PCEP Extensions for PCE-initiated LSP Setup in a Stateful PCE Model
draft-ietf-pce-pce-initiated-lsp-07

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.

   The extensions for stateful PCE provide stateful control of
   Multiprotocol Label Switching (MPLS) Traffic Engineering Label
   Switched Paths (TE LSP) via PCEP, for a model where the PCC delegates
   control over one or more locally configured LSPs to the PCE. This
   document describes the creation and deletion of PCE-initiated LSPs
   under the stateful PCE model.

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

   This Internet-Draft will expire on January 19, 2017.

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1. Introduction

   [RFC5440] describes the Path Computation Element Protocol PCEP. PCEP
   defines the communication between a Path Computation Client (PCC) and
   a Path Control Element (PCE), or between PCE and PCE, enabling
   computation of Multiprotocol Label Switching (MPLS) for Traffic
   Engineering Label Switched Path (TE LSP) characteristics.

   Stateful pce [I-D.ietf-pce-stateful-pce] specifies a set of
   extensions to PCEP to enable stateful control of 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.

   This document describes the setup, maintenance and teardown of PCE-
   initiated LSPs under the stateful PCE model, without the need for
   local configuration on the PCC, thus allowing for a dynamic network
   that is centrally controlled and deployed.

2. Terminology

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

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

   The following terms are defined in this document:

   PCE-initiated LSP: LSP that is instantiated as a result of a request
      from the PCE.

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

3. Architectural Overview

3.1. Motivation

   [I-D.ietf-pce-stateful-pce] provides stateful control over LSPs that
   are locally configured on the PCC. This model relies on the Label
   Edge Router (LER) taking an active role in delegating locally

configured LSPs to the PCE, and is well suited in environments where
the LSP placement is fairly static. However, in environments where
the LSP placement needs to change in response to application demands,
it is useful to support dynamic creation and tear down of LSPs. The
ability for a PCE to trigger the creation of LSPs on demand can make
possible agile software-driven network operation, and can be
seamlessly integrated into a controller-based network architecture,
where intelligence in the controller can determine when and where to
set up paths.

A possible use case is one of a software-driven network, where
applications request network resources and paths from the network
infrastructure. For example, an application can request a path with
certain constraints between two LSRs by contacting the PCE. The PCE
can compute a path satisfying the constraints, and instruct the head
end LSR to instantiate and signal it. When the path is no longer
required by the application, the PCE can request its teardown.

Another use case is one of dynamically adjusting aggregate bandwidth
between two points in the network using multiple LSPs. This
functionality is very similar to auto-bandwidth, but allows for
providing the desired capacity through multiple LSPs. This approach
overcomes two of the limitations auto-bandwidth can experience: 1)
growing the capacity between the endpoints beyond the capacity of
individual links in the path and 2) achieving good bin-packing
through use of several small LSPs instead of a single large one. The
number of LSPs varies based on the demand, and LSPs are created and
deleted dynamically to satisfy the bandwidth requirements.

Another use case is that of demand engineering, where a PCE with
visibility into both the network state and the demand matrix can
anticipate and optimize how traffic is distributed across the
infrastructure. Such optimizations may require creating new paths
across the infrastructure.

3.2. Operation overview

A PCC or PCE indicates its ability to support PCE provisioned dynamic
LSPs during the PCEP Initialization Phase via a new flag in the
STATEFUL-PCE-CAPABILITY TLV (see details in Section 4.1).

The decision when to instantiate or delete a PCE-initiated LSP is out
of the scope of this document. To instantiate or delete an LSP, the
PCE sends a new message, the Path Computation LSP Initiate Request
(PCInitiate) message to the PCC. The LSP Initiate Request MUST
include the SRP and LSP objects ([I-D.ietf-pce-stateful-pce]), and
the LSP object MUST include the Symbolic Path Name TLV and MUST have
a PLSP-ID ([I-D.ietf-pce-stateful-pce]) of 0.

For an instantiation operation, the PCE MUST include the ERO and END-
POINTS object and may include various attributes as per [RFC5440].
The PCC creates the LSP using the attributes communicated by the PCE,
and local values for the unspecified parameters. It assigns a unique
PLSP-ID for the LSP and automatically delegates the LSP to the PCE.
It also generates an LSP State Report (PCRpt) for the LSP, carrying
the newly assigned PLSP-ID and indicating the delegation via the
Delegate flag in the LSP object. In addition to the Delegate flag,
the PCC also sets the Create flag in the LSP object (see
Section 5.3.1), to indicate that the LSP was created as a result of a
PCInitiate message and SHOULD include the optional SPEAKER-IDENTITY-
ID TLV defined in [I-D.ietf-pce-stateful-sync-optimizations]
identifying the PCE that requested the LSP creation. This PCRpt
message MUST include the SRP object, with the SRP-id-number used in
the SRP object of the PCInitate message. The PCE may update the
attributes of the LSP via subsequent PCUpd messages. Subsequent LSP
State Report and LSP Update Request for the LSP will carry the PCC-
assigned PLSP-ID, which uniquely identifies the LSP. See details in
Section 5.3.

Once instantiated, the delegation procedures for PCE-initiated LSPs
are the same as for PCC initiated LSPs as described in
[I-D.ietf-pce-stateful-pce], with the exception that the PCC cannot
revoke a delegation for a PCE-initiated LSP. This applies to the
case of a PCE failure as well. In order to allow for network cleanup
without manual intervention, the PCC SHOULD support removal of PCE-
initiated LSPs as one of the behaviors applied on expiration of the
State Timeout Interval [I-D.ietf-pce-stateful-pce]. The behavior
SHOULD be picked based on local policy, and can result either in LSP
removal, or into reverting to operator-defined default parameters.
See details in Section 6. A PCE MAY return a delegation to the PCC
in order to facilitate re-delegation of its LSPs to an alternate PCE.

To indicate a delete operation, the PCE MUST use the new R flag in
the SRP object in a PCInitiate message as described in Section 5.2.
As a result of the deletion request, the PCC MUST remove all state
related to the LSP, and send a PCRpt with the R flag set in the LSP
object for the removed state. See details in Section 5.4.

LSP State Synchronization procedures are described in section 5.4 of
[I-D.ietf-pce-stateful-pce]. During State Synchronization, a PCC
reports the state of its LSPs to the PCE using PCRpt messages and
setting the SYNC flag in the LSP Object. For PCE-initiated LSPs, the
PCC MUST also include the Create Flag in the LSP Object and SHOULD
include the SPEAKER-IDENTITY-ID TLV identifying the PCE that
requested the LSP creation. At the end of state synchronization, the
PCE SHOULD do a sanity check between the reported PCE-Initiated LSPs
and local configurations at PCE to initiate LSPs. For any mismatch,

the PCE SHOULD send a PCInitiate message to either initiate (again)
or remove the LSP.

4. Support of PCE-initiated LSPs

A PCEP speaker indicates its ability to support PCE provisioned
dynamic LSPs during the PCEP Initialization phase. The Open Object
in the Open message contains the "Stateful PCE Capability" TLV,
defined in [I-D.ietf-pce-stateful-pce]. A new flag, the I (LSP-
INSTANTIATION-CAPABILITY) flag is introduced to indicate support for
instantiation of PCE-initiated LSPs. A PCE can initiate LSPs only
for PCCs that advertised this capability and a PCC will follow the
procedures described in this document only on sessions where the PCE
advertised the I flag.

4.1. Stateful PCE Capability TLV

The format of the STATEFUL-PCE-CAPABILITY TLV is shown in the
following figure:

```
 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             |            Length=4            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              Flags                                    |I|S|U|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
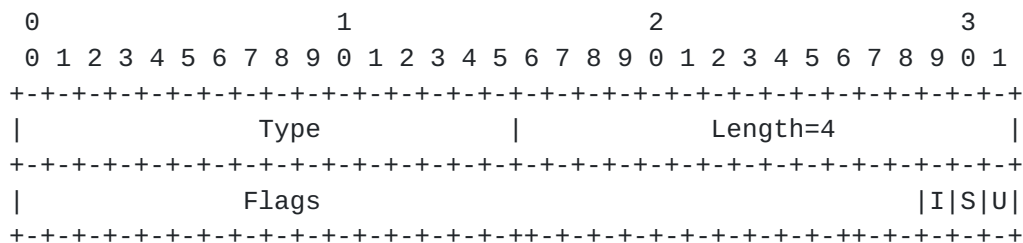
             Figure 1: STATEFUL-PCE-CAPABILITY TLV format

The type of the TLV is defined in [I-D.ietf-pce-stateful-pce] and it
has a fixed length of 4 octets.

The value comprises a single field - Flags (32 bits). The U and S
bits are defined in [I-D.ietf-pce-stateful-pce] and
[I-D.ietf-pce-stateful-sync-optimizations] respectively.

I (LSP-INSTANTIATION-CAPABILITY - 1 bit): If set to 1 by a PCC, the
   I Flag indicates that the PCC allows instantiation of an LSP by a
   PCE. If set to 1 by a PCE, the I flag indicates that the PCE may
   attempt to instantiate LSPs. The LSP-INSTANTIATION-CAPABILITY
   flag must be set by both PCC and PCE in order to support PCE-
   initiated LSP instantiation.

Unassigned bits are considered reserved. They MUST be set to 0 on
transmission and MUST be ignored on receipt.

5. PCE-initiated LSP instantiation and deletion

To initiate an LSP, a PCE sends a PCInitiate message to a PCC. The
message format, objects and TLVs are discussed separately below for
the creation and the deletion cases.

5.1. The LSP Initiate Message

A Path Computation LSP Initiate Message (also referred to as
PCInitiate message) is a PCEP message sent by a PCE to a PCC to
trigger LSP instantiation or deletion. The Message-Type field of the
PCEP common header for the PCInitiate message is set to 12 (suggested
value, to be assigned by IANA). The PCInitiate message MUST include
the SRP and the LSP objects, and may contain other objects, as
discussed later in this section. If the SRP object is missing, the
PCC MUST send a PCErr with error-type 6 (Mandatory Object missing)
and error-value=10 (SRP Object missing) (per
[I-D.ietf-pce-stateful-pce]). If the LSP object is missing, the PCC
MUST send a PCErr with error-type 6 (Mandatory Object missing) and
error-value=8 (LSP Object missing) (per [I-D.ietf-pce-stateful-pce]).
LSP instantiation is done by sending an LSP Initiate Message with an
LSP object with the reserved PLSP-ID 0. LSP deletion is done by
sending an LSP Initiate Message with an LSP object carrying the PLSP-
ID of the LSP to be removed and an SRP object with the R flag set
(see Section 5.2).

The format of a PCInitiate message for LSP instantiation is as
follows:

```
   <PCInitiate Message> ::= <Common Header>
                           <PCE-initiated-lsp-list>
 Where:

   <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-instantiation> ::= <SRP>
                                         <LSP>
                                         <END-POINTS>
                                         <ERO>
                                         [<attribute-list>]

   <PCE-initiated-lsp-deletion> ::= <SRP>
                                    <LSP>

 Where:
   <attribute-list> is defined in [RFC5440] and extended by
   PCEP extensions.
```

The SRP object is used to correlate between initiation requests sent
by the PCE and the error reports and state reports sent by the PCC.
Every request from the PCE receives a new SRP-ID-number. This number
is unique per PCEP session and is incremented each time an operation
(initiation, update, etc) is requested from the PCE. The value of
the SRP-ID-number MUST be echoed back by the PCC in PCErr and PCRpt
messages to allow for correlation between requests made by the PCE
and errors or state reports generated by the PCC. Details of the SRP
object and its use can be found in [I-D.ietf-pce-stateful-pce].

5.2. The R flag in the SRP Object

The format of the SRP object is shown Figure 2:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            Flags                            |R|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        SRP-ID-number                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
//                       Optional TLVs                         //
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
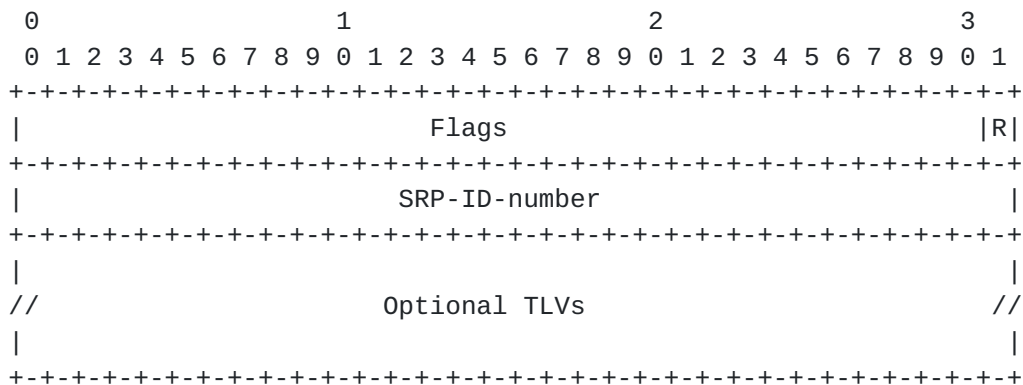
Figure 2: The SRP Object format

The type object is defined in [I-D.ietf-pce-stateful-pce].

A new flag is defined to indicate a delete operation initiated by the PCE:

R (LSP-REMOVE - 1 bit): If set to 1, it indicates a removal request
   initiated by the PCE.

5.3. LSP instantiation

LSP instantiation is done by sending an LSP Initiate Message with an
LSP object with the reserved PLSP-ID 0. The LSP is set up using
RSVP-TE, extensions for other setup methods are outside the scope of
this draft.

Receipt of a PCInitiate Message with a non-zero PLSP-ID and the R
flag in the SRP object set to zero results in a PCErr message of type
19 (Invalid Operation) and value to be assigned by IANA, suggested
value 8 (Non-zero PLSP-ID in LSP initiation request).

The END-POINTS Object is mandatory for an instantiation request of an
RSVP-signaled LSP. It contains the source and destination addresses
for provisioning the LSP. If the END-POINTS Object is missing, the
PCC MUST send a PCErr message with Error-type=6 (Mandatory Object
missing) and Error-value=3 (END-POINTS Object missing).

The ERO Object is mandatory for an instantiation request. It
contains the ERO for the LSP. If the ERO Object is missing, the PCC
MUST send a PCErr message with Error-type=6 (Mandatory Object
missing) and Error-value=9 (ERO Object missing).

The LSP Object MUST include the SYMBOLIC-PATH-NAME TLV, which will be
used to correlate between the PCC-assigned PLSP-ID and the LSP. If

the TLV is missing, the PCC MUST send a PCErr message with Error-
type=10 (Invalid object) and Error-value to be assigned by IANA,
suggested value 8, (SYMBOLIC-PATH-NAME TLV missing). The symbolic
name used for provisioning PCE-initiated LSPs must not have conflict
with the LSP name of any existing LSP in the PCC. (Existing LSPs may
be either statically configured, or initiated by another PCE). If
there is conflict with the LSP name, the PCC MUST send a PCErr
message with Error-type to be assigned by IANA, suggested value 23
(Bad Parameter value) and Error-value=1 (SYMBOLIC-PATH-NAME in use).
The only exception to this rule is for LSPs for which the State
timeout timer is running (see Section 6).

The PCE MAY include various attributes as per [RFC5440]. The PCC
MUST use these values in the LSP instantiation, and local values for
unspecified parameters. After the LSP setup, the PCC MUST send a
PCRpt to the PCE, reflecting these values. The SRP object in the
PCRpt message MUST echo the value of the PCInitiate message that
triggered the setup. LSPs that were instantiated as a result of a
PCInitiate message MUST have the C flag (Section 5.3.1) set in the
LSP object.

If the PCC determines that the LSP parameters proposed in the
PCInitiate message are unacceptable, it MUST trigger a PCErr with
error-type to be assigned by IANA, suggested value 24 (PCE
instantiation error) and error-value=1 (Unacceptable instantiation
parameters). If the PCC encounters an internal error during the
processing of the PCInitiate message, it MUST trigger a PCErr with
error-type to be assigned by IANA, suggested vlaue 24 (PCE
instantiation error) and error-value=2 (Internal error).

A PCC MUST relay to the PCE errors it encounters in the setup of PCE-
initiated LSP by sending a PCErr with error-type to be assigned by
IANA, suggeseted value 24 (PCE instantiation error) and error-value=3
(Signaling error). The PCErr MUST echo the SRP-id-number of the
PCInitiate message. The PCEP-ERROR object SHOULD include the RSVP
Error Spec TLV (if an ERROR SPEC was returned to the PCC by a
downstream node). After the LSP is set up, errors in RSVP signaling
are reported in PCRpt messages, as described in
[I-D.ietf-pce-stateful-pce].

A PCC SHOULD be able to place a limit on either the number of LSPs or
the percentage of resources that are allocated to honor PCE-initiated
LSP requests. As soon as that limit is reached, the PCC MUST send a
PCErr message of type 19 (Invalid Operation) and value to be assigned
by IANA (PCE-initiated limit reached) and is free to drop any
incoming PCInitiate messages without additional processing.

Similarly, the PCE SHOULD be able to place a limit on either the
number of LSP initiation requests pending for a particular PCC, or on
the time it waits for a response (positive or negative) to a
PCInitiate request from a PCC and MAY take further action (such as
closing the session or removing all its LSPs) if this limit is
reached.

On succesful completion of the LSP instantiation, the PCC assigns a
PLSP-ID, and immediately delegates the LSP to the PCE by sending a
PCRpt with the Delegate flag set. The PCRpt MUST include the SRP-ID-
number of the PCInitiate request that triggered its creation. PCE-
initiated LSPs are identified with the Create flag in the LSP Object.

5.3.1. The Create flag

The LSP object is defined in [I-D.ietf-pce-stateful-pce] and included
here for easy reference.

```
  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
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                PLSP-ID                 |Flags  |C|   O|A|R|S|D|
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 //                         TLVs                                //
 |                                                              |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
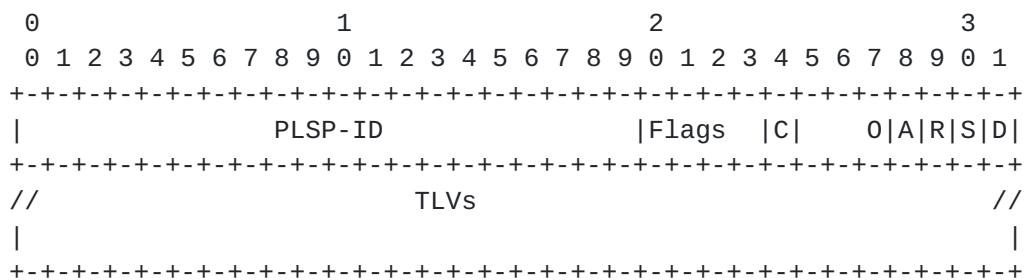
Figure 3: The LSP Object format

A new flag, the Create (C) flag is introduced. On a PCRpt message,
the C Flag set to 1 indicates that this LSP was created via a
PCInitiate message. The C Flag MUST be set to 1 on each PCRpt
message for the duration of existence of the LSP. The Create flag
allows PCEs to be aware of which LSPs were PCE-initiated (a state
that would otherwise only be known by the PCC and the PCE that
initiated them).

5.3.2. The SPEAKER-IDENTITY-ID TLV

The optional SPEAKER-IDENTITY-ID TLV defined in
[I-D.ietf-pce-stateful-sync-optimizations] MAY be included in the LSP
object in a PCRpt message, as an optional TLV for LSPs for which the
C-flag is 1. The SPEAKER-IDENTITY-ID TLV identifies the PCE who
initiated the creation of the LSP on all PCEP sessions, a state that
would otherwise only be known by the PCC and the PCE that initiated
the LSP. If the TLV appears in a PCRpt for an LSP for which the C
flag is 0, the TLV MUST be ignored the and the PCE MUST send a PCErr

message with Error-type 23 ("Bad parameter value") and error value 2
("Speaker identity included for an LSP that is not PCE-initiated").

5.4. LSP deletion

PCE-initiated removal of a PCE-initiated LSP is done by setting the R
(remove) flag in the SRP Object in the PCInitiate message from the
PCE. The LSP is identified by the PLSP-ID in the LSP object. If the
PLSP-ID is unknown, the PCC MUST generate a PCErr with error type 19,
error value 3, "Unknown PLSP-ID" ([I-D.ietf-pce-stateful-pce]). A
PLSP-ID of zero removes all LSPs that were initiated by the PCE. If
the PLSP-ID specified in the PCInitiate message is not delegated to
the PCE, the PCC MUST send a PCErr message indicating "LSP is not
delegated" (Error code 19, error value 1
([I-D.ietf-pce-stateful-pce]). If the PLSP-ID specified in the
PCInitiate message was not created by a PCE, the PCC MUST send a
PCErr message indicating that the LSP is not PCE-initiated, Error
code 19, error value to be assigned by IANA, suggested value 9 (LSP
is not PCE-initiated). Following the removal of the LSP, the PCC
MUST send a PCRpt as described in [I-D.ietf-pce-stateful-pce]. The
SRP object in the PCRpt MUST include the SRP-ID-number from the
PCInitiate message that triggered the removal. The R flag in the SRP
object SHOULD be set.

6. LSP delegation and cleanup

PCE-initiated LSPs are automatically delegated by the PCC to the PCE
upon instantiation. The PCC MUST set the delegation bit to 1 in the
PCRpt that includes the assigned PLSP-ID. All subsequent messages
from the PCC to the PCE that initiated the LSP must have the
delegation bit set to 1. The PCC cannot revoke the delegation for
PCE-initiated LSPs for an active PCEP session. Sending a PCRpt
message with the delegation bit set to 0 to the PCE that initiated
the LSP results in a PCErr message of type 19 (Invalid Operation) and
error-value value to be assigned by IANA, suggested value 7,
(Delegation for PCE-initiated LSP cannot be revoked). The PCE MAY
further react by closing the session.

A PCE MAY return a delegation to the PCC, to allow for LSP transfer
between PCEs. Doing so MUST trigger the State Timeout Interval timer
([I-D.ietf-pce-stateful-pce]) for that particular LSP.

In case of PCEP session failure, control over PCE-initiated LSPs
reverts to the PCC at the expiration of the redelegation timeout. At
this point, the LSP is an "orphan" until the expiration of the State
Timeout timer. To obtain control of a PCE-initiated LSP, a PCE
(either the original or one of its backups) sends a PCInitiate
message, including just the SRP and LSP objects, and carrying the

PLSP-ID of the LSP it wants to take control of. Receipt of a
PCInitiate message with a non-zero PLSP-ID normally results in the
generation of a PCErr. If the LSP is an orphan, the PCC MUST NOT
generate an error and MUST redelegate the LSP to the PCE. The State
Timeout timer for the LSP is stopped upon the redelegation. After
obtaining control of the LSP, the PCE may remove it using the
procedures described in this document.

The State Timeout timer ensures that a PCE crash does not result in
automatic and immediate disruption for the services using PCE-
initiated LSPs. PCE-initiated LSPs are not be removed immediately
upon PCE failure. Instead, they are cleaned up on the expiration of
this timer. This allows for network cleanup without manual
intervention. The PCC SHOULD support removal of PCE-initiated LSPs
as one of the behaviors applied on expiration of the State Timeout
Interval [I-D.ietf-pce-stateful-pce]. The behavior SHOULD be picked
based on local policy, and can result either in LSP removal, or into
reverting to operator-defined default parameters.

7. Implementation status

This section to be removed by the RFC editor.

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 [RFC6982].
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 RFC 6982, "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".

Two vendors are implementing the extensions described in this draft
and have included the functionality in releases that will be shipping
in the near future. An additional entity is working on implementing
these extensions in the scope of research projects.

8. IANA considerations

8.1. PCEP Messages

IANA is requested to allocate a new message type within the "PCEP
Messages" sub-registry of the PCEP Numbers registry, as follows:

Value	Meaning	Reference
12	Initiate	This document

8.2. LSP Object

[I-D.ietf-pce-stateful-pce] defines the LSP Object and requests that
IANA creates a registry to manage the value of the LSP Object's Flag
field. IANA is requested to allocate a new bit in the LSP Object
Flag Field registry, as follows:

Bit	Description	Reference
4	Create	This document

8.3. SRP object

This document requests that a new sub-registry, named "SRP Object
Flag Field", is created within the "Path Computation Element Protocol
(PCEP) Numbers" registry to manage the Flag field of the SRP object.
New values are to be assigned by Standards Action [RFC5226]. Each
bit should be tracked with the following qualities: bit number
(counting from bit 0 as the most significant bit), description and
defining RFC.

The following values are defined in this document:

Bit	Description	Reference
31	LSP-Remove	This document

8.4. STATEFUL-PCE-CAPABILITY TLV

[I-D.ietf-pce-stateful-pce] defines the STATEFUL-PCE-CAPABILITY TLV
and requests that IANA creates a registry to manage the value of the
STATEFUL-PCE-CAPABILITY TLV's Flag field. IANA is requested to
allocate a new bit in the STATEFUL-PCE-CAPABILITY TLV Flag Field
registry, as follows:

Bit	Description	Reference
29	I (LSP-INSTANTIATION-CAPABILITY)	This document

8.5. 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, as follows:

Error-Type	Meaning
10	Invalid Object
	Error-value=8: SYMBOLIC-PATH-NAME TLV missing
19	Invalid operation
	Error-value=6: PCE-initiated LSP limit reached
	Error-value=7: Delegation for PCE-initiated LSP cannot be revoked
	Error-value=8: Non-zero PLSP-ID in LSP initiation request
	Error-value=9: LSP is not PCE-initiated
	Error-value=10: PCE-initiated operation-frequency limit reached
23	Bad parameter value
	Error-value=1: SYMBOLIC-PATH-NAME in use
	Error-value=2: Speaker identity included for an LSP that is not PCE-initiated
24	LSP instantiation error
	Error-value=1: Unacceptable instantiation parameters
	Error-value=2: Internal error
	Error-value=3: Signaling error

9. Security Considerations

The security considerations described in [I-D.ietf-pce-stateful-pce] apply to the extensions described in this document. Additional considerations related to a malicious PCE are introduced.

9.1. Malicious PCE

The LSP instantiation mechanism described in this document allows a PCE to generate state on the PCC and throughout the network. As a result, it introduces a new attack vector: an attacker may flood the

PCC with LSP instantiation requests and consume network and LSR resources, either by spoofing messages or by compromising the PCE itself.

A PCC can protect itself from such an attack by imposing a limit on either the number of LSPs or the percentage of resources that are allocated to honor PCE-initiated LSP requests. As soon as that limit is reached, the PCC MUST send a PCErr message of type 19 (Invalid Operation) and value to be assigned by IANA, suggested value 6 (PCE-initiated LSP limit reached) and is free to drop any incoming PCInitiate messages for LSP instantiation without additional processing.

Rapid flaps triggered by the PCE can also be an attack vector. A PCC can protect itself from such an attack by imposing a limit on the number of flaps per unit of time that it allows a PCE to generate. As soon as that limit is reached, a PCC MUST send a PCErr message of type 19 (Invalid Operation) and value to be assigned by IANA, suggested value 10 (PCE-initiated operation frequency reached) and is free to treat the session as having reached the limit in terms of resources allocated to honor PCE-initiated LSP requests, either permanently or for a locally-defined cool-off period.

9.2. Malicious PCC

The LSP instantiation mechanism described in this document requires the PCE to keep state for LSPs that it instantiates and relies on the PCC responding (with either a state report or an error message) to requests for LSP instantiation. A malicious PCC or one that reached the limit of the number of PCE-initiated LSPs, can ignore PCE requests and consume PCE resources. A PCE can protect itself by imposing a limit on the number of requests pending, or by setting a timeout and it MAY take further action such as closing the session or removing all the LSPs it initiated.

10. Acknowledgements

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