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**PCEP Extensions for Establishing Relationships Between Sets of LSPs
and Virtual Networks
draft-leedhody-pce-vn-association-03**

Abstract

This document describes how to extend Path Computation Element (PCE) Communication Protocol (PCEP) association mechanism introduced by the PCEP Association Group specification, to further associate sets of LSPs with a higher-level structure such as a virtual network (VN) requested by clients or applications. This extended association mechanism can be used to facilitate virtual network control using PCE architecture.

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[1. Introduction](#)

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.

[RFC8051] describes general considerations for a stateful PCE deployment and examines its applicability and benefits, as well as its challenges and limitations through a number of use cases.

[[I-D.ietf-pce-stateful-pce](#)] describes a set of extensions to PCEP to provide stateful control. A stateful PCE has access to not only the information carried by the network's Interior Gateway Protocol (IGP), but also the set of active paths and their reserved resources for its computations. The additional state allows the PCE to compute constrained paths while considering individual LSPs and their interactions.

[I-D.ietf-pce-pce-initiated-lsp] describes the setup, maintenance and teardown of PCE-initiated LSPs under the stateful PCE model.

[I-D.ietf-pce-association-group] introduces a generic mechanism to create a grouping of LSPs. This grouping can then be used to define association between sets of LSPs or between a set of LSPs and a set of attributes.

[ACTN-REQ] describes various Virtual Network (VN) operations initiated by a customer/application. In this context, there is a need for associating a set of LSPs with a VN "construct" to facilitate VN operations in PCE architecture. This association allows the PCEs to identify which LSPs belong to a certain VN. The PCE could then use this association to optimize all LSPs belonging to the VN together. The PCE could further take VN specific actions on the LSPs such as relaxation of constraints, policy actions, setting default behavior etc.

[I-D.ietf-pce-applicability-actn] examines the PCE and ACTN architecture and describes how the PCE architecture is applicable to ACTN. [[RFC6805](#)] and [[I-D.ietf-pce-stateful-hpce](#)] describes a hierarchy of stateful PCEs with Parent PCE coordinating multi-domain path computation function between Child PCE(s) and thus making it the base for PCE applicability for ACTN. In this text child PCE would be same as Physical Network Controller (PNC), and the parent PCE as Multi-domain Service Coordinator (MDSC) [[ACTN-FWK](#)].

This document specifies a PCEP extension to associate a set of LSPs based on Virtual Network (VN) (or customer). A Virtual Network (VN) is a customer view of the TE network. Depending on the agreement between client and provider various VN operations and VN views are possible as described in [[ACTN-FWK](#)].

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. Terminology

The terminology is as per [[RFC4655](#)], [[RFC5440](#)], [[RFC6805](#)], [I-D.ietf-pce-stateful-pce] and [[ACTN-FWK](#)].

3. Operation Overview

As per [[I-D.ietf-pce-association-group](#)], LSPs are associated with other LSPs with which they interact by adding them to a common association group.

An association group based on VN is useful for various optimizations that should be applied by considering all the LSPs in the association. This includes, but not limited to -

- o Path Computation: When computing path for a LSP, the impact of this LSP, on the other LSPs belonging to the same VN is useful to analyze. The aim would be optimize overall VN and all LSPs, rather than a single LSP. Also, the optimization criteria such as minimize the load of the most loaded link (MLL) [[RFC5541](#)] and other could be applied for all the LSP belonging to the same VN, identified by the VN association.

- o Path Re-Optimization: The child PCE or the parent PCE would like to use advanced path computation algorithm and optimization technique that consider all the LSPs belonging to a VN/customer and optimize them all together during the re-optimization.

This association is useful in PCEP session between parent PCE (MDSC) and child PCE (PNC).

Local policies on the PCE MAY define the computational and optimization behavior for the LSPs in the VN. An LSP MUST belong to a single VNAG. If an implementation encounters more than one VNAG, it

MUST consider the first occurrence and ignore the others.

This Association-Type is dynamic in nature and created by the Parent PCE (MDSC) for the LSPs belonging to the same VN or customer. These associations are conveyed via PCEP messages to the PCEP peer. Operator-configured Association Range SHOULD NOT be set for this association-type and MUST be ignored.

4. Extensions to PCEP

[I-D.ietf-pce-association-group] introduces the ASSOCIATION object, the format of VNAG is as follows:



Figure 1: The VNAG Object formats

Please refer to [I-D.ietf-pce-association-group] for the definition of each field in Figure 1. This document defines one mandatory TLV "VIRTUAL-NETWORK-TLV" and one optional TLV "VENDOR-INFORMATION-TLV" -

- o VIRTUAL-NETWORK-TLV: Used to communicate the VN Identifier.

- o VENDOR-INFORMATION-TLV: Used to communicate arbitrary vendor specific behavioral information, described in [[RFC7470](#)].

The format of VIRTUAL-NETWORK-TLV is as follows.

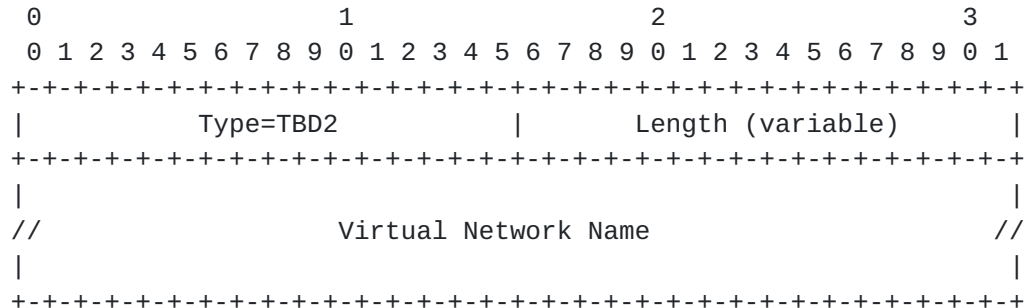


Figure 2: The VIRTUAL-NETWORK-TLV formats

Type: TBD2 (to be allocated by IANA)

Length: Variable Length

Virtual Network Name(variable): an unique symbolic name for the VN. The VN name is a human-readable string that identifies a VN. The VN name MUST remain constant throughout an LSP's lifetime, which may span across multiple consecutive PCEP sessions and/or PCC restarts. The VN name MAY be specified by an operator or auto-generated by the PCEP speaker.

The VIRTUAL-NETWORK-TLV MUST be included in VNAG object. If a PCEP speaker receives the VNAG object without the VIRTUAL-NETWORK-TLV, it MUST send a PCerr message with Error-Type=6 (mandatory object missing) and Error-Value=TBD3 (VIRTUAL-NETWORK-TLV missing) and close the session.

The format of VENDOR-INFORMATION-TLV is defined in [[RFC7470](#)].

5. Applicability to H-PCE architecture

The ability to compute shortest constrained TE LSPs in Multiprotocol Label Switching (MPLS) and Generalized MPLS (GMPLS) networks across multiple domains has been identified as a key motivation for PCE development. [[RFC6805](#)] describes a Hierarchical PCE (H-PCE) architecture which can be used for computing end-to-end paths for inter-domain MPLS Traffic Engineering (TE) and GMPLS Label Switched Paths (LSPs). Within the hierarchical PCE architecture, the parent PCE is used to compute a multi-domain path based on the domain connectivity information. A child PCE may be responsible for a single domain or multiple domains, it is used to compute the intra-

domain path based on its domain topology information.

[I-D.ietf-pce-stateful-hpce] introduces general considerations for stateful PCE(s) in hierarchical PCE architecture. In particular, the behavior changes and additions to the existing stateful PCE mechanisms in the context of a H-PCE architecture.

In Stateful H-PCE architecture, the Parent PCE receives a virtual network creation request by its client over its Northbound API. This VN is uniquely identified by an Association ID in VNAG as well as the VIRTUAL-NETWORK name. This VN may comprise multiple LSPs in the network in a single domain or across multiple domains.

As the Parent PCE computes the optimum E2E paths for each tunnel in VN, it MUST associate each LSP with the VN to which it belongs. Parent PCE sends a PCInitiate Message with this association information in the VNAG Object (See [Section 4](#) for details). This in effect binds an LSP that is to be instantiated at the child PCE with the VN.

Whenever changes occur with the instantiated LSP in a domain network, the domain child PCE reports the changes using a PCRpt Message in which the VNAG Object indicates the relationship between the LSP and the VN.

Whenever an update occurs with VNs in the Parent PCE (via the client's request), the parent PCE sends an PCUpd Message to inform each affected child PCE of this change.

The Child PCE could then use this association to optimize all LSPs belonging to the same VN association together. The Child PCE could further take VN specific actions on the LSPs such as relaxation of constraints, policy actions, setting default behavior etc. The parent PCE could also maintain all E2E LSP or per-domain path segments under a single VN association.

6. Security Considerations

This document defines one new type for association, which do not add any new security concerns beyond those discussed in [[RFC5440](#)], [I-D.ietf-pce-stateful-pce] and [[I-D.ietf-pce-association-group](#)] in itself.

Some deployments may find VN associations and their implications as extra sensitive and thus should employ suitable PCEP security mechanisms like TCP-AO or [[I-D.ietf-pce-pceps](#)].

7. IANA Considerations

7.1. Association Object Type Indicator

This document defines a new association type, originally defined in [[I-D.ietf-pce-association-group](#)], for path protection. IANA is requested to make the assignment of a new value for the sub-registry "ASSOCIATION Type Field" (request to be created in [[I-D.ietf-pce-association-group](#)]), as follows:

Value	Name	Reference
TBD1	VN Association Type	[This I.D.]

7.2. PCEP TLV Type Indicator

This document defines a new TLV for carrying additional information of LSPs within a path protection association group. IANA is requested to make the assignment of a new value for the existing "PCEP TLV Type Indicators" registry as follows:

Value	Name	Reference
TBD2	VIRTUAL-NETWORK-TLV	[This I.D.]

7.3. PCEP Error

This document defines new Error-Type and Error-Value related to path protection association. IANA is requested to allocate new error values within the "PCEP-ERROR Object Error Types and Values" sub-registry of the PCEP Numbers registry, as follows:

Error-Type	Meaning
6	Mandatory Object missing Error-value=TBD3: VIRTUAL-NETWORK TLV missing [This I.D.]

8. Manageability Considerations

8.1. Control of Function and Policy

An operator MUST BE allowed to mark LSPs that belong to the same VN. This could also be done automatically based on the VN configuration.

8.2. Information and Data Models

The PCEP YANG module [[I-D.ietf-pce-pcep-yang](#)] should support the association between LSPs including VN association.

8.3. Liveness Detection and Monitoring

Mechanisms defined in this document do not imply any new liveness detection and monitoring requirements in addition to those already listed in [[RFC5440](#)].

8.4. Verify Correct Operations

Mechanisms defined in this document do not imply any new operation verification requirements in addition to those already listed in [[RFC5440](#)].

8.5. Requirements On Other Protocols

Mechanisms defined in this document do not imply any new requirements on other protocols.

8.6. Impact On Network Operations

Mechanisms defined in this document do not have any impact on network operations in addition to those already listed in [[RFC5440](#)].

9. References

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