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RFC 9753
Extension for Stateful PCE to Allow Optional Processing of Path Computation Element Communication Protocol (PCEP) Objects

Abstract

This document introduces a mechanism to mark some of the Path Computation Element Communication Protocol (PCEP) objects as optional during PCEP message exchange, so the stateful Path Computation Element (PCE) model can relax some constraints during path computation and setup. This document introduces this relaxation to stateful PCE, and it updates RFC 8231.

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1. Introduction

[RFC5440] describes the Path Computation Element Communication Protocol (PCEP), which enables communication between a Path Computation Client (PCC) and a Path Control Element (PCE), or between two PCEs based on the PCE architecture [RFC4655].

PCEP extensions for the stateful PCE model [RFC8231] describes a set of extensions to PCEP to enable active control of Multiprotocol Label Switching Traffic Engineering (MPLS-TE) and Generalized MPLS (GMPLS) tunnels. [RFC8281] describes the setup and teardown of PCE-initiated LSPs under the active stateful PCE model, without the need for local configuration on the PCC, thus allowing for dynamic control.

[RFC5440] defined the P flag (Processing-Rule) in the Common Object Header to allow a PCC to specify in a Path Computation Request (PCReq) message (sent to a PCE) whether the object must be taken into account by the PCE during path computation or is optional. The I flag (Ignore) is used by the PCE in a Path Computation Reply (PCRep) message to indicate to a PCC whether or not an optional object was considered by the PCE during path computation. Stateful PCE [RFC8231] specifies that the P and I flags of the PCEP objects are to be set to zero on transmission and ignored on receipt, since they are exclusively related to the path computation requests. This document defines a new flag, the R (RELAX) flag in STATEFUL-PCE-CAPABILITY TLV, in the PCEP common object header to indicate a PCE speaker supporting P and I flags processing, and it also specifies how the P and I flags could be used in the stateful PCE model to identify optional objects in the Path Computation State Report (PCRpt) [RFC8231], the Path Computation Update Request (PCUpd) [RFC8231], and the LSP Initiate Request (PCInitiate) [RFC8281] messages.

This document updates [RFC8231] concerning usage of the P and I flags as well as the handling of unknown objects in stateful PCEP message exchange.

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. Overview

Setting the P flag in the PCReq message to handle unknown objects is as described in Section 7.2 of [RFC5440]. Further, [RFC8231] defined the usage of the LSP Error Code TLV in the PCRpt message in response to a failed LSP Update Request via the PCUpd message (for example, due to an unsupported object or TLV).

This document specifies the procedure of marking some objects as 'optional to be processed' by the PCEP peer in the stateful PCEP messages. Furthermore, this document updates the procedure for handling unknown objects in stateful PCEP messages based on the P flag.

2.1. Usage Example

The PCRpt message is used to report the current state of an LSP. As part of the message, both the <intended-attribute-list> and <actual-attribute-list> are encoded (see [RFC8231]). For example, the <intended-attribute-list> could include the METRIC object to indicate a limiting constraint (Bound 'B' flag set) for the Path Delay Variation metric [RFC8233]. In some scenarios, it would be useful to indicate that this constraint can be relaxed by the PCE in case it cannot find a path. In these cases, it would be useful to mark the objects as 'optional' so they could be ignored by the PCEP peer. Also, it would be useful for the PCEP speaker to learn if the PCEP peer has relaxed the constraint and ignored the processing of the PCEP object.

Thus, this document specifies how the already existing P and I flags in the PCEP common object header could be used during the stateful PCEP message exchange. The scope of how P and I flags are applied is defined in [RFC5440] and is unchanged by this document. Therefore, these flags can only be applied to an entire PCEP object; they cannot be applied at the granularity of optional TLVs encoded in the PCEP object.

3. PCEP Extension

3.1. STATEFUL-PCE-CAPABILITY TLV

A PCEP speaker indicates its ability to support the handling of the P and I flags in the stateful PCEP message exchange during the PCEP initialization phase, as follows. During the PCEP initialization phase, a PCC sends an Open message with an OPEN object that contains the STATEFUL-PCE-CAPABILITY TLV, as defined in [RFC8231]. A new flag, the R (RELAX) flag, is added to this TLV to indicate support for relaxing the processing of some objects via the use of the P and I flags in the PCEP common object header.

R (RELAX bit - 17): If set to 1 by a PCEP Speaker, the R flag indicates that the PCEP Speaker is willing to handle the P and I flags in the PCEP common object header for the PCEP objects in the stateful PCEP messages. If the bit is unset, it indicates that the PCEP Speaker will not handle the P and I flags in the PCEP common object header for stateful PCE messages.

The R flag **MUST** be set by both the PCC and PCE to indicate support for handling the P and I flags in the PCEP common object header to allow relaxing some constraints by marking objects as 'optional to process'. If the PCEP speaker does not set the R flag but receives PCEP objects with the P or I bits set, it **MUST** ignore the flags. [RFC8231] states that P and I flags of the PCEP objects are set to 0 on transmission and ignored on receipt. It fails to mention the behaviour of objects defined outside of [RFC8231], leading to ambiguity.

3.2. Handling of the P Flag

3.2.1. The PCRpt Message

The P flag in the PCRpt message [RFC8231] allows a PCC to specify to a PCE whether the object must be taken into account by the PCE (during state maintenance, path computation, or re-optimisation) or is optional to process. When the P flag is set in the PCRpt message received on a PCEP session on which the R bit is set by both peers, the object **MUST** be taken into account by the PCE. Conversely, when the P flag is cleared, the object is optional and the PCE can ignore it. The P flag for the mandatory objects, such as the LSP and the ERO (Explicit Route Object) object (intended path), **MUST** be set in the PCRpt message. If a mandatory object is received with the P flag set incorrectly according to the rules stated above, the receiving peer **MUST** send a PCErr message with Error-Type=10 (Reception of an invalid object) and Error-value=1 (Reception of an object with P flag not set). On a PCEP session on which the R bit was set by both peers, the PCC **SHOULD** set the P flag by default, unless a local configuration or local policy indicates that some constraints (corresponding PCEP objects) can be marked as optional and could be ignored by the PCE or the object itself conveys informational parameters that can be safely ignored.

3.2.1.1. Delegation

Delegation is an operation to grant a PCE temporary rights to modify a subset of parameters on one or more LSPs by a PCC as described in [RFC8051]. Note that for the delegated LSPs, the PCE can update and mark some objects as ignored even when the PCC has set the P flag during the delegation. Similarly, the PCE can update and mark some objects as a 'must to process' even when the PCC has not set the P flag during delegation.

The PCC **MUST** acknowledge this by sending the PCRpt message with the P flag set as per the PCE expectation for the corresponding object. If the PCC cannot accept the update message, it **MUST** react as per the processing rules of unacceptable update in Section 5.8.3 of [RFC8231].

3.2.2. The PCUpd Message and the PCInitiate Message

The P flag in the PCUpd message [RFC8231] and the PCInitiate message [RFC8281] allows a PCE to specify to a PCC whether the object must be taken into account by the PCC (during path setup) or is optional to process. When the P flag is set in the PCUpd/PCInitiate message received on a PCEP session on which the R bit was set by both peers, the object **MUST** be taken into account by the PCC. Conversely, when the P flag is cleared, the object is optional and the PCC can ignore it. The P flag for the mandatory objects -- such as the SRP (Stateful PCE Request Parameters), the LSP, and the ERO -- **MUST** be set in the PCUpd/PCInitiate message. If a mandatory object is received with the P flag set incorrectly according to the rules stated above, the receiving peer **MUST** send a PCErr message with Error-Type=10 (Reception of an invalid object) and Error-value=1

(Reception of an object with P flag not set). On a PCEP session in which both peers set the R bit, the PCE **SHOULD** set the P flag by default unless a local configuration/policy indicates that some constraints (corresponding PCEP objects) can be marked as optional and can be ignored by the PCC or the object itself conveys informational parameters that can be safely ignored.

3.3. Handling of the I Flag

3.3.1. The PCUpd Message

The I flag in the PCUpd message [RFC8231] allows a PCE to indicate to a PCC whether or not an optional object was processed. The PCE **MAY** include the ignored optional object in its update request and set the I flag to indicate that the optional object was ignored. When the I flag is cleared, the PCE indicates that the optional object was processed.

Note that when a PCE is unable to find the path that meets all the constraints as per the PCEP object that cannot be ignored (i.e. the P flag is set), the PCUpd message **MAY** optionally include the PCEP objects that caused the path computation to fail along with the empty ERO.

3.3.2. The PCRpt Message

The I flag in the PCRpt message [RFC8231] allows a PCC to indicate to a PCE whether or not an optional object was processed in response to a PCUpd or PCInitiate message. The PCC **MAY** include the ignored optional object in its report and set the I flag to indicate that the optional object was ignored at PCC. When the I flag is cleared, the PCC indicates that the optional object was processed. The I flag has no meaning if the PCRpt message is not in response to a PCUpd or PCInitiate message (i.e., without the SRP object in the PCRpt message).

Note that when a PCC is unable to set up a path that meets all the parameters as per the PCEP object that cannot be ignored (i.e., the P flag is set), the PCRpt message **MAY** optionally include the PCEP objects that caused the path setup to fail along with the LSP-ERROR-CODE TLV [RFC8231] indicating the reason for the failure.

3.3.3. The PCInitiate Message

The I flag has no meaning in the PCInitiate message [RFC8281], so the I flag **MUST** set to 0 on transmission and ignored on receipt.

3.4. Unknown Object Handling

This document updates the handling of unknown objects in the stateful PCEP messages by setting the P flag in the common object header in a similar way as described in [RFC5440]. That is, if a PCEP speaker does not understand an object with the P flag set, or if the PCEP speaker understands the object but decides to ignore the object, the entire stateful PCEP message **MUST** be rejected, and the PCE **MUST** send a PCErr message with Error- Type="Unknown Object" or "Not supported object" [RFC5440]. If the P flag is not set, the PCEP speaker can ignore the object and continue with the message processing as defined.

[RFC8231] defined the LSP Error Code TLV to be carried in the PCRpt message in the LSP object to convey error information. This document does not change that procedure.

4. Security Considerations

This document specifies how the already existing P and I flags in the PCEP common object header could be used during stateful PCEP exchanges. It updates the unknown object error handling in stateful PCEP message exchange. On their own, these changes do not add any new security concerns. The security considerations identified in [RFC5440], [RFC8231], and [RFC8281] continue to apply.

As per [RFC8231], it is **RECOMMENDED** that these PCEP extensions can only be activated on authenticated and encrypted sessions across PCEs and PCCs belonging to the same administrative authority, using Transport Layer Security (TLS) [RFC8253] as per the recommendations and best current practices described in [RFC9325].

5. IANA Considerations

5.1. STATEFUL-PCE-CAPABILITY TLV

[RFC8231] defined the STATEFUL-PCE-CAPABILITY TLV and IANA created the "STATEFUL-PCE-CAPABILITY TLV Flag Field" registry to manage the value of the STATEFUL-PCE-CAPABILITY TLV's Flag field. IANA has allocated a new bit in the registry, as follows:

Bit	Description	Reference
17	RELAX	RFC 9753

Table 1

6. Manageability Considerations

6.1. Control of Function and Policy

An implementation supporting this document **SHOULD** allow configuration of the capability to support relaxation of constraints in the stateful PCEP message exchange. They **SHOULD** also allow configuration of related LSP constraints (or parameters) that are optional to process.

6.2. Information and Data Models

An implementation supporting this document **SHOULD** allow the operator to view the capability defined in this document. To serve this purpose, the PCEP YANG module [PCEP-YANG] could be extended in the future.

6.3. 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].

6.4. Verify Correct Operations

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

6.5. Requirements on Other Protocols

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

6.6. 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].

7. References

7.1. Normative References

[RFC2119]   Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC5440]   Vasseur, JP., Ed. and JL. Le Roux, Ed., "Path Computation Element (PCE) Communication Protocol (PCEP)", RFC 5440, DOI 10.17487/RFC5440, March 2009, <https://www.rfc-editor.org/info/rfc5440>.

[RFC8174]   Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <https://www.rfc-editor.org/info/rfc8174>.

[RFC8231]   Crabbe, E., Minei, I., Medved, J., and R. Varga, "Path Computation Element Communication Protocol (PCEP) Extensions for Stateful PCE", RFC 8231, DOI 10.17487/RFC8231, September 2017, <https://www.rfc-editor.org/info/rfc8231>.

[RFC8253]   Lopez, D., Gonzalez de Dios, O., Wu, Q., and D. Dhody, "PCEPS: Usage of TLS to Provide a Secure Transport for the Path Computation Element Communication Protocol (PCEP)", RFC 8253, DOI 10.17487/RFC8253, October 2017, <https://www.rfc-editor.org/info/rfc8253>.

[RFC8281]   Crabbe, E., Minei, I., Sivabalan, S., and R. Varga, "Path Computation Element Communication Protocol (PCEP) Extensions for PCE-Initiated LSP Setup in a Stateful PCE Model", RFC 8281, DOI 10.17487/RFC8281, December 2017, <https://www.rfc-editor.org/info/rfc8281>.

7.2. Informative References

[PCEP-YANG]

Dhody, D., Ed., Beeram, V. P., Hardwick, J., and J. Tantsura, "A YANG Data Model for Path Computation Element Communications Protocol (PCEP)", Work in Progress, Internet-Draft, draft-ietf-pce-pcep-yang-30, 26 January 2025, <https://datatracker.ietf.org/doc/html/draft-ietf-pce-pcep-yang-30>.

[RFC4655]   Farrel, A., Vasseur, J.-P., and J. Ash, "A Path Computation Element (PCE)-Based Architecture", RFC 4655, DOI 10.17487/RFC4655, August 2006, <https://www.rfc-editor.org/info/rfc4655>.

[RFC8051]   Zhang, X., Ed. and I. Minei, Ed., "Applicability of a Stateful Path Computation Element (PCE)", RFC 8051, DOI 10.17487/RFC8051, January 2017, <https://www.rfc-editor.org/info/rfc8051>.

[RFC8233]   Dhody, D., Wu, Q., Manral, V., Ali, Z., and K. Kumaki, "Extensions to the Path Computation Element Communication Protocol (PCEP) to Compute Service-Aware Label Switched Paths (LSPs)", RFC 8233, DOI 10.17487/RFC8233, September 2017, <https://www.rfc-editor.org/info/rfc8233>.

[RFC9325]   Sheffer, Y., Saint-Andre, P., and T. Fossati, "Recommendations for Secure Use of Transport Layer Security (TLS) and Datagram Transport Layer Security (DTLS)", BCP 195, RFC 9325, DOI 10.17487/RFC9325, November 2022, <https://www.rfc-editor.org/info/rfc9325>.

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