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Path Computation Element Protocol (PCEP) Extension for Color
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Abstract

Color is a 32-bit numerical (unsigned integer) attribute used to associate a Traffic Engineering (TE) tunnel or policy with an intent or objective. For example, a TE Tunnel constructed to deliver low latency services and whose path is optimized for delay can be tagged with a color that represents "low latency." This document specifies extensions to the Path Computation Element Protocol (PCEP) to carry the color attribute.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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1. Introduction

A Traffic Engineering (TE) tunnel ([RFC3209]) or Segment Routing (SR) policy ([RFC9256]) can be associated with an intent or objective (e.g., low latency) by tagging it with a color. This color attribute is used as a guiding criterion for mapping services onto the TE tunnel ([RFC9012]) or SR policy ([RFC9256]). The term color used in this document must not be interpreted as the 'thread color' specified in [RFC3063] or the 'resource color' (also referred to as 'link color') specified in [RFC3630], [RFC5329], [RFC5305] and [RFC7308].

[RFC8231] specifies extensions to the Path Computation Element Protocol (PCEP) that enable the deployment of a stateful Path Computation Element (PCE) model. These extensions allow a Path Computation Client (PCC) to delegate control of the Label Switched Paths (LSPs) associated with its TE Tunnels to a stateful PCE. [RFC8281] specifies extensions that allow a PCE to instantiate and manage PCE-initiated LSPs on a PCC under the stateful PCE model. [RFC8664] specifies extensions that enable stateful control of SR paths via PCEP.

This document introduces extensions to PCEP to allow a color tag to be assigned to any TE path operated under a stateful PCE model (including those set up using RSVP-TE [RFC8408] or Segment Routing [RFC8664]). The only exception where the extensions defined in this document MUST NOT be used to carry the color attribute is for SR paths established using the extensions defined in [I-D.ietf-pce-segment-routing-policy-cp]. For these SR paths, the associated color is already included as part of the SR policy identifier encoding.

The mechanism employed by the PCC for mapping services onto a TE path associated with a color attribute is outside the scope of this document, as is any other use of the color tag.

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. Protocol Operation

When the PCEP session is created, a PCEP (PCE/PCC) speaker sends an Open message with an OPEN object that contains the STATEFUL-PCE-CAPABILITY TLV, as defined in [RFC8231]. A STATEFUL-PCE-CAPABILITY TLV Flag (See Section 3.1) is introduced in this document to enable the PCEP speaker to advertise color capability.

In PCRpt, PCUpd, and PCInitiate messages, the LSP object ([RFC8231], [RFC8281]) is a mandatory inclusion and is used to carry information specific to the target LSP. A TLV called the Color TLV (see Section 3.2), which MAY be carried in the LSP object, is introduced in this document to carry the color attribute associated with the LSP. Only one COLOR TLV SHOULD be included in the LSP object. If the COLOR TLV appears in the LSP object more than once, only the first occurrence is processed, and any others MUST be ignored.

A PCEP speaker that has advertised color capability MUST NOT send Color TLV encoded in the LSP object to a PCEP Peer that has not advertised color capability. A PCEP speaker that advertises both color capability and SR Policy Association capability ([I-D.ietf-pce-segment-routing-policy-cp]) MUST NOT send Color TLV encoded in the LSP object for SR Paths. The Color TLV is ignored if it shows up in the LSP object of a message which carries an ASSOCIATION object of type SR Policy Association ([I-D.ietf-pce-segment-routing-policy-cp]). The color encoded in the SR Policy Association takes precedence in such a scenario.

If a PCC is unable to honor a color value passed in a PCUpd or a PCInitiate message, the PCC MUST reject the message and send a PCErr message with Error-type=19 (Invalid Operation) and error-value=TBD1 (Invalid color). This is expected behavior in scenarios where a PCC implementation does not support a color value of zero for specific path setup types, and it receives that value in the COLOR TLV of a PCUpd or a PCInitiate message.

When LSPs that belong to the same TE tunnel are within the same Path Protection Association Group [RFC8745], they are all expected to have the same color attached to them. If a PCEP speaker determines inconsistency in the color associated with the LSPs belonging to the same Path Protection Association Group, it MUST reject the message carrying the inconsistent color and send a PCErr message with Error-type=19 (Invalid Operation) and error-value=TBD2 (Inconsistent color).

3. Protocol Extensions

3.1. Color Capability

Section 7.1.1 of [RFC8231] defines STATEFUL-PCE-CAPABILITY TLV flags. The following flag is used to indicate if the speaker supports color capability:

C-bit (Bit 20): A PCE/PCC indicates that it supports the color capability defined in this document by setting this bit.

3.2. Color TLV

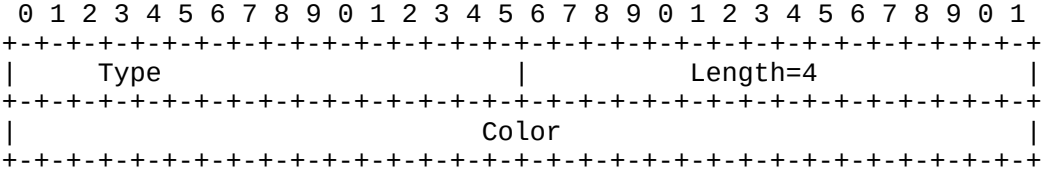

Figure 1: Color TLV

Type has the value 67. Length carries a value of 4. The 'color' field is 4-bytes long, and carries the actual color value (specified as an unsigned integer). A color value of zero is allowed.

4. Security Considerations

This document defines a TLV for color and a flag for color capability negotiation, which do not add any security concerns beyond those discussed in [RFC5440], [RFC8231] and [RFC8281].

An unauthorized PCE may maliciously associate the LSP with an incorrect color. The procedures described in [RFC8253] and [RFC9325] can be used to protect against this attack.

5. Manageability Considerations

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

5.1. Control of Function through Configuration and Policy

An implementation supporting this document SHOULD allow the operator to turn on and off the PCEP color capability advertisement (Section 3.1). An implementation supporting this document SHOULD allow the configuration of color assignment to a TE Tunnel or an SR Policy. A PCC MAY have a local policy configuration that specifies how the color tag is used. This policy configuration is outside the scope of this document.

5.2. Information and Data Models

An implementation supporting this document SHOULD allow the inclusion of color in the data model used to retrieve the operational state of a TE tunnel or an SR policy. The YANG model in [I-D.ietf-teas-yang-te] could be used to retrieve the operational state of a TE tunnel, and the YANG model in [I-D.ietf-spring-sr-policy-yang] could be used to retrieve the operational state of an SR policy.

5.3. Liveness Detection and Monitoring

The extensions defined in this document do not require any additional liveness detection and monitoring support. See [RFC5440] and [RFC5886] for more information.

5.4. Verifying Correct Operation

The operator MAY retrieve the operational state of TE Paths to verify if they are tagged with the correct intended color.

5.5. Requirements on Other Protocols

This document places no explicit requirements on other protocols.

5.6. Impact on Network Operation

The impact on network operations depends on how the color tag is used in the deployment. This is outside the scope of this document.

6. IANA Considerations

6.1. PCEP TLV Type Indicator

This document introduces a value in the "PCEP TLV Type Indicators" registry of the "Path Computation Element Protocol (PCEP) Numbers" registry group as follows:

Value	Description	Reference
67	Color	This document

Note: The code point specified for the TLV Type Indicator is an early allocation by IANA.

6.2. STATEFUL-PCE-CAPABILITY TLV Flag Field

This document introduces a bit value in the "STATEFUL-PCE-CAPABILITY TLV Flag Field" registry of the "Path Computation Element Protocol (PCEP) Numbers" registry group as follows:

Value	Description	Reference
20	COLOR-CAPABILITY	This document

Note: The code point specified for the STATEFUL-PCE-CAPABILITY TLV Flag is an early allocation by IANA.

6.3. PCEP-Error Object

This document introduces two Error-values for Error-Type=19 (Invalid Operation) within the "PCEP-ERROR Object Error Types and Values" registry of the "Path Computation Element Protocol (PCEP) Numbers" registry group as follows:

Error-Type	Meaning	Error-value	Reference
19	Invalid Operation	TBD1: Invalid Color	This document
		TBD2: Inconsistent Color	This document

6.4. LSP-ERROR-CODE TLV Error Code Field

An earlier version of this document added an error code in the "LSP-ERROR-CODE TLV Error Code Field" registry of the "Path Computation Element Protocol (PCEP) Numbers" registry group, which was also early allocated by the IANA.

IANA is requested to cancel the early allocation made which is not needed anymore. As per the instructions from the chairs, please mark it as deprecated.

Value	Meaning	Reference
9	Deprecated (Unsupported Color)	This document

7. 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 catalog 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".

At the time of publication of this version, there are no known implementations. Juniper Networks has plans to implement the extensions defined in this document.

8. Acknowledgments

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