         PCEP Procedures and Extension for VLAN-based Traffic Forwarding
              draft-wang-pce-vlan-based-traffic-forwarding-01

Abstract

   This document defines the Path Computation Element Communication
   Protocol (PCEP) extension for VLAN-based traffic forwarding in native
   IP network and describes the essential elements and key processes of
   the data packet forwarding system based on VLAN info to accomplish
   the End to End (E2E) traffic assurance for VLAN-based traffic
   forwarding in native IP network.

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1. Introduction

   Based on the PCEP, a southbound interface protocol of the controller,
   the PCE can calculate the optimal path for various applications and
   sends it to the network equipment through the centralized path
   calculation mechanism, so as to control the packet forwarding and
   make the separation of path calculation and establishment function.

   With the large scale deployment of Ethernet interface, it is possible
   to use the info contained in the Layer2 message to simplify the
   processing of a distributed control plane. This document defines a
   Path Computation Element Communication Protocol (PCEP) Extension for
   VLAN-based traffic forwarding by using the VLAN info contained in the
   Ethernet frame in native IP network. It is an end to end traffic

guarantee mechanism based on the PCEP protocol in the native IP
environment, which can ensure the connection-oriented network
communication. It can simplifiy the calculation and forwarding
process of the optimal path by blending it with elements of PCEP and
without necessarily completely replacing it. Compared with other
traffic assurance technologies such as mpls or srv6, the VLAN-based
traffic forwarding mechanism uses a completely new address space
which will not conflict with other existing protocols. It is
suitable for ipv4 and ipv6 networks and can leverage the existing PCE
technologies as much as possible.

2. Conventions used in this document

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] .

3. Terminology

The following terms are defined in this draft:

o   PCC: Path Computation Client

o   PCE: Path Computation Element

o   PCEP: PCE Communication Protocol

o   PCECC: PCE-based Central Controller

o   LSP: Lable Switching Path

o   PST: Path Setup Type

4. Procedures for VLAN-based Traffic Forwarding

In order to set up the VLAN-based traffic forwarding paths for
different applications in native IP network, multiple BGP sessions
should be deployed between the ingress PCC and egress PCC at the edge
of the network respectively. Based on the business requirements, the
PCE calculates the explict route and sends the route information to
the PCCs through PCInitiate messages. When received the PCInitiate
message, the ingress PCC will form a VLAN-Forwarding routing table
defined in this document. The packet to be guaranteed will be
matched in the table and then be labeled with corresponding VLAN tag.
The labeled packet will be further sent to the PCC's specific
subinterface identified by the VLAN tag and then be forwarded.
Similarly, the transit PCC and the egress PCC will form a VLAN-
Crossing routing table after received the PCInitiate message. The

packet to be guaranteed will be relabled with new VLAN tag and then
be forwarded. The whole procedures mainly forcus on the end-to-end
traffic for key application which can ensure the adequacy of VLAN
number for this scenario. During the whole packet forwarding
process, the packet can be encapsulated with reserved multicast MAC
addresses(e.g. 0180:C200:0014 for ISIS levle1, 0180:C200:0015 for
ISIS levle2) and don't need to change hop by hop so as to accept by
each PCC.

5. Capability Advertisement

During the PCEP Initialization Phase, PCEP Speakers (PCE or PCC)
advertise their support of VLAN-based trafficforwarding extensions.
This document defines a new Path Setup Type (PST)[RFC8408] for PCECC,
as follows:

o PST=TBD1: Path is a VLAN-based traffic forwarding type.

A PCEP speaker MUST indicate its support of the function described in
this document by sending a PATH-SETUP-TYPE-CAPABILITY TLV in the OPEN
object with this new PST included in the PST list.

Because the path is set up through PCE, a PCEP speaker must advertise
the PCECC capability by using PCECC-CAPABILITY sub-TLV which is used
to exchange information about their PCECC capability as per PCEP
extensions defined in
[I-D.ietf-pce-pcep-extension-for-pce-controller]

A new flag is defined in PCECC-CAPABILITY sub-TLV for VLAN-based
traffic forwarding.

V (VLAN-based-forwarding-CAPABILITY - 1 bit - TBD2): If set to 1 by a
PCEP speaker, it indicates that the PCEP speaker supports the
capability of VLAN based traffic forwarding as specified in this
document. The flag MUST be set by both the PCC and PCE in order to
support this extension.

If a PCEP speaker receives the PATH-SETUP-TYPE-CAPABILITY TLV with
the newly defined path setup type, but without the V bit set in
PCECC-CAPABILITY sub-TLV, it MUST:

o Send a PCErr message with Error-Type=10(Reception of an invalid
   object) and Error-Value TBD3(PCECC VLAN-based-forwarding-
   CAPABILITY bit is not set).

o Terminate the PCEP session

6. PCEP message

   As per [RFC8281] ,the PCInitiate message sent by a PCE was defined to
   trigger LSP instantiation or deletion with the SRP and LSP object
   included during the PCEP initialization phase. The Path Computation
   LSP State Report message (PCRpt message) was defined in [RFC8231],
   which is used to report the current state of a LSP. A PCC can send a
   LSP State Report message in response to a LSP instantiation.
   Besides, the message can either in response to a LSP Update Request
   from a PCE or asynchronously when the state of a LSP changes .

   [I-D.ietf-pce-pcep-extension-for-pce-controller] defines an object
   called Central Controller Instructions (CCI) to specify the
   forwarding instructions to the PCC. During the coding process used
   for central controller instructions, the object contains the label
   information and is carried within PCInitiate or PCRpt message for
   label download .

   This document specify two new CCI object-types for VLAN-based traffic
   forwarding in the native IP network and are said to be mandatory in a
   PCEP message when the object must be included for the message to be
   considered valid. In addition, this document enxtends the PCEP
   message to handle the VLAN-based traffic forwarding path in the
   native IP network with the new CCI object.

6.1. The PCInitiate message

   The PCInitiate message[RFC8281] extended
   in[I-D.ietf-pce-pcep-extension-for-pce-controller] can be used to
   download or remove labels by using the CCI Object.

   Based on the extended PCInitiate message and PCRpt described in
   [I-D.ietf-pce-pcep-extension-native-ip], the (BGP Peer Info (BPI)
   Object and the Peer Prefix Association (PPA) Object is used to
   establish multi BGP sessions and advertise route prefixes among
   different BGP sessions before setting up a VLAN-based traffic
   forwarding path.

   This document extends the PCInitiate message as shown below:

```
   <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-central-control>)

          <PCE-initiated-lsp-central-control> ::= <SRP>
                                                  <LSP>
                                                  <cci-list>|
                                                  ((<BPI>|<PPA>)
                                                  <new-CCI>)

          <cci-list> ::=  <new-CCI>
                          [<cci-list>]

   Where:

           <cci-list> is as per
           [I-D.ietf-pce-pcep-extension-for-pce-controller].
           <PCE-initiated-lsp-instantiation> and
           <PCE-initiated-lsp-deletion> are as per [RFC8281].
           <BPI> and <PPA> are as per
           [draft-ietf-pce-pcep-extension-native-ip-09]
```

   When PCInitiate message is used to create VLAN-based forwarding
   instructions, the SRP, LSP and CCI objects MUST be present. The
   error handling for missing SRP, LSP or CCI object is as per
   [I-D.ietf-pce-pcep-extension-for-pce-controller]. Further only one
   of BPI, PPA or one type of CCI objects MUST be present. If none of
   them are present, the receiving PCE MUST send a PCErr message with
   Error- type=6 (Mandatory Object missing) and Error-value=TBD4 (VLAN-
   based forwarding object missing). If there are more than one of BPI,
   PPA or one type of CCI objects are presented, the receiving PCC MUST
   send a PCErr message with Error-type=19(Invalid Operation) and Error-
   value=TBD5(Only one of BPI, PPA or one type of the CCI objects for
   VLAN can be included in this message).

6.2. The PCRpt message

   The PCRpt message is used to report the state and confirm the VLAN
   info that were allocated by the PCE, to be used during the state
   synchronization phase or as acknowledgemnt to PCInitiate message.

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>|
                              <central-control-report>)

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

          <central-control-report> ::= [<SRP>]
                                       <LSP>
                                       <cci-list>|
                                       ((<BPI>|<PPA>)
                                       (<new-CCI>)


        Where:
          <path> is as per [RFC8231] and the LSP and SRP object are
          also defined in [RFC8231].
          <BPI> and <PPA> are as per
          [draft-ietf-pce-pcep-extension-native-ip-09]
```

The error handling for missing LSP or CCI object is as per
[I-D.ietf-pce-pcep-extension-for-pce-controller]. Further only one
of BPI, PPA or one type of CCI objects MUST be present. If none of
them are present, the receiving PCE MUST send a PCErr message with
Error- type=6 (Mandatory Object missing) and Error-value=TBD4 (VLAN-
based forwarding object missing). If there are more than one of BPI,
PPA or one type of CCI objects are presented, the receiving PCC MUST
send a PCErr message with Error-type=19(Invalid Operation) and Error-
value=TBD5(Only one of BPI, PPA or one type of the CCI objects for
VLAN can be included in this message).

7. VXLAN-based traffic forwarding Procedures

7.1. Multiple BGP Session Establishment Procedures

As described in section 4, multiple BGP sessions should be deployed
between the ingress device and egress device at the edge of the
network respectively in order to carry informations of different
applications. As per [I-D.ietf-pce-pcep-extension-native-ip], the
PCE should send the BPI((BGP Peer Info) Object to the ingress and

egress device with the indicated Peer AS and Local/Peer IP address.
The Ingress and egress devices will receive multiple BPI objects to
establish sessions with different next hop. The specific process is
as follows:

```
            +----------------------+
  +---------+-        PCE         + --------+
  |         +----------^-----------+        |
  |         |          |          |         |
  |       +--+        +--+       +--+        |
  |------- +R2+ ------+R3+-------+R4+ --------
  |        +--+        +--+       +--+        |
  |                                          |
  +--+                +--+                  +--+
  +R1+----------------+R5+----------------+R6+
  +--+                +--+                  +--+
  |                                          |
  |<------------- BGP Session A ------------>|
  |<------------- BGP Session B ------------>|
  |<------------- BGP Session C ------------>|
```
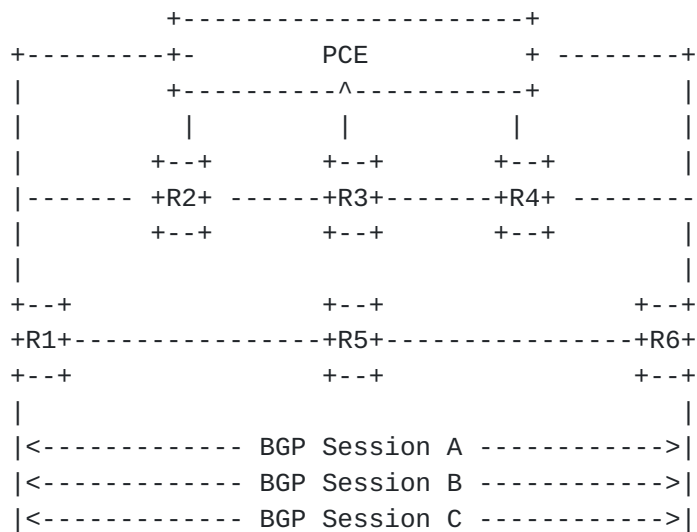
  Figure 1: BGP Session Establishment Procedures

7.2. BGP Prefix Advertisement Procedures

The detail procedures for BGP prefix advertisement procedures is
introduced in [I-D.ietf-pce-pcep-extension-native-ip], using
PCInitiate and PCRpt message pair.

The BGP prefix for different BGP sessions should be sent to the
ingress and egress device respectively. The end-to-end traffic for
key application can be identified based on these BGP prefix
informations and be further assured. As per
[I-D.ietf-pce-pcep-extension-native-ip], the PPA(Peer Prefix
Association) object with list of prefix subobjects and the peer
address will be sent through the PCInitiate and PCRpt message
pair.The specific process is as follows,:

```
                 +----------------------+
    +----------+-         PCE          + --------+
    |          +----------^-----------+         |
    |            |          |          |         |
    |          +--+       +--+       +--+        |
    |-------- +R2+ ------+R3+-------+R4+ --------
    |          +--+       +--+       +--+         |
    |                                            |
    +--+                  +--+                +--+
    +R1+----------------+R5+----------------+R6+
    +--+                  +--+                +--+
```
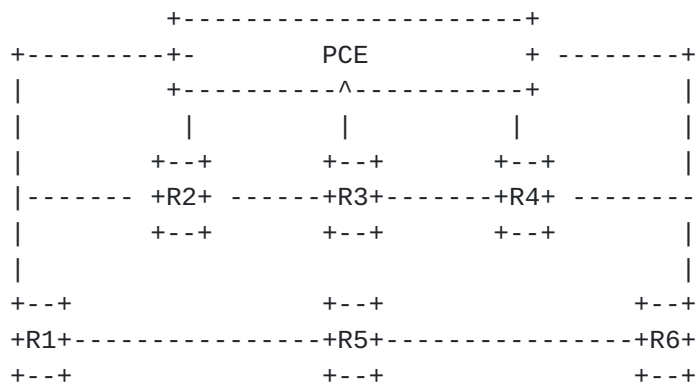
              Figure 2: BGP Prefix Advertisement Procedures

   Through BGP protocol, the ingress device can learn different BGP
   prefix of the egress device based on the different BGP sessions.

7.3. VLAN mapping info Advertisement Procedures

   After the BGP prefix for different BGP session are successfully
   advertised, informations of different applications should be
   forwarded to different VLAN-based traffic forwarding paths. In order
   to set up a VLAN-based traffic forwarding path, the PCE should send
   the VLAN forwarding CCI Object with the VLAN-ID included to the
   ingress PCC and the VLAN crossing CCI Object to the transit PCC and
   egrss PCC.

7.3.1. VLAN-Based forwarding info Advertisement Procedures

   The detail procedures for VLAN-Based forwarding info advertisement
   contained in the VLAN forwarding CCI Object is shown below, using
   PCInitiate and PCRpt message pair.

   The VLAN forwarding CCI Object should be sent through the PCInitiate
   and PCRpt message pair. After the PCC receives the CCI object (with
   the R bit set to 0 in SRP object) in PCInitiate message, the PCC will
   form a VLAN-Forwarding routing table and the PCC's subinterface will
   set up the specific vlan based on the VLAN forwarding CCI object,
   source and destination BGP prefix learnt before. When the ingress
   PCC receives a packet, it will look up the VLAN-Forwarding routing
   table based on the source and destination IP contained in the packet.
   The packet to be guaranteed will be matched in the table and then be
   labeled with corresponding VLAN tag. After that, The labeled packet
   will be further forwarded to the specific subinterface.

   When the packet is tagged and successfully sent, the PCC should
   report the result via the PCRpt messages, with VLAN forwarding CCI
   Object and the corresponding SRP object included.

When PCC receives the VLAN forwarding CCI Object with the R bit set
to 1 in SRP object in PCInitiate message, the PCC should withdraw the
VLAN-Based forwarding info advertisement to the peer that indicated
by this object.

When PCC withdraws the VLAN-Based forwarding info that indicated by
this object successfully, it should report the result via the PCRpt
message, with the corresponding SRP and CCI object included.

```
                    +----------------------+
      +---------+           PCE           + --------+
      |          +----------^-----------+          |
      |          |          |          |          |
    M1&M1-R      |          |          |          |
      |          |          |          |          |
      |          |          |          |          |
      |       +--+        +--+        +--+         |
      |------- +R2+ ------+R3+-------+R4+ --------
      |       +--+        +--+        +--+         |
      |                                           |
    +--+                 +--+                    +--+
    +R1+---------------+R5+----------------+R6+
    +--+                 +--+                    +--+
```
Figure 3: VLAN-Based forwarding info Advertisement
                Procedures for Ingress PCC

The message number, message peers, message type and message key
parameters in the above figures are shown in below table:

Table 1: Message Information

No.	Peers	Type	Message Key Parameters
M1	PCE/R1	PCInitiate	CC-ID=X1
M1-R		PCRpt	VLAN Forwarding CCI Object
			(Peer_IP=R6_A,Interface_Address=INF1,
			VLAN_ID=VLAN_R1_R2)

7.3.2. VLAN-Based crossing info Advertisement Procedures

The detail procedures for VLAN-Based crossing info advertisement
contained in the VLAN crossing CCI Object is shown below, using
PCInitiate and PCRpt message pair.

The PCC would receive VLAN crossing CCI Objects with the in-VLAN CCI
without the O bit set and the out-VLAN CCI with the O bit set. After
the process of VLAN-Based forwarding info advertisement mentioned

above, the PCC will form a VLAN-crossing routing table and the PCC's
subinterface will set up the specific vlan based on the VLAN crossing
CCI Object(with the R bit set to 0 in SRP object) contained in the
PCInitiate message. The VLAN-crossing routing table consists of an
in-VLAN tag and an out-VLAN tag which specifies a new VLAN forwarding
path. When the transit PCC receives a data packet that has been
labeled with VLAN by ingress PCC before, it will look up the VLAN-
Crossing routing table based on the VLAN tag. If matched, the in-
VLAN tag of this PCC will be replaced by a new out-VLAN tag of the
previous PCC according to the table.The packet with the new VLAN tag
will be further forwarded to the next hop.

For the egress PCC, the out-VLAN tag in the VLAN-crossing routing
table should be 0 which indicates it is the last hop of the
transmission. So the egress PCC will directly remove the in-VLAN tag
of the packet and the packet will be forwarded.

When the packet is tagged and successfully sent to the specific
subinterface, the PCC should report the result via the PCRpt
messages, with the corresponding SRP and CCI object included.

When PCC receives the VLAN crossing CCI Object with the R bit set to
1 in SRP object in PCInitiate message, the PCC should withdraw the
VLAN-Based crossing info advertisement to the peer that indicated by
this object.

When PCC withdraws the VLAN-Based crossing info that indicated by
this object successfully, it should report the result via the PCRpt
message, with the corresponding SRP and CCI object included.

When the out-VLAN tag conflicts with a pre-defined VLAN tag or the
PCC can not set up a VLAN forwarding path with the out-VLAN tag, an
error (Error-type=TBD6, VLAN-based forwarding failure, Error-
value=TBD7, VLAN crossing CCI Object peer info mismatch) should be
reported via the PCRpt message.

```
                    +---------------------+
        +---------+            PCE         +  --------+
        |         +----------^----------+        |
        |          |          |          |        |
        |      M1&M1-R     M2&M2-R    M3&M3-R    M4&M4-R
        |          |          |          |        |
        |        +--+       +--+       +--+       |
        |------- +R2+ ------+R3+-------+R4+ -------|
        |        +--+       +--+       +--+       |
        |                                         |
      +--+                   +--+                +--+
      +R1+---------------+R5+---------------+R6+
      +--+                   +--+                +--+
```
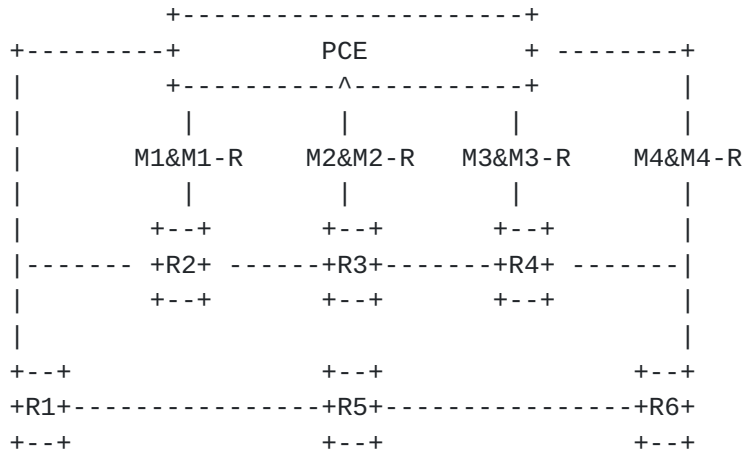
       Figure 4: VLAN-Based crossing info Advertisement Procedures
                    for transit PCC and egress PCC

     The message number, message peers, message type and message key
     parameters in the above figures are shown in below table:

                       Table 2: Message Information

No.	Peers	Type	Message Key Parameters
M1	PCE/R2	PCInitiate	CC-ID=X1
M1-R		PCRpt	VLAN crossing CCI Object(IN)
			(O=0,Interface_Address=INF1,IN_VLAN_ID=VLAN_R1_R2)
			VLAN crossing CCI Object(OUT)
			(O=1,Interface_Address=INF2,OUT_VLAN_ID=VLAN_R2_R3)
M2	PCE/R3	PCInitiate	CC-ID=X1
M2-R		PCRpt	VLAN crossing CCI Object(IN)
			(O=0,Interface_Address=INF1,IN_VLAN_ID=VLAN_R2_R3)
			VLAN crossing CCI Object(OUT)
			(O=1,Interface_Address=INF2,OUT_VLAN_ID=VLAN_R3_R4)
M3	PCE/R4	PCInitiate	CC-ID=X1
M3-R		PCRpt	VLAN crossing CCI Object(IN)
			(O=0,Interface_Address=INF1,IN_VLAN_ID=VLAN_R3_R4)
			VLAN crossing CCI Object(OUT)
			(O=1,Interface_Address=INF2,OUT_VLAN_ID=VLAN_R4_R6)
M4	PCE/R6	PCInitiate	CC-ID=X1
M4-R		PCRpt	VLAN crossing CCI Object(IN)
			(O=0,Interface_Address=INF1,IN_VLAN_ID=VLAN_R4_R6)
			VLAN crossing CCI Object(OUT)
			(O=1,Interface_Address=INF2,OUT_VLAN_ID=0)

8. New PCEP Objects

The Central Control Instructions (CCI) Object is used by the PCE to
specify the forwarding instructions is defined in
[I-D.ietf-pce-pcep-extension-for-pce-controller]. This document
defines another two CCI object-types for VLAN-based traffic
forwarding network. All new PCEP objects are compliant with the PCEP
object format defined in [RFC5440].

8.1. VLAN forwarding CCI Object

The VLAN forwarding CCI Object is used to set up the specific vlan
forwarding path of the logical subinterface that the traffic will be
forwarded to and transfer the packet to the specific hop. Combined
with this type of CCI Object and the Peer Prefix Association
object(PPA) defined in [I-D.ietf-pce-pcep-extension-native-ip], the
ingress PCC will form a VLAN-Forwarding routing table which is used
to identify the traffic that needs to be protected. This object
should only be included and sent to the ingress PCC of the end2end
path.

CCI Object-Class is 44.

CCI Object-Type is TBD8 for VLAN forwarding info in the native IP
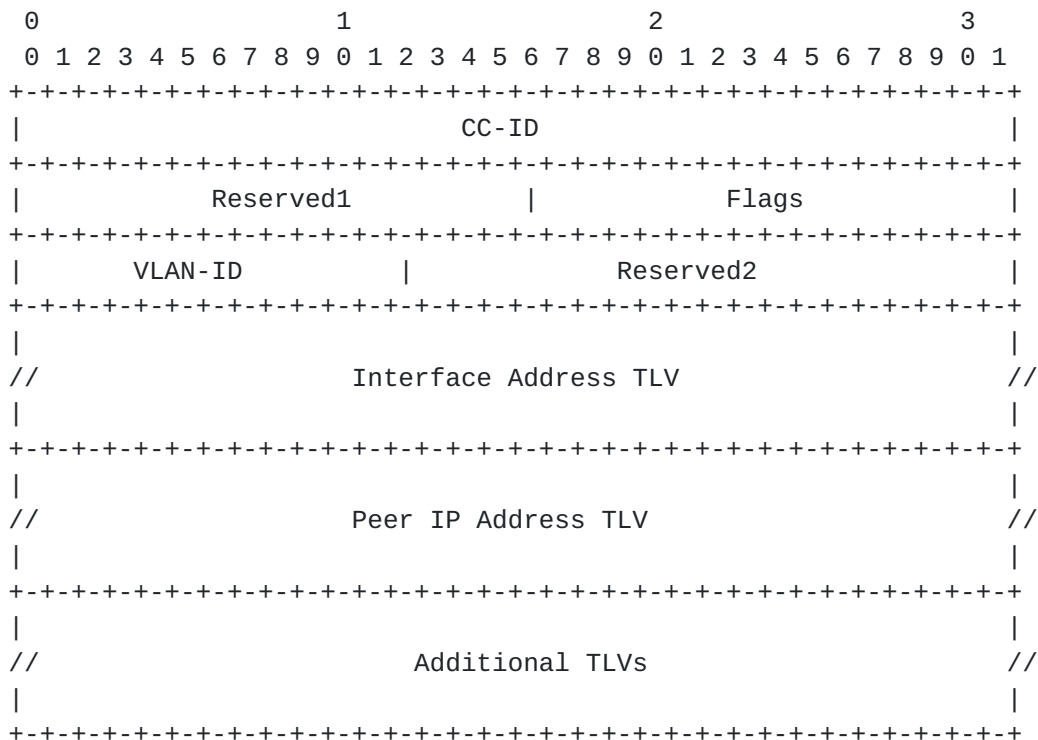network.

```
    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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                            CC-ID                             |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |           Reserved1          |            Flags              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |       VLAN-ID       |              Reserved2                 |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                              |
   //                   Interface Address TLV                    //
   |                                                              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                              |
   //                     Peer IP Address TLV                    //
   |                                                              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                              |
   //                       Additional TLVs                      //
   |                                                              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                   Figure 5: VLAN Forwarding CCI Object

   The fields in the CCI object are as follows:

   CC-ID: is as described in
   [I-D.ietf-pce-pcep-extension-for-pce-controller]. Following fields
   are defined for CCI Object-Type TBD8.

   Reserved1(16 bits): is set to zero while sending, ignored on receipt.

   Flags(16 bits): is used to carry any additional information
   pertaining to the CCI. Currently no flag bits are defined.

   VLAN ID(12 bits):the ID of the VLAN forwarding path that the PCC will
   set up on its logical subinterface in order to transfer the packet to
   the specific hop.

   Reserved2(20 bits): is set to zero while sending, ignored on receipt.

   Interface Address TLV [RFC8779] MUST be included in this CCI Object-
   Type TBD8 to specify the interface which will set up the vlan defined
   in the VLAN Forwarding CCI Object.

   The Peer IP Address TLV[RFC8779]MUST be included in this CCI Object-
   Type TBD8 to identify the end to end TE path in VLAN-based traffic
   forwarding network and MUST be unique.

8.2. Address TLVs

   [RFC8779] defines IPV4-ADDRESS, IPV6-ADDRESS, and UNNUMBERED-ENDPOINT
   TLVs for the use of Generalized Endpoint. The same TLVs can also be
   used in the CCI object to find the Peer address that matches egress
   PCC and further identify the packet to be guaranteed. If the PCC is
   not able to resolve the peer information or can not find the
   corresponding ingress device, it MUST reject the CCI and respond with
   a PCErr message with Error-Type = TBD6 ("VLAN-based forwarding
   failure") and Error Value = TBD9 ("Invalid egress PCC information").

8.3. VLAN crossing CCI Object

   The VLAN crossing CCI object is defined to control the transmission-
   path of the packet by VLAN-ID.This new type of CCI Object can be
   carried within a PCInitiate message sent by the PCE to the transit
   PCC and the egress PCC in the VLAN-based traffic forwarding
   scenarios.

   CCI Object-Class is 44.

   CCI Object-Type is TBD10 for VLAN crossing info in the native IP
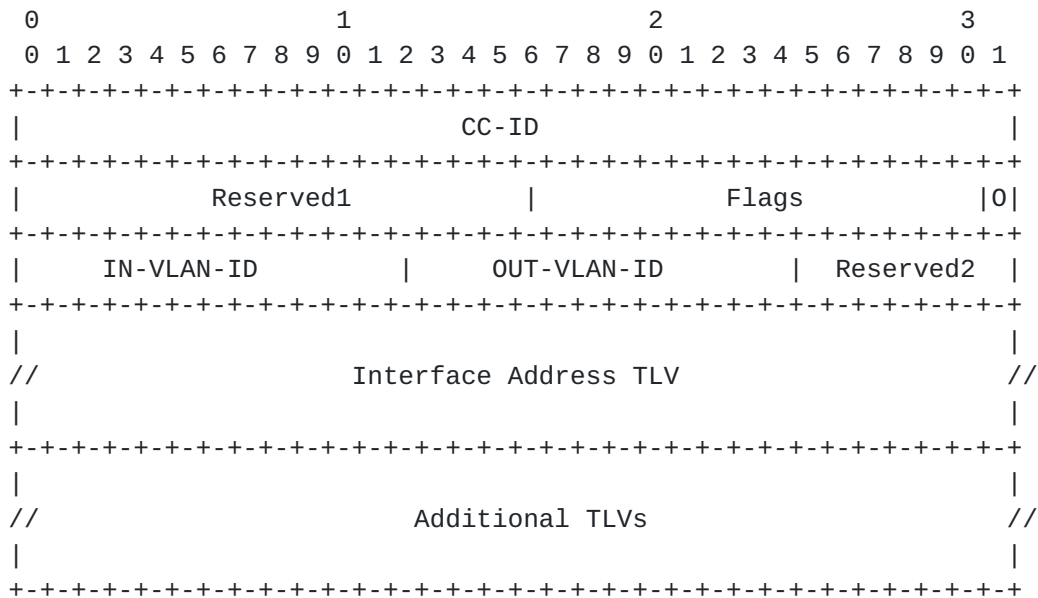   network.

```
    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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                            CC-ID                              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |          Reserved1             |          Flags           |O|
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |      IN-VLAN-ID        |      OUT-VLAN-ID       |  Reserved2  |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                              |
   //                   Interface Address TLV                    //
   |                                                              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                              |
   //                     Additional TLVs                        //
   |                                                              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                  Figure 6: VLAN Crossing CCI Object

   CC-ID: is as described in
   [I-D.ietf-pce-pcep-extension-for-pce-controller]. Following fields
   are defined for CCI Object-Type TBD10.

Reserved1(16 bits): is set to zero while sending, ignored on receipt.

Flags(16 bits): is used to carry any additional information
pertaining to the CCI.Currently, the following flag bit are defined:

* O bit (out-label) : If the bit is set to '1', it specifies the VLAN
is the out-VLAN, and it is mandatory to encode the egress interface
information(via Interface Address TLVs in the CCI object). If the
bit is not set or set to '0', it specifies the VLAN is the in-VLAN,
and it is mandatory to encode the ingress interface information.

IN-VLAN ID(12 bits): The ID of the VLAN forwarding path which is used
to identify the traffic that needs to be protected.

OUT-VLAN ID(12 bits):The ID of the VLAN forwarding path that the PCC
will set up on its logical subinterface in order to transfer the
packet labeld with this VLAN ID to the specific hop.To the transit
PCC, the value must not be 0 to indicate it is not the last hop of
the VLAN-based traffic forwarding path. To the egress PCC, the value
must be 0 to indicate it is the last hop of the VLAN-based traffic
forwarding path.

Reserved2(8 bits): is set to zero while sending, ignored on receipt.

Interface Address TLV [RFC8779] MUST be included in this CCI Object-
Type TBD8 to specify the interface which will set up the vlan defined
in the VLAN Forwarding CCI Object.

9. Deployment Considerations

10. Security Considerations

11. IANA Considerations

11.1. Path Setup Type Registry

[RFC8408] created a sub-registry within the "Path Computation Element
Protocol (PCEP) Numbers" registry called "PCEP Path Setup Types".
IANA is requested to allocate a new code point within this registry,
as follows:

```
Value        Description                          Reference
TBD1         VLAN-Based Traffic Forwarding Path    This document
```

11.2. PCECC-CAPABILITY sub-TLV's Flag field

   [I-D.ietf-pce-pcep-extension-for-pce-controller] created a sub-
   registry within the "Path Computation Element Protocol (PCEP)
   Numbers" registry to manage the value of the PCECC-CAPABILITY sub-
   TLV's 32-bits Flag field. IANA is requested to allocate a new bit
   position within this registry, as follows:

Value	Description	Reference
TBD2(V)	VLAN-Based Forwarding CAPABILITY	This document

11.3. PCEP Object Types

   IANA is requested to allocate new registry for the PCEP Object Type:

Object-Class Value	Name	Reference
44	**CCI Object-Type**	This document
	TBD8: VLAN forwarding CCI	
	TBD10: VLAN crossing CCI	

11.4. 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	Error-value	Reference
6	**Mandatory Object missing**	TBD4:VLAN-based forwarding object missing	This document
10	**Reception of an** invalid object	TBD3:PCECC VLAN-based-forwarding -CAPABILITY bit is not set	This document
19	**Invalid Operation**	TBD5: Only one of BPI, PPA or one type of the CCI objects for VLAN can be included in this message	This document
TBD6	VLAN-based forwarding failure	TBD7: VLAN crossing CCI Object peer info mismatch	This document
		TBD9: Invalid egress PCC information	This document

12. Acknowledgement

13. Normative References

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