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PCEP Extensions for Associated Bidirectional Segment Routing (SR) Paths
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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. Segment routing (SR) leverages the source routing and tunneling paradigms. The Stateful PCEP extensions allow stateful control of Segment Routing (SR) Traffic Engineering (TE) Paths. Furthermore, PCEP can be used for computing SR TE paths in the network.

This document defines PCEP extensions for grouping two unidirectional SR Paths (one in each direction in the network) into a single Associated Bidirectional SR Path. The mechanisms defined in this document can also be applied using a Stateful PCE for both PCE-Initiated and PCC-Initiated LSPs, as well as when using a Stateless PCE.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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1. Introduction

Segment routing (SR) [RFC8402] leverages the source routing and tunneling paradigms. SR supports steering packets onto an explicit forwarding path at the ingress node. SR is specified for unidirectional paths. However, some applications require bidirectional paths in SR networks, for example, in mobile backhaul transport networks. The requirement for bidirectional SR Paths is specified in [I-D.ietf-spring-mpls-path-segment].

[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 Traffic Engineering (TE) Label Switched Paths (LSP). [RFC8231] specifies a set of extensions to PCEP to enable stateful control of TE LSPs within and across PCEP sessions. The mode of operation where LSPs are initiated from the PCE is described in [RFC8281].

[RFC8408] 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 them.

[RFC8697] 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, and is equally applicable to the active and passive modes of a Stateful PCE [RFC8231] or a stateless PCE [RFC5440].

[I-D.ietf-pce-association-bidir] defines PCEP extensions for grouping two unidirectional RSVP-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. It specifies the procedure for Double-sided Bidirectional LSP Association, where the PCE creates the association and provisions the forward LSPs at their ingress nodes. The RSVP-TE signals the forward LSPs to the egress nodes. Thus, both endpoints learn the reverse LSPs forming the bidirectional LSP association.

This document extends the bidirectional LSP association to SR by specifying PCEP extensions for grouping two unidirectional SR Paths into a bidirectional SR Path. For bidirectional SR, there are use cases such as directed BFD [I-D.ietf-mpls-bfd-directed] and SR performance measurement [I-D.gandhi-spring-twamp-srpm] those require

PCC to be aware of the reverse direction SR path. For such use-cases, the reverse SR paths are also communicated to the ingress nodes using the PCEP extensions defined in this document. This allows both endpoints to be aware of SR Paths in both directions, including their status and all other path related information.

2. Terminology

This document makes use of the terms defined in [RFC8408]. The reader is assumed to be familiar with the terminology defined in [RFC5440], [RFC8231], [RFC8281], [RFC8697], and [I-D.ietf-pce-association-bidir].

2.1. 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.

3. PCEP Extensions

As per [RFC8697], TE LSPs are associated by adding them to a common association group by a PCEP peer. [I-D.ietf-pce-association-bidir] uses the the association group object and the procedures as specified in [RFC8697] to group two unidirectional RSVP-TE LSPs. Similarly, two SR Paths can also be associated using similar technique. This document extends these association mechanisms for bidirectional SR Paths. Two unidirectional SR Paths (one in each direction in the network) can be associated together by using the Bidirectional SR Path Association Group defined in this document for PCEP messages.

Note that the association group defined in this document is specific to the bidirectional SR Paths. The procedure for this association group is different than the RSVP-TE bidirectional association groups defined in [I-D.ietf-pce-association-bidir].

[I-D.ietf-pce-sr-path-segment] defines a mechanism for communicating Path Segment Identifier (PSID) in PCEP for SR. The PSID is defined for SR-MPLS in [I-D.ietf-spring-mpls-path-segment]. The PSID can be used for identifying an SR Path of an associated bidirectional SR Path. The PATH-SEGMENT TLV MAY be included for each SR Path in the LSP object to support required use-cases. The PATH-SEGMENT TLV MUST be handled as defined in [I-D.ietf-pce-sr-path-segment] and is not modified for associated bidirectional SR Path.

3.1. Double-sided Bidirectional SR Path Association Group

For associating two unidirectional SR paths, this document defines a new Association Type called 'Double-sided Bidirectional SR Path Association Group' for Association Group Object (Class-Value 40) as follows:

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

Similar to RSVP-TE bidirectional LSP 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 [RFC8697] 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 Bidirectional SR Path Association Group' can take the role of a forward or reverse SR Path and follow the similar rules defined in [I-D.ietf-pce-association-bidir] for LSPs.

- An SR Path (forward or reverse) cannot be part of more than one 'Double-sided Bidirectional SR Path Association Group'.

- The endpoints of the SR Paths in this associations cannot be different.

3.1.1. Bidirectional LSP Association Group TLV

In Bidirectional SR Association Group, for properties such as forward and reverse direction and co-routed path, it uses the Bidirectional 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. PCEP Procedures

For bidirectional SR path, an ingress PCC is aware of the forward direction SR path beginning from itself to the egress PCC using the existing PCEP procedures. For the use-cases which require the ingress PCC to be aware of the reverse direction SR path, PCE informs the reverse SR Path to the ingress PCC. 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 matching association group). These PCInitiate message MUST NOT trigger initiation of SR Paths on PCCs.

For a bidirectional LSP computation when using both direction LSPs on a node, the same LSP would need to be identified using 2 different PLSP-IDs based on the PCEP session to the ingress or the egress node. Note that the PLSP-ID space is independent at each PCC, the PLSP-ID allocated by the egress PCC cannot be used for the LSP at the ingress PCC (PLSP-ID conflict may occur). As per normal PCInitiate operations, PCC assigns the PLSP-IDs for the local LSPs. Hence, when the PCE notifies an ingress PCC of the reverse LSP, it does so by using PCInitiate operations and sets PLSP-ID to zero and sets the R bit in the Bidirectional LSP Association Group TLV in the association object to indicate that this PCInitiate LSP is a reverse LSP. The PCC upon receiving the PCInitiate MUST locally assign a new PLSP-ID and it MUST issue a PCRpt to PCE for this LSP containing the new PLSP-ID. This reverse direction LSP MUST NOT be instantiated on the PCC.

In other words, a given LSP will be identified by PLSP-ID A at the ingress node while it will be identified by PLSP-ID B at the egress node. The PCE will maintain two PLSP-IDs for the same LSP. For example, ingress PCC1 may report to PCE an LSP1 with PLSP-ID 100. Egress PCC2 may report to PCE an LSP2 with PLSP-ID 200. Both of these LSPs are part of a bidirectional association. When PCE notifies PCC1 of the reverse direction LSP2, it does so by sending a PCInitiate to PCC1 with PLSP-ID set to zero and R bit set in the Bidirectional LSP Association Group TLV. PCC1 upon reception of this generates a new PLSP-ID (example PLSP-ID 300) and issues a PCRpt to PCE. Thus there would two PLSP-ID associated for LSP2 (300 at PCC1 and 200 at PCC2).

4.1. PCE Initiated Associated Bidirectional SR Paths

As specified in [RFC8697], Bidirectional SR Path Association Group can be created by a Stateful PCE as shown in Figure 1.

- Stateful PCE can create and update the forward and reverse SR Paths independently for 'Double-sided Bidirectional SR Path Association Group'.

- Stateful PCE can establish and remove the association relationship on a per SR Path basis.

- 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 [RFC8697].

- The reverse direction SR Path (LSP2(R) at node S, LSP1(R) at node D as shown in Figure 1) SHOULD be informed by the PCE via PCInitiate message with the matching association group for the use-cases which require the PCC to be aware of the reverse direction SR path.

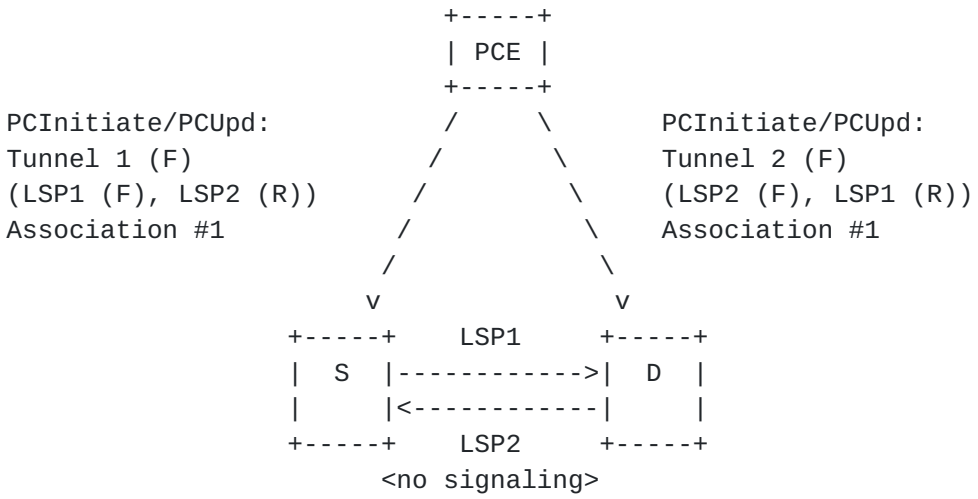

Figure 1: PCE-Initiated Double-sided Bidirectional SR Path with Forward and Reverse Direction SR Paths

4.2. PCC Initiated Associated Bidirectional SR Paths

As specified in [RFC8697], Bidirectional SR Path Association Group can also be created by a PCC as shown in Figure 2a and 2b.

- PCC can create and update the forward SR Path and update the reverse SR Path independently for a 'Double-sided Bidirectional SR Path Association Group'.

- PCC cannot instantiate a reverse SR Path in a bidirectional SR Path.

- PCC can establish and remove the association relationship on a per SR Path basis.

- PCC MUST report the change in the association group of an SR Path to PCE(s) via PCRpt message.

- PCC can report the forward and reverse SR Paths independently to PCE(s) via PCRpt message.

- PCC can delegate the forward and reverse SR Paths independently to a Stateful PCE, where PCE would control the SR Paths.

- Stateful PCE can update the SR Paths in the 'Double-sided Bidirectional SR Path Association Group' via PCUpd message, using the procedures described in [RFC8697].

- The reverse direction SR Path (LSP2(R) at node S, LSP1(R) at node D as shown in Figure 2b) SHOULD be informed by the PCE via PCInitiate message with the matching association group for the use-cases which require the PCC to be aware of the reverse direction SR path.

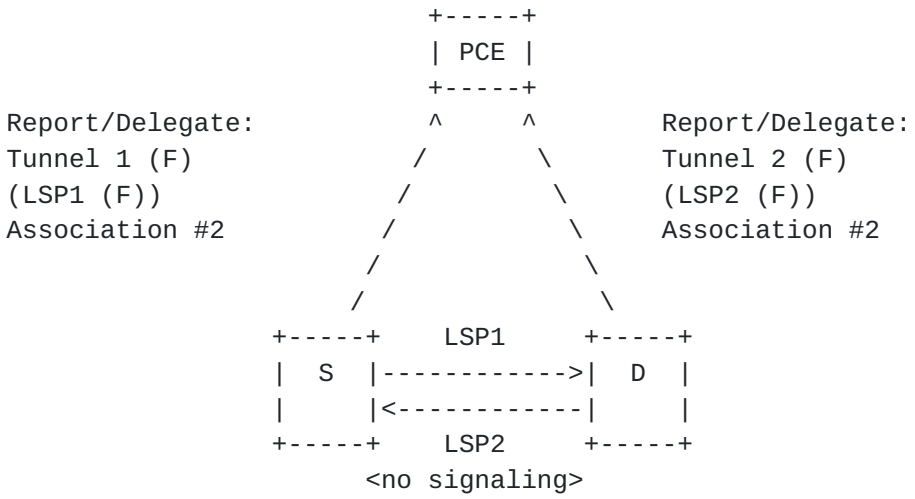

Figure 2a: Step 1: PCC-Initiated Double-sided Bidirectional SR Path with Forward Direction SR Paths

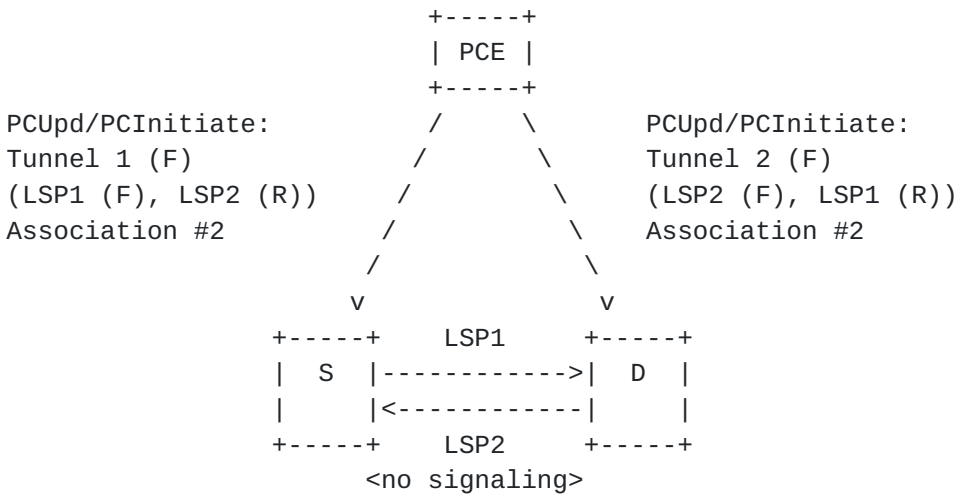

Figure 2b: Step 2: PCE-Updated/Initiated Double-sided Bidirectional SR Path with Reverse Direction SR Paths

4.3. Stateless PCE

As defined in [I-D.ietf-pce-association-bidir], for a stateless PCE, it might be useful to associate a path computation request to an association group, thus enabling it to associate a common set of configuration parameters or behaviors with the request. A PCC can request co-routed or non-co-routed forward and reverse direction paths from a stateless PCE for a bidirectional SR association group.

4.4. Bidirectional (B) Flag

As defined in [RFC5440], the Bidirectional (B) flag in Request Parameters (RP) object MUST be set when the PCC specifies that the path computation request relates to a bidirectional TE LSP. The B-flag also MUST be set when the PCC specifies that the path computation request relates to an associated bidirectional SR Path.

Note that the B-flag defined in Stateful PCE Request Parameter (SRP) object [I-D.ietf-pce-pcep-stateful-pce-gmpls] is not required for associated bidirectional SR path as association group is used to indicate that the path is bidirectional.

4.5. State Synchronization

During state synchronization, a PCC MUST report all the existing Bidirectional SR Association Groups to the Stateful PCE as per [RFC8697]. After the state synchronization, the PCE MUST remove all stale Bidirectional SR Associations.

4.6. Error Handling

The error handling as described in section 5.7 of [I-D.ietf-pce-association-bidir] continue to apply.

The PCEP Path Setup Type (PST) for SR is set to 'TE Path is Setup using Segment Routing' [RFC8408]. If a PCEP speaker receives a different PST value for Bidirectional SR Path association group and it does not support; it MUST send a PCErr message with Error-Type = 26 (Association Error) and Error-Value = TBD2 (Bidirectional LSP Association - Path Setup Type Not Supported).

5. Implementation Status

[Note to the RFC Editor - remove this section before publication, as well as remove the reference to [RFC7942].

This section records the status of known implementations of the protocol defined by this specification at the time of posting of this

Internet-Draft, and is based on a proposal described in [RFC7942]. The description of implementations in this section is intended to assist the IETF in its decision processes in progressing drafts to RFCs. Please note that the listing of any individual implementation here does not imply endorsement by the IETF. Furthermore, no effort has been spent to verify the information presented here that was supplied by IETF contributors. This is not intended as, and must not be construed to be, a catalog of available implementations or their features. Readers are advised to note that other implementations may exist.

According to [RFC7942], "this will allow reviewers and working groups to assign due consideration to documents that have the benefit of running code, which may serve as evidence of valuable experimentation and feedback that have made the implemented protocols more mature. It is up to the individual working groups to use this information as they see fit".

5.1. Huawei's Commercial Delivery

The feature is developing based on Huawei VRP8.

- Organization: Huawei
- Implementation: Huawei's Commercial Delivery implementation based on VRP8.
- Description: The implementation is under development.
- Maturity Level: Product
- Contact: tanren@huawei.com

5.2. ZTE's Commercial Delivery

- Organization: ZTE
- Implementation: ZTE's Commercial Delivery implementation based on Rosng v8.
- Description: The implementation is under development.
- Maturity Level: Product
- Contact: zhan.shuangping@zte.com.cn

6. Security Considerations

The security considerations described in [RFC5440], [RFC8231], [RFC8281], and [RFC8408] 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' is introduced in this document. Additional security considerations related to LSP associations due to a malicious PCEP speaker is described in [RFC8697] and apply to this Association Type. Hence, securing the PCEP session using Transport Layer Security (TLS) [RFC8253] is recommended.

7. Manageability Considerations

All manageability requirements and considerations listed in [RFC5440], [RFC8231], and [RFC8281] apply to PCEP protocol extensions defined in this document. In addition, requirements and considerations listed in this section apply.

7.1. Control of Function and Policy

The mechanisms defined in this document do not imply any control or policy requirements in addition to those already listed in [RFC5440], [RFC8231], and [RFC8281].

7.2. Information and Data Models

[RFC7420] describes the PCEP MIB, there are no new MIB Objects defined for Bidirectional SR Path associations. The PCEP YANG module [I-D.ietf-pce-pcep-yang] defines data model for Bidirectional SR Path associations.

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], [RFC8231], and [RFC8281].

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], [RFC8231], and [RFC8408].

7.5. Requirements On Other Protocols

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

7.6. Impact On Network Operations

Mechanisms defined in [RFC5440], [RFC8231], and [RFC8408] also apply to PCEP extensions defined in this document.

8. IANA Considerations

8.1. Association Type

This document defines a new Association Type for the Association Object (Class Value 40) defined [RFC8697]. IANA is requested to make the assignment of a type for the sub-registry "ASSOCIATION Type" as follows:

Type	Name	Reference
TBD1	Double-sided Bidirectional SR Path Association Group	This document

8.2. PCEP Errors

This document defines new Error value for Error Type 26 (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
26	Association Error	
	Error value: TBD2 Bidirectional LSP Association - Path Setup Type Not Supported	This document

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9.1. Normative References

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