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PCEP Procedures and Protocol Extensions for Using PCE as a Central Controller (PCECC) of SR-LSPs
draft-zhao-pce-pcep-extension-pce-controller-sr-02

Abstract

In certain networks deployment scenarios, service providers would like to keep all the existing MPLS functionalities in both MPLS and GMPLS while removing the complexity of existing signaling protocols such as LDP and RSVP-TE. PCE has been proposed to be used as a central controller (PCECC) so that LSP can be calculated/setup/initiated and label forwarding entries are downloaded through a centralized PCE server to each network devices along the path while leveraging the existing PCE technologies as much as possible.

This document specifies the procedures and PCEP protocol extensions when the PCE functions as one of the central controller components in Segment Routing(SR).

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1. Introduction

The Path Computation Element communication Protocol (PCEP) provides mechanisms for Path Computation Elements (PCEs) to perform route computations in response to Path Computation Clients (PCCs) requests. PCEP Extensions for PCE-initiated LSP Setup in a Stateful PCE Model [RFC8231] describes a set of extensions to PCEP to enable active control of MPLS-TE and GMPLS tunnels.

[RFC8281] describes the setup and tear down of PCE-initiated LSPs under the active stateful PCE model, without the need for local configuration on the PCC, thus allowing for a dynamic MPLS network that is centrally controlled and deployed.

[RFC8283] introduces the architecture for PCE as a central controller, examines the motivations and applicability for PCEP as a southbound interface, and introduces the implications for the protocol. [I-D.ietf-teas-pcecc-use-cases] describes the use cases for the PCECC architecture.

[I-D.zhao-pce-pcep-extension-for-pce-controller] specify the PCEP extension for the PCE as the central controller (PCECC). This document extends the PCECC procedures for Segment Routing (SR).

Segment Routing (SR) technology leverage the source routing and tunneling paradigms. A source node can choose a path without relying on hop-by-hop signaling protocols such as LDP or RSVP-TE. Each path is specified as a set of "segments" advertised by link- state routing protocols (IS-IS or OSPF).

[I-D.ietf-spring-segment-routing] provides an introduction to SR technology. The corresponding IS-IS and OSPF extensions are

specified in [I-D.ietf-isis-segment-routing-extensions] and [I-D.ietf-ospf-segment-routing-extensions] , respectively.

A Segment Routed path (SR path) can be derived from an IGP Shortest Path Tree (SPT). Segment Routed Traffic Engineering paths (SR-TE paths) may not follow IGP SPT. Such paths may be chosen by a suitable network planning tool and provisioned on the source node of the SR-TE path.

It is possible to use a stateful PCE for computing one or more SR-TE paths taking into account various constraints and objective functions. Once a path is chosen, the stateful PCE can instantiate an SR-TE path on a PCC using PCEP extensions specified in [RFC8281] using the SR specific PCEP extensions described in [I-D.ietf-pce-segment-routing].

PCECC may further use PCEP protocol for SR label distribution instead of IGP extensions with some benefits.

The [I-D.zhao-pce-pcep-extension-for-pce-controller], specifies the procedures and PCEP protocol extensions for using the PCE as one of the the central controller components and user cases where LSPs are calculated/setup/initiated and label forwarding entries are downloaded on each hop along the path, through extending the existing PCE architectures and PCEP.

This draft specify the procedures and PCEP protocol extensions for using the PCE as the central controller for SR label distribution and user cases where SR LSPs are calculated/setup/initiated/downloaded through extending the existing PCE architectures and PCEP.

[Important Note - Note that this document achieves by extending the new PCEP message defined in [I-D.zhao-pce-pcep-extension-for-pce-controller]. The authors and WG also debated on the use of existing PCEP messages. Section 5 defines the first approach where as Appendix A defines the latter. The authors are open to either of the approach and will follow the direction of the WG.]

1.1. 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.

2. Terminology

Terminologies used in this document is same as described in the draft [RFC8283] and [I-D.ietf-teas-pcecc-use-cases].

3. PCECC SR

[I-D.ietf-pce-segment-routing] specifies extensions to PCEP that allow a stateful PCE to compute, update or initiate SR-TE paths. An ingress node of an SR-TE path appends all outgoing packets with a list of MPLS labels (SIDs). This is encoded in SR-ERO subobject, capable of carrying a label (SID) as well as the identity of the node/adjacency label (SID).

The notion of segment and SID is defined in [I-D.ietf-spring-segment-routing], which fits the MPLS architecture [RFC3031] as the label which is managed by a local allocation process of LSR (similarly to other MPLS signaling protocols) [I-D.ietf-spring-segment-routing-mpls]. The SR information such as node/adjacency label (SID) is flooded via IGP as specified in [I-D.ietf-isis-segment-routing-extensions] and [I-D.ietf-ospf-segment-routing-extensions].

As per [RFC8283], PCE as a central controller can allocate and provision the node/adjacency label (SID) via PCEP.

Rest of the processing is similar to existing stateful PCE with SR mechanism.

For the purpose of this document, it is assumed that label range to be used by a PCE is set on both PCEP peers. Further, a global label range is assumed to be set on all PCEP peers in the SR domain.

4. PCEP Requirements

Following key requirements for PCECC-SR should be considered when` designing the PCECC based solution:

- PCEP speaker supporting this draft MUST have the capability to advertise its PCECC-SR capability to its peers.

- PCEP speaker not supporting this draft MUST be able to reject PCECC-SR related message with a reason code that indicates no support for PCECC.

- PCEP SHOULD provide a means to update (or cleanup) the label- map entry to the PCC.

- PCEP SHOULD provide a means to synchronize the SR labels between PCE to PCC in PCEP messages.

5. Procedures for Using the PCE as the Central Controller (PCECC) in Segment Routing

5.1. Stateful PCE Model

Active stateful PCE is described in [RFC8231]. PCE as a central controller (PCECC) reuses existing Active stateful PCE mechanism as much as possible to control the LSP.

5.2. New LSP Functions

This document uses the same PCEP messages and its extenstions which are described in [I-D.zhao-pce-pcep-extension-for-pce-controller] for PCECC-SR as well.

PCEP messages PCRpt, PCInitiate, PCUpd are also used to send PCECC-SR Reports, LSP setup and LSP update respectively.

PCLabelUpd message described in [I-D.zhao-pce-pcep-extension-for-pce-controller] is used to download or cleanup SR Label entry.

PCLabelRpt message described in [I-D.zhao-pce-pcep-extension-for-pce-controller] is also used to report the set of SR Label entries from PCC to PCE for which explicit action is required from PCE (update or cleanup or do nothing for these Label entries).

[Editor's Note: [I-D.zhao-pce-pcep-extension-for-pce-controller] defines new messages PCLabelUpd and PCLabelRpt. The authors and WG also debated on the use of existing PCEP messages. Further the document also includes an appendix on how the existing messages can be extended to add this functionality. WG needs to decide the final direction i.e. new specific messages are needed or existing PCEP messages can be extended. See See Appendix A to see the extension of existing message for PCECC-SR functionality.]

5.3. PCECC Capability Advertisement

During PCEP Initialization Phase, PCEP Speakers (PCE or PCC) advertise their support of PCECC extensions. A PCEP Speaker includes the "PCECC Capability" sub-TLV, described in [I-D.zhao-pce-pcep-extension-for-pce-controller].

A new S-bit is added in PCECC-CAPABILITY sub-TLV to indicate support for PCECC-SR. A PCC MUST set S-bit in PCECC-CAPABILITY sub-TLV and include SR-PCE-CAPABILITY sub-TLV ([I-D.ietf-pce-segment-routing]) in OPEN Object (inside the the PATH-SETUP-TYPE-CAPABILITY TLV) to support the PCECC SR extensions defined in this document. If S-bit is set in PCECC-CAPABILITY sub-TLV and SR-PCE-CAPABILITY sub-TLV is not advertised in OPEN Object, PCE SHOULD send a PCErr message with Error-Type=19 (Invalid Operation) and Error-value=TBD(SR capability was not advertised) and terminate the session.

5.4. PCEP session IP address and TEDB Router ID

PCE may construct its TEDB by participating in the IGP ([RFC3630] and [RFC5305] for MPLS-TE; [RFC4203] and [RFC5307] for GMPLS). An alternative is offered by BGP-LS [RFC7752] and [I-D.dhodylee-pce-pcep-ls].

PCEP [RFC5440] speaker MAY use any IP address while creating a TCP session. It is important to link the session IP address with the Router ID in TEDB for successful PCECC operations.

During PCEP Initialization Phase, PCC SHOULD advertise the TE mapping information. Thus a PCC includes the "Node Attributes TLV" [I-D.dhodylee-pce-pcep-ls] with "IPv4/IPv6 Router-ID of Local Node", in the OPEN Object for this purpose. [RFC7752] describes the usage as auxiliary Router-IDs that the IGP might be using, e.g., for TE purposes. If there are more than one auxiliary Router-ID of a given type, then multiple TLVs are used to encode them.

If "IPv4/IPv6 Router-ID" TLV is not present, the TCP session IP address is directly used for the mapping purpose.

5.5. LSP Operations

The PCEP messages pertaining to PCECC-SR MUST include PATH-SETUP-TYPE TLV [I-D.ietf-pce-lsp-setup-type] in the SRP object to clearly identify the PCECC-SR LSP is intended.

5.5.1. PCECC Segment Routing (SR)

Segment Routing (SR) as described in [I-D.ietf-spring-segment-routing] depends on "segments" that are advertised by Interior Gateway Protocols (IGPs). The SR-node allocates and advertises the SID (node, adj etc) and flood via the IGP. This document proposes a new mechanism where PCE allocates the SID (label) centrally and uses PCEP to advertise the SID. In some deployments PCE (and PCEP) are better suited than IGP because of

centralized nature of PCE and direct TCP based PCEP session to the node.

5.5.1.1. PCECC SR Node/Prefix Label allocation

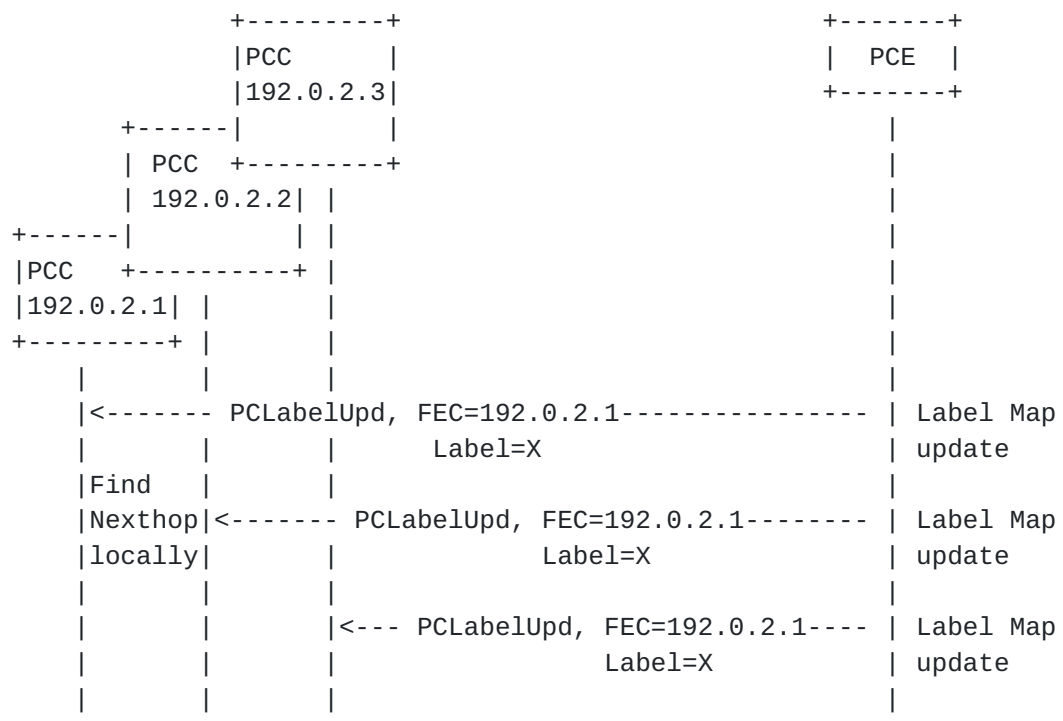
Each node (PCC) is allocated a node-SID (label) by the PCECC. The PCECC sends PCLabelUpd to update the label map of each node to all the nodes in the domain. The TE router ID is determined from the TEDB or from "IPv4/IPv6 Router-ID" Sub-TLV [I-D.dhodylee-pce-pcep-ls], in the OPEN Object Section 5.4.

Note: See Appendix A for how we could use PCInitiate message instead.]

It is RECOMMENDED that PCEP session with PCECC SR capability to use a different session IP address during TCP session establishment than the node Router ID in TEDB, to make sure that the PCEP session does not get impacted by the SR Node/Prefix Label maps (Section 5.4).

If a node (PCC) receives a PCLabelUpd message with a Label, out of the range set aside for the global label, it MUST send a PCErr message with Error-type=TBD (label download failure) and Error-value=TBD (Label out of range) and MUST include the SRP object to specify the error is for the corresponding label update [I-D.zhao-pce-pcep-extension-for-pce-controller].

On receiving the label map, each node (PCC) uses the local information to determine the next-hop and download the label forwarding instructions accordingly. The PCLabelUpd message in this case MUST NOT have LSP object but uses new FEC object.



The forwarding behaviour and the end result is similar to IGP based "Node-SID" in SR. Thus, from anywhere in the domain, it enforces the ECMP-aware shortest-path forwarding of the packet towards the related node.

PCE relies on the Node/Prefix Label cleanup using the same PCLabelUpd message.

5.5.1.2. PCECC SR Adjacency Label allocation

[I-D.ietf-pce-segment-routing] extends PCEP to allow a stateful PCE to compute and initiate SR-TE paths, as well as a PCC to request a path subject to certain constraint(s) and optimization criteria in SR networks.

For PCECC SR, apart from node-SID, Adj-SID is used where each adjacency is allocated an Adj-SID (label) by the PCECC. The PCECC sends PCLabelUpd to update the label map of each Adj to the corresponding nodes in the domain. Each node (PCC) download the label forwarding instructions accordingly. Similar to SR Node/Prefix Label allocation, the PCLabelUpd message in this case MUST NOT have LSP object but uses new FEC object. Note: See Appendix A for how we could use PCInitiate message instead.]

```
                    +---------+                         +-------+
                    |PCC      |                         |  PCE  |
                    |192.0.2.3|                         +-------+
             +------|         |                             |
             | PCC  +---------+                             |
             | 192.0.2.2| |                                 |
      +------|          | |                                 |
      |PCC   +----------+ |                                 |
      |192.0.2.1|  |      |                                 |
      +---------+  |      |                                 |
          |        |      |                                 |
          |<------ PCLabelUpd, FEC=192.0.2.1 / ------------ | Label Map
          |        |      |          192.0.2.2              | update
          |        |      |      Label=A                    |
          |        |      |                                 |
          |        |<----- PCLabelUpd, FEC=192.0.2.2------- | Label Map
          |        |      |                 192.0.2.1       | update
          |        |      |             Label=B             |
          |        |      |                                 |
```

The forwarding behavior and the end result is similar to IGP based "Adj-SID" in SR.

The Path Setup Type for segment routing MUST be set for PCECC SR (see Section 7.2). All PCEP procedures and mechanism are similar to [I-D.ietf-pce-segment-routing].

PCE relies on the Adj label cleanup using the same PCLabelUpd message.

5.5.1.3. Redundant PCEs

[I-D.litkowski-pce-state-sync] describes synchronization mechanism between the stateful PCEs. The SR Labels allocated by a PCE should also be synchronized among PCEs for PCECC SR state synchronization. Note that the SR labels are downloaded independent to the PCECC LSP, and remains intact till any topology change. The redundant PCEs MUST have a common view of all SR labels allocated in the domain.

Incase the session to the PCE that allocated the SR labels is down, similar to the LSP re-delegation mechanims, the SR labels are re-delegated to a redundant PCE using the PCLabelRpt message. This is done so that the SR labels remains intact and cosntant in case of session disconnect.

5.5.1.4. Session Termination

[I-D.zhao-pce-pcep-extension-for-pce-controller] describes the action needed for label provisioned for the Basic PCECC LSP on this terminated session. Similarly actions should be applied for SR Labels as well.

Additionally, if PCC has any alternate PCEP session with another PCE, then PCC MUST deligate the SR labels of this session to this alternate PCE in a sequence of PCLabelRpt message. PCE can accept it and can send PCLabelUpd message to update or clean the label.

Extensions for PCLabelUpd and PCLabelRpt message for SR label are described in Section 6.1.

5.5.1.5. LABEL-DB Synchronization

[I-D.zhao-pce-pcep-extension-for-pce-controller] describes LABEL-DB Synchronization procedures needed for the labels provisioned for the Basic PCECC LSP. Same procedures should be applied for SR labels as well.

See [I-D.palle-pce-controller-labeldb-sync] for the optimizations for LABEL-DB synchronization procedure.

6. PCEP messages

As defined in [RFC5440], a PCEP message consists of a common header followed by a variable-length body made of a set of objects that can be either mandatory or optional. An object is said to be mandatory in a PCEP message when the object must be included for the message to be considered valid. For each PCEP message type, a set of rules is defined that specify the set of objects that the message can carry. An implementation MUST form the PCEP messages using the object ordering specified in this document.

6.1. Label Operations

[Editor's Note: [I-D.zhao-pce-pcep-extension-for-pce-controller] defines new messages PCLabelUpd and PCLabelRpt. The authors and WG also debated on the use of existing PCEP messages. Further the document also includes an appendix on how the existing messages can be extended to add this functionality. WG needs to decide the final direction i.e. new specific messages are needed or existing PCEP messages can be extended. See See Appendix A to see the extension of existing message for PCECC-SR functionality.]

6.1.1. The PCLabelUpd message

Label Update Message (PCLabelUpd) defined in [I-D.zhao-pce-pcep-extension-for-pce-controller] is extended to update the label map at the PCC.

The format of the extended PCLabelUpd message is as follows:

```
<PCLabelUpd Message> ::= <Common Header>
                         <pce-label-update-list>
Where:
<pce-label-update-list> ::= <pce-label-update>
                    [<pce-label-update-list>]

<pce-label-update> ::= (<pce-label-download>|<pce-label-map>)

Where:

<pce-label-map> ::= <SRP>
                    <LABEL>
                    <FEC>

<pce-label-download> is defined in
[I-D.zhao-pce-pcep-extension-for-pce-controller].
```

The FEC object is defined in Section 7.3. Either FEC object or LSP object defined in [I-D.zhao-pce-pcep-extension-for-pce-controller] is mandatory in PCLabelUpd message. The FEC object encodes the Node and Adjacency information of the Label Map.

6.1.2. The PCLabelRpt message

Label Report Message (PCLabelRpt) defined in [I-D.zhao-pce-pcep-extension-for-pce-controller] is extended to report or delegate the label map to PCE.

The format of the PCLabelRpt message is as follows:

```
<PCLabelRpt Message> ::= <Common Header>
                         <pce-label-report-list>
Where:
<pce-label-report-list> ::= <pce-label-report>
                   [<pce-label-report-list>]

<pce-label-report> ::= (<pce-label-delegate>|<pce-label-map>)

Where:

<pce-label-map> ::= <SRP>
                    <LABEL>
                    <FEC>

<pce-label-delegate> is defined in
```

[I-D.zhao-pce-pcep-extension-for-pce-controller].

The FEC object is defined in Section 7.3. Either FEC object or LSP object defined in [I-D.zhao-pce-pcep-extension-for-pce-controller] is mandatory in PCLabelRpt message. The FEC object encodes the Node and Adjacency information of the Label Map.

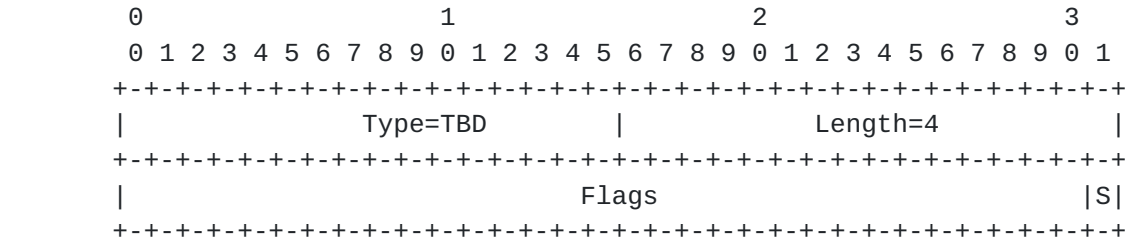
7. PCEP Objects

7.1. OPEN Object

7.1.1. PCECC Capability sub-TLV

[I-D.zhao-pce-pcep-extension-for-pce-controller] defined the PCECC-CAPABILITY TLV.

A new S-bit is defined in PCECC-CAPABILITY sub-TLV for PCECC-SR:



S (PCECC-SR-CAPABILITY - 1 bit): If set to 1 by a PCEP speaker, it indicates that the PCEP speaker is capable for PCECC-SR capability and PCE would allocate node and Adj label on this session.

7.2. PATH-SETUP-TYPE TLV

The PATH-SETUP-TYPE TLV is defined in [I-D.ietf-pce-lsp-setup-type]. PST = 1 (defined in [I-D.ietf-pce-segment-routing]) can be reused when Path is setup via PCECC SR mode.

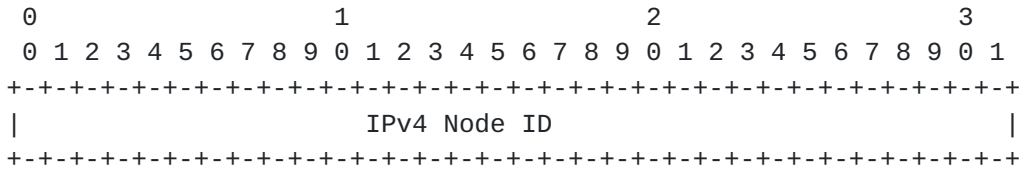
On a PCRpt/PCUpd/PCInitiate message, the PST=1 indicates that this LSP was setup via a SR based mechanism where either the labels are allocated by PCE via PCECC mechanism or advertised by IGP. For the label map download or cleanup the PST type is set to PCECC as per [I-D.zhao-pce-pcep-extension-for-pce-controller].

7.3. FEC Object

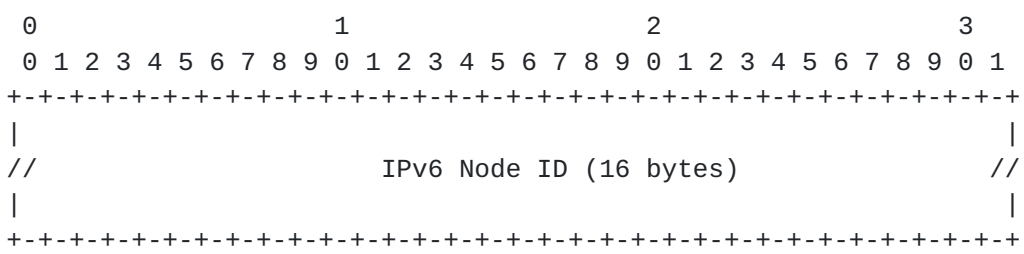
The FEC Object is used to specify the FEC information and MAY be carried within PCLabelUpd message.

FEC Object-Class is TBD.

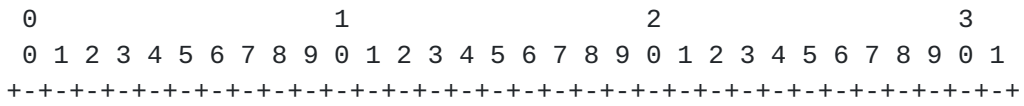
FEC Object-Type is 1 'IPv4 Node ID'.

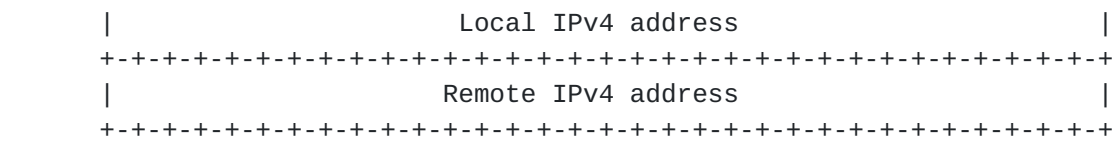


FEC Object-Type is 2 'IPv6 Node ID'.

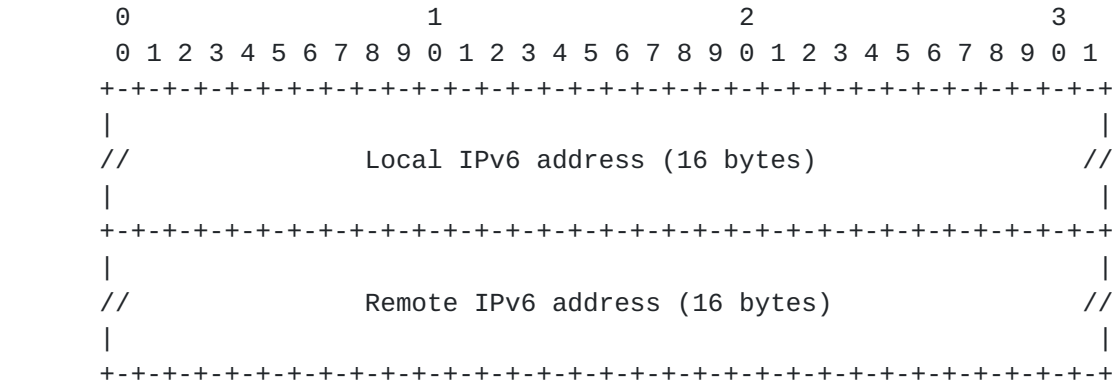


FEC Object-Type is 3 'IPv4 Adjacency'.

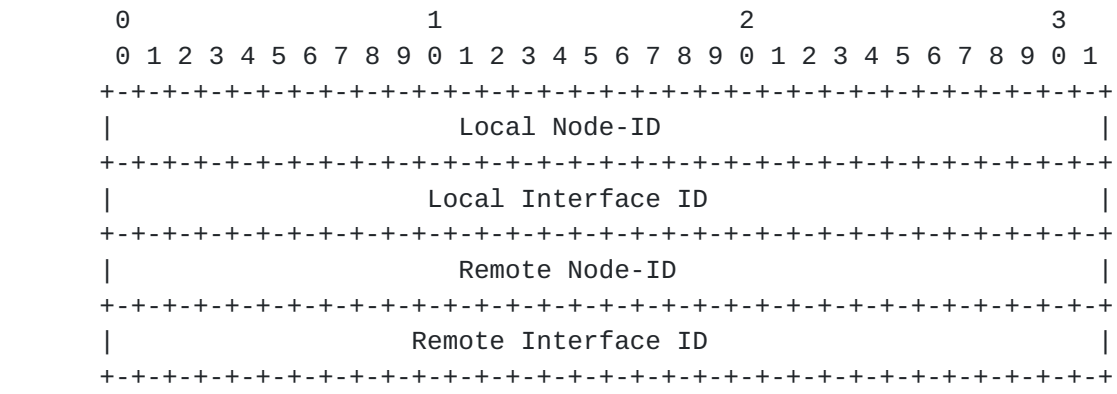




FEC Object-Type is 4 'IPv6 Adjacency'.



FEC Object-Type is 5 'Unnumbered Adjacency with IPv4 NodeIDs'.



The FEC objects are as follows:

IPv4 Node ID: where IPv4 Node ID is specified as an IPv4 address of the Node. FEC Object-type is 1, and the Object-Length is 4 in this case.

IPv6 Node ID: where IPv6 Node ID is specified as an IPv6 address of the Node. FEC Object-type is 2, and the Object-Length is 16 in this case.

IPv4 Adjacency: where Local and Remote IPv4 address is specified as pair of IPv4 address of the adjacency. FEC Object-type is 3, and the Object-Length is 8 in this case.

IPv6 Adjacency: where Local and Remote IPv6 address is specified as pair of IPv6 address of the adjacency. FEC Object-type is 4, and the Object-Length is 32 in this case.

Unnumbered Adjacency with IPv4 NodeID: where a pair of Node ID / Interface ID tuples is used. FEC Object-type is 5, and the Object-Length is 16 in this case.

8. Security Considerations

The security considerations described in [I-D.zhao-pce-pcep-extension-for-pce-controller] apply to the extensions described in this document.

9. Manageability Considerations

9.1. Control of Function and Policy

A PCE or PCC implementation SHOULD allow to configure to enable/ disable PCECC SR capability as a global configuration.

9.2. Information and Data Models

[RFC7420] describes the PCEP MIB, this MIB can be extended to get the PCECC SR capability status.

The PCEP YANG module [I-D.ietf-pce-pcep-yang] could be extended to enable/disable PCECC SR capability.

9.3. 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].

9.4. Verify Correct Operations

Mechanisms defined in this document do not imply any new operation verification requirements in addition to those already listed in [RFC5440] and [RFC8231].

9.5. Requirements On Other Protocols

PCEP extensions defined in this document do not put new requirements on other protocols.

9.6. Impact On Network Operations

PCEP implementation SHOULD allow a limit to be placed on the rate of PCLabelUpd messages sent by PCE and processed by PCC. It SHOULD also allow sending a notification when a rate threshold is reached.

10. IANA Considerations

10.1. PCECC-CAPABILITY TLV

[I-D.zhao-pce-pcep-extension-for-pce-controller] defines the PCECC-CAPABILITY TLV and requests that IANA creates a registry to manage the value of the PCECC-CAPABILITY TLV's Flag field. IANA is requested to allocate a new bit in the PCECC-CAPABILITY TLV Flag Field registry, as follows:

Bit	Description	Reference
31	S((PCECC-SR-CAPABILITY))	This document

10.2. PCEP Object

IANA is requested to allocate new registry for FEC PCEP object.

Object-Class Value	Name	Reference
TBD	FEC	This document
	Object-Type : 1	IPv4 Node ID
	Object-Type : 2	IPv6 Node ID
	Object-Type : 3	IPv4 Adjacency
	Object-Type : 4	IPv6 Adjacency
	Object-Type : 5	Unnumbered Adjacency with IPv4 NodeID

10.3. PCEP-Error Object

IANA is requested to allocate new error types and error values within the "PCEP-ERROR Object Error Types and Values" sub-registry of the PCEP Numbers registry for the following errors:

Error-Type	Meaning	
19	Invalid operation.	
	Error-value = TBD :	SR capability was not advertised

11. Acknowledgments

We would like to thank Robert Tao, Changjing Yan, Tieying Huang and Avantika for their useful comments and suggestions.

12. References

12.1. Normative References

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Appendix A. Using existing PCEP message

This is a temporary section added to this document, till the time a decision on the use of new messages v/s extending existing message is resolved. This section should be removed before the final publication of the document.

The PCInitiate message can be used to download or remove the labels -

```
    <PCInitiate Message> ::= <Common Header>
                             <PCE-initiated-lsp-list>
  Where:
    <Common Header> is defined in [RFC5440]

    <PCE-initiated-lsp-list> ::= <PCE-initiated-lsp-request>
                                 [<PCE-initiated-lsp-list>]

    <PCE-initiated-lsp-request> ::=
                         (<PCE-initiated-lsp-instantiation>|
                          <PCE-initiated-lsp-deletion>|
                          <PCE-initiated-lsp-label-download>|
                          <PCE-initiated-label-map>)

    <PCE-initiated-lsp-label-download> ::= <SRP>
                                           <LSP>
                                           <label-list>

    <label-list> ::=  <LABEL>
                      [<label-list>]

   <PCE-initiated-label-map> ::= <SRP>
                                 <LABEL>
                                 <FEC>

  Where:
      <PCE-initiated-lsp-instantiation> and
      <PCE-initiated-lsp-deletion> are as per
      [RFC8281].

      The LSP and SRP object is defined in [RFC8231].
```

The PCRpt message can be used to report the labels that were allocated by the PCE, to be used during the state synchronization phase.

The format of the PCRpt message is as follows:

```
      <PCRpt Message> ::= <Common Header>
                          <state-report-list>
   Where:

      <state-report-list> ::= <state-report>[<state-report-list>]

      <state-report> ::= (<lsp-state-report>|
                          <pce-label-report>)

      <lsp-state-report> ::= [<SRP>]
                             <LSP>
                             <path>

      <pce-label-report> ::= (<pce-label-delegate>|
                              <pce-label-map>)

      <pce-label-delegate> ::= <SRP>
                               <LSP>
                               <label-list>

      <label-list> ::=  <LABEL>
                       [<label-list>]

      <pce-label-map> ::= <SRP>
                          <LABEL>
                          <FEC>


    Where:
      <path> is as per [RFC8231] and the LSP and SRP object are
      also defined in [RFC8231].
```

The procedure for LSP-DB synchronization would also change, in-case we use the existing message. It will be the PCCs that would first report all the labels downloaded by the PCE during the state synchronization from PCC towards PCE, and then in case of any discrepancies PCE would use the PCInitiate message to add/remove labels.

Appendix B. Contributor Addresses

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