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## **Local Protection Enforcement in PCEP**

### **Abstract**

This document extends the base specification to clarify usage of the local protection desired bit signalled in the Path Computation Element Protocol (PCEP). This document also introduces a new flag for signalling protection strictness in PCEP.

### **Status of This Memo**

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## 1. Introduction

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

PCEP [[RFC5440](#)] utilizes flags, values and concepts previously defined in RSVP-TE Extensions [[RFC3209](#)] and Fast Reroute Extensions to RSVP-TE [[RFC4090](#)]. One such concept in PCEP is the 'Local Protection Desired' (L flag in the LSPA Object in [[RFC5440](#)]), which was originally defined in the SESSION-ATTRIBUTE Object in RFC3209. In RSVP, this flag signals to downstream routers that they may use a local repair mechanism. The headend router calculating the path does not know whether a downstream router will or will not protect a hop during its calculation. Therefore, a local protection desired does not require the transit router to satisfy protection in order to establish the RSVP signalled path. This flag is signalled in PCEP as an attribute of the LSP via the LSP Attributes object.

PCEP Extensions for Segment Routing ([[RFC8664](#)]) extends support in PCEP for Segment Routed LSPs (SR-LSPs) as defined in the Segment Routing Architecture [[RFC8402](#)]. As per the Segment Routing Architecture, Adjacency Segment Identifiers(Adj-SID) may be eligible

for protection (using IPFRR or MPLS-FRR). The protection eligibility is advertised into the IGP ([[RFC8665](#)] and [[RFC8667](#)]) as the B-Flag part of the Adjacency SID sub-tlv and can be discovered by a PCE via BGP-LS [[RFC7752](#)] using the BGP-LS Segment Routing Extensions ([[RFC9085](#)]). An Adjacency SID may or may not have protection eligibility and, for a given adjacency between two routers, there may be multiple Adjacency SIDs, some of which are protected and some which are not.

A Segment Routed path calculated by a PCE may contain various types of segments, as defined in [[RFC8402](#)] such as Adjacency, Node or Binding. The protection eligibility for Adjacency SIDs can be discovered by the PCE, so therefore the PCE can take the protection eligibility into consideration as a path constraint. If a path is calculated to include other segment identifiers which are not applicable to having their protection state advertised, as they may only be locally significant for each router processing the SID such as Node SIDs, it may not be possible for PCE to include the protection constraint as part of the path calculation.

It is desirable for an operator to define the enforcement, or strictness of the protection requirement when it can be applied.

This document updates [[RFC5440](#)] by further describing the behaviour with Local Protection Desired Flag (L flag) and extends on it with the introduction of Enforcement Flag (E flag).

## **2. Requirements Language**

In this document, the key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" are to be interpreted as described in BCP 14, [[RFC2119](#)].

## **3. Terminology**

This document uses the following terminology:

PROTECTION MANDATORY: The Path MUST have protection eligibility on all links.

UNPROTECTED MANDATORY: The Path MUST NOT have protection eligibility on all links.

PROTECTION PREFERRED: The Path SHOULD have protection eligibility on all links but MAY contain links which do not have protection eligibility.

UNPROTECTED PREFERRED: The Path SHOULD NOT have protection eligibility on all links but MAY contain links which have protection eligibility.

PCC: Path Computation Client. Any client application requesting a path computation to be performed by a Path Computation Element.

PCE: Path Computation Element. 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.

PCEP: Path Computation Element Protocol.

## **4. Motivation**

### **4.1. Implementation differences**

As defined in [\[RFC5440\]](#) the mechanism to signal protection enforcement in PCEP is with the previously mentioned L flag defined in the LSPA Object. The name of the flag uses the term "Desired", which by definition means "strongly wished for or intended" and the use case originated from the RSVP. For RSVP signalled paths, local protection is not within control of the PCE. However, [\[RFC5440\]](#) does state "When set, this means that the computed path must include links protected with Fast Reroute as defined in [\[RFC4090\]](#)." Implementations of [\[RFC5440\]](#) have either interpreted the L flag as PROTECTION MANDATORY or PROTECTION PREFERRED, leading to operational differences.

### **4.2. SLA Enforcement**

The boolean bit flag is unable to distinguish between the different options of PROTECTION MANDATORY, UNPROTECTED MANDATORY, PROTECTION PREFERRED and UNPROTECTED PREFERRED. The selection for one of the options is typically dependent on the service level agreement the operator wishes to impose on the LSP. A network may be providing transit to multiple service agreement definitions against the same base topology network, whose behavior could vary, such as wanting local protection to be invoked on some LSPs and not wanting local protection on others. When enforcement is used, the resulting shortest path calculation is impacted.

For example, PROTECTION MANDATORY is for use cases where an operator may need the LSP to follow a path which has local protection provided along the full path, ensuring that if there is anywhere along the path that traffic will be fast re-routed at the point of failure.

For example, UNPROTECTED MANDATORY is when an operator may intentionally prefer an LSP to not be locally protected, and thus

would rather local failures to cause the LSP to go down. An example scenario is one where an LSP is protected with path protection via a secondary diverse LSP. Each LSP is traffic engineered to follow specific traffic engineered criteria computed by the PCE to satisfy SLA. Upon a failure, if local protection is invoked on the active LSP traffic, the traffic may temporarily traverse links which violate the TE requirements and could negatively impact the resources being traversed (ex: insufficient bandwidth). In addition, depending on the network topological scenario, it may be not feasible for the PCE to reroute the LSP while respecting the TE requirements which include path diversity, resulting for the LSP to be torn down and switched to the protected path anyways. In such scenarios its desirable for the LSP to be simply torn down immediately and not re-routed through local protection, so that traffic may be forwarded through an already established traffic-engineered secondary path.

There are also use cases where there is simply no requirement to enforce protection or no protection along a path. This can be considered as "do not care to enforce". This is a relaxation of the protection constraint. The path calculation is permitted the use of any SID which is available along the calculated path. The SID backup availability does not impact the shortest path computation. Since links may have both protected and unprotected SIDs available, the option PROTECTION PREFERRED or UNPROTECTED PREFERRED is used to instruct the PCE a preference on which SID to select, as the behaviour of the LSP would differ during a local failure depending on which SID is selected.

## 5. Protection Enforcement Flag (E flag)

Section 7.11 in Path Computation Element Protocol [[RFC5440](#)] describes the encoding of the Local Protection Desired (L flag). A new flag is proposed in this document in the LSP Attributes Object which extends the L flag to identify the protection enforcement.

Bit 6 has been early allocated by IANA as the Protection Enforcement flag.

Codespace of the Flag field (LSPA Object)

Bit	Description	Reference
7	Local Protection Desired	RFC5440
6	Local Protection Enforcement	This I-D

The format of the LSPA Object as defined in [[RFC5440](#)] is:

```

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
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
|                               Exclude-any                               |
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
|                               Include-any                               |
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
|                               Include-all                             |
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
|  Setup Prio   |  Holding Prio  |      Flags |E|L|      Reserved   |
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
|
//                               Optional TLVs                               //
|
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

```

Flags (8 bits)

\*L Flag: As defined in [[RFC5440](#)] and further updated by this document. When set to 1, protection is desired. When set to 0, protection is not desired. The enforcement of the protection is identified via the E flag.

\*E Flag (Protection Enforcement): This flag controls the strictness in which the PCE must apply the L flag. When set to 1, the value of the L flag MUST be respected during SID selection by the PCE. When E flag is set to 0, the value of the L flag SHOULD be respected as selection criteria however the PCE is permitted to relax or ignore the L flag when computing a path. The statements below indicate preference when E flag is set to 0 in combination with the L flag value.

When both the L flag and E flag are set to 1, then the PCE MUST consider the protection eligibility as a PROTECTION MANDATORY constraint.

When the L flag is set to 1 and the E flag is set to 0, then the PCE MUST consider the protection eligibility as a PROTECTION PREFERRED constraint.

When both L flag and E flag are set to 0, then the PCE SHOULD consider the protection eligibility as an UNPROTECTED PREFERRED constraint but MAY consider protection eligibility as an UNPROTECTED MANDATORY constraint.

When L flag is set to 0 and E flag is set to 1, then the PCE MUST consider the protection eligibility as an UNPROTECTED MANDATORY constraint.

UNPROTECTED PREFERRED and PROTECTED PREFERRED may seem similar but they indicate the preference of selection of a SID if PCE has an option of either protected or unprotected available on a link. The definition of UNPROTECTED PREFERRED is primarily as a guidance on how PCE should interpret and behave when L bit is not set, maintaining compatibility with existing known implementations prior to this document. When presented with either option, PCE SHOULD select the SID which has a protection state matching the state of the L flag.

The protection enforcement constraint can only be applied to resource selection in which the protection state or eligibility for protection is known to PCE. It is RECOMMENDED for a PCE to assume a Node SID is protected. It is RECOMMENDED for a PCE to assume an Adjacency SID is protected if the backup flag advertised with the Adjacency SID is set. If a PCE is unable to infer protection status of a resource, PCE MAY use local policy to define protected status assumptions.

### **5.1. Backwards Compatibility**

Considerations in the message passing between the PCC and the PCE for the E flag bit which are not supported by the entity are outlined in this section, with requirements for the PCE and the PCC implementing this document described at the end.

For a PCC or PCE which does not yet support this document, the E flag is ignored and set to zero in PCRpt and/or PCUpd as per [\[RFC5440\]](#) for PCC-initiated or as per [\[RFC8281\]](#) for PCE-initiated LSPs. It is important to note that [\[RFC8231\]](#) and [\[RFC8281\]](#) permit the LSP Attribute Object to be included in PCUpd messages for PCC-initiated and PCE-initiated LSPs.

For PCC-initiated LSPs, PCUpd E flag (and L flag) is an echo from the previous PCRpt however the bit value is ignored on the PCE from the previous PCRpt, therefore the E flag value set in the PCUpd is zero. A PCE which does not support this document sends PCUpd messages with the E flag set to 0 for PCC-initiated LSPs even if set to 1 in the prior PCReq or PCRpt.

A PCC which does not support this document sends PCRpt messages with the E flag set to 0 for PCE-initiated LSPs even if set to 1 in the prior PCInitiate or PCUpd.

For a PCC which does support this document, it MAY set E flag to 1 depending on local configuration. If communicating with a PCE which does not yet support this document, the PCE follows the behaviour specified in [\[RFC5440\]](#) and will ignore the E flag thus it will not compute a path respecting the enforcement constraint.

For PCC-initiated LSPs, the PCC SHOULD ignore the E flag value received from the PCE in a PCUpd message.

For PCE-initiated LSPs, the PCC MAY process the E flag value received from the PCE in a PCUpd message. PCE SHOULD ignore the E flag value received from the PCC in a PCRpt message.

## **6. Implementation Status**

[Note to the RFC Editor - remove this section before publication, as well as remove the reference to RFC 7942.]

This section records the status of known implementations of the protocol defined by this specification at the time of posting of this Internet-Draft, and is based on a proposal described in [\[RFC7942\]](#). The description of implementations in this section is intended to assist the IETF in its decision processes in progressing drafts to RFCs. Please note that the listing of any individual implementation here does not imply endorsement by the IETF. Furthermore, no effort has been spent to verify the information presented here that was supplied by IETF contributors. This is not intended as, and must not be construed to be, a catalogue of available implementations or their features. Readers are advised to note that other implementations may exist.

According to [\[RFC7942\]](#), "this will allow reviewers and working groups to assign due consideration to documents that have the benefit of running code, which may serve as evidence of valuable experimentation and feedback that have made the implemented protocols more mature. It is up to the individual working groups to use this information as they see fit".

### **6.1. Nokia Implementation**

\*Organization: Nokia

\*Implementation: NSP PCE and SROS PCC.

\*Description: Implementation for calculation and conveying intention described in this document

\*Maturity Level: Demo

\*Coverage: Full

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### **6.2. Cisco Implementation**

\*Organization: Cisco Systems, Inc.

\*Implementation: IOS-XR PCE and PCC.

\*Description: Implementation for calculation and conveying intention described in this document

\*Maturity Level: Demo

\*Coverage: Full

\*Contact: ssidor@cisco.com

## 7. Security Considerations

This document clarifies the behaviour of an existing flag and introduces a new flag to provide further control of that existing behaviour. The introduction of this new flag and behaviour clarification does not create any new sensitive information. No additional security measure is required.

Securing the PCEP session using Transport Layer Security (TLS) [RFC8253], as per the recommendations and best current practices in [RFC7525] is RECOMMENDED.

## 8. IANA Considerations

### 8.1. LSPA Object

This document defines a new bit value in the sub-registry "LSPA Object Flag Field" in the "Path Computation Element Protocol (PCEP) Numbers" registry. IANA is requested to confirm the early-allocated codepoint.

Bit	Name	Reference
6	Protection Enforcement	This I-D

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