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PCEP Extensions for Service Function Chaining (SFC)
draft-wu-pce-traffic-steering-sfc-12

Abstract

This document provides an overview of the usage of Path Computation Element (PCE) to dynamically structure service function chains. Service Function Chaining (SFC) is a technique that is meant to facilitate the dynamic enforcement of differentiated traffic forwarding policies within a domain. Service function chains are composed of an ordered set of elementary Service Functions (such as firewalls, load balancers) that need to be invoked according to the design of a given service. Corresponding traffic is thus forwarded along a Service Function Path (SFP) that can be computed by means of PCE.

This document specifies extensions to the Path Computation Element Protocol (PCEP) that allow a stateful PCE to compute and instantiate Service Function Paths.

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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This Internet-Draft will expire on December 29, 2017.

Table of Contents

1. Introduction

Service Function Chaining (SFC) enables the creation of composite

services that consist of an ordered set of Service Functions (SF) that must be applied to packets and/or frames and/or flows selected as a result of service-inferred traffic classification as described in [RFC7665]. A Service Function Path (SFP) is a path along which traffic that is bound to a specific service function chain will be

forwarded. Packets typically follow a Service Function Path from a classifier through the Service Functions (SF) that need to be invoked according to the SFC instructions. Forwarding decisions are made by Service Function Forwarders (SFF) according to such instructions.

[RFC5440] describes the Path Computation Element Protocol (PCEP) as the protocol used by a Path Computation Client (PCC) and a Path Control Element (PCE) to exchange information, thereby enabling the computation of Multiprotocol Label Switching (MPLS) for Traffic Engineering Label Switched Path (TE LSP), in particular.

[I-D.ietf-pce-stateful-pce] specifies extensions to PCEP to enable a stateful control of MPLS TE LSPs. [I-D.ietf-pce-pce-initiated-lsp] provides the extensions needed for stateful PCE-initiated LSP instantiation.

This document specifies PCEP extensions that allow a stateful PCE to compute and instantiate traffic-engineered Service Function Paths (SFP).

2. 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 RFC2119 [RFC2119].

This document makes use of these acronyms:

PCC: Path Computation Client.

PCE: Path Computation Element.

PCEP: Path Computation Element Protocol.

PDP: Policy Decision Point.

SF: Service Function.

SFC: Service Function Chain.

SFP: Service Function Path.

RSP: Rendered Service Path.

SFF: Service Function Forwarder.

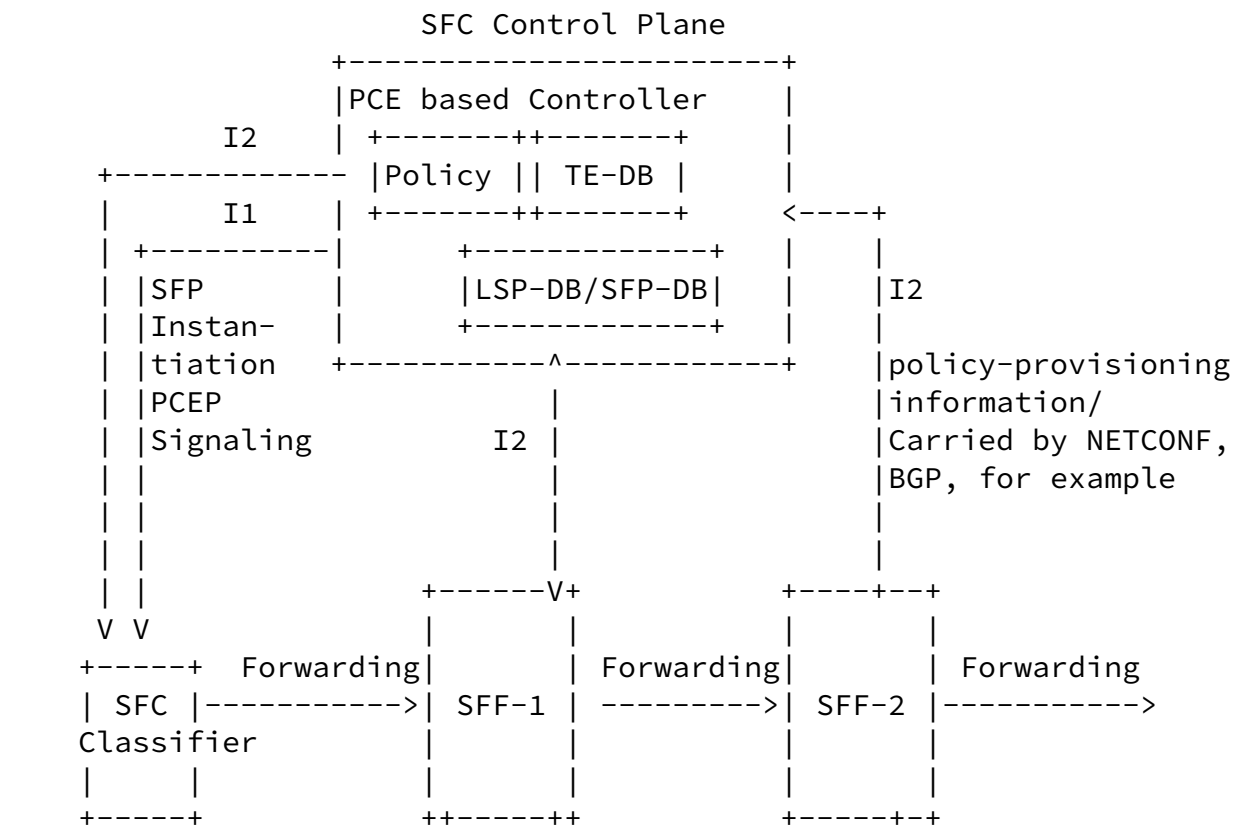
UNI: User-Network Interface.

3. Service Function Paths and PCE

Service function chains are constructed as a sequence of SFs, where a SF can be virtualized or embedded in a physical network element. One or several SFs may be supported by the same physical network element. A SFC creates an abstracted view of a service and specifies the set of required SFs as well as the order in which they must be executed.

When an SFC is created, it is necessary to select the specific instances of SFs that will be used. A service function path for that SFC will then be established (notion of rendered service path) or can be precomputed, based upon the sequence of SFs that need to be invoked by the corresponding traffic, i.e., the traffic that is bound to the corresponding SFC. Note that a SF instance can be serviced by one or multiple SFFs. One or multiple SF instances can be serviced by one SFF. Thus, the instantiation of an SFC results in the establishment of a Service Function Path, either in a hop-by-hop fashion, or by means of traffic-engineering capabilities. In the latter case, the SFP is precomputed, i.e., an SFP is an instantiation of the defined SFC as described in [RFC7665].

The computation, the selection, and the establishment of a traffic-engineered SFP can rely upon a set of (service-specific) policies (forwarding and routing, QoS, security, etc., or a combination thereof). Stateful PCE with appropriate SFC-aware PCEP extensions can be used to compute traffic-engineered SFPs.


SFC Control Plane
PCE based Controller
I2
Policy || TE-DB
I1
SFP
Instan-
tiation
PCEP
Signaling
LSP-DB/SFP-DB
I2
I2
policy-provisioning
information/
Carried by NETCONF,
BGP, for example
Forwarding
SFC
Classifier
Forwarding
SFF-1
Forwarding
SFF-2
Forwarding

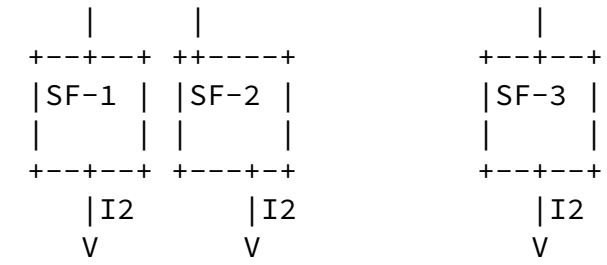


Figure 1: PCE-based SFP instantiation

In Figure 1, the PCE-based Controller [I-D.ietf-teas-pce-central-control] in the SFC Control plane is responsible for computing the path for a given service function chain. This PCE-based controller can operate as a stateful PCE ([I-D.draft_ietf-stateful-pce]) that will provide a classifier (a headend from a PCE standpoint) with the PCEP-formatted information to instantiate a given SFP. As a consequence, the PCE-based controller derives the set of policy-provisioning information (namely SFP configuration information and traffic classification rules) that will be provided to the various elements (Classifier, SFF) involved in the establishment of the SFP.

By doing so, SFC Classifier can bind a flow to a service function chain and forward such flow along the corresponding SFP. The SFC Control Plane [I-D.ietf-sfc-control-plane] is also responsible for defining the appropriate policies (traffic classification, forwarding and routing, etc.) that will be enforced by SFC Classifiers,SFF Nodes

and SF Nodes, as described in [RFC7665]. From that standpoint, the SFC Control Plane embeds a Policy Decision Point that is responsible for defining the SFC policies. SFC policies will be provided by the PDP and enforced by SFC components like classifiers and SFFs by means of policy-provision information. A protocol like NETCONF, BGP can be used to carry such policy-provisioning information.

4. Overview of PCEP Operation in SFC-Enabled Networks

A PCEP speaker indicates its ability to support PCE-computed SFP paths during the PCEP Initialization phase via a mechanism described in Section 5.1. A PCE may initiate SFPs only for PCCs that advertised this capability; a PCC follows the procedures described in this document only for sessions where the PCE advertised this capability.

As per Section 5.1 of [I-D.ietf-pce-pce-initiated-lsp], the PCE sends a Path Computation LSP Initiate Request (PCInitiate) message to the PCC to instantiate or delete a LSP. The Explicit Route Object (ERO) is used to encode either a full sequence of SF instances or a specific sequence of SFFs and SFs to establish an SFP. If the said SFFs and SFs are identified with an IP address, the IP sub-object can be used as a SF/SFF identification means. This document makes no change to the PCInitiate message format but extends LSP objects described in Section 5.2.

Editor's note: In case a PCE-Initiated signaling mechanism is used to set up the service function path, does the classifier / PCE-Initiated signaling protocol need to understand whether an IP address is assigned to a SFF or a SF, or the signaling protocol is only used to signal IP addresses for SFs?

To prevent multiple classifiers assign the same SFP ID to one Service Function Path(SFP ID assignment conflict),in this document, we assume SFP ID can be predetermined and assigned by stateful PCE when stateful PCE can be used to compute traffic-engineered SFPs.

4.1. SFP Instantiation

The instantiation of a SFP is the same as defined in Section 5.3 of [I-D.ietf-pce-pce-initiated-lsp]. Rules for processing and error codes remain unchanged.

4.2. SFP Withdrawal

The withdrawal of an SFP is the same as defined in Section 5.4 of [I-D.ietf-pce-pce-initiated-lsp]: the PCE sends an LSP Initiate Message with an LSP object carrying the PLSP-ID of the SFP and the

SFP Identifier to be removed, as well as an SRP object with the R flag set (LSP-REMOVE as per Section 5.2 of [I-D.ietf-pce-pce-initiated-lsp]). Rules for processing and error codes remain unchanged.

4.3. SFP Delegation and Cleanup

SFP delegation and cleanup operations are similar to those defined in

Section 6 of [I-D.ietf-pce-pce-initiated-lsp]. Rules for processing and error codes remain unchanged.

4.4. SFP State Synchronization

State Synchronization operations described in Section 5.4 of [I-D.ietf-pce-stateful-pce] can be applied to SFP state maintenance as well.

4.5. SFP Update and Report

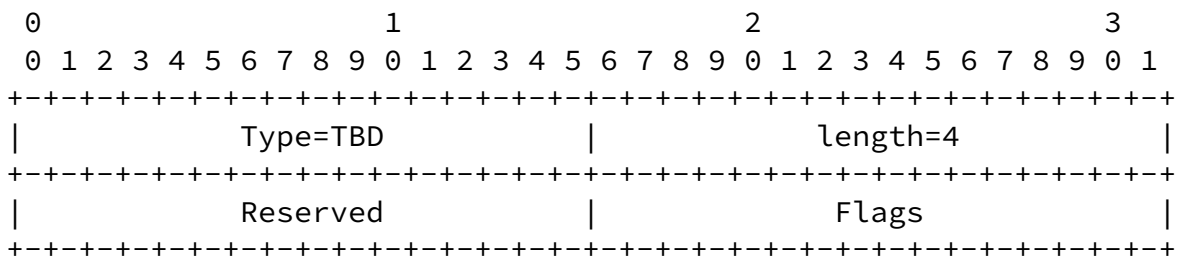
A PCE can send an SFP Update request to a PCC to update one or more attributes of an SFP and to re-signal the SFP with the updated attributes. A PCC can send an SFP state report to a PCE, and which contains the SFP State information. The mechanism is described in [I-D.ietf-pce-stateful-pce] and can be applied to SFPs as well.

5. Object Formats

5.1. The OPEN Object

The optional TLV shown in Figure 2 is defined for use in the OPEN Object to indicate the PCEP speaker's Service Function Chaining capability.

The SFC-PCE-CAPABILITY TLV is an optional TLV to be carried in the OPEN Object to advertise the SFC capability during the PCEP session.



SFC-PCE-CAPABILITY TLV Format

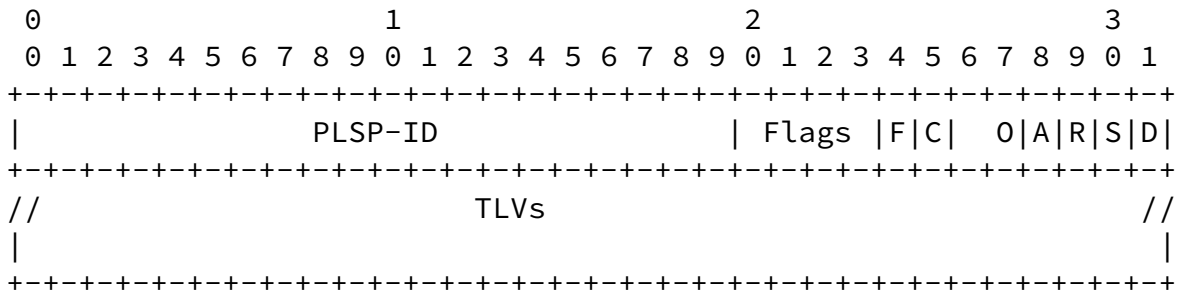
The code point for the TLV type is to be defined by IANA (see Section 9). The TLV length is 4 octets.

As per [I-D.ietf-pce-stateful-pce], a PCEP speaker advertises the

capability of instantiating PCE-initiated LSPs via the Stateful PCE Capability TLV (LSP-INSTANTIATION-CAPABILITY bit) carried in an Open message. The inclusion of the SFC-PCE-CAPABILITY TLV in an OPEN object indicates that the sender is SFC-capable. Both mechanisms indicate the SFP instantiation capability of the PCEP speaker.

5.2. The LSP Object

The LSP object is defined in [I-D.ietf-pce-pce-initiated-lsp] and included here for reference (Figure 3).



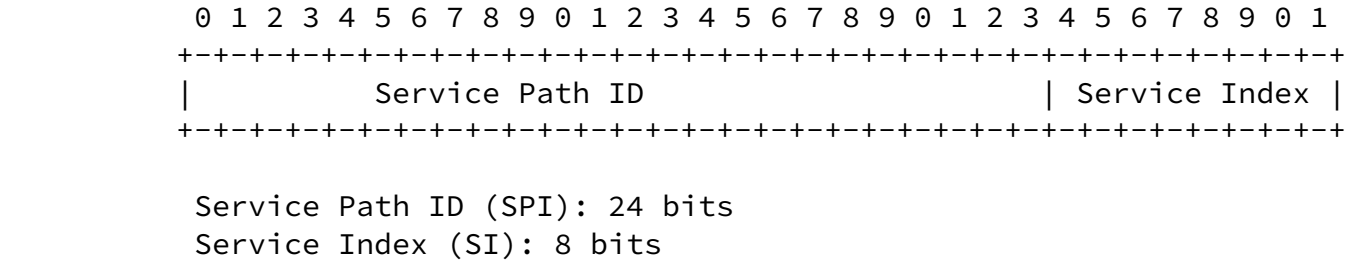
LSP Object Format

A new flag, called the SFC flag (F-bit), is introduced. The F-bit set to "1" indicates that this LSP is actually an SFP. The C flag will also be set to indicate it was created via a PCInitiate message.

5.2.1. SFP Identifiers TLV

As described in section 4, SFP ID is predetermined and assigned by stateful PCE. The SFP Identifiers TLV MUST be included in the LSP object for SFPs. The SFP Identifier TLV is used by the classifier to select the SFP along which some traffic will be forwarded, according to the traffic classification rules applied by the classifier [RFC7665]. The SFP Identifier is part of the SFC metadata carried in packets and is used by the SFF to invoke service functions and identify the next SFF.

The format of the SFP Identifier TLV is shown in Figure 4.



Service Path ID (SPI): 24 bits
Service Index (SI): 8 bits

Figure 4

SPI: identifies a service path. The same ID is used by the participating nodes for path setup/selection. An administrator can use the SPI for reporting and troubleshooting packets along a specific path. SPI along with PLSP-ID is used by PCEP to identify the Service Path.

SI: provides location within the service path.

6. Backward Compatibility

The SFP instantiation capability defined as a PCEP extension and documented in this draft MUST NOT be used if PCCs or the PCE did not advertise their stateful SFP instantiation capability,Section 5.1. If this is not the case and stateful operations on SFPs are attempted, then a PCErr message with error-type 19 (Invalid Operation) and error-value TBD needs to be generated.

[Editor's note: more information on exact error value is needed]

7. SFP Instantiation Signaling and Forwarding Considerations

The PCE-initiated SFP instantiation signaling described in this document is exchanged between PCE server and SFC Classifier and does not assume any specific mechanism to exchange SFP information(e.g.,path identification information,metadata [I-D.ietf-sfc-nsh]) between SFFs or between SFF and SF, or between the controller and SFF and establish SFP in the data plane throughout a SFC domain. For example, such mechanism can rely upon the use of the SFC Encapsulation defined in [I-D.ietf-sfc-nsh] to exchange SFP information between SFFs or rely upon the use of BGP Control plane defined in [I-D.ietf-bess-nsh-bgp-control-plane] to exchange SFP information between the Controller and SFF.

Likewise, [I-D.ietf-teas-pce-central-control] can use the signaling mechanism described in this draft to enforce SFC-inferred traffic engineering policies and provide load balancing between service

function nodes. The approach that relies upon the Segment Routing technique [I-D.ietf-pce-segment-routing] can also take advantage of

the signaling mechanism described in this document to support Service Path instantiation, which does not require any additional specific extension to the Segment Routing machinery.

8. Security Considerations

The security considerations described in [RFC5440] and [I-D.ietf-pce-pce-initiated-lsp] are applicable to this specification. This document does not raise any additional security issue.

9. IANA Considerations

IANA is requested to allocate a new code point in the PCEP TLV Type Indicators registry, as follows:

Value	Meaning	Reference
TBD	SFC-PCE-CAPABILITY	This document

10. Acknowledgements

Many thanks to Ron Parker, Hao Wang, Dave Dolson, Jing Huang, and Joel M. Halpern for the discussion about the content for the document.

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