC-Initiated Double-sided Bidirectional SR Path along with opposite direction SR path

### 5.3. Error Handling

The error handling as described in section 5.5 of [\[I-D.ietf-pce-association-bidir\]](#) continue to apply.

The Path Setup Type (PST) MUST be set to SR for the LSP belonging to the 'Double-sided Bidirectional SR Path Association Group', in case a



PCEP speaker receives a different PST value, it MUST send an PCErr message with Error-Type = 29 (Early allocation by IANA) (Association Error) and Error-Value = TBD2 (Bidirectional LSP Association - PST Mismatch).

## 6. IANA Considerations

### 6.1. Association Type

This document adds a new Association Type for the Association Object defined [[I-D.ietf-pce-association-group](#)]. IANA is requested to make the assignment of a value for the sub-registry "ASSOCIATION Type Field" (to be created in [[I-D.ietf-pce-association-group](#)]), as follows:

| Value | Name  | Reference     |
|-------|---|---------------|
| ----- |   |               |
| TBD1  | Double-sided Bidirectional<br>SR Path Association Group | This document |

### 6.2. PCEP Errors

This document defines new Error value for Error Type 29 (Association Error). IANA is requested to allocate new Error value within the "PCEP-ERROR Object Error Types and Values" sub-registry of the PCEP Numbers registry, as follows:

| Error Type | Description                                  | Reference     |
|------------|--|---------------|
| -----      |  |               |
| 29         | Association Error                            |               |
|            | Error value: TBD2                            | This document |
|            | Bidirectional LSP Association - PST Mismatch |               |

## 7. Security Considerations

The security considerations described in [[RFC5440](#)], [[RFC8231](#)], [[RFC8281](#)], and [[I-D.ietf-pce-segment-routing](#)] apply to the extensions defined in this document as well.

A new Association Type for the Association Object, Double-sided Associated Bidirectional SR Path Association Group are introduced in this document. Additional security considerations related to LSP associations due to a malicious PCEP speaker is described in [[I-D.ietf-pce-association-group](#)] and apply to these Association Types. Hence, securing the PCEP session using Transport Layer Security (TLS) [[RFC8253](#)] is recommended.





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