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Y. Liu
ZTE Corporation
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PCEP Extension for Flow Specification Version 2
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Abstract

Traffic flows may be categorized and described using "Flow Specifications". RFC8955 defines the Flow Specification and describes how Flow Specification components are used to describe traffic flows. RFC8955 also defines how Flow Specifications may be distributed in BGP to allow specific traffic flows to be associated with routes. The flow specification protocol defined in RFC8955, RFC8956, RFC9117 is called BGP flow specification version 1 (BGP FSV1).

RFC9168 specifies a set of extensions to PCEP to support the dissemination of Flow Specifications. This allows a PCE to indicate what traffic should be placed on each path that it is aware of. RFC9168 inherits the BGP Flow Spec registry and ordering rules as well as the limitations in BGP FSV1.

This document proposes extensions to PCEP to add the support of Flow Specification v2 to allow the user to order the flow specification rules.

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1. Introduction

BGP flow specification as defined by [RFC8955], [RFC8956], [RFC9117] specifies the distribution of traffic filter policy (traffic filters and actions) via BGP to a mesh of BGP peers. The traffic filter policy is applied when packets are received on a router with the flow specification function turned on. The flow specification protocol defined in [RFC8955], [RFC8956], [RFC9117] is called BGP flow specification version 1 (BGP FSV1).

To address the limitations of BGP FSV1, [I-D.ietf-idr-flowspec-v2] specifies version 2 of the BGP flow specification protocol (BGP FSV2). [I-D.ietf-idr-fsv2-ip-basic] provides the basic FSV2 framework specification for transmitting user-ordered IP filters in the FSV2 NLRI with Extended Community to specify actions.

[RFC9168] specifies a set of extensions to PCEP to support dissemination of Flow Specifications. This allows a PCE to indicate what traffic should be placed on each path that it is aware of. [I-D.ietf-pce-pcep-l2-flowspec] further extends the support for Ethernet Layer 2 (L2) and Layer 2 Virtual Private Network (L2VPN) traffic filtering rules in PCEP Flow Specifications.

The current PCEP Extensions for Flow Specification [RFC9168] [I-D.ietf-pce-pcep-l2-flowspec] inherit the BGP Flow Spec registry and ordering rules in BGP FSV1 [RFC8955] [RFC8956], so it has the same limitations as BGP FSV1 in the aspect of flow filtering as analyzed in [I-D.ietf-idr-flowspec-v2], that is, lack of consistent TLV encoding prevented extension of encodings and inability to allow user defined order for filtering rules. In terms of the action associated with the Flow Specification, PCEP Flow Specification is not affected by shortcoming of inability to order actions to provide deterministic interactions or to allow users to define order for actions in BGPv1, since there is only one action that is applicable in the PCEP context (that is, directing the matching traffic to the identified LSP).

This document proposes extensions to PCEP to add the support of Flow Specification v2 to allow the user to order the flow specification rules.

Currently, only the IP Basic Filters are considered in this document. Future version may add the support of MPLS/L2/SFC/Tunneled Flow Specifications with the development of BGP FSV2 [I-D.ietf-idr-flowspec-v2].

A new object called the FLOWSPECv2 object is defined in this document. The flow filtering rules indicated by the Flow Specifications are mainly defined by BGP Flow version 2 Specifications in in [I-D.ietf-idr-flowspec-v2] and [I-D.ietf-idr-fsv2-ip-basic]. And the coexistence of FLOWSPEC object defined in [RFC9168] and FLOWSPECv2 object are also considered.

2. Terminology

This document uses the following terms defined in [RFC5440]: PCC, PCE, PCEP Peer.

The following term from [RFC8955] is used frequently throughout this document:

A Flow Specification is an n-tuple consisting of several matching criteria that can be applied to IP traffic. A given IP packet is said to match the defined Flow Specification if it matches all the specified criteria.

This document uses the following terms defined in [I-D.ietf-idr-flowspec-v2]: BGP FSv1, BGP FSv2.

The term "PCEP FSv1" is used to refer to the PCEP flow specification defined in [RFC9168], and "PCEP FSv2" is used to indicate the PCEP flow specification extensions proposed in this document.

2.1. 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.

3. Procedures for PCE Use of Flow Specification v2

The steps in the setup and use of LSPs section 3 of [RFC9168] defines the procedures for PCE use of Flow Specifications. For PCEP Flow Specification v2, the steps in the setup and use of LSPs follow the same specification defined in section 3.1 of [RFC9168] respectively.

As for the elements of the procedure, this document also follows the specification in section 3.2 of [RFC9168] except that:

- * a new "PCE FlowSpecv2 Capability TLV" is defined in this document to indicate the ability to support Flow Specifications can be indicated in the PCEP Open message;

- * a new PCE-CAP-FLAGS sub-TLV bit, the "FlowSpecv2 Capable flag" is defined in this document to indicate that an advertising PCE supports the procedures of PCE FlowSpecv2 defined in this document;
- * a new "PCEP FLOWSPECv2 object" is defined in this document to carry version 2 of Flow Specifications in PCEP messages.

The following sections describe these points.

4. PCE FlowSpecv2 Capability TLV

The PCE-FLOWSPECv2-CAPABILITY TLV is an optional TLV that can be carried in the OPEN object [RFC5440] to exchange the PCE FlowSpecv2 capabilities of the PCEP speakers.

The format of the PCE-FLOWSPECv2-CAPABILITY TLV follows the format of all PCEP TLVs as defined in [RFC5440] and is shown in Figure 1.

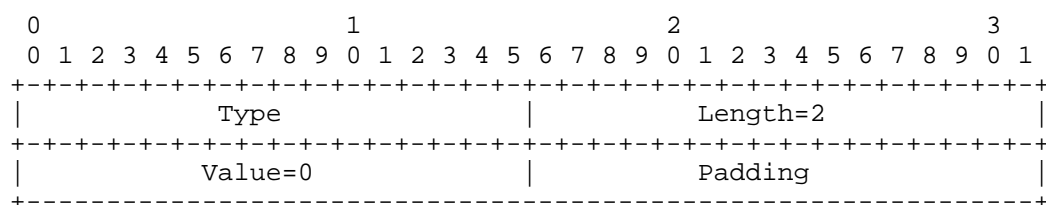


Figure 1: PCE-FLOWSPECv2-CAPABILITY TLV Format

The type of the PCE-FLOWSPECv2-CAPABILITY TLV is TBD1, and it has a fixed length of 2 octets. The Value field MUST be set to 0 and MUST be ignored on receipt. The two bytes of padding MUST be set to zero and ignored on receipt.

The inclusion of this TLV in an OPEN object indicates that the sender can perform FlowSpecv2 handling as defined in this document.

5. PCEP FLOWSPECv2 Object

The PCEP FLOWSPECv2 object defined in this document is compliant with the PCEP object format defined in [RFC5440]. It is OPTIONAL in the PCReq, PCRep, PCErr, PCInitiate, PCRpt, and PCUpd messages and MAY be present zero, one, or more times. Each instance of the object specifies a separate traffic flow.

The PCEP FLOWSPECv2 object MAY carry FlowSpecv2 filter rules encoded in a Flow Filter TLV as defined in Section 6.

The FLOWSPECv2 Object-Class is TBD2.

The FLOWSPECv2 Object-Type is TBD3.

The format of the body of the PCEP FLOWSPECv2 object is shown in Figure 2.

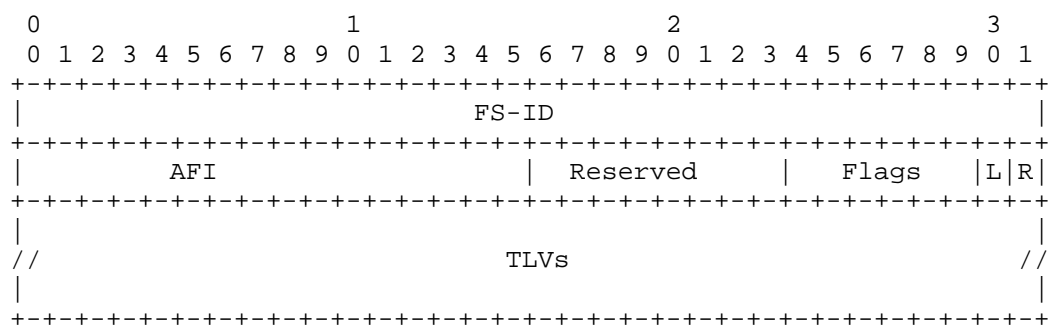


Figure 2: PCEP FLOWSPECv2 Object Body Format

FS-ID (32 bits): A PCEP-specific identifier for the FlowSpec information. A PCE or PCC creates an FS-ID for each FlowSpec that it originates, and the value is unique within the scope of that PCE or PCC and is constant for the lifetime of a PCEP session. All subsequent PCEP messages can identify the FlowSpec using the FS-ID. The values 0 and 0xFFFFFFFF are reserved and MUST NOT be used. Note that [I-D.gont-numeric-ids-sec-considerations] gives advice on assigning transient numeric identifiers such as the FS-ID so as to minimize security risks.

AFI (16 bits): Address Family Identifier as used in BGP [RFC4760]. AFI=1 for IPv4, AFI=2 for IPv6, AFI=6 for L2, AFI=25 for L2VPN, and AFI=31 for SFC as per [I-D.ietf-idr-flowspec-v2].

Reserved (8 bits): MUST be set to zero on transmission and ignored on receipt.

Flags (8 bits): Two flags are currently assigned:

R bit: The Remove bit is set when a PCEP FLOWSPECv2 object is included in a PCEP message to indicate removal of the Flow Specification from the associated tunnel. If the bit is clear, the Flow Specification is being added or modified.

L bit: The Longest Prefix Match (LPM) bit is set to indicate that

the Flow Specification is to be installed as a route subject to LPM forwarding. If the bit is clear, the Flow Specification described by the IP Basic Flow Filter TLV (see Section 6) is to be installed as a Flow Specification. If the bit is set, only IP Basic Flow Filter TLV that describe IPv4 or IPv6 destinations are meaningful in the Flow Filter TLV, and others are ignored. If the L is set and the receiver does not support the use of Flow Specifications that are present in the IP Basic Flow Filter TLV for the installation of a route subject to LPM forwarding, then the PCEP peer MUST respond with a PCErr message with Error-Type 30 (FlowSpec Error) and Error-value 5 (Unsupported LPM Route).

Unassigned bits MUST be set to zero on transmission and ignored on receipt.

If the PCEP speaker receives a message with the R bit set in the FLOWSPECv2 object and the Flow Specification identified with an FS-ID does not exist, it MUST generate a PCErr with Error-Type 30 (FlowSpec Error) and Error-value 4 (Unknown FlowSpec).

If the PCEP speaker does not understand or support the AFI in the FLOWSPEC message, the PCEP peer MUST respond with a PCErr message with Error-Type 30 (FlowSpec Error) and Error-value 2 (Malformed FlowSpec).

The following TLVs can be used in the FLOWSPEC object:

Speaker Entity Identifier TLV: As specified in [RFC8232], the SPEAKER-ENTITY-ID TLV encodes a unique identifier for the node that does not change during the lifetime of the PCEP speaker. This is used to uniquely identify the FlowSpec originator and thus is used in conjunction with the FS-ID to uniquely identify the FlowSpec information. This TLV MUST be included. If the TLV is missing, the PCEP peer MUST respond with a PCErr message with Error-Type 30 (FlowSpec Error) and Error-value 2 (Malformed FlowSpec). If more than one instance of this TLV is present, the first MUST be processed, and subsequent instances MUST be ignored.

IP Basic Flow Filter TLV (variable): One TLV MAY be included. The Flow Filter TLV is OPTIONAL when the R bit is set.

The IP Basic Flow Filter TLV MUST be present when the R bit is clear. If the TLV is missing when the R bit is clear, the PCEP peer MUST respond with a PCErr message with Error-Type 30 (FlowSpec Error) and Error-value 2 (Malformed FlowSpec).

6. IP Basic Flow Filter TLV

One new PCEP TLV is defined to convey Flow Specification version 2 filtering rules that specify what traffic is carried on a path. The TLV follows the format of all PCEP TLVs as defined in [RFC5440].

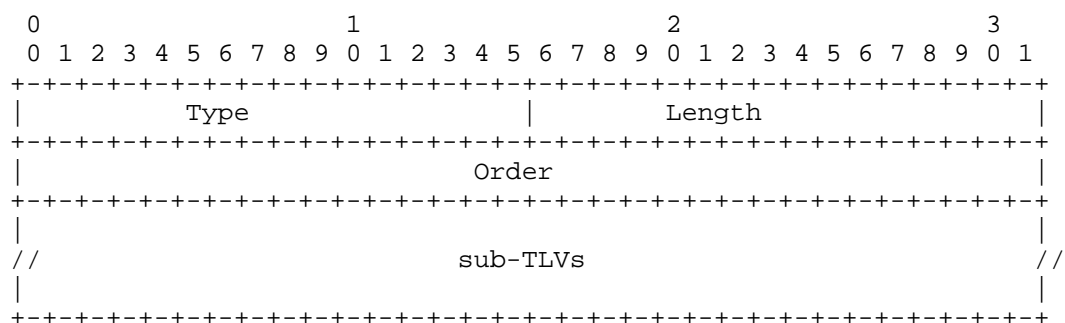


Figure 3: IP Basic Flow Filter TLV

The Type field values come from the code point space for PCEP TLVs and has the value TBB4 for IP Basic Flow Filter TLV.

The value field contains an order field, it is a 4-octet field with a value 1-N following the semantic . The value 0 (zero) is invalid, if the value 0 is received, the PCEP peer MUST respond with a PCErr message with Error-Type 30 (FlowSpec Error) and Error-value 2 (Malformed FlowSpec).

(Currently, the dependency filter chain field in the IP Basic TLV [I-D.ietf-idr-fsv2-ip-basic] is not carried in IP Basic Flow Filter TLV defined in this document since this field is set all zero for the IP Basic Filter rules in [I-D.ietf-idr-fsv2-ip-basic])

The Value field of the TLV contains one or more sub-TLVs (the Flow Specification TLVs) as defined in Section 7, and they represent the complete definition of a IP Flow Specification for traffic to be placed on the tunnel. This tunnel is indicated by the PCEP message in which the PCEP FLOWSPECV2 object is carried. The set of Flow Specification TLVs in a single instance of a Flow Filter TLV is combined to indicate the specific Flow Specification.

7. IP Basic Flow Specification TLVs

The IP Basic Flow Filter TLV carries one or more IP Basic Flow Specification TLVs. IP Basic Flow Specification TLV follows the format of all PCEP TLVs as defined in [RFC5440]. However, the Type values are selected from a separate IANA registry rather than from the common PCEP TLV registry.

Type values are chosen so that there can be commonality with Flow Specifications defined for use with BGP [I-D.ietf-idr-fsv2-ip-basic]. This is possible because the BGP Flow Spec version 2 encoding uses a single octet to encode the type, whereas PCEP uses 2 octets. Thus, the space of values for the Type field is partitioned as shown in Table 1.

Range	Description
0-255	Per BGP Flow Spec registry defined by [I-D.ietf-idr-fsv2-ip-basic].
	Not to be allocated in this registry.
256-65535	New PCEP Flow Specifications allocated according to the registry defined in this document.

Table 1: IP Basic Flow Specification TLV Type Ranges

[I-D.ietf-idr-fsv2-ip-basic] is the reference for the "BGP FSv2 Component Types" registry and defines the allocations it contains.

The content of the Value field in each TLV is specific to the type/AFI and describes the parameters of the Flow Specification. The definition of the format of many of these Value fields is inherited from BGP FSv2 specifications for basic IP [I-D.ietf-idr-fsv2-ip-basic], but it may also be inherited from future BGP specifications.

When used in other protocols (such as BGP), these Flow Specifications are also associated with actions to indicate how traffic matching the Flow Specification should be treated. In PCEP, however, the only action is to associate the traffic with a tunnel and to forward matching traffic onto that path, so no encoding of an action is needed.

8. Detailed Procedures

When using the protocol extensions defined in this document, the following procedures of PCEP FSV1 defined in [RFC5440] apply as well.

- * Default Behavior and Backward Compatibility: same as [RFC5440] section 8.1.
- * Composite Flow Specifications: same as [RFC5440] section 8.2.
- * Modifying Flow Specifications: same as [RFC5440] section 8.3.
- * Multiple Flow Specifications: same as [RFC5440] section 8.4 for the the PCEP FLOWSPECv2 object.
- * Adding and Removing Flow Specifications: same as [RFC5440] section 8.5 for the the PCEP FLOWSPECv2 object.

Besides, the following subsections outline some additional procedures for using the protocol extensions defined in this document.

8.1. Priorities and Overlapping Flow Specifications

Flow Specifications can overlap. For example, two different Flow Specifications may be identical except for the length of the prefix in the destination address. In these cases, the PCC must determine how to prioritize the Flow Specifications so as to know which path to assign packets that match both Flow Specifications. That is, the PCC must assign a precedence to the Flow Specifications so that it checks each incoming packet for a match in a predictable order.

[I-D.ietf-idr-flowspec-v2] specifies the ordering of FSV2 Filters and it provides rules and features to keep filters in a deterministic order between FSV1 and FSV2. PCCs MUST apply the same ordering rules as defined in [I-D.ietf-idr-flowspec-v2].

When the PCC receives both the PCEP FLOWSPEC object and PCEP FLOWSPECv2 object, the FSV1 rules are added after FSV2 rules

FSV2 rules are ordered based on user-specified order. The user-specified order is carried in the FSV2 NLRI and a numerical lower value takes precedence over a numerically higher value. For rules received with the same order value, the FSV1 rules apply (order by component type and then by value of the components).

An implementation that receives a PCEP message carrying a Flow Specification that it cannot resolve against other Flow Specifications already installed (for example, because the new Flow

Specification has irresolvable conflicts with other Flow Specifications that are already installed) MUST respond with a PCErr message with Error-Type 30 (FlowSpec Error) and Error-value 3 (Unresolvable Conflict) and MUST NOT install the Flow Specification.

9. IANA Considerations

This document requests that IANA allocate code points for the protocol elements defined in this document.

9.1. PCEP Objects

Each PCEP object has an Object-Class and an Object-Type. IANA maintains a subregistry called "PCEP Objects". IANA is requested to make an assignment from this subregistry as follows:

Object-Class Value	Name	Object-Type	Reference
TBD5	FLOWSPEC	0: Reserved	[This.I-D]
		1: Flow Specification version 2	[This.I-D]

Table 2: PCEP Objects Subregistry Additions

9.1.1. PCEP FLOWSPECv2 Object Flag Field

This document requests that a new subregistry, "FLOWSPEC Object Flag Field", be created within the "Path Computation Element Protocol(PCEP) Numbers" registry to manage the Flag field of the FLOWSPECv2 object. New values are to be assigned by Standards Action [RFC8126]. Each bit should be tracked with the following qualities:

- * Bit number (counting from bit 0 as the most significant bit)
- * Capability description
- * Defining RFC

The initial population of this registry is as follows:

Bit	Description	Reference
0-5	Unassigned	
6	LPM (L bit)	[This.I-D]
7	Remove (R bit)	[This.I-D]

Table 3: Initial Contents of the
FLOWSPEC Object Flag Field
Registry

9.2. PCEP TLV Type Indicators

IANA maintains a subregistry called "PCEP TLV Type Indicators". IANA is requested to make an assignment from this subregistry as follows:

Value	Description	Reference
TBD1	PCE-FLOWSPECv2-CAPABILITY TLV	[This.I-D]
TBD4	IP Basic FLOW FILTER TLV	[This.I-D]

Table 4: PCEP TLV Type Indicators Subregistry
Additions

9.3. IP Basic Flow Specification TLV Type Indicators

IANA is requested to create a new subregistry called the "PCEP Flow Specification TLV Type Indicators" registry.

Allocations from this registry are to be made according to the following assignment policies [RFC8126]:

Range	Registration Procedures
0-255	Reserved - must not be allocated. Usage mirrors the BGP Flow Spec registry [RFC8955] [RFC8956].
256-64506	Specification Required
64507-65531	First Come First Served
65532-65535	Experimental Use

Table 5: Registration Procedures for the PCEP
Flow Specification TLV Type Indicators
Subregistry

10. Security Considerations

TBA

11. Manageability Considerations

11.1. Control of Function and Policy

[RFC9168] describe the management of multiple flowspecs as well as control via configurations and policies. This is applicable to the Tunneled flowspec defined in this document.

11.2. Information and Data Models

The PCEP YANG module [RFC9826] would need to be augmented to cover tunneled flowspec.

11.3. 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].

11.4. Verify Correct Operations

Mechanisms defined in this document do not imply any new operation verification requirements in addition to those already listed in [RFC9168].

11.5. Requirements On Other Protocols

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

11.6. Impact On Network Operations

Mechanisms defined in this document do not have any new impact on network operations in addition to those already listed in [RFC9168].

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Author's Address

Yao Liu
ZTE Corporation
China
Email: liu.yao71@zte.com.cn