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Authors: Z. Li   S. Chen   H. Wang
         Huawei   Huawei   Huawei

Generalized IPv6 Tunnel (GIP6)

Abstract

This document defines the generalized IPv6 tunnel based on the analysis of challenges of the existing problems of IP tunnels.

Requirements Language

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].

Status of This Memo

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1. Introduction

Currently there are many types of IP tunnels, such as VXLAN and GRE. On IPv6 networks, it is hard to define extensions for all these tunnels to support new features. On the other hand it is not recommended to extend new features based on the IPv4 data plane for these tunnels []. This document analyzes the problems of IP tunnels and defines a generalized IPv6 tunnel to support the new features.

2. Terminology

APN: Application-aware Networking

GRE: Generic Routing Encapsulation

IPv4: Internet Protocol version 4

IPv6: Internet Protocol version 6

IOAM: In-situ Operations, Administration, and Maintenance

ISATAP: Intra-Site Automatic Tunnel Addressing Protocol

L2TPv3: Layer Two Tunneling Protocol Version 3

MPLS: Multiprotocol Label Switching

NVO3: Network Virtualization Overlays

SRv6: Segment Routing IPv6

SID: SR Identification

VNI: VXLAN Network Identifier

VXLAN: Virtual eXtensible Local Area Network

3. Problem Statement

There have been many types of IP tunnels, including:

- GRE Tunnels: it is defined in [RFC2784].

- IP in IP Tunnels: it is defined in [RFC1853].

- L2TPv3 Tunnels: it is defined in [RFC3931].

- ISATAP Tunnels: it is defined in [RFC4214].

- IPv4/IPv6 over IPv6 (4over6) Tunnels: it is defined in[RFC2473].

- VXLAN Tunnels: it is defined in [RFC7348].

- NVGRE Tunnels: it is defined in [RFC7637].

- MPLS over UDP: it is defined in [RFC7510].

- VXLAN-GPE (Generic Protocol Extension for VXLAN) Tunnels: it is defined in [I-D.ietf-nvo3-vxlan-gpe].

Currently many new features are emerging and the corresponding encapsulations over the IPv6 are defined:

- [I-D.ietf-6man-ipv6-alt-mark] defines IPv6 encapsulation for Alternate Marking.

- [I-D.ietf-ippm-ioam-ipv6-options] defines IPv6 encapsulation for IOAM.

- [I-D.dong-6man-enhanced-vpn-vtn-id] defines the IPv6 encapsulation used to determine resource isolation.

- [I-D.li-apn-ipv6-encap] defines the IPv6 encapsulation of an APN.

If the existing IP tunnels need to support new features such as Alternate Marking, IOAM, resource isolation, and APN, the following problems exist:

- All of the IP tunnels mentioned above need to be extended accordingly, resulting in a lot of standardization work.

- It is hard to keep the consistency between IPv4 and IPv6 for these IP tunnels (except IPv4 transition tunnels) since the possible extensions are recommended to be only done over the IPv6.

- IPv6 can directly support some functions of these IP tunnels which cannot be done over the IPv4. This means such functions becomes redundant over the IPv6. For example, VXLAN takes use of the UDP to support ECMP. However for the IPv6 VXLAN, the Flow Label in the IPv6 header can also be used to support ECMP.

- Some IP tunnels such as VXLAN and GRE have their own headers. If these tunnels need to support new features over the IPv6, there will face the challenge of the choice between reusing the exiting IPv6 encapsulations for these new features based on the IPv6 extension header and define new extensions based on their own tunnel headers.

-- If the tunnel header is extended, it will be redundant with the existing IPv6 encapsulation for the new features based on the IPv6 extension header.

-- For some existing IP tunnels (such as IP in IP) that do not have their own headers, they have to reuse the IPv6 encapsulations for these new features based the IPv6 header. extensions need to be redefined in the IPv6 extension header. As a result, their extensions may be different from that of the IP tunnels which have their own headers.

4. Design Consideration

In order to solve the above problems, the following choice can be taken into account:

1. It is not recommended to support the new features over the IPv4 for these IP tunnels.

2. It is to reuse the existing IPv6 encapsulations based on the IPv6 extension header when support the new features for these IP tunnels over the IPv6.

If these IP tunnels takes use of the existing encapsulations based on the IPv6 extension header, for the IP tunnels which have their own headers, there are two possible options to cope with their own headers:

Option 1: They use the IPv6 extension headers to support new features and their own headers are retained.

Option 2: Define a generalized IPv6 tunnel that contains the IPv6 extension header which not only reuses the existing IPv6 encapsulations to support new features, but also introduces the new extensions to support the necessary functions of their own headers.

But the Option 1 has the following problems:

1. Redundant Functions: For example, the UDP-based IP tunnel can directly use IPv6 flow label to implement ECMP.

2. Separated process of tunnel functions: Some functions use IPv6 extension headers and some functions use headers of tunnels. As a result, tunnel processing is separated and complex. If the IPSec extension header is used, the tunnel's own header maybe encrypted and unable to be parsed when necessary process is needed.

According to the above design consideration, Option 2 is recommended in this document.

5. Structure of a GIP6 Encapsulated Packet

The Generalized IPv6 (GIP6) tunnel is defined to use the IPv6 header and IPv6 extension header to support both existing IP tunnels functions and new features.

A GIP6 encapsulated packet has the following format:

```
+ - - - - - - - - - - - - - - - - - - - - - - - - - -+     ----
|                IPv6 Header                         |      |
+ - - - - - - - - - - - - - - - - - - - - - - - - - -+     GIP6
|               IPv6 Extension Header                | Encapsulation
|       (Encapsulations of new features +            |      |
| Encapsulations of functions of existing IP tunnels)|      |
+ - - - - - - - - - - - - - - - - - - - - - - - - - -+     ----
|                Payload packet                      |
+ - - - - - - - - - - - - - - - - - - - - - - - - - -+
               Figure 1. GIP6 Encapsulation
```

Different types of tunneled payloads, such as IPv4, IPv6, MPLS, Ethernet, etc., can be indicated by the IPv6 Next Header.

Packets encapsulated with the GIP6 tunnel can directly support new functions based on existing encapsulation, including Alternate-Marking, IOAM, Resource-Isolation, and APN.

6. GIP6 for VXLAN

To support existing VXLAN functions, the GIP6 tunnel is extended as follows:

1. The function of the UDP is replaced by the flow label of the IPv6 header in the GIP6 tunnel. To ensure compatibility, the value of the

flow label calculated for the purpose of ECMP SHOULD be the same as that of the source port of the UDP.

2. Definition of the VN Option

A new option called VN Option is defined to carry the VXLAN header information. The VN Option MUST only be encapsulated in the Destination Options Header (DOH).

The following figure shows the data fields format of the VN option:

```
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
                              +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                              |  Option Type  |  Opt Data Len |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
|                VXLAN Header (8 Bytes)                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                     Figure 2. VN Option
```

The VN Option contains the following fields:

* Option Type: 8-bit selector. VN option. Value TBD by IANA.

* Opt Data Len: 8-bit unsigned integer. Length of the option, in octets, excluding the Option Type and Option Length fields. This field MUST be set to 8.

* Option Data: 64-bits VXLAN Header Information.

The following figure shows the definition of VXLAN headers in [RFC7358]. For the detailed definition of the data fields, please refer to [RFC7358].

```
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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| VXLAN Flags |                  Reserved                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       VXLAN Network Identifier(VNI)           |  Reserved     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                      Figure 3. VXLAN headers
```

7. GIP6 for GRE

A new option called GRE Option is defined to carry the GRE header information. The GRE Option MUST only be encapsulated in the Destination Options header (DOH).

The definition of a new TLV for the Options Extension Headers, carrying the data fields dedicated to the GRE information, is reported below.

The following figure shows the data fields format of the GRE option.

```
 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
                               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                               |  Option Type  |  Opt Data Len |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
|                GRE Header (16 Bytes)                          |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                    Figure 4. GRE Option
```

The GRE Option contains the following fields:

* Option Type: 8-bit selector. GRE option. Value TBD by IANA.

* Opt Data Len: 8-bit unsigned integer. Length of the option, in octets, excluding the Option Type and Option Length fields. This field MUST be set to 16.

* Option Data: 128-bits GRE Header Information.

The following figure shows the definition of the GRE header in [RFC2890]. For the detailed definition of the data fields, please refer to [RFC2784] and [RFC2890].

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|C| |K|S| Reserved0       | Ver |         Protocol Type         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      Checksum (optional)      |       Reserved1 (Optional)    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Key (optional)                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                 Sequence Number (Optional)                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                    Figure 5. GRE Header
```

Note: The function of the Protocol Type in the GRE header can be replaced by that of the NH in the IPv6 header or IPv6 extension header.

8. GIP6 for Other Existing IP Tunnels

They will be defined in the future version.

9. Security Considerations

TBD.

10. IANA Considerations

The Option Type should be assigned in IANA's "Destination Options" registry.

This draft requests the following IPv6 Option Type assignment from the Destination Options sub-registry of Internet Protocol Version 6 (IPv6) Parameters (https://www.iana.org/assignments/ipv6-parameters/).

Hex Value	Binary Value			Description	Reference
	act	chg	rest		
TBD	00	0	TBD	VN	[This draft]
TBD	00	0	TBD	GRE	[This draft]

Figure 6. IANA Considerations

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Authors' Addresses

Zhenbin Li
Huawei
156 Beiqing Road
Beijing,100095
P.R. China

Email: lizhenbin@huawei.com

Shuanglong Chen
Huawei
156 Beiqing Road
Beijing, 100095
P.R. China

Email: chenshuanglong@huawei.com

Haibo Wang
Huawei
156 Beiqing Road
Beijing, 100095
P.R. China

Email: rainsword.wang@huawei.com