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Conveying Vendor-Specific Constraints in the Path Computation Element Communication Protocol

Abstract

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

This document defines a facility to carry vendor-specific information in PCEP using a dedicated object and a new Type-Length-Variable that can be carried in any existing PCEP object.

Status of This Memo

This is an Internet Standards Track document.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Further information on Internet Standards is available in Section 2 of RFC 5741.

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at http://www.rfc-editor.org/info/rfc7150.

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 communication 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 endpoints 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 Traffic Engineering (TE) metric of the computed path).

The PCE also needs to use an 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 new assignments can be made according to "IETF Review" and "First Come First Served" policies [RFC5226]. PCE implementations may also choose to offer proprietary, vendor-specific

objective functions, and there is scope for this within the codepoint registry created by [RFC5541] using the codepoints that are flagged as "Reserved 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 information.

This document defines a new PCEP object, the Vendor Information object that can be used to carry arbitrary, proprietary information such as vendor-specific constraints.

This document also defines a new PCEP TLV, the VENDOR-INFORMATION-TLV that can be used to carry arbitrary information within any PCEP object that supports TLVs.

It should be noted that by the very definition of "vendor-specific", the inclusion of either a Vendor Information object or the VENDOR-INFORMATION-TLV implies an inability to interoperate at a functional level with implementations from other vendors unless there is some cooperation agreement between vendors. Sections 2.1 and 3.1 discuss backward compatibility, which indicates how these protocol constructs are handled by implementations that do not support them at all, while text in Sections 2 and 3 describe how implementations handle the constructs if they understand them, but do not support the embedded Enterprise Number that indicates to which vendor the constructs apply.

When vendor-specific information is used by an implementation, the vendor is encouraged to document the meaning of the information to encourage wider use and implementation. In particular, when there is more general interest in a vendor-specific extension, the vendor is encouraged to bring it to the IETF for standardization as a regular protocol construct moving it out of the vendor-specific space.

1.1. Conventions Used in This Document

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 [RFC2119].

2. Procedures for the Vendor Information Object

A PCC that wants to convey proprietary or vendor-specific constraints or metrics to a PCE does so by including a Vendor Information object in the PCReq message. The contents and format of the object are described in Section 4, 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 PCE that receives a PCReq message containing a Vendor Information object MUST act according to the P flag in the object header. That is, if the P flag is set, the object will be treated as mandatory and the request will either be processed using the contents of the object or be rejected as defined in [RFC5440] (see also Section 2.1). If the P flag is clear, then, as defined in [RFC5440], the object may be used by the PCE or may be ignored. The PCC sets the P flag according to how it wishes the request to be processed.

The PCE determines how to interpret the information in the Vendor Information object by examining the Enterprise Number it contains. An implementation that supports the Vendor Information object, but receives one carrying an Enterprise Number that it does not support MUST act according to the P flag in the object. That is, if the P flag is set, the PCE MUST reject the PCReq as defined in [RFC5440] by sending an Error message with Error-Type="Not supported Object" along with the corresponding Vendor Information object.

The Vendor Information 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. Different instances of the object can have different Enterprise Numbers.

The object can be present in 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-info-list>]
                    [<svec-list>]

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

    <vendor-info-list> ::= <VENDOR-INFORMATION>
                           [<vendor-info-list>]

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

    <request> ::= <RP>
                  [<vendor-info-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-info-list>]
                                  [<end-point-rro-pair-list>]

    <RRO-List> ::= <RRO> [<BANDWIDTH>] [<RRO-List>]

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

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

Thus, the PCRep is encoded as follows:

```
<PCRep Message> ::= <Common Header>
                    <response>

<response> ::= <RP>
               [<vendor-info-list>]
               [<end-point-path-pair-list>]
               [<NO-PATH>]
               [<attribute-list>]
```

where:

```
 <end-point-path-pair-list> ::=
                [<END-POINTS>]
                <path>
                [<vendor-info-list>]
                [<end-point-path-pair-list>]

<path> ::= (<ERO>|<SERO>) [<path>]

<attribute-list> ::= [<OF>]
                     [<LSPA>]
                     [<BANDWIDTH>]
                     [<metric-list>]
                     [<IRO>]
```

2.1. Backward Compatibility for the Vendor Information Object

A legacy implementation that does not recognize the Vendor Information object will act according to the procedures set out in [RFC5440]. If the P flag is set in the object, the message will be rejected using a PCErr message with an Error Type of 3 ("Unknown Object"). If the P flag is not set, the object can safely be ignored by the recipient.

3. Procedures for the Vendor Information TLV

The Vendor Information TLV can be used to carry vendor-specific information that applies to a specific PCEP object by including the TLV in the object.

The PCE determines how to interpret the Vendor Information TLV by examining the Enterprise Number it contains. If the Enterprise Number is unknown to the PCE, it MUST treat the Vendor Information TLV as an unknown TLV and handle it as described in [RFC5440] (see also Section 3.1).

Further specifications are needed to define the position and meaning of the Vendor Information TLV for specific PCEP objects.

3.1. Backward Compatibility

A legacy implementation that does not recognize the Vendor Information TLV in an object will act according to the procedures set out in [RFC5440]. As described in Section 7.1 of [RFC5440], unrecognized TLVs MUST be ignored.

4. Protocol Elements

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

VENDOR-INFORMATION Object-Class 32

VENDOR-INFORMATION Object-Type 1

VENDOR-INFORMATION-TLV Type 7

The format of the VENDOR-INFORMATION object and the format of the VENDOR-INFORMATION-TLV are the same and are as shown in Figure 1.

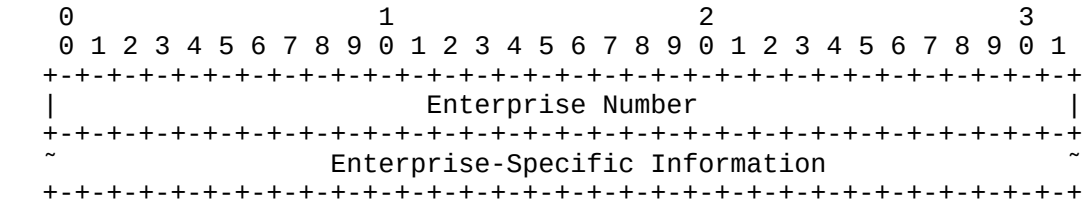

Figure 1 : Format of the Vendor Information Object and TLV

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.

5. IANA Considerations

IANA maintains a registry of PCEP parameters called the "Path Computation Element Protocol (PCEP) Numbers".

5.1. New PCEP Object

IANA has made an allocation from the "PCEP Objects" subregistry as follows.

Object-Class Value	Name	Reference
32	VENDOR-INFORMATION	[RFC7150]
Object-Type		
0: Unassigned		
1: Vendor-Specific Constraints		[RFC7150]
2-255: Unassigned		

5.2. New PCEP TLV

IANA has made an allocation from the "PCEP TLV Type Indicators" subregistry as follows.

Value	Description	Reference
7	VENDOR-INFORMATION-TLV	[RFC7150]

6. Management Considerations

This section follows the guidance of [RFC5706] and [RFC6123].

6.1. 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 information MAY make the use of this information configurable either across the whole PCC, per PCE that the PCC uses, or per path computation request. A PCE that supports vendor-specific information MAY make the support of this information configurable, and MAY allow configuration of policies for the use of the information.

6.2. 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 be extended to include detailed information about the content of the Vendor Information object or TLV. However, the standard MIB module MAY be extended to report the use of the Vendor Information object or TLV and the Enterprise Numbers that the objects and TLVs contain.

6.3. Liveness Detection and Monitoring

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

6.4. Verifying Correct Operation

This document makes no change to the basic operation of PCEP, 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 information unless multiple PCEs support the same set of vendor information.

6.5. 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 information 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.

6.6. Impact on Network Operation

The availability of vendor information 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 information supplied by the PCC. Thus, a PCC SHOULD monitor the capabilities of a PCE either by discovery mechanisms as described in Section 6.5 or through the receipt of negative responses. A PCC SHOULD NOT include vendor information in a PCReq message to a PCE that it believes does not support the information and that will not forward the request to some other PCE that does support the information.

7. 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. Note that further security considerations for the use of PCEP over TCP are presented in [RFC6952].

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 Information object and TLV may provide a vector for this type of attack. It may be protected against by using the authentication and integrity procedures described in [RFC5440].

8. References

8.1. Normative References

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9. Acknowledgements

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