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Conveying Vendor-Specific Constraints in the Path Computation Element Protocol

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Abstract

The Path Computation Element Protocol (PCEP) is used to convey path computation requests and responses between Path Computation Clients (PCCs) and Path Computation Elements (PCEs), and also between

cooperating PCEs. In PCEP the path computation requests carry details of the constraints and objective functions that the PCC wishes the PCE to apply in its computation.

The mechanisms defined for indicating objective functions include the capability to convey vendor-specific objective functions. This document defines a facility to carry vendor-specific constraints in PCEP.

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 [RFC-2119](#) [[RFC2119](#)].

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[1.](#) Introduction

A Path Computation Element (PCE) is an entity (component, application or network node) that is capable of computing a network path or route based on a network graph and applying computational constraints. An architecture for the use of PCEs is defined in [[RFC4655](#)].

The Path Computation Element Protocol (PCEP) is defined in [[RFC5440](#)] to exchange path computation requests and responses between Path Computation Clients (PCCs) and PCEs. It is also used between cooperating PCEs.

Path computations performed by a PCE depend on a set of constraints indicated by the PCC. These constraints include the end points of the path to compute (source and destination), and may include other simple constraints such as bandwidth requirements and metric maxima (for example, a maximum threshold for the hop count or the TE metric of the computed path).

The PCE also needs to use some objective function to qualify the path it selects as meeting the requirements of the PCC. The PCE may have a default objective function, but the PCC can also indicate which objective function it wants applied by placing an Objective Function object in the path computation request message [[RFC5541](#)]. A core set of objective functions to be supported in PCEP messages is defined in the base PCEP requirements [[RFC4657](#)], and [[RFC5541](#)] defines each of these functions as an abstract formula.

The registry of codepoints used to indicate objective functions is managed by IANA and can be extended in future documents. PCE implementations may choose to offer proprietary, vendor-specific objective functions, and there is scope for this within the codepoint registry created by [[RFC5541](#)]. That is, in the "PCE Objective Function" code point registry managed by IANA, the rules for the assignment of objective function code point values are as follows (using terms defined in [[RFC5226](#)])

- o Function code values 1 through 1023 are assigned by IANA using the "IETF Review" policy.
- o Function code values 1024 through 32767 are assigned by IANA, using the "First Come First Served" policy.
- o Function code values in the range 32768-65535 are for "Private Use".

Proprietary objective functions may operate on non-standard constraints or metrics. The PCEP Metric Object defined in [[RFC5440](#)] has scope for the definition of new, standardized metrics, but no facility for the definition of vendor-specific metrics. At the same time, there is no mechanism in PCEP for carrying other, more complex, vendor-specific constraints.

This document defines a new PCEP object, the Vendor Constraints object that can be used to carry arbitrary constraint information.

This document also defines a new PCEP TLV, the VENDOR-CONSTRAINT-TLV that can be used to carry arbitrary constraint information within an existing PCEP object.

2. Procedures

A PCC that wants to convey proprietary or vendor-specific constraints or metrics to a PCE does so by including a Vendor Constraints object in the PCReq message. The contents and format of the object are described in [Section 3](#), but it is important to note that the object includes an Enterprise Number that is a unique identifier of an organization responsible for the definition of the content and meaning of the object.

A PCC that wants to convey endpoints-specific vendor specific constraints to a PCE may do so by including a Vendor Constraints TLV in the endpoint-restriction-list of the END-POINTS with object type Generalized Endpoint.

This Vendor Constraints TLV MAY also present in PCEP Objects supporting TLVs and using the registry for the PCEP TLVs, to indicate a vendor-specific constraint that applies to the PCEP object.

A PCE that receives a PCReq message containing a Vendor Constraints object MUST act according to the P-bit in the object header. That is, if the P-bit is set, the object MUST be treated as mandatory and the request must either be processed using the contents of the object or rejected as defined in [\[RFC5440\]](#). If the P-bit is clear, the object MAY be used by the PCE or MAY be ignored. The PCC sets the P-bit according to how it wishes the request to be processed.

The PCE determines how to interpret the Vendor Constraints object or TLV by examining the Enterprise Number it contains.

The Vendor Constraints object is optional in a PCReq message. Multiple instances of the object MAY be used on a single PCReq message and each MUST be treated according to its P-bit setting. The object can be present in two places within the PCReq message to enable it to apply to a single path computation request or to a set of synchronized requests. This usage mirrors the usage of the Objective Function object [\[RFC5541\]](#). Thus, the PCReq message based

on [\[RFC6006\]](#) is encoded as follows using the syntax described in [\[RFC5511\]](#).

```
<PCReq Message> ::= <Common Header>
                    [<svec_list>]
                    <request-list>
```

where

```
<svec-list> ::= <SVEC>
                [<OF>]
                [<GC>]
                [<XRO>]
                [<metric-list>]
                [<vendor-constraint-list>]
                [<svec-list>]

<metric-list> ::= <METRIC>
                  [<metric-list>]

<vendor-constraint-list> ::= <VENDOR-CONSTRAINT>
                             [<vendor-constraint-list>]

<request-list> ::= <request>
                  [<request-list>]

<request> ::= <RP>
              [<vendor-constraint-list>]
              <end-point-rro-pair-list>
              [<LSPA>]
              [<BANDWIDTH>]
              [<metric-list>]
              [<OF>]
              [<RRO>]
              [<IRO>]
              [<LOAD-BALANCING>]
```

where

```
<end-point-rro-pair-list> ::=
    <END-POINTS>
    [<RRO-List>]
    [<BANDWIDTH>]
    [<vendor-constraint-list>]
    [<end-point-rro-pair-list>]

<RRO-List> ::= <RRO> [<BANDWIDTH>] [<RRO-List>]
<metric-list> ::= <METRIC> [<metric-list>]
```


The Vendor Constraints object is included in a PCRep message in exactly the same way as any other object as defined in [RFC5440].

The Vendor Constraints TLV is optional in the END-POINTS with object type Generalized Endpoint. The vendor restriction TLV MAY be inserted at any place in the endpoint-restriction-list.

The VENDOR-CONSTRAINT-TLV MUST be taken into account. If the P flag of the containing object is set, but the PCE does not understand the TLV and its enterprise number, the entire PCEP message MUST be rejected and the PCE MUST send a PCErr message with Error-Type="Reception of an invalid object" and Error-Value="Unsupported VENDOR-CONSTRAINT-TLV" along with the corresponding object.

When present in the END-POINTS with object type Generalized Endpoint the endpoint-restriction-list is encoded as follow:

```
<endpoint-restriction> ::=
    <LABEL-REQUEST><label-restriction-list>|
    <VENDOR-CONSTRAINT-TLV>]|
```

3. Protocol Elements

The Vendor Constraints object and TLV conform to the format for PCEP objects and TLVs defined in [RFC5440].

VENDOR-CONSTRAINT Object-Class is to be assigned by IANA (recommended value=23).

VENDOR-CONSTRAINT Object-Type is to be assigned by IANA (recommended value=1)

VENDOR-CONSTRAINT-TLV Type is to be assigned by IANA (recommended value=16)

The format of the VENDOR-CONSTRAINT object, VENDOR-CONSTRAINT-TLV body is as follows:

```

      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
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|               Enterprise Number               |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
~               Enterprise-Specific Information               ~
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
```


Enterprise Number

A unique identifier of an organization encoded as a 32-bit integer. Enterprise Numbers are assigned by IANA and managed through an IANA registry [[RFC2578](#)].

Enterprise-Specific Information

The detailed enterprise-specific constraint information carried by the object. The format and interpretation of this information is a matter for the enterprise identified by the Enterprise Number. Such formats and interpretation MAY be published by the enterprise (possibly through an informational RFC or through commercial documentation) so that PCCs or PCEs that are not part of the organization can use the information.

4. IANA Considerations

IANA maintains a registry of PCEP parameters. This includes sub-registry for PCEP Objects and PCEP TLV Type Indicators.

IANA is requested to make an allocation from the sub-registry PCEP Objects as follows. The values here are suggested for use by IANA.

Object	Name	Reference Class
23	VENDOR-CONSTRAINT	[This.I-D]
	Object-Type	
	1: Vendor-Specific Constraints	[This.I-D]

IANA is requested to do the following allocations in the "PCEP TLV Type Indicators" as follow. The Values are suggested for use by IANA.

Value	Meaning	Reference
16	Vendor Constraint TLV	[This.I-D]

IANA is requested to make an allocation from the sub registry "PCEP-ERROR Object Error Types and Values" as follow. The Values are suggested for use by IANA.

Error Name	Reference
Type	
10 Reception of an invalid object	
Error-Value=8 Unsupported VENDOR-CONSTRAINT-TLV	[This.I-D]

5. Management Considerations

This section follows the guidance of [[MANAGE](#)].

[5.1. Control of Function and Policy](#)

A PCEP implementation SHOULD allow configuring of various parameters as described in [[RFC5440](#)]. A PCC implementation that uses vendor-specific constraints MAY make the use of these constraints configurable either across the whole PCC, per PCE that the PCC uses, or per path computation request. A PCE that supports vendor-specific constraints MAY make the support of these constraints configurable, and MAY allow configuration of policies for the use of the constraints.

[5.2. Information and Data Models](#)

A PCEP MIB module is defined in [[PCE-MIB](#)] that describes managed objects for modeling of PCEP communications.

It is NOT RECOMMENDED that standard MIB modules are extended to include detailed information about the content of the Vendor Constraints object. However, the standard MIB module MAY be extended to report the use of the Vendor Specific object and the Enterprise Numbers that the objects contain.

[5.3. Liveness Detection and Monitoring](#)

This document makes no change to the basic operation of PCEP and so there are no changes to the requirements for liveness detection and monitoring set out in [[RFC4657](#)] and [[RFC5440](#)].

[5.4. Verifying Correct Operation](#)

This document makes no change to the basic operation of PCEP and so there are no changes to the requirements or techniques for monitoring the correct operation of the protocol out in [[RFC4657](#)] and [[RFC5440](#)].

Note that "correct operation" in this context refers to the operation of the protocol itself, and not to the operation of the computation algorithms which are out of scope for all PCEP work. Mechanisms for verifying the correct operation of computation algorithms might involve comparing the results returned by more than one PCE. Scope for this might be limited by the use of vendor constraints unless multiple PCEs support the same set of constraints.

[5.5. Requirements on Other Protocols and Functional Components](#)

This document does not place any new requirements on other network components or protocols. However, it may be beneficial to consider

whether a PCE should advertise the enterprise numbers and vendor constraints it supports. This advertisement could be within PCE Discovery ([[RFC5088](#)], [[RFC5089](#)]) or through extensions to PCEP [[RFC5440](#)].

Extensions for discovery and advertisement are outside the scope of this document.

5.6. Impact on Network Operation

The availability of vendor constraints in PCEP messages may facilitate more complex and detailed path computations that may enhance the way in which the network is operated.

On the other hand, the presence of additional vendor-specific information in PCEP messages may congest the operation of the protocol especially if the PCE does not support the constraints supplied by the PCC. Thus, a PCC SHOULD monitor the capabilities of a PCE either by discovery mechanisms as described in [Section 5.5](#), or through the receipt of negative responses. A PCC SHOULD NOT include vendor constraints in a PCReq message to a PCE that it believes does not support the constraints and that will not forward the request to some other PCE that does support the constraints.

6. Security Considerations

The protocol extensions defined in this document do not substantially change the nature of PCEP. Therefore, the security considerations set out in [[RFC5440](#)] apply unchanged.

Operators should note that an attack on PCEP may involve making PCEP messages as large as possible in order to consume bandwidth and processing power. The Vendor Constraints object may provide a mechanism for this type of attack. It may be protected against by using the authentication and integrity procedures described in [[RFC5440](#)].

7. References

7.1. Normative References

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7.2. Informative References

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8. Acknowledgements

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