

PCE Working Group  
Li  
Internet-Draft  
Chen  
Intended status: Standards Track  
Technologies  
Expires: September 14, 2020  
Cheng  
Mobile  
Gandhi  
Inc.  
Xiong  
Corporation  
2020

C.  
M.  
Huawei  
W.  
China  
R.  
Cisco Systems,  
Q.  
ZTE  
March 13,

PCEP Extensions for Associated Bidirectional Segment Routing (SR) Paths  
[draft-ietf-pce-sr-bidir-path-02](#)

#### 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 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](#).

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at <https://datatracker.ietf.org/drafts/current/>.

Internet-Drafts are draft documents valid for a maximum of six months

and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on September 14, 2020.

Li, et al.  
1]

Expires September 14, 2020

[Page

## Copyright Notice

Copyright (c) 2020 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to [BCP 78](https://trustee.ietf.org/license-info) and the IETF Trust's Legal Provisions Relating to IETF Documents (<https://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

## Table of Contents

<a href="#">1.</a>	Introduction . . . . .	<a href="#">3</a>
<a href="#">2.</a>	Terminology . . . . .	<a href="#">4</a>
<a href="#">2.1.</a>	Requirements Language . . . . .	<a href="#">4</a>
<a href="#">3.</a>	PCEP Extensions . . . . .	<a href="#">4</a>
3.1.	Double-sided Bidirectional with Reverse LSP Association Group . . . . .	<a href="#">5</a>
<a href="#">3.1.1.</a>	Bidirectional LSP Association Group TLV . . . . .	<a href="#">5</a>
<a href="#">4.</a>	PCEP Procedures . . . . .	<a href="#">6</a>
<a href="#">4.1.</a>	PCE Initiated Associated Bidirectional SR Paths . . . . .	<a href="#">7</a>
<a href="#">4.2.</a>	PCC Initiated Associated Bidirectional SR Paths . . . . .	<a href="#">7</a>
<a href="#">4.3.</a>	Stateless PCE . . . . .	<a href="#">9</a>
<a href="#">4.4.</a>	Bidirectional (B) Flag . . . . .	<a href="#">10</a>
<a href="#">4.5.</a>	State Synchronization . . . . .	<a href="#">10</a>
<a href="#">4.6.</a>	Error Handling . . . . .	<a href="#">10</a>
<a href="#">5.</a>	Implementation Status . . . . .	<a href="#">10</a>
<a href="#">5.1.</a>	Huawei's Commercial Delivery . . . . .	<a href="#">11</a>
<a href="#">5.2.</a>	ZTE's Commercial Delivery . . . . .	<a href="#">11</a>
<a href="#">6.</a>	Security Considerations . . . . .	

[11](#) 7. Manageability Considerations . . . . .

[12](#) [7.1.](#) Control of Function and Policy . . . . .

[12](#) [7.2.](#) Information and Data Models . . . . .

[12](#) [7.3.](#) Liveness Detection and Monitoring . . . . .

[12](#) [7.4.](#) Verify Correct Operations . . . . .

[12](#) [7.5.](#) Requirements On Other Protocols . . . . .

[12](#) [7.6.](#) Impact On Network Operations . . . . .

[12](#) 8. IANA Considerations . . . . .

[12](#) [8.1.](#) Association Type . . . . .

[13](#) 9. References . . . . .

[13](#) [9.1.](#) Normative References . . . . .

[13](#) [9.2.](#) Informative References . . . . .

[14](#) Acknowledgments . . . . .

[15](#)

Contributors . . . . .  
[15](#)  
Authors' Addresses . . . . .  
[16](#)

## [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 (PM) [[I-D.gandhi-spring-twamp-srpm](#)] those

Li, et al.  
3]

Expires September 14, 2020

[Page

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 the SR Paths in both directions, including their status and all other path related information. Associating an unidirectional SR Path with a reverse direction unidirectional RSVP-TE LSP to form a bidirectional LSP and vice versa, are outside the scope of this document.

## **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 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 association group defined in this document for PCEP messages.

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

TE

LSPs.

[\[I-D.ietf-pce-sr-path-segment\]](#) 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 with Reverse LSP Association Group**

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

- o Association Type (TBD1 to be assigned by IANA) = Double-sided Bidirectional with Reverse LSP Association Group

Similar to RSVP-TE bidirectional LSP associations, this Association Type is also operator-configured in nature and statically created by the operator on the PCEP peers. 'Operator-configured Association Range' TLV (Value 29) [[RFC8697](#)] MUST NOT be sent for this

Association

Type, and MUST be ignored, so that the entire range of association ID can be used for it.

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 with Reverse LSP Association Group' can take the role of a forward or reverse direction SR Path and follow the similar rules defined in [[I-D.ietf-pce-association-bidir](#)] for LSPs.

- o An SR Path (forward or reverse) cannot be part of more than one 'Double-sided Bidirectional with Reverse LSP Association Group'.
- o The endpoints of the SR Paths in 'Double-sided Bidirectional with Reverse LSP Association Group' cannot be different.

#### **3.1.1. Bidirectional LSP Association Group TLV**

In 'Double-sided Bidirectional with Reverse LSP 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 a 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.

The SR Path can be identified by an LSP of an SR Policy as described in [[I-D.barth-pce-segment-routing-policy-cp](#)].

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], Associated Bidirectional SR Paths can be created by a Stateful PCE as shown in Figure 1.

- o Stateful PCE can create and update the forward and reverse SR Paths independently for 'Double-sided Bidirectional with Reverse LSP Association Group'.
- 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 [RFC8697].
- o 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.

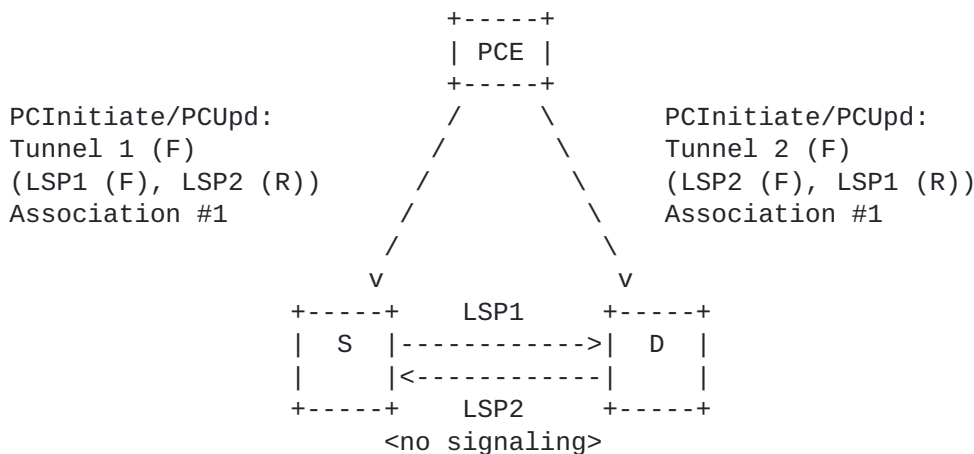


Figure 1: PCE-Initiated Associated Bidirectional SR Path with Forward and Reverse Direction SR Paths

**4.2. PCC Initiated Associated Bidirectional SR Paths**

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



- o PCC can create and update the forward SR Path and update the reverse SR Path independently for a 'Double-sided Bidirectional with Reverse LSP Association Group'.
- o PCC cannot instantiate a reverse SR Path in a bidirectional SR Path.
- 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 Bidirectional with Reverse LSP Association Group' via PCUpd message, using the procedures described in [[RFC8697](#)].
- o 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.





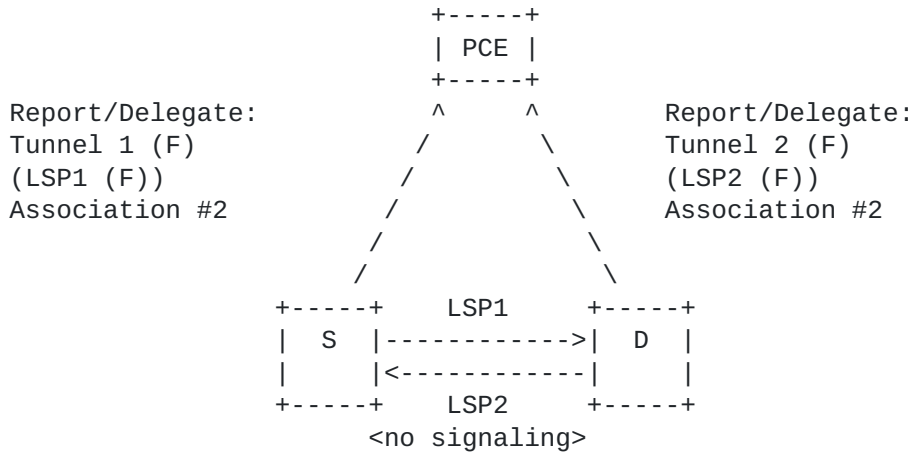


Figure 2a: Step 1: PCC-Initiated Associated Bidirectional SR Path with Forward Direction SR Paths

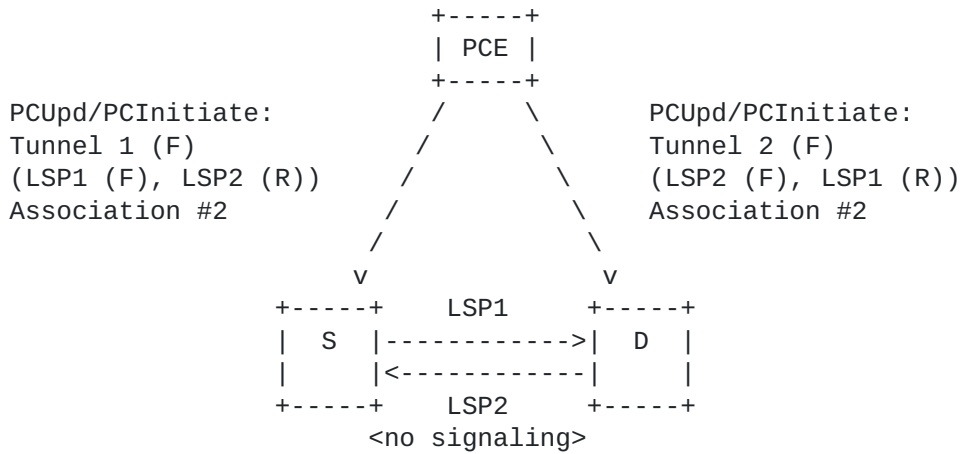


Figure 2b: Step 2: PCE-Updated/Initiated Associated Bidirectional SR Path with Reverse Direction SR Paths

### 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**

The Bidirectional (B) flag in Request Parameters (RP) object [[RFC5440](#)] and Stateful PCE Request Parameter (SRP) object [[I-D.ietf-pce-pcep-stateful-pce-gmpls](#)] follow the procedure defined in [[I-D.ietf-pce-association-bidir](#)].

#### **4.5. State Synchronization**

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

#### **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 'Double-sided Bidirectional with Reverse LSP Association Group' and it does not support; it MUST send a PCErr message with Error-Type = 26 (Association Error) and Error-Value = 'Bidirectional LSP Association - Path Setup Type Not Supported' defined in [[I-D.ietf-pce-association-bidir](#)].

### **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

Li, et al.  
10]

Expires September 14, 2020

[Page

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.

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

### **5.2. ZTE's Commercial Delivery**

- o Organization: ZTE
- o Implementation: ZTE's Commercial Delivery implementation based on Rosng v8.
- o Description: The implementation is under development.
- o Maturity Level: Product
- o 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 Bidirectional with Reverse LSP 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 'Double-sided Bidirectional with Reverse LSP Association Groups'. The PCEP YANG module [I-D.ietf-pce-pcep-yang] defines data model for Associated Bidirectional SR Paths.

### **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 with Reverse LSP Association Group	This document

## 9. References

### 9.1. Normative References

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), DOI 10.17487/RFC2119, March 1997, <<https://www.rfc-editor.org/info/rfc2119>>.
- [RFC5440] Vasseur, JP., Ed. and JL. Le Roux, Ed., "Path Computation Element (PCE) Communication Protocol (PCEP)", [RFC 5440](#), DOI 10.17487/RFC5440, March 2009, <<https://www.rfc-editor.org/info/rfc5440>>.
- [RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in [RFC 2119](#) Key Words", [BCP 14](#), [RFC 8174](#), DOI 10.17487/RFC8174, May 2017, <<https://www.rfc-editor.org/info/rfc8174>>.
- [RFC8231] Crabbe, E., Minei, I., Medved, J., and R. Varga, "Path Computation Element Communication Protocol (PCEP) Extensions for Stateful PCE", [RFC 8231](#), DOI 10.17487/RFC8231, September 2017, <<https://www.rfc-editor.org/info/rfc8231>>.
- [RFC8281] Crabbe, E., Minei, I., Sivabalan, S., and R. Varga, "Path Computation Element Communication Protocol (PCEP) Extensions for PCE-Initiated LSP Setup in a Stateful PCE Model", [RFC 8281](#), DOI 10.17487/RFC8281, December 2017, <<https://www.rfc-editor.org/info/rfc8281>>.



[RFC8697] Minei, I., Crabbe, E., Sivabalan, S., Ananthakrishnan, H., Dhody, D., and Y. Tanaka, "Path Computation Element Communication Protocol (PCEP) Extensions for Establishing Relationships between Sets of Label Switched Paths (LSPs)", [RFC 8697](#), DOI 10.17487/RFC8697, January 2020, <<https://www.rfc-editor.org/info/rfc8697>>.

[I-D.ietf-pce-association-bidir]  
Gandhi, R., Barth, C., and B. Wen, "PCEP Extensions for Associated Bidirectional Label Switched Paths (LSPs)", [draft-ietf-pce-association-bidir-05](#) (work in progress), February 2020.

[I-D.ietf-pce-sr-path-segment]  
Li, C., Chen, M., Cheng, W., Gandhi, R., and Q. Xiong, "Path Computation Element Communication Protocol (PCEP) Extension for Path Segment in Segment Routing (SR)", [draft-ietf-pce-sr-path-segment-00](#) (work in progress), October 2019.

## **9.2. Informative References**

[RFC8253] Lopez, D., Gonzalez de Dios, O., Wu, Q., and D. Dhody, "PCEPS: Usage of TLS to Provide a Secure Transport for the Path Computation Element Communication Protocol (PCEP)", [RFC 8253](#), DOI 10.17487/RFC8253, October 2017, <<https://www.rfc-editor.org/info/rfc8253>>.

[RFC8402] Filsfils, C., Ed., Previdi, S., Ed., Ginsberg, L., Decraene, B., Litkowski, S., and R. Shakir, "Segment Routing Architecture", [RFC 8402](#), DOI 10.17487/RFC8402, July 2018, <<https://www.rfc-editor.org/info/rfc8402>>.

[RFC7942] Sheffer, Y. and A. Farrel, "Improving Awareness of Running Code: The Implementation Status Section", [BCP 205](#), [RFC 7942](#), DOI 10.17487/RFC7942, July 2016, <<https://www.rfc-editor.org/info/rfc7942>>.

[RFC7420] Koushik, A., Stephan, E., Zhao, Q., King, D., and J. Hardwick, "Path Computation Element Communication Protocol (PCEP) Management Information Base (MIB) Module", [RFC 7420](#), DOI 10.17487/RFC7420, December 2014, <<https://www.rfc-editor.org/info/rfc7420>>.

[RFC8408] Sivabalan, S., Tantsura, J., Minei, I., Varga, R., and J. Hardwick, "Conveying Path Setup Type in PCE Communication Protocol (PCEP) Messages", [RFC 8408](#), DOI 10.17487/RFC8408,

July 2018, <<https://www.rfc-editor.org/info/rfc8408>>.

Li, et al.  
14]

Expires September 14, 2020

[Page

[I-D.ietf-mpls-bfd-directed]

Mirsky, G., Tantsura, J., Varlashkin, I., and M. Chen,  
"Bidirectional Forwarding Detection (BFD) Directed Return  
Path", [draft-ietf-mpls-bfd-directed-13](#) (work in  
progress),  
December 2019.

[I-D.gandhi-spring-twamp-srpm]

Gandhi, R., Filsfils, C., Voyer, D., Chen, M., and B.  
Janssens, "Performance Measurement Using TWAMP Light and  
STAMP for Segment Routing Networks", [draft-gandhi-spring-  
twamp-srpm-07](#) (work in progress), March 2020.

[I-D.ietf-spring-mpls-path-segment]

Cheng, W., Li, H., Chen, M., Gandhi, R., and R. Zigler,  
"Path Segment in MPLS Based Segment Routing Network",  
[draft-ietf-spring-mpls-path-segment-02](#) (work in  
progress),  
February 2020.

[I-D.ietf-pce-pcep-yang]

Dhody, D., Hardwick, J., Beeram, V., and J. Tantsura, "A  
YANG Data Model for Path Computation Element  
Communications Protocol (PCEP)", [draft-ietf-pce-pcep-  
yang-13](#) (work in progress), October 2019.

[I-D.ietf-pce-pcep-stateful-pce-gmpls]

Lee, Y., Zheng, H., Dios, O., Lopezalvarez, V., and Z.  
Ali, "Path Computation Element (PCE) Protocol Extensions  
for Stateful PCE Usage in GMPLS-controlled Networks",  
[draft-ietf-pce-pcep-stateful-pce-gmpls-12](#) (work in  
progress), October 2019.

[I-D.barth-pce-segment-routing-policy-cp]

Koldychev, M., Sivabalan, S., Barth, C., Li, C., and H.  
Bidgoli, "PCEP extension to support Segment Routing  
Policy  
Candidate Paths", [draft-barth-pce-segment-routing-policy-  
cp-04](#) (work in progress), October 2019.

#### Acknowledgments

Many thanks to Marina Fizgeer, Adrian Farrel, and Andrew Stone for  
the detailed review of this document and providing many useful  
comments.

#### Contributors

The following people have substantially contributed to this  
document:



Dhruv Dhody  
Huawei Technologies  
Divyashree Techno Park, Whitefield  
Bangalore, Karnataka 560066  
India

Email: dhruv.ietf@gmail.com

Zhenbin Li  
Huawei Technologies  
Huawei Campus, No. 156 Beiqing Rd.  
Beijing 100095  
China

Email: lizhenbin@huawei.com

Jie Dong  
Huawei Technologies  
Huawei Campus, No. 156 Beiqing Rd.  
Beijing 100095  
China

Email: jie.dong@huawei.com

#### Authors' Addresses

Cheng Li  
Huawei Technologies  
Huawei Campus, No. 156 Beiqing Rd.  
Beijing 100095  
China

Email: chengli13@huawei.com

Mach(Guoyi) Chen  
Huawei Technologies  
Huawei Campus, No. 156 Beiqing Rd.  
Beijing 100095  
China

Email: Mach.chen@huawei.com





Weiqiang Cheng  
China Mobile  
China

Email: [chengweiqiang@chinamobile.com](mailto:chengweiqiang@chinamobile.com)

Rakesh Gandhi  
Cisco Systems, Inc.  
Canada

Email: [rgandhi@cisco.com](mailto:rgandhi@cisco.com)

Quan Xiong  
ZTE Corporation  
China

Email: [xiong.quan@zte.com.cn](mailto:xiong.quan@zte.com.cn)

