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Stateful PCE extensions for MPLS-TE LSPs
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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.

[I-D.ietf-pce-stateful-pce] describes a set of extensions to PCEP to provide stateful control. This document describes the objects and TLVs to be used with these PCEP extensions to control Multiprotocol Label Switching (MPLS) Traffic Engineering Label Switched Paths (TE LSP) via a stateful PCE.

Requirements Language

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].

Status of this Memo

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1. Introduction

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.

[I-D.ietf-pce-stateful-pce] describes a set of extensions to PCEP to provide stateful control. This document describes the objects and TLVs to be used with these PCEP extensions to control Multiprotocol Label Switching (MPLS) Traffic Engineering Label Switched Paths (TE LSP) via a stateful PCE.

2. Terminology

This document uses the following terms defined in [RFC5440]: PCC, PCE, PCEP Peer.

This document uses the following terms defined in [RFC4090]: MPLS TE Fast Reroute (FRR), FRR One-to-One Backup, FRR Facility Backup.

This document uses the following terms defined in [I-D.ietf-pce-stateful-pce] : Passive Stateful PCE, Active Stateful PCE, Delegation, Delegation Timeout Interval, LSP State Report, LSP Update Request, LSP Priority, LSP State Database, Revocation.

Within this document, when describing PCE-PCE communications, the requesting PCE fills the role of a PCC. This provides a saving in documentation without loss of function.

The message formats in this document are specified using Routing Backus-Naur Format (RBNF) encoding as specified in [RFC5511].

3. Motivation

Several use cases for stateful PCE in an MPLS-TE network are included in [I-D.ietf-pce-stateful-pce].

4. MPLS-TE specific descriptors used in 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. [I-D.ietf-pce-stateful-pce] describes the messages and objects needed in support of stateful PCE. The following sections contain MPLS-TE specific descriptors used in some of these messages.

4.1. MPLS-TE specific descriptors for the PCRpt Message

The format of the PCRpt message is defined in [I-D.ietf-pce-stateful-pce] as follows, and included here for easy reference:

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

Where:

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

<state-report> ::= <LSP>
                   [<path-list>]
```

Where:

```
<path-list>::=<path>[<path-list>]
```

For MPLS-TE LSPs, the path descriptor is defined as follows:

```
<path>::=<ERO><attribute-list>
```

Where:

```
 <attribute-list> ::= [<LSPA>]
                      [<BANDWIDTH>]
                      [<RRO>]
                      [<metric-list>]

 <metric-list> ::= <METRIC>[<metric-list>]
```

The LSP State Report MAY contain a path descriptor for the primary path and one or more path descriptors for backup paths. A path descriptor MUST contain an ERO object as it was specified by a PCE or an operator. A path descriptor MUST contain the RRO object if a primary or secondary LSP is set up along the path in the network. A path descriptor MAY contain the LSPA, BANDWIDTH, and METRIC objects. The ERO,LSPA, BANDWIDTH, METRIC, and RRO objects are defined in[RFC5440].

4.2. MPLS-TE specific descriptors for the PCUpd Message

A Path Computation LSP Update Request message (also referred to as PCUpd message) is a PCEP message sent by a PCE to a PCC to update attributes of an LSP. A PCUpd message can carry more than one LSP Update Request. The Message-Type field of the PCEP common header for the PCUpd message is set to [TBD].

The format of the PCUpd message is defined in [I-D.ietf-pce-stateful-pce] and included here for easy reference:

```
   <PCUpd Message> ::= <Common Header>
                       <udpate-request-list>
Where:

   <update-request-list> ::= <update-request>[<update-request-list>]

   <update-request> ::= <LSP>
                        [<path-list>]

Where:

   <path-list>::=<path>[<path-list>]
```

For MPLS-TE LSPs, the endoding of path descriptor is defined as follows:

```
   <path>::=<ERO><attribute-list>

Where:
   <path>::=<ERO><attribute-list>

Where:

   <attribute-list> ::= [<LSPA>]
                        [<BANDWIDTH>]
                        [<metric-list>]

   <metric-list> ::= <METRIC>[<metric-list>]
```

There is one mandatory object that MUST be included within each LSP Update Request in the PCUpd message: the LSP object (see [I-D.ietf-pce-stateful-pce]). If the LSP object is missing, the receiving PCE MUST send a PCErr message with Error-type=6 (Mandatory Object missing) and Error-value=[TBD] (LSP object missing).

The LSP Update Request MUST contain a path descriptor for the primary path, and MAY contain one or more path descriptors for backup paths. A path descriptor MUST contain an ERO object. A path descriptor MAY further contain the BANDWIDTH, IRO, and METRIC objects. The ERO, LSPA, BANDWIDTH, METRIC, and IRO objects are defined in [RFC5440].

Each LSP Update Request results in a separate LSP setup operation at a PCC. An LSP Update Request MUST contain all LSP parameters that a PCC wishes to set for the LSP. A PCC MAY set missing parameters from

locally configured defaults. If the LSP specified the Update Request is already up, it will be re-signaled. The PCC will use make-before-break whenever possible in the re-signaling operation.

A PCC MUST respond with an LSP State Report to each LSP Update Request to indicate the resulting state of the LSP in the network. A PCC MAY respond with multiple LSP State Reports to report LSP setup progress of a single LSP.

If the rate of PCUpd messages sent to a PCC for the same target LSP exceeds the rate at which the PCC can signal LSPs into the network, the PCC MAY perform state compression and only re-signal the last modification in its queue.

Note that a PCC MUST process all LSP Update Requests - for example, an LSP Update Request is sent when a PCE returns delegation or puts an LSP into non-operational state. The protocol relies on TCP for message-level flow control.

Note also that it’s up to the PCE to handle inter-LSP dependencies; for example, if ordering of LSP set-ups is required, the PCE has to wait for an LSP State Report for a previous LSP before triggering the LSP setup of a next LSP.

4.3. MPLS-TE specific encoding for the PCReq Message for stateful PCE

A PCC MAY include the LSP object defined in [I-D.ietf-pce-stateful-pce] in the PCReq message if the stateful PCE capability has been negotiated on a PCEP session between the PCC and a PCE. The definition of the PCReq message (see [RFC5440], Section 6.4) is then extended as follows:

```
      <PCReq Message>::= <Common Header>
                         [<svec-list>]
                         <request-list>
```

Where:

```
      <svec-list>::=<SVEC>[<svec-list>]
      <request-list>::=<request>[<request-list>]

      <request>::= <RP>
                   <END-POINTS>
                   [<LSP>]              <--- New Object
                   [<LSPA>]
                   [<BANDWIDTH>]
                   [<metric-list>]
                   [<RRO>[<BANDWIDTH>]]
                   [<IRO>]
                   [<LOAD-BALANCING>]
```

Where:

```
      <metric-list>::=<METRIC>[<metric-list>]
```

4.4. MPLS-TE specific encoding for the PCRep Message for stateful PCE

A PCE MAY include the LSP object defined in [I-D.ietf-pce-stateful-pce] in the PCRep message if the stateful PCE capability has been negotiated on a PCEP session between the PCC and the PCE and the LSP object was included in the corresponding PCReq message from the PCC. The definition of the PCRep message (see [RFC5440], Section 6.5) is then extended as follows

```
      <PCRep Message> ::= <Common Header>
                          <response-list>
```

Where:

```
      <response-list>::=<response>[<response-list>]

      <response>::=<RP>
                  [<LSP>]                <--- New Object
                  [<NO-PATH>]
                  [<attribute-list>]
                  [<path-list>]

      <path-list>::=<path>[<path-list>]

      <path>::= <ERO><attribute-list>
```

Where:

```
    <attribute-list>::=[<LSPA>]
                       [<BANDWIDTH>]
                       [<metric-list>]
                       [<IRO>]

    <metric-list>::=<METRIC>[<metric-list>]
```

5. Object and TLV Formats

The PCEP objects defined in this document are compliant with the PCEP object format defined in [RFC5440]. The P flag and the I flag of the PCEP objects defined in this document MUST always be set to 0 on transmission and MUST be ignored on receipt since these flags are exclusively related to path computation requests.

5.1. LSP Identifiers TLVs

Whenever the value of an LSP identifier changes, a PCC MUST send out an LSP State Report, where the LSP Object carries the LSP Identifiers TLV that contains the new value. The LSP Identifiers TLV MUST also be included in the LSP object during state synchronization. There are two LSP Identifiers TLVs, one for IPv4 and one for IPv6.

The format of the IPV4-LSP-IDENTIFIERS TLV is shown in the following figure:

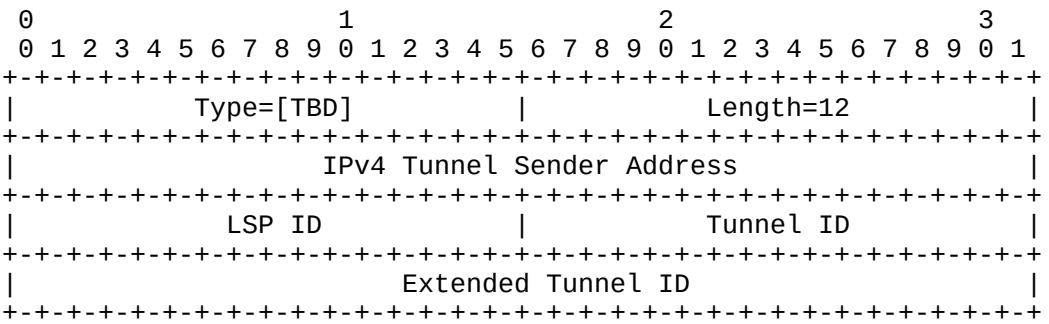

Figure 1: IPV4-LSP-IDENTIFIERS TLV format

The type of the TLV is [TBD] and it has a fixed length of 12 octets. The value contains the following fields:

IPv4 Tunnel Sender Address: contains the sender node's IPv4 address, as defined in [RFC3209], Section 4.6.2.1 for the LSP_TUNNEL_IPv4 Sender Template Object.

LSP ID: contains the 16-bit 'LSP ID' identifier defined in [RFC3209], Section 4.6.2.1 for the LSP_TUNNEL_IPv4 Sender Template Object.

Tunnel ID: contains the 16-bit 'Tunnel ID' identifier defined in [RFC3209], Section 4.6.1.1 for the LSP_TUNNEL_IPv4 Session Object. Tunnel ID remains constant over the life time of a tunnel. However, when Global Path Protection or Global Default Restoration is used, both the primary and secondary LSPs have their own Tunnel IDs. A PCC will report a change in Tunnel ID when traffic switches over from primary LSP to secondary LSP (or vice versa).

Extended Tunnel ID: contains the 32-bit 'Extended Tunnel ID' identifier defined in [RFC3209], Section 4.6.1.1 for the LSP_TUNNEL_IPv4 Session Object.

The format of the IPV6-LSP-IDENTIFIERS TLV is shown in l following figure:

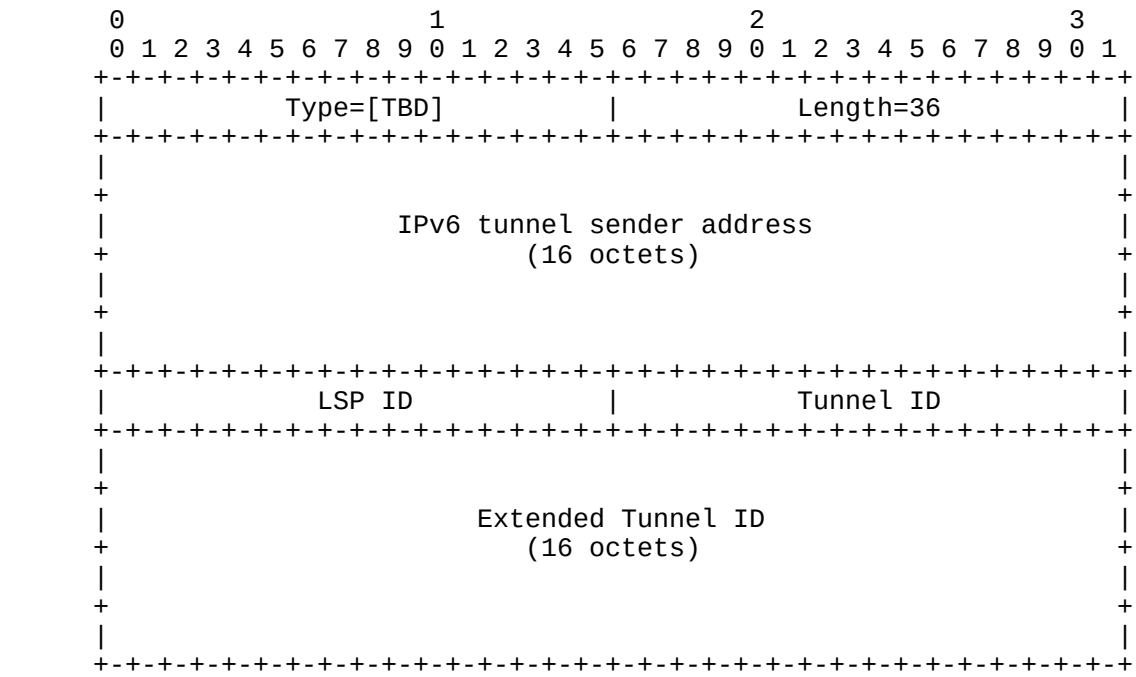

Figure 2: IPV6-LSP-IDENTIFIERS TLV format

The type of the TLV is [TBD] and it has a fixed length of 36 octets. The value contains the following fields:

IPv6 Tunnel Sender Address: contains the sender node's IPv6 address, as defined in [RFC3209], Section 4.6.2.2 for the LSP_TUNNEL_IPv6 Sender Template Object.

LSP ID: contains the 16-bit 'LSP ID' identifier defined in [RFC3209], Section 4.6.2.2 for the LSP_TUNNEL_IPv6 Sender Template Object.

Tunnel ID: contains the 16-bit 'Tunnel ID' identifier defined in [RFC3209], Section 4.6.1.2 for the LSP_TUNNEL_IPv6 Session Object. Tunnel ID remains constant over the life time of a tunnel. However, when Global Path Protection or Global Default Restoration is used, both the primary and secondary LSPs have their own Tunnel IDs. A PCC will report a change in Tunnel ID when traffic switches over from primary LSP to secondary LSP (or vice versa).

Extended Tunnel ID: contains the 128-bit 'Extended Tunnel ID' identifier defined in [RFC3209], Section 4.6.1.2 for the LSP_TUNNEL_IPv6 Session Object.

5.2. Tunnel ID TLV

The Tunnel ID TLV MAY be included in the LSPA object.

The format of the TUNNEL TLV is shown in the following figure:

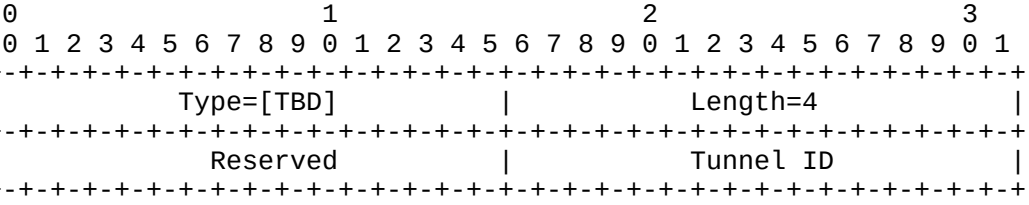

Figure 3: Tunnel-ID TLV format

The type of the TLV is [TBD] and it has a fixed length of 4 octets. The value contains a single field:

Tunnel ID: contains the 16-bit 'Tunnel ID' identifier defined in [RFC3209], Section 4.6.1.1 for the LSP_TUNNEL_IPv4 Session Object. Tunnel ID remains constant over the life time of a tunnel. However, when Global Path Protection or Global Default Restoration is used, both the primary and secondary LSPs have their own Tunnel IDs.

5.3. LSP Update Error Code TLV

If an LSP Update Request failed, an LSP State Report MUST be sent to all connected stateful PCEs. LSP State Report MUST contain the LSP Update Error Code TLV, indicating the cause of the failure.

The format of the LSP-UPDATE-ERROR-CODE TLV is shown in the following figure:

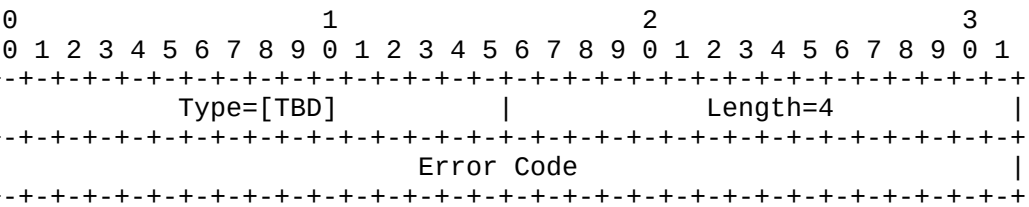

Figure 4: LSP-UPDATE-ERROR-CODE TLV format

The type of the TLV is [TBD] and it has a fixed length of 4 octets. The value contains the error code that indicates the cause of the LSP setup failure. Error codes will be defined in a later revision of this document.

6. IANA Considerations

This document requests IANA actions to allocate code points for the protocol elements defined in this document. Values shown here are suggested for use by IANA.

6.1. PCEP Objects

This document defines the following new PCEP Object-classes and Object-values:

Object-Class Value	Name	Reference
32	LSP Object-Type 1	This document

6.2. PCEP-Error Object

This document defines new Error-Type and Error-Value for the following new error conditions:

Error-Type	Meaning
6	Mandatory Object missing
	Error-value=9: ERO Object missing for a path in an LSP Update Request where TE-LSP setup is requested
	Error-value=10: BANDWIDTH Object missing for a path in an LSP Update Request where TE-LSP setup is requested
	Error-value=11: LSPA Object missing for a path in an LSP Update Request where TE-LSP setup is requested

6.3. PCEP TLV Type Indicators

This document defines the following new PCEP TLVs:

Value	Meaning	Reference
18	IPV4-LSP-IDENTIFIERS	This document
19	IPV6-LSP-IDENTIFIERS	This document
20	LSP-UPDATE-ERROR-CODE	This document
24	TUNNEL-ID	This document

7. Security Considerations

The security considerations listed in [I-D.ietf-pce-stateful-pce] apply to this document as well.

8. Acknowledgements

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