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          PCEP Extensions for MPSL-TE LSP Path Protection with stateful PCE
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Abstract

   A stateful Path Computation Element (PCE) is capable of computing as
   well as controlling via Path Computation Element Protocol (PCEP)
   Multiprotocol Label Switching Traffic Engineering Label Switched
   Paths (MPLS LSP). Furthermore, it is also possible for a stateful
   PCE to create, maintain, and delete LSPs. This document describes
   PCEP extension to associate two or more LSPs to provide end-to-end
   path protection.

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

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1. Introduction

   [RFC5440] describes PCEP for communication between a Path Computation
   Client (PCC) and a PCE or between one a pair of PCEs. A PCE computes
   paths for MPLS-TE LSPs based on various constraints and optimization
   criteria.

   Stateful pce [I-D.ietf-pce-stateful-pce] specifies a set of
   extensions to PCEP to enable stateful control of paths such as MPLS
   TE LSPs between and across PCEP sessions in compliance with
   [RFC4657]. It includes mechanisms to effect LSP state
   synchronization between PCCs and PCEs, delegation of control of LSPs
   to PCEs, and PCE control of timing and sequence of path computations
   within and across PCEP sessions and focuses on a model where LSPs are
   configured on the PCC and control over them is delegated to the PCE.
   Furthermore, a mechanism to dynamically instantiate LSPs on a PCC
   based on the requests from a stateful PCE or a controller using
   stateful PCE is specified in [I-D.ietf-pce-pce-initiated-lsp].

   Path protection refers to a paradigm in which the working LSP is
   protected by one or more protection LSP(s). When the working LSP
   fails, protection LSP(s) is/are activated. When the working LSPs are

computed and controlled by the PCE, there is benefit in a mode of
operation where protection LSPs are as well.

This document specifies a stateful PCEP extension to associate two or
more LSPs for the purpose of setting up path protection. The
proposed extension covers the following scenarios:

1. A protection LSP is initiated on a PCC by a stateful PCE which
    retains the control of the LSP. The PCE is responsible for
    computing the path of the LSP and updating the PCC with the
    information about the path.

2. A PCC initiates a protection LSP and retains the control of the
    LSP. The PCC computes the path and updates the PCE with the
    information about the path as long as it controls the LSP.

3. A PCC initiates a protection LSP and delegates the control of the
    LSP to a stateful PCE. The PCE may compute the path for the LSP
    and update the PCC with the information about the path as long as
    it controls the LSP.

Note that protection LSP can be established (e.g., using RSVP-TE
signaling) prior to the failure (in which case the LSP is said to me
in standby mode) or post failure of the corresponding working LSP
according to the operator choice/policy.

2. Terminology

The following terminologies are used in this document:

AGID: Association Group ID.

ERO: Explicit Route Object.

LSP: Label Switched Path.

PCC: Path Computation Client.

PCE: Path Computation Element

PCEP: Path Computation Element Protocol.

PPAG: Path Protection Association Group.

TLV: Type, Length, and Value.

3. PCEP Extensions

   LSPs are not associated by listing the other LSPs with which they
   interact, but rather by making them belong to an association group
   referred to as "Path Protection Association Group" (PPAG) in this
   document. All LSPs join a PPAG individually. PPAG is based on the
   generic Association object used to associate two or more LSPs
   specified in [I-D.minei-pce-association-group]. A member of a PPAG
   can take the role of working or protection LSP. This document
   defines a new association type called "Path Protection Association
   Type" of value TBD. A PPAG can have one working LSP and one or more
   protection LSPs. The source and destination of all LSPs within a
   PPAG MUST be the same.

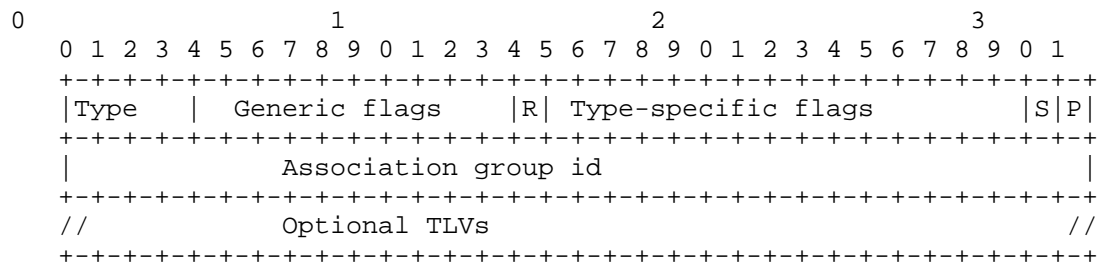   The format of the Association object used for PPAG is shown in
   Figure 1:

```
0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Type   |  Generic flags    |R| Type-specific flags         |S|P|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               Association group id                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
//              Optional TLVs                                 //
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

               Figure 1: The Association Object format

   Type - TBD for the Path Protection Associaiton Type

   The description of the flags are as follows:

   The 'P' Flag indicates whether the LSP associated with the PPAG is
      working or protection LSP. If this flag is set, the LSP is
      protection LSP.

   The 'S' Flag if P flag is set, S flag indicates whether the
      protection LSP associated with the PPAG is in standby mode (e.g.,
      signaled via RSVP-TE prior to failure). The S flag is ignored if
      P flag is set to 0.

4. Operation

   A PCE can create/update working and protection LSPs independently.
   However, it can add a protection LSP to a PPAG only after adding a
   working LSP to that group. As specified in
   [I-D.minei-pce-association-group], Association Group ID (AGID) is
   allocated by PCC. In order to reserve an AGID, PCE sends an
   association object with AGID of 0 either in PCInitiate message or
   PCUpd message for a working LSP, with both the P and S flags set to
   0. Upon receiving an association object with AGID of 0, PCC MUST
   allocate a new AGID and send it the PCE via PCRpt message. Once the
   PCE receives the AGID, it can either create one or more protection
   LSP(s) and add it/them to the PPAG or simply add already existing
   LSP(s) to the PPAG.

   A PCE can remove a protection LSP from a PPAG as specified in
   [I-D.minei-pce-association-group].

   A PCC can associate a set of LSPs under its control for path
   protection purpose. Similarly, the PCC can remove one or more LSPs
   under its control from the corresponding PPAG. In both cases, the
   PCC must report the change in association to PCE(s) via PCRpt
   message.

   The forwarding behavior after failure of the protected LSP, in
   particular how and whether traffic will be load balanced among
   protection pahts will be detailed in a future version of this
   document.

4.1. State Synchronization

   During state synchronization, a PCC MUST report all the existing path
   protection association groups as well as any path protection flags to
   PCE(s). Following the state synchronization, the PCE MUST remove all
   stale path protection associations.

4.2. Error Handling

   All LSPs (working or protection) within a PPAG MUST have the same
   source and destination. If a PCE attempts to add an LSP to a PPAG
   and the source and/or destination of the LSP is/are different from
   the LSP(s) in the PPAG, the PCC MUST send PCErr with Error-Type= TBD
   (Path Protection Association Error) and Error-Value = 1 (End points
   mismatch).

5. IANA considerations

5.1. Association Type

   This document defines a new association type for path protection as
   follows:

   +----------------------+--------------------------+----------------+
   | Association Type | Association Name | Reference |
   | Value | | |
   +----------------------+--------------------------+----------------+
   | 1 | Path Protection | This |
   | | Association | document |
   +----------------------+--------------------------+----------------+

5.2. PCEP Errors

   This document defines new Error-Type and Error-Value related to path
   protection association as follows:

       +------------+----------------------------------+
       | Error-Type | Meaning |
       +------------+----------------------------------+
       | 25 | Path Protection Association error: |
       | | Error-value=1: End-Points mismatch |
       +------------+----------------------------------+

6. Security Considerations

   The same security considerations apply in head end as described in
   [I-D.ietf-pce-pce-initiated-lsp]

7. References

7.1. Normative References

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