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## **Support for Virtual Transport Network (VTN) in the Path Computation Element Communication Protocol (PCEP)**

### **Abstract**

With the introduction and evolvement of 5G and other network scenarios, some existing or new customers may require connectivity services with advanced characteristics comparing to traditional Virtual Private Networks (VPNs). Such kind of network service is called enhanced VPNs (VPN+). The typical application of VPN+ is to provide network slice services.

A Virtual Transport Network (VTN) is a virtual underlay network which consists of a set of dedicated or shared network resources allocated from the physical underlay network, and is associated with a customized logical network topology. VPN+ services can be delivered by mapping one or a group of overlay VPNs to the appropriate VTNs as the virtual underlay. Then traffic flows of the VPN+ service can be steered onto the TE paths within the VTN.

The Path Computation Element (PCE) provides path computation functions in support of traffic engineering in Multiprotocol Label Switching (MPLS), Generalized MPLS (GMPLS) and Segment Routing (SR) networks.

This document specifies the extensions to PCE communication Protocol (PCEP) to carry VTN information in the PCEP messages. The extensions in this document can be used in the basic PCE computation, the stateful PCE and the PCE-initiated LSP mechanisms to indicate path computation, path status report and path initialization within a specific VTN.

### **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.

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## 1. Introduction

[[RFC5440](#)] describes the Path Computation Element (PCE) Communication Protocol (PCEP). PCEP enables the communication between a Path Computation Client (PCC) and a PCE, or between PCE and PCE, for the purpose of computation of Multiprotocol Label Switching (MPLS) as well as Generalized MPLS (GMPLS) Traffic Engineering Label Switched Path (TE LSP) characteristics.

[[RFC8231](#)] specifies a set of extensions to PCEP to enable stateful control of TE LSPs within and across PCEP sessions in compliance with [[RFC4657](#)]. It includes mechanisms to effect LSP State Synchronization between PCCs and PCEs, delegation of control over LSPs to PCEs, and PCE control of timing and sequence of path computations within and across PCEP sessions. The model of operation where LSPs are initiated from the PCE is described in [[RFC8281](#)]. [[RFC8664](#)] specifies PCEP extensions to allow a stateful PCE to compute and initiate TE paths, as well as a PCC to request a path subject to certain constraints and optimization criteria in SR networks.

With the introduction and evolvement of 5G and other network scenarios, some existing or new customers may require connectivity services with advanced characteristics comparing to traditional Virtual Private Networks (VPNs). Such kind of network service is called enhanced VPNs (VPN+). The typical application of VPN+ is to provide network slice services. The concept and general framework of IETF network slice are described in [[I-D.ietf-teas-ietf-network-slices](#)].

[[I-D.ietf-teas-enhanced-vpn](#)] describes a framework and the candidate component technologies for providing VPN+ services. It also introduces the concept of Virtual Transport Network (VTN). A Virtual Transport Network (VTN) is a virtual underlay network which consists of a set of dedicated or shared network resources allocated from the physical underlay network, and is associated with a customized logical network topology. VPN+ services can be delivered by mapping one or a group of overlay VPNs to the appropriate VTNs as the underlay, so as to provide the network characteristics required by the customers. Then the traffic flows of the VPN+ service can be steered onto the TE paths within the VTN.

In MPLS or SR based network, the set of network resources allocated to a VTN can be identified using resource-aware SR SIDs as defined in [[I-D.ietf-spring-resource-aware-segments](#)] [[I-D.ietf-spring-sr-for-enhanced-vpn](#)], or the VTN Resource ID as defined in [[I-D.dong-6man-enhanced-vpn-vtn-id](#)]. The logical topology associated with a VTN could be specified using mechanisms such as Multi-

Topology [[RFC4915](#)], [[RFC5120](#)] or Flex-Algo [[I-D.ietf-lsr-flex-algo](#)], etc.

To meet specific service requirement, traffic flows of a VPN+ service need be steered onto TE paths of the corresponding VTN. A PCC may request the PCE for computing a TE path within a VTN, so that the path computation would take the resource attribute and the associated topology of the VTN into consideration. Correspondingly, a PCE may reply or initiate a TE path with VTN-specific control and data plane information to a PCC.

This document extends PCEP to allow VTN information to be encoded in the PCEP messages. The extensions in this document can be used in the basic PCE computation, the stateful PCE and the PCE-initiated LSP mechanisms to indicate path computation, path status report and path initialization within the context of a specific VTN.

## 2. PCEP Extensions

### 2.1. New TLV in LSPA Object

A new VTN TLV for use in the LSPA Object is defined to indicate the VTN ID and the related information as constraints. The format of the VTN TLV is as follows:

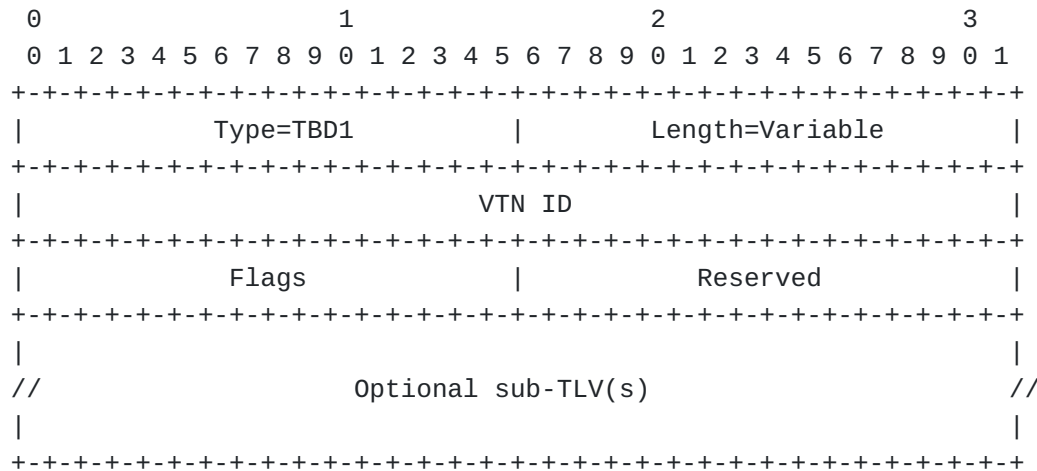


Figure 1: VTN TLV Format

Where:

\*VTN ID: A global significant 32-bit identifier which is used to identify a VTN.

\*Flags: 16-bit flags. Currently all the flags are reserved for future use. They SHOULD be set to zero on transmission and MUST be ignored on receipt.

\*Reserved: 16-bit reserved field for future use. All the bits SHOULD be set to zero on transmission and MUST be ignored on receipt.

\*Optional sub-TLVs: Additional information which can be used in as VTN-specific constraints. Currently no sub-TLV is defined in this document.

## 2.2. Capability Advertisement

A PCEP speaker indicates whether it supports VTN specific path computation using a new PCEP capability called "VTN-CAPABILITY". When the PCEP session is created, it sends an Open message with an OPEN Object containing the VTN-CAPABILITY TLV. The format of this TLV is as follows:

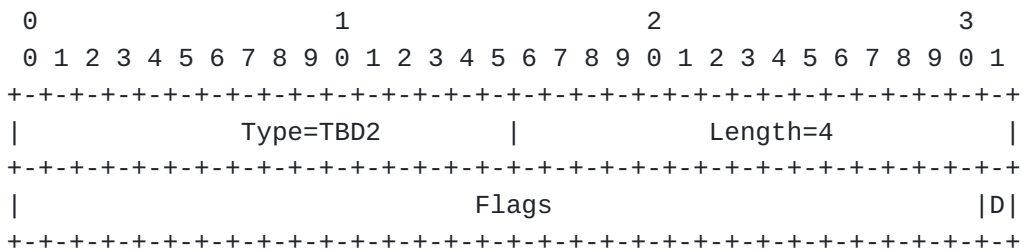


Figure 2: VTN CAPABILITY TLV

The type (16 bits) of the TLV is TBA. The length field is 16 bits long and has a fixed value of 4.

The value comprises a single field -- Flags (32 bits):

\*D (Data Plane VTN-ID CAPABILITY - 1 bit): if set to 1 by a PCC, the D flag indicates that the PCC supports the encapsulation of data plane VTN-ID in data packet; if set to 1 by a PCE, the D flag indicates that the PCE supports to provide path computation result with the data plane VTN-ID.

\*Unassigned bits in the Flags field MUST be set to zero and ignored on receipt.

## 3. Operations

The new VTN TLV defined in this document can be used in the basic PCE computation, the stateful PCE and the PCE-initiated LSP mechanisms to indicate path computation, path status report and path initialization within the context of a specific VTN.

Information about the VTN-specific network resource and topology attributes can be obtained by the PCE either from the network

planning system, or using a distributed control plane such as IGP or BGP-LS with necessary extensions. The detailed mechanism is out of the scope of this document. The obtained VTN specific attributes can be used in path computation when the VTN-ID is specified in the path computation request.

With the basic path computation mechanism, the new VTN TLV can be used to indicate the VTN in which the path computation is requested. In a PCReq message, the VTN TLV MAY be carried in the LSPA Object to indicate that the path computation needs to be executed using the resource and topological attributes of the VTN. The PCE SHOULD use the network resource and topology attributes associated with the specified VTN as the parameters of path computation. In a PCRep message, the VTN TLV MAY be carried in the LSPA Object in case of failure to indicate the path computation in the VTN was not successful.

The new VTN TLV can also be used in the stateful PCE mechanisms. A PCC MAY include the VTN TLV in PCRpt message to indicate the VTN in which the TE path is reported. And A PCE MAY include the VTN TLV in PCUpd Message to indicate the VTN in which the TE path needs to be updated.

With the PCE-Initiated LSP mechanism, the PCE MAY include the VTN TLV in PCInitiate or PCUpd message to indicate the VTN in which the path is computed, so that the PCC will use the VTN-specific resources and data plane VTN-ID in constructing or updating the TE path.

#### **4. Security Considerations**

This document defines a new VTN TLV that do not add any new security concerns beyond those discussed in [\[RFC5440\]](#) in itself. Some deployments may find the VTN information to be extra sensitive and could be used to influence path computation and setup with adverse effect. Additionally, snooping of PCEP messages with such data or using PCEP messages for network reconnaissance may give an attacker sensitive information about the operations of the network. Thus, such deployment should employ suitable PCEP security mechanisms like TCP Authentication Option (TCP-AO) [\[RFC5925\]](#) or Transport Layer Security (TLS) [\[RFC8253\]](#). The procedure based on TLS is considered a security enhancement and thus is much better suited for the sensitive information.

#### **5. IANA Considerations**

This document makes following requests to IANA for action.

IANA is requested to make the following allocations in the "PCEP TLV Type Indicators" subregistry of the "Path Computation Element Protocol (PCEP) Numbers" registry:

Value	Description	Reference
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TBD1	VTN	This document
TBD2	VTN CAPABILITY	This document

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## 7. Acknowledgments

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