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Dissemination of Flow Specification Rules for IPv6
draft-ietf-idr-flow-spec-v6-17

Abstract

Dissemination of Flow Specification Rules provides a Border Gateway Protocol extension for the propagation of traffic flow information for the purpose of rate limiting or filtering IPv4 protocol data packets.

This document extends I-D.ietf-idr-rfc5575bis with IPv6 functionality. It also updates I-D.ietf-idr-rfc5575bis by changing the IANA Flow Spec Component Types registry.

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 April 23, 2021.

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1. Introduction

The growing amount of IPv6 traffic in private and public networks requires the extension of tools used in IPv4-only networks to be also capable of supporting IPv6 data packets.

This document analyzes the differences of IPv6 [RFC8200] flows description from those of traditional IPv4 packets and propose a subset of new Border Gateway Protocol [RFC4271] encoding formats to

enable Dissemination of Flow Specification Rules [I-D.ietf-idr-rfc5575bis] for IPv6.

This specification is an extension of the base [I-D.ietf-idr-rfc5575bis]. It only defines the delta changes required to support IPv6 while all other definitions and operation mechanisms of Dissemination of Flow Specification Rules will remain in the main specification and will not be repeated here.

1.1. Definitions of Terms Used in This Memo

AFI - Address Family Identifier.

AS - Autonomous System.

NLRI - Network Layer Reachability Information.

SAFI - Subsequent Address Family Identifier.

VRF - Virtual Routing and Forwarding instance.

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. IPv6 Flow Specification encoding in BGP

[I-D.ietf-idr-rfc5575bis] defines SAFIs 133 (Dissemination of Flow Specification) and 134 (L3VPN Dissemination of Flow Specification) in order to carry the corresponding Flow Specification.

Implementations wishing to exchange IPv6 Flow Specifications MUST use BGP's Capability Advertisement facility to exchange the Multiprotocol Extension Capability Code (Code 1) as defined in [RFC4760]. The (AFI, SAFI) pair carried in the Multiprotocol Extension Capability MUST be: (AFI=2, SAFI=133) for IPv6 Flow Specification, and (AFI=2, SAFI=134) for VPNv6 Flow Specification.

3. IPv6 Flow Specification components

The encoding of each of the components begins with a type field (1 octet) followed by a variable length parameter. The following sections define component types and parameter encodings for IPv6.

Types 4, 5, 6, 9, 10 and 11, as defined in [I-D.ietf-idr-rfc5575bis], also apply to IPv6. Note that IANA is requested to update the "Flow

Spec Component Types" registry in order to contain both IPv4 and IPv6 Flow Specification component type numbers in a single registry (Section 8).

3.1. Type 1 - Destination IPv6 Prefix

Encoding: <type (1 octet), length (1 octet), offset (1 octet), pattern (variable), padding(variable) >

Defines the destination prefix to match. The offset has been defined to allow for flexible matching on part of the IPv6 address where it is required to skip (don't care) of N first bits of the address. This can be especially useful where part of the IPv6 address consists of an embedded IPv4 address and matching needs to happen only on the embedded IPv4 address. The encoded pattern contains enough octets for the bits used in matching (length minus offset bits).

length - The length field indicates the N-th most significant bit in the address where bitwise pattern matching stops.

offset - The offset field indicates the number of most significant address bits to skip before bitwise pattern matching starts.

pattern - Contains the matching pattern. The length of the pattern is defined by the number of bits needed for pattern matching (length minus offset).

padding - The minimum number of bits required to pad the component to an octet boundary. Padding bits MUST be 0 on encoding and MUST be ignored on decoding.

In the case Length minus Offset is 0 every address matches. Length MUST always be in the range 0-128 and Length minus Offset MUST always be 0 or more, otherwise this component is malformed.

3.2. Type 2 - Source IPv6 Prefix

Encoding: <type (1 octet), length (1 octet), offset (1 octet), pattern (variable), padding(variable) >

Defines the source prefix to match. The length, offset, pattern and padding are the same as in Section 3.1

3.3. Type 3 - Upper-Layer Protocol

Encoding: <type (1 octet), [numeric_op, value]+>

Contains a list of {numeric_op, value} pairs that are used to match the first Next Header value octet in IPv6 packets that is not an extension header and thus indicates that the next item in the packet is the corresponding upper-layer header (see [RFC8200] Section 4).

This component uses the Numeric Operator (numeric_op) described in [I-D.ietf-idr-rfc5575bis] Section 4.2.1.1. Type 3 component values SHOULD be encoded as single octet (numeric_op len=00).

Note: While IPv6 allows for more than one Next Header field in the packet, the main goal of the Type 3 Flow Specification component is to match on the first upper-layer IP protocol value. Therefore the definition is limited to match only on this specific Next Header field in the packet.

3.4. Type 7 - ICMPv6 Type

Encoding: <type (1 octet), [numeric_op, value]+>

Defines a list of {numeric_op, value} pairs used to match the type field of an ICMPv6 packet (see also [RFC4443] Section 2.1).

This component uses the Numeric Operator (numeric_op) described in [I-D.ietf-idr-rfc5575bis] Section 4.2.1.1. Type 7 component values SHOULD be encoded as single octet (numeric_op len=00).

In case of the presence of the ICMPv6 Type component only ICMPv6 packets can match the entire Flow Specification. The ICMPv6 Type component, if present, never matches when the packet's upper-layer IP protocol value is not 58 (ICMPv6), if the packet is fragmented and this is not the first fragment, or if the system is unable to locate the transport header. Different implementations may or may not be able to decode the transport header.

3.5. Type 8 - ICMPv6 Code

Encoding: <type (1 octet), [numeric_op, value]+>

Defines a list of {numeric_op, value} pairs used to match the code field of an ICMPv6 packet (see also [RFC4443] Section 2.1).

This component uses the Numeric Operator (numeric_op) described in [I-D.ietf-idr-rfc5575bis] Section 4.2.1.1. Type 8 component values SHOULD be encoded as single octet (numeric_op len=00).

In case of the presence of the ICMPv6 Code component only ICMPv6 packets can match the entire Flow Specification. The ICMPv6 code component, if present, never matches when the packet's upper-layer IP

protocol value is not 58 (ICMPv6), if the packet is fragmented and this is not the first fragment, or if the system is unable to locate the transport header. Different implementations may or may not be able to decode the transport header.

3.6. Type 12 - Fragment

Encoding: <type (1 octet), [bitmask_op, bitmask]+>

Defines a list of {bitmask_op, bitmask} pairs used to match specific IP fragments.

This component uses the Bitmask Operator (bitmask_op) described in [I-D.ietf-idr-rfc5575bis] Section 4.2.1.2. The Type 12 component bitmask MUST be encoded as single octet bitmask (bitmask_op len=00).

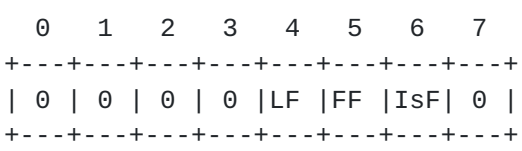

Figure 1: Fragment Bitmask Operand

Bitmask values:

IsF - Is a fragment other than the first - match if IPv6 Fragment Header ([RFC8200] Section 4.5) Fragment Offset is not 0

FF - First fragment - match if IPv6 Fragment Header ([RFC8200] Section 4.5) Fragment Offset is 0 AND M flag is 1

LF - Last fragment - match if IPv6 Fragment Header ([RFC8200] Section 4.5) Fragment Offset is not 0 AND M flag is 0

0 - MUST be set to 0 on NLRI encoding, and MUST be ignored during decoding

3.7. Type 13 - Flow Label (new)

Encoding: <type (1 octet), [numeric_op, value]+>

Contains a list of {numeric_op, value} pairs that are used to match the 20-bit Flow Label IPv6 header field ([RFC8200] Section 3).

This component uses the Numeric Operator (numeric_op) described in [I-D.ietf-idr-rfc5575bis] Section 4.2.1.1. Type 13 component values SHOULD be encoded as 1-, 2-, or 4-byte quantities (numeric_op len=00, len=01 or len=10).

3.8. Encoding Example

3.8.1. Example 1

The following example demonstrates the prefix encoding for: "packets from ::1234:5678:9A00:0/64-104 to 2001:DB8::/32 and upper-layer-protocol tcp".

length	destination	source	ul-proto
0x12	01 20 00 20 01 0D B8	02 68 40 12 34 56 78 9A	03 81 06

Decoded:

Value		
0x12	length	18 octets (len<240 1-octet)
0x01	type	Type 1 - Dest. IPv6 Prefix
0x20	length	32 bit
0x00	offset	0 bit
0x20	pattern	
0x01	pattern	
0x0D	pattern	
0xB8	pattern	(no padding needed)
0x02	type	Type 2 - Source IPv6 Prefix
0x68	length	104 bit
0x40	offset	64 bit
0x12	pattern	
0x34	pattern	
0x56	pattern	
0x78	pattern	
0x9A	pattern	(no padding needed)
0x03	type	Type 3 - upper-layer-proto
0x81	numeric_op	end-of-list, value size=1, ==
0x06	value	06

This constitutes a NLRI with a NLRI length of 18 octets.

Neither for the destination prefix pattern (length - offset = 32 bit) nor for the source prefix pattern (length - offset = 40 bit) any padding is needed (both patterns end on a octet boundary).

3.8.2. Example 2

The following example demonstrates the prefix encoding for: "all packets from ::1234:5678:9A00:0/65-104 to 2001:DB8::/32".

length	destination	source
0x0f	01 20 00 20 01 0D B8	02 68 41 24 68 ac f1 34

Decoded:

Value		
0x0f	length	15 octets (len<240 1-octet)
0x01	type	Type 1 - Dest. IPv6 Prefix
0x20	length	32 bit
0x00	offset	0 bit
0x20	pattern	
0x01	pattern	
0x0D	pattern	
0xB8	pattern	(no padding needed)
0x02	type	Type 2 - Source IPv6 Prefix
0x68	length	104 bit
0x41	offset	65 bit
0x24	pattern	
0x68	pattern	
0xac	pattern	
0xf1	pattern	
0x34	pattern/pad	(contains 1 bit padding)

This constitutes a NLRI with a NLRI length of 15 octets.

The source prefix pattern is 104 - 65 = 39 bits in length. After the pattern one bit of padding needs to be added so that the component ends on a octet boundary. However, only the first 39 bits are actually used for bitwise pattern matching starting with a 65 bit offset from the topmost bit of the address.

4. Ordering of Flow Specifications

The definition for the order of traffic filtering rules from [I-D.ietf-idr-rfc5575bis] Section 5.1 is reused with new consideration for the IPv6 prefix offset. As long as the offsets are equal, the comparison is the same, retaining longest-prefix-match

semantics. If the offsets are not equal, the lowest offset has precedence, as this flow matches the most significant bit.

The code in Appendix A shows a Python3 implementation of the resulting comparison algorithm. The full code was tested with Python 3.7.2 and can be obtained at https://github.com/stoffi92/draft-ietf-idr-flow-spec-v6/tree/master/flowspec-cmp [1].

5. Validation Procedure

The validation procedure is the same as specified in [I-D.ietf-idr-rfc5575bis] Section 6 with the exception that item a) of the validation procedure should now read as follows:

> a) A destination prefix component with offset=0 is embedded in the Flow Specification

6. IPv6 Traffic Filtering Action changes

Traffic Filtering Actions from [I-D.ietf-idr-rfc5575bis] Section 7 can also be applied to IPv6 Flow Specifications. To allow an IPv6 address specific route-target, a new Traffic Filtering Action IPv6 address specific extended community is specified in Section 6.1 below.

6.1. Redirect IPv6 (rt-redirect-ipv6) Type/Sub-Type 0x80/TBD

The redirect IPv6 address specific extended community allows the traffic to be redirected to a VRF routing instance that lists the specified IPv6 address specific route-target in its import policy. If several local instances match this criteria, the choice between them is a local matter (for example, the instance with the lowest Route Distinguisher value can be elected).

This extended community uses the same encoding as the IPv6 address specific Route Target extended community [RFC5701] Section 2 with the high-order octet of the Type always set to 0x80 and the Sub-Type always TBD.

Interferes with: All BGP Flow Specification redirect Traffic Filtering Actions (with itself and those specified in [I-D.ietf-idr-rfc5575bis] Section 7.4).

7. Security Considerations

This document extends the functionality in [I-D.ietf-idr-rfc5575bis] to be applicable to IPv6 data packets. The same Security Considerations from [I-D.ietf-idr-rfc5575bis] now also apply to IPv6

networks. Otherwise, no new security issues are added to the BGP protocol.

8. IANA Considerations

This section complies with [RFC7153].

8.1. Flow Spec IPv6 Component Types

IANA has created and maintains a registry entitled "Flow Spec Component Types". IANA is requested to add [this document] to the reference for this registry. Furthermore the registry should be rewritten to also contain the IPv6 Flow Specification Component Types as described below. The registration procedure should remain unchanged.

8.1.1. Registry Template

Type Value:
Contains the assigned Flow Specification component type value.

IPv4 Name:
Contains the associated IPv4 Flow Specification component name as specified in [I-D.ietf-idr-rfc5575bis].

IPv6 Name:
Contains the associated IPv6 Flow Specification component name as specified in this document.

Reference:
Contains referenced to the specifications.

8.1.2. Registry Contents

+ Type Value: 0
+ IPv4 Name: Reserved
+ IPv6 Name: Reserved
+ Reference: [I-D.ietf-idr-rfc5575bis] [this document]

+ Type Value: 1
+ IPv4 Name: Destination Prefix
+ IPv6 Name: Destination IPv6 Prefix
+ Reference: [I-D.ietf-idr-rfc5575bis] [this document]

+ Type Value: 2
+ IPv4 Name: Source Prefix

+ IPv6 Name: Source IPv6 Prefix
+ Reference: [I-D.ietf-idr-rfc5575bis] [this document]

+ Type Value: 3
+ IPv4 Name: IP Protocol
+ IPv6 Name: Upper-Layer Protocol
+ Reference: [I-D.ietf-idr-rfc5575bis] [this document]

+ Type Value: 4
+ IPv4 Name: Port
+ IPv6 Name: Port
+ Reference: [I-D.ietf-idr-rfc5575bis] [this document]

+ Type Value: 5
+ IPv4 Name: Destination Port
+ IPv6 Name: Destination Port
+ Reference: [I-D.ietf-idr-rfc5575bis] [this document]

+ Type Value: 6
+ IPv4 Name: Source Port
+ IPv6 Name: Source Port
+ Reference: [I-D.ietf-idr-rfc5575bis] [this document]

+ Type Value: 7
+ IPv4 Name: ICMP Type
+ IPv6 Name: ICMPv6 Type
+ Reference: [I-D.ietf-idr-rfc5575bis] [this document]

+ Type Value: 8
+ IPv4 Name: ICMP Code
+ IPv6 Name: ICMPv6 Code
+ Reference: [I-D.ietf-idr-rfc5575bis] [this document]

+ Type Value: 9
+ IPv4 Name: TCP flags
+ IPv6 Name: TCP flags
+ Reference: [I-D.ietf-idr-rfc5575bis] [this document]

+ Type Value: 10
+ IPv4 Name: Packet length

+ IPv6 Name: Packet length
+ Reference: [I-D.ietf-idr-rfc5575bis] [this document]

+ Type Value: 11
+ IPv4 Name: DSCP
+ IPv6 Name: DSCP
+ Reference: [I-D.ietf-idr-rfc5575bis] [this document]

+ Type Value: 12
+ IPv4 Name: Fragment
+ IPv6 Name: Fragment
+ Reference: [I-D.ietf-idr-rfc5575bis] [this document]

+ Type Value: 13
+ IPv4 Name: Unassigned
+ IPv6 Name: Flow Label
+ Reference: [this document]

+ Type Value: 14-254
+ IPv4 Name: Unassigned
+ IPv6 Name: Unassigned
+ Reference:

+ Type Value: 255
+ IPv4 Name: Reserved
+ IPv6 Name: Reserved
+ Reference: [I-D.ietf-idr-rfc5575bis] [this document]

8.2. Extended Community Flow Spec IPv6 Actions

IANA maintains a registry entitled "Generic Transitive Experimental Use Extended Community Sub-Types". For the purpose of this work, IANA is requested to assign a new value:

Sub-Type Value	Name	Reference
TBD	Flow spec rt-redirect-ipv6 format	[this document]

Table 1: Registry: Generic Transitive Experimental Use Extended Community Sub-Types

9. Acknowledgements

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11. References

11.1. Normative References

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11.2. URIs

[1] https://github.com/stoffi92/draft-ietf-idr-flow-spec-v6/tree/master/flowspec-cmp

Appendix A. Example python code: flow_rule_cmp_v6

```
<CODE BEGINS>
"""
Copyright (c) 2020 IETF Trust and the persons identified as authors
```

```
"""

import itertools
import collections
import ipaddress


EQUAL = 0
A_HAS_PRECEDENCE = 1
B_HAS_PRECEDENCE = 2
IP_DESTINATION = 1
IP_SOURCE = 2

FS_component = collections.namedtuple('FS_component',
                                      'component_type value')


class FS_IPv6_prefix_component:
    def __init__(self, prefix, offset=0,
                 component_type=IP_DESTINATION):
        self.offset = offset
        self.component_type = component_type
        # make sure if offset != 0 that non of the
        # first offset bits are set in the prefix
        self.value = prefix
        if offset != 0:
            i = ipaddress.IPv6Interface(
                (self.value.network_address, offset))
            if i.network.network_address != \
                ipaddress.ip_address('0::0'):
                raise ValueError('Bits set in the offset')


class FS_nlri(object):
    """
    FS_nlri class implementation that allows sorting.

    By calling .sort() on a array of FS_nlri objects these
    will be sorted according to the flow_rule_cmp algorithm.

    Example:
```

```
       nlri = [ FS_nlri(components=[
                FS_component(component_type=4,
                             value=bytearray([0,1,2,3,4,5,6])),
                ]),
                FS_nlri(components=[
                FS_component(component_type=5,
                             value=bytearray([0,1,2,3,4,5,6])),
                FS_component(component_type=6,
                             value=bytearray([0,1,2,3,4,5,6])),
                ]),
              ]
       nlri.sort() # sorts the array accorinding to the algorithm
       """
       def __init__(self, components = None):
           """
           components: list of type FS_component
           """
           self.components = components

       def __lt__(self, other):
           # use the below algorithm for sorting
           result = flow_rule_cmp_v6(self, other)
           if result == B_HAS_PRECEDENCE:
               return True
           else:
               return False


   def flow_rule_cmp_v6(a, b):
       """
       Implementation of the flowspec sorting algorithm in
       draft-ietf-idr-flow-spec-v6.
       """
       for comp_a, comp_b in itertools.zip_longest(a.components,
                                                   b.components):
           # If a component type does not exist in one rule
           # this rule has lower precedence
           if not comp_a:
               return B_HAS_PRECEDENCE
           if not comp_b:
               return A_HAS_PRECEDENCE
           # Higher precedence for lower component type
           if comp_a.component_type < comp_b.component_type:
               return A_HAS_PRECEDENCE
           if comp_a.component_type > comp_b.component_type:
               return B_HAS_PRECEDENCE
           # component types are equal -> type specific comparison
           if comp_a.component_type in (IP_DESTINATION, IP_SOURCE):
```

```
                if comp_a.offset < comp_b.offset:
                    return A_HAS_PRECEDENCE
                if comp_a.offset < comp_b.offset:
                    return B_HAS_PRECEDENCE
                # both components have the same offset
                # assuming comp_a.value, comp_b.value of type
                # ipaddress.IPv6Network
                # and the offset bits are reset to 0 (since they are
                # not represented in the NLRI)
                if comp_a.value.overlaps(comp_b.value):
                    # longest prefixlen has precedence
                    if comp_a.value.prefixlen > \
                        comp_b.value.prefixlen:
                        return A_HAS_PRECEDENCE
                    if comp_a.value.prefixlen < \
                        comp_b.value.prefixlen:
                        return B_HAS_PRECEDENCE
                    # components equal -> continue with next
                    # component
                elif comp_a.value > comp_b.value:
                    return B_HAS_PRECEDENCE
                elif comp_a.value < comp_b.value:
                    return A_HAS_PRECEDENCE
            else:
                # assuming comp_a.value, comp_b.value of type
                # bytearray
                if len(comp_a.value) == len(comp_b.value):
                    if comp_a.value > comp_b.value:
                        return B_HAS_PRECEDENCE
                    if comp_a.value < comp_b.value:
                        return A_HAS_PRECEDENCE
                    # components equal -> continue with next
                    # component
                else:
                    common = min(len(comp_a.value),
                                 len(comp_b.value))
                    if comp_a.value[:common] > \
                        comp_b.value[:common]:
                        return B_HAS_PRECEDENCE
                    elif comp_a.value[:common] < \
                          comp_b.value[:common]:
                        return A_HAS_PRECEDENCE
                    # the first common bytes match
                    elif len(comp_a.value) > len(comp_b.value):
                        return A_HAS_PRECEDENCE
                    else:
                        return B_HAS_PRECEDENCE
        return EQUAL
```

<CODE ENDS>

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