         LABEL-DB Synchronization Procedures for a PCE as a central
                          controller(PCECC)
               draft-palle-pce-controller-labeldb-sync-03

Abstract

   PCE as a central controller specifies the procedures and PCEP
   protocol extensions where LSPs are calculated/setup/initiated and
   label forwarding entries are downloaded through a centralized PCE
   server to each network devices along the LSP path while leveraging
   the existing PCE technologies as much as possible.

   Labels downloaded to forwarding entries requires a reliable
   synchronization mechanism between the path computation clients (PCCs)
   and the PCE. The basic mechanism for label database (LABEL-DB
   synchronization is part of the PCE as a central controller
   specification. This document presents motivations for optimizations
   to the LABEL-DB synchronization and the corresponding PCEP procedures
   and extensions.

Status of This Memo

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1. Introduction

    [I-D.zhao-pce-pcep-extension-for-pce-controller] specify the
    procedures and PCEP protocol extensions for using the PCE as the
    central controller [RFC8283] and user cases where LSPs are
    calculated/setup/initiated/downloaded through extending the existing
    PCE architectures and PCEP.

    [I-D.zhao-pce-pcep-extension-for-pce-controller] and
    [I-D.zhao-pce-pcep-extension-pce-controller-sr] specifies reliable
    synchronization mechanism between the path computation clients (PCCs)
    and the PCECC.

    This draft specify the optimizations for LABEL-DB synchronization and
    the corresponding PCEP procedures and extensions.

    [Important Note - [I-D.zhao-pce-pcep-extension-for-pce-controller]
    defined new messages for label download and cleanup. The authors and
    WG also debated on the use of existing PCEP messages. The appendix
    of the document includes the details related to use of existing
    messages. This document is related to new messages as a new
    procedure for Label DB sync was defined. In case existing messages
    are used, some modifications needs to be made to the existing LSP-DB
    synchronization mechanism to also handle the label synchronization.
    These details are not present in the document at this stage.   ]

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. LABEL-DB Synchronization

    PCECC MUST maintains the LABEL-DB for each PCEP session separately.
    The purpose of LABEL-DB synchronization is to make sure that the
    PCECC's view of LABEL-DB matches with the PCC's LABEL-DB. The LABEL-
    DB synchronization MUST be performed from PCECC to PCC immediately
    after the LSP state synchronization. [RFC8231] describes the basic
    mechanism for LSP state synchronization. [RFC8233] describes the
    optimizations for LSP state synchronization.

    Full LABEL-DB synchronization performed from PCECC to PCC on Initial
    session UP or every session flap is described in
    [I-D.zhao-pce-pcep-extension-for-pce-controller] and
    [I-D.zhao-pce-pcep-extension-pce-controller-sr].

Providing an Optimizations for LABEL-DB synchronization can result in
significant savings in both control-plane data exchanges and the time
it takes for the PCC to become fully operational.

Optimizations for LABEL-DB synchronization describes the need that
both PCEP speakers support label database version capability and
maintain label database version for each session. See Section 3 for
detail procedures.

[Editor's Note: [I-D.zhao-pce-pcep-extension-for-pce-controller]
defines new messages PCLabelUpd and PCLabelRpt. Questions where
raised on the need for the new messages. Further appendix in
[I-D.zhao-pce-pcep-extension-for-pce-controller] and
[I-D.zhao-pce-pcep-extension-pce-controller-sr] describes 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. The optimization
procedure would need to be modified based on the above decision.]

3. Optimizations for LABEL-DB Synchronization

   This section add some of the optimization mechanisms for LABEL-DB
   synchronization. By default, the full LABEL-DB synchronization is
   performed.

3.1. LABEL-DB Synchronization Avoidance Procedure

   The LABEL-DB synchronization MAY be skipped following a PCEP session
   restart if there is no change in the LABEL-DB of the session at
   PCECC, during the period prior to session re-initialization. To be
   able to make this determination, labels must be exchanged and
   maintained by both PCECC and PCC during normal operation. This is
   accomplished by keeping track of the changes to the label database,
   using a version tracking field called the Label Database Version
   Number.

   The Label Database Version Number, carried in LABEL-DB-VERSION TLV
   (see Section 4.3), is owned by a PCECC and it MUST be incremented by
   1 for each successive change in the PCECC's label database. The
   Label Database Version Number MUST start at 1 and may wrap around.
   Values 0 and 0xFFFFFFFFFFFFFFFF are reserved. If either of the two
   values are used during LABEL-DB synchronization, the PCC speaker
   receiving this node should send back a PCErr with Error-type TBD1
   Error-value 3 'Received an invalid Label Database Version Number',
   and close the PCEP session. Operations that trigger a change to the
   Label database include an addition or deletion of labels that would
   trigger a label update to the PCC.

LABEL-DB synchronization avoidance is advertised on a PCEP session
during session startup using the INCLUDE-LABEL-DB-VERSION (I) bit in
the PCECC capability sub-TLV (see Section 4.2). The PCEP peer MAY
include the SPEAKER-ENTITY-ID TLV described in [RFC8233] in the OPEN
message to identify the peer in case of IP address change.

If both PCEP speakers set the I flag in the OPEN object's PCECC
Capability sub-TLV to 1, the PCECC MUST include the LABEL-DB-VERSION
TLV in each LABEL object of the PCLabelUpd message. If the LABEL-DB-
VERSION TLV is missing in a PCLabelUpd message, the PCC will generate
an error with Error-Type 6 (mandatory object missing) and Error-Value
TBD2 'LABEL-DB-VERSION TLV missing' and close the session. If LABEL-
DB synchronization avoidance has not been enabled on a PCEP session,
the PCECC SHOULD NOT include the LABEL-DB-VERSION TLV in the LABEL
Object and the PCC SHOULD ignore it were it to receive one.

If a PCC's label database survived the restart of a PCEP session, the
PCC will include the LABEL-DB-VERSION TLV in its OPEN object, and the
TLV will contain the last Label Database Version Number received on
an Label Update from the PCECC in the previous PCEP session. If a
PCECC's Label Database survived the restart of a PCEP session, the
PCECC will include the LABEL-DB-VERSION TLV in its OPEN object and
the TLV will contain the latest Label Database Version Number. If a
PCEP speaker's label database did not survive the restart of a PCEP
session, the PCEP speaker MUST NOT include the LABEL-DB-VERSION TLV
in the OPEN object.

If both PCEP speakers include the LABEL-DB-VERSION TLV in the OPEN
Object and the TLV values match, the PCECC MAY skip LABEL-DB
synchronization. Otherwise, the PCECC MUST perform full LABEL-DB
synchronization ([I-D.zhao-pce-pcep-extension-for-pce-controller] and
[I-D.zhao-pce-pcep-extension-pce-controller-sr]) or incremental
LABEL-DB synchronization (see Section 3.2) to the PCC, In case, the
PCECC attempts to skip LABEL-DB synchronization, by setting the SYNC
Flag to 0 on the first Label Update from the PCECC, the PCC MUST send
back a PCErr with Error-type TBD1 (Label Database Synchronization
Error) and Error-value 4(Label Database Version mismatch), and close
the PCEP session.

If LABEL-DB synchronization is required, then prior to completing the
initialization phase, the PCC MUST mark any labels in the label
database that were previously updated by the PCECC as stale. When
the PCECC updates a label during LABEL-DB synchronization, if the
label already exists in the label database, the PCC MUST update the
label database and clear the stale marker from the label. When it
has finished LABEL-DB synchronization, the PCECC MUST immediately
send an end of synchronization marker. The end of synchronization
marker is a Path Computation Label Update (PCLabelUpd) message with a

SRP object containing the SYNC flag set to 0 (see Section 4.1) and
Label as 0 in the LABEL object. The LABEL-DB-VERSION TLV MUST be
included in this PCLabelUpd message. On receiving this Label Update,
the PCC MUST report all the labels in the label database that are
still marked as stale to PCECC.

Note that a PCECC/PCC MAY force LABEL-DB synchronization by not
including the LABEL-DB-VERSION TLV in its OPEN object.

Figure 1 shows an example sequence where the LABEL-DB synchronization
is skipped.

```
          +-+-+-+                          +-+-+
          |PCECC|                          |PCC|
          +-+-+-+                          +-+-+
             |              ,----Open---|
             |             /   DBv=35   |
             |--Open--,   /      I=1     |
             |  DBv=35 \  /              |
             |    I=1   \/               |
             |          \/               |
             |          /\               |
             |         /    `------------->| (OK to skip sync)
  (Skip sync) |<--------`                 |
             |          .                |
             |          .                |
             |          .                |
             |                           |
             |--PCLabelUpd,DBv=36,SYNC=0-->| (Regular
             |                           |  Label Update)
             |--PCLabelUpd,DBv=37,SYNC=0-->| (Regular
             |                           |  Label Update)
             |--PCLabelUpd,DBv=38,SYNC=0-->|
             |                           |
```
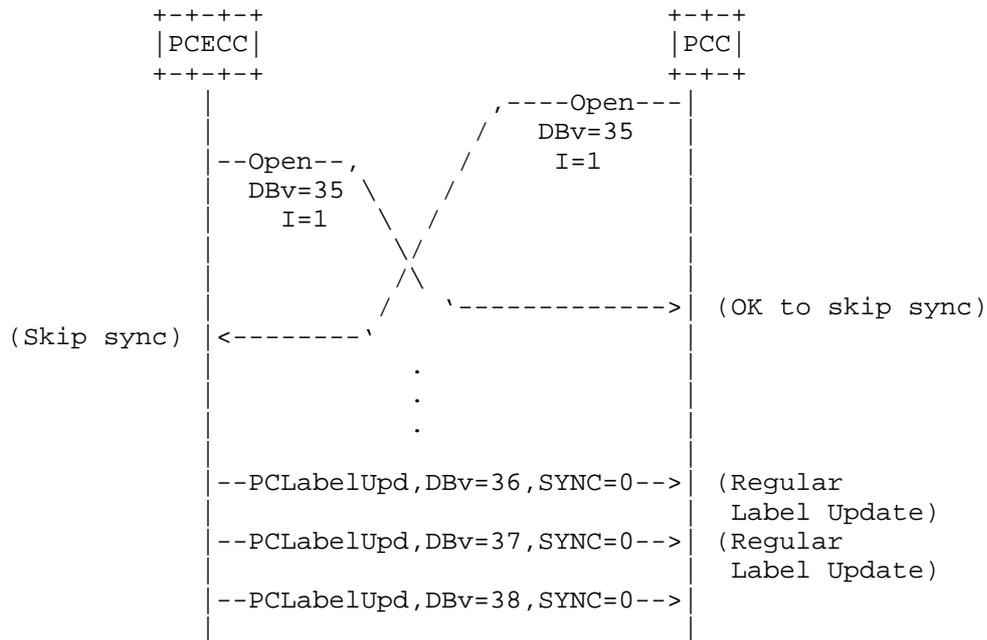
Figure 1: LABEL-DB synchronization Skipped

Figure 2 shows an example sequence where the LABEL-DB synchronization
is performed due to label database version mismatch during the PCEP
session setup. Note that the same LABEL-DB synchronization sequence
would happen if either the PCC or the PCECC would not include the
LABEL- DB-VERSION TLV in their respective Open messages.

```
                +-+-+-+                         +-+-+
                |PCECC|                         |PCC|
                +-+-+-+                         +-+-+
                   |              ,----Open---|
                   |             /  DBv=35    |
                   |--Open--,   /     I=1     |
                   | DBv=39 \   /             |
                   |   I=1   \ /              |
                   |         \/               |
                   |         /\               |
                   |        /  `------------->| (Expect sync)
        (Do sync)  |<--------`                |
                   |                          |
                   |--PCLabelUpd,DBv=39,SYNC=1-->| (Sync start)
                   |              .           |
                   |              .           |
                   |              .           |
                   |--PCLabelUpd,DBv=39,SYNC=0-->| (Sync done)
                   |              .           |
                   |              .           |
                   |              .           |
                   |--PCLabelUpd,DBv=40,SYNC=0-->| (Regular
                   |                          |  Label Update)
                   |--PCLabelUpd,DBv=41,SYNC=0-->| (Regular
                   |                          |  Label Update)
                   |--PCLabelUpd,DBv=42,SYNC=0-->|
                   |                          |
```
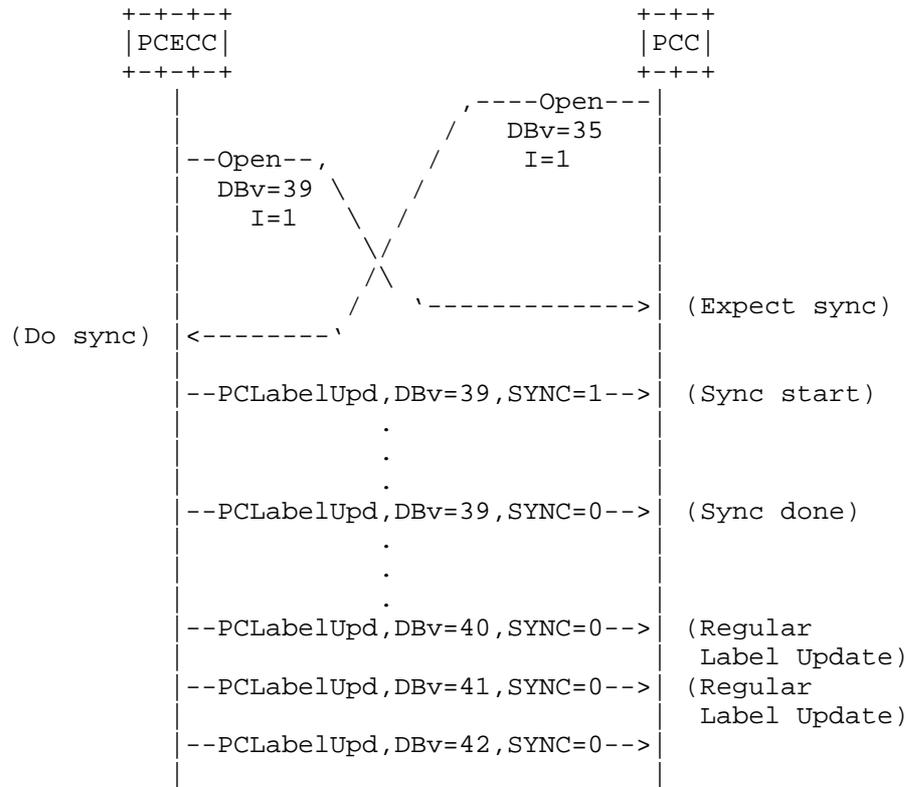
          Figure 2: LABEL-DB synchronization Performed

   Figure 3 shows an example sequence where the LABEL-DB synchronization
   is skipped, but because one or both PCEP speakers set the I Flag to
   0, the PCECC does not send LABEL-DB-VERSION TLVs in subsequent
   PCLabelUpd messages to the PCC. If the current PCEP session
   restarts, the PCEP speakers will have to perform full LABEL-DB
   synchronization, since the PCC does not know the PCECC's latest Label
   Database Version Number information.

```
              +-+-+-+                          +-+-+
              |PCECC|                          |PCC|
              +-+-+-+                          +-+-+
                 |              ,----Open---|
                 |             /   DBv=43    |
                 |--Open--,   /      I=0     |
                 |  DBv=43 \  /              |
                 |   I=0    \ /              |
                 |          \/               |
                 |          /\               |
                 |         /  `------------->| (OK to skip sync)
     (Skip sync) |<--------`                 |
                 |          .                |
                 |          .                |
                 |          .                |
                 |------PCLabelUpd,SYNC=0----->| (Regular
                 |                           |  Label Update)
                 |------PCLabelUpd,SYNC=0----->| (Regular
                 |                           |  Label Update)
                 |------PCLabelUpd,SYNC=0----->|
                 |                           |
```
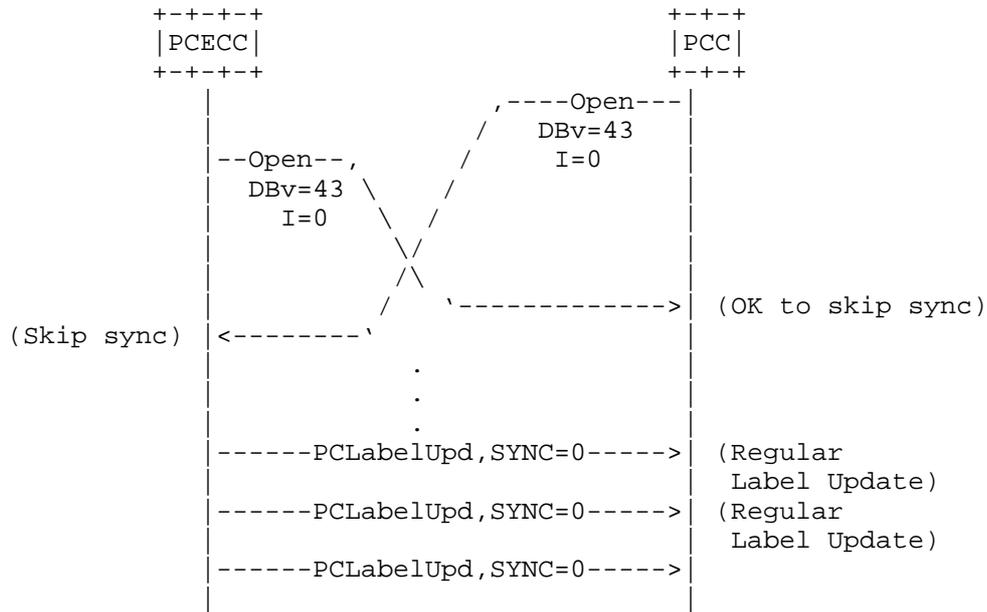
     Figure 3: LABEL-DB Synchronization Skipped, no LABEL-DB-VERSION TLVs
                            sent from PCECC

3.2. Incremental LABEL-DB Synchronization Procedure

   If a PCC restarts and its label database survived, PCECC with
   mismatched Label Database Version Number will send all their Labels
   information (full LABEL-DB) to the PCC, even if only a small number
   of changes happened. It can take a long time and consume large
   communication channel bandwidth.

   This section extends the idea to only synchronize the delta (changes)
   in case of Label Database Version Number of both PCEP peers is non-
   zero and mismatch.

   If both PCEP speakers include the LABEL-DB-VERSION TLV in the OPEN
   object and the LABEL-DB-VERSION TLV values match, the PCECC MAY skip
   LABEL-DB synchronization. Otherwise, the PCECC MUST perform LABEL-DB
   synchronization. Incremental label database synchronization
   capability is advertised on a PCEP session during session startup
   using the DELTA-LABEL-SYNC-CAPABILITY (D) bit in the capabilities TLV
   (see Section 4.2). Instead of dumping full LABEL-DB to the PCC
   again, the PCECC synchronizes the delta (changes) as described in
   Figure 4 when D flag and I flag is set to 1 by both PCC and PCECC.
   Other combinations of D and I flags setting by PCC and PCECC result
   in full LABEL-DB synchronization procedure as described in

[I-D.zhao-pce-pcep-extension-for-pce-controller] and
[I-D.zhao-pce-pcep-extension-pce-controller-sr]. The PCECC MAY force
a full LABEL-DB synchronization by setting the D flag to zero in the
OPEN message.

```
              +-+-+-+                        +-+-+
              |PCECC|                        |PCC|
              +-+-+-+                        +-+-+
                 |             ,----Open---|
                 |            /   DBv=35    |
              |--Open--,     /      I=1     |
                 | DBv=39 \    /      D=1     |
                 |   I=1    \  /             |
                 |           \/              |
                 |           /\              |
                 |          /   `------------->|  (Expect Delta sync)
      (Do sync)|<--------'                  |
      (Delta)  |                            |
                 |                            |
   (Delta       |--PCLabelUpd,DBv=39,SYNC=1-->|
   Sync starts) |             .              |
                 |             .              |
                 |             .              |
                 |             .              |
                 |--PCLabelUpd,DBv=39,SYNC=0-->|  (Sync done)
                 |                            |
                 |                            |
                 |--PCLabelUpd,DBv=40,SYNC=0-->|  (Regular
                 |                            |   Label Update)
                 |--PCLabelUpd,DBv=41,SYNC=0-->|  (Regular
                 |                            |   Label Update)
                 |--PCLabelUpd,DBv=42,SYNC=0-->|
                 |                            |
```
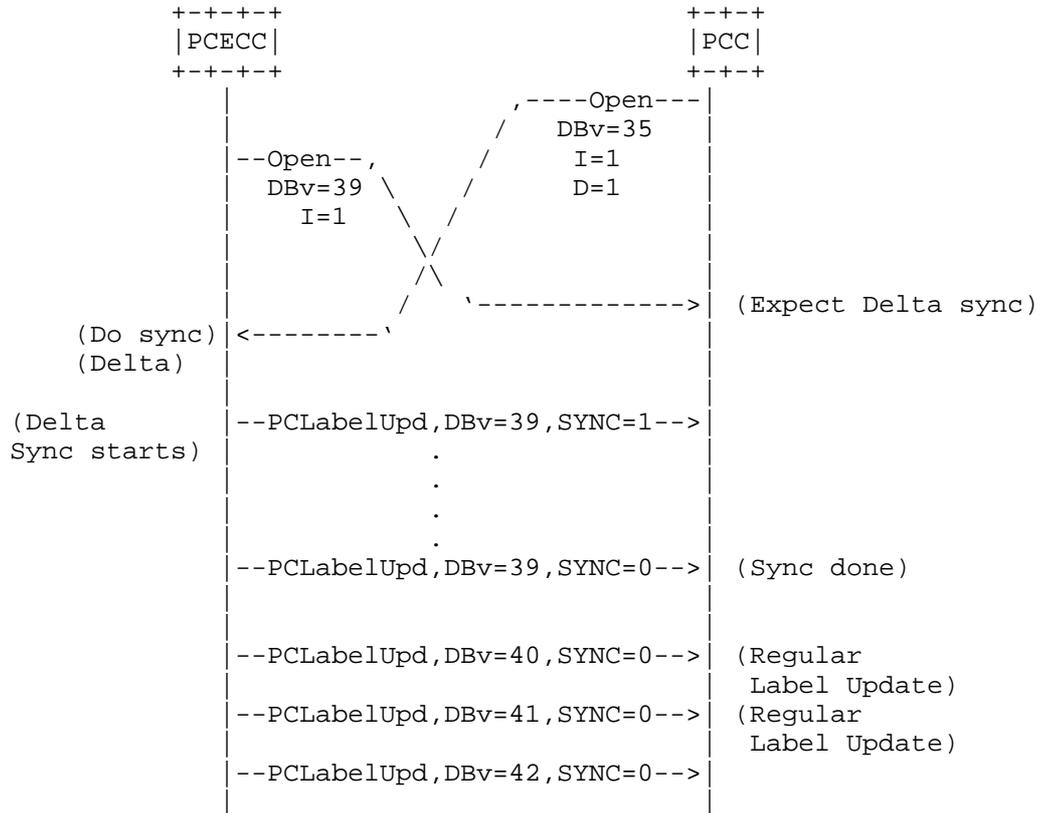
           Figure 4: Incremental Synchronization Procedure

   As per Section 3.1, the Label Database Version Number is incremented
   each time a change is made to the PCECC's label database. Each label
   is associated with the DB version at the time of its addition. This
   is needed to determine which label and what information needs to be
   synchronized in incremental LABEL-DB synchronization.

   It is not necessary for a PCECC to store a complete history of label
   database change, but rather remember the labels (including label
   addition and deletion) that happened between the PCEP session(s)
   restart in order to carry out incremental LABEL-DB synchronization.
   After the synchronization procedure finishes, the PCECC can dump this

history information. In the example shown in Figure 4, the PCECC
needs to store the label changes that happened between DB Version 35
to 39 and synchronizes these changes only when performing incremental
label update. So a PCECC needs to remember at least the label
changes that happened after an existing PCEP session with a PCC goes
down to have any chance of doing incremental synchronization when the
session is re-established.

If a PCECC finds out it does not have sufficient information to
complete incremental synchronization after advertising incremental
LABEL-DB synchronization capability, it MUST send a PCErr with Error-
Type TBD1 and Error-Value 5 'A PCECC indicates to a PCC that it can
not complete the LABEL-DB synchronization' and terminate the session.
The PCECC SHOULD re-establish the session with the D bit set to 0 in
the OPEN message.

The other procedures and error checks remain unchanged from the
default LABEL-DB synchronization defined in
[I-D.zhao-pce-pcep-extension-for-pce-controller] and
[I-D.zhao-pce-pcep-extension-pce-controller-sr].

4. PCEP Extensions

4.1. Extension of SRP object

   SRP object extension for SYNC flag to specify the LABEL-DB
   synchronization operation is defined in
   [I-D.zhao-pce-pcep-extension-for-pce-controller].

4.2. Extension of PCECC Capability sub-TLV

   PCECC Capability sub-TLV is defined in
   [I-D.zhao-pce-pcep-extension-for-pce-controller]. This draft defines
   a new 'INCLUDE-LABEL-DB-VERSION' flag (I bit) to specify the label
   database version capability and 'DELTA-LABEL-SYNC-CAPABILITY' to
   specify the incremental label database synchronization capability.

   The TLV format is as per [RFC5440]. The format of the PCECC
   Capability sub-TLV is shown Figure 5:

```
 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                             |D|I|S|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
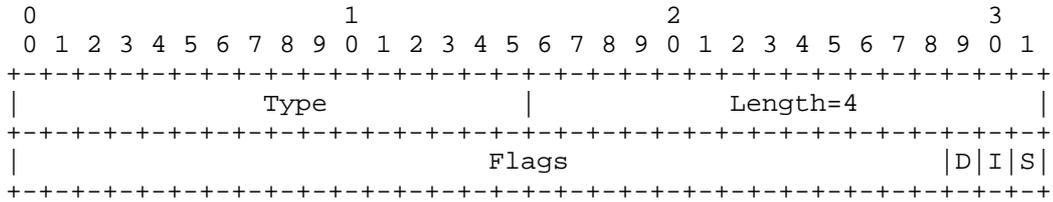
Figure 5: PCECC Capability sub-TLV

I (INCLUDE-LABEL-DB-VERSION - 1 bit): if set to 1 by both PCEP
Speakers, the PCECC will include the LABEL-DB-VERSION TLV in each
LABEL Object.

D (DELTA-LABEL-SYNC-CAPABILITY - 1 bit): if set to 1 by a PCEP
speaker, it indicates that the PCEP speaker allows incremental
(delta) LABEL-DB synchronization.

4.3. New LABEL-DB-VERSION TLV

The Label Database Version Number (LABEL-DB-VERSION) TLV is an
optional TLV that MAY be included in the OPEN object and the LABEL
object.

The TLV format is as per [RFC5440]. The format of the LABEL-DB-
VERSION 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=[TBD3]          |          Length=8             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               Label Database Version Number                  |
|                                                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 6: LABEL-DB-VERSION TLV format

The type of the TLV is [TBD3] and it has a fixed length of 8 octets.
The value contains a 64-bit unsigned integer, representing the Label
Database Version Number.

5. IANA Considerations

5.1. PCEP TLV Type Indicators

   IANA is requested to confirm the early allocation of the following
   TLV Type Indicator values within the "PCEP TLV Type Indicators" sub-
   registry of the PCEP Numbers registry, and to update the reference in
   the registry to point to this document, when it is an RFC:

           Value   Meaning   Reference
           [TBD]   LABEL-DB-VERSION TLV   This document

5.2. PCECC-CAPABILITY sub-TLV

   [I-D.zhao-pce-pcep-extension-for-pce-controller] defines the PCECC-
   CAPABILITY sub-TLV and
   [I-D.zhao-pce-pcep-extension-pce-controller-sr] extends this sub-TLV
   to add PCECC-SR-CAPABILITY.

   Requests that IANA creates a registry to manage the value of the new
   PCECC-CAPABILITY sub-TLV's Flag field. IANA is requested to allocate
   a new bits in the PCECC-CAPABILITY sub-TLV Flag Field registry, as
   follows:

      Bit   Description   Reference
      TBD   I (INCLUDE-LABEL-DB-VERSION)   This document
      TBD   D (DELTA-LABEL-SYNC-CAPABILITY) This document

6. Manageability Considerations

   All manageability requirements and considerations listed in
   [RFC5440], [RFC8231] and
   [I-D.zhao-pce-pcep-extension-for-pce-controller] apply to PCEP
   protocol extensions defined in this document. In addition,
   requirements and considerations listed in this section apply.

6.1. Control of Function and Policy

6.2. Information and Data Models

6.3. Liveness Detection and Monitoring

6.4. Verify Correct Operations

6.5. Requirements On Other Protocols

6.6. Impact On Network Operations

7. Security Considerations

   The security considerations listed in [RFC8231] and
   [I-D.zhao-pce-pcep-extension-for-pce-controller] apply to this
   document as well. Securing the PCEP session using Transport Layer
   Security (TLS) [RFC8253], as per the recommendations and best current
   practices in [RFC7525], is RECOMMENDED.

8. Acknowledgements

   This document borrows some of the structure and text from [RFC8253],
   and would like to thanks the authors and contributors of the
   document.

9. References

9.1. Normative References

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9.2. Informative References

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