Consideration of IPv6 Encapsulation for Path Services

draft-li-6man-ipv6-sfc-ifit-00

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Motivations

- Service Function Chaining (SFC) [RFC7665] and In-situ Flow Information Telemetry (IFIT) [I-D.song-o psawg-ifit-framework] are important path services along with the packets.
- In order to support these services, several encapsulations have been defined
  - For SFC encapsulations
    - Network Service Header (NSH) is defined in [RFC8300]
  - For IFIT encapsulations
    - In-situ OAM (iOAM) Header is defined in [I-D.ietf-ippm-ioam-data]
    - Postcard-Based Telemetry (PBT) Header is defined in [I-D.song-ippm-postcard-based-telemetry]
  - Inband Flow Analyzer (IFA) is also defined in [I-D.kumar-ippm-ifa]
    - to record flow specific information from an end station and/or switches across a network
- In the IPv6 scenario, these encapsulations propose challenges for the data plane
- The document analyzes the problems and proposes possible optimized IPv6 encapsulation

Problem Statements
Challenges for the IPv6 data plane proposed by the encapsulations

```
Pre-allocated and incremental trace option headers:

 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Namespace-ID           |NodeLen  | Flags | RemainingLen|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               IOAM-Trace-Type              |    Reserved      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+


The trace option data MUST be 4-octet aligned:

+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+<-+
|                                                             |  |
|                      node data list [0]                     |  |
|                                                             |  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ D
|                                                             |  a
|                      node data list [1]                     |  t
|                                                             |  a
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                            ...                               ~ S
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ p
|                                                             |  a
|                     node data list [n-1]                    |  c
|                                                             |  e
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |
|                                                             |  |
|                      node data list [n]                     |  |
|                                                             |  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+<-+
```

IPv6 Extension Header Order (recommended in RFC8200)

```
            IPv6 header
   ──────►  Hop-by-Hop Options header
   ──────►  Destination Options header  (note 1)
   ──────►  Routing header
            Fragment header
            Authentication header  (note 2)
            Encapsulating Security Payload header  (note 2)
            Destination Options header  (note 3)
            Upper-Layer header
```
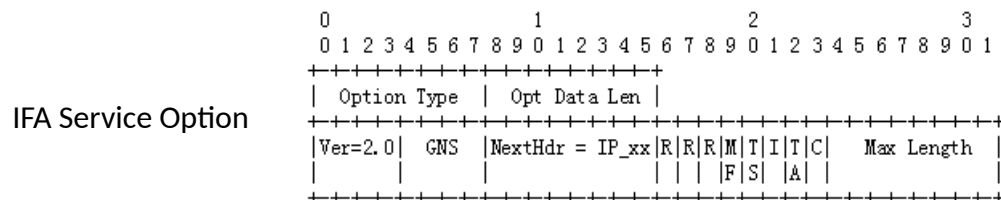
- The incremental IOAM data challenges the parsing depth if put in the HBH or DOH

- IPv6 path and SRv6 path distinguished

- Metadata recorded separately for IOAM, IFA
  - Maybe redundancy and inconsistency
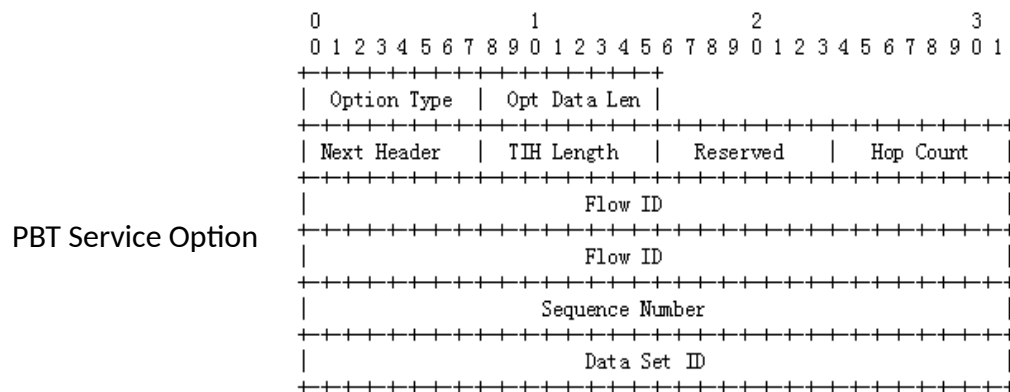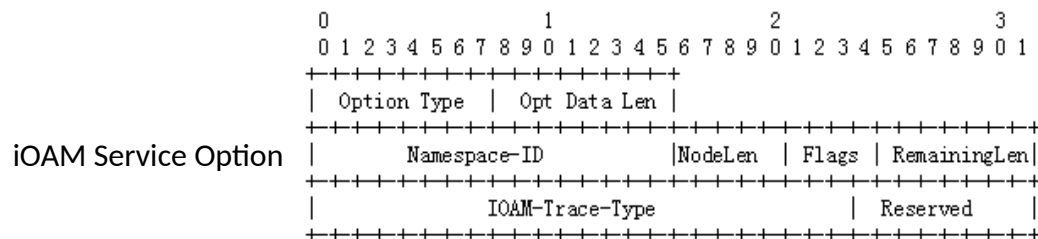 - Future extensibility
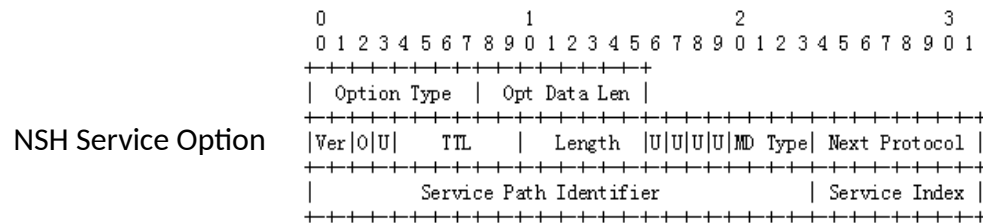
3

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Design Considerations
- Optimization of path service encapsulations in IPv6 and SRv6

- To separate the path service encapsulation into two parts, i.e. instruction and recording
    - Service Option: The instruction part (uniform IPv6 service option)
        - Placed in the front IPv6 extension headers including HBH, RH, etc.
            - either in the HBH indicating the path service processed by <u>all IPv6 enabled nodes along the path</u>
            - or in the SRH TLVs indicating the path service processed only by <u>the SRv6 nodes along the SRv6 path</u>
        - fixed as much as possible to facilitate hardware process to keep forwarding performance

    - IPv6 Metadata header: The recording part (unified container)
        - to record the service metadata of SFC, IFIT and other possible path services
        - placed in the back IPv6 EXH such as being placed after IPv6 Routing Header
        - enables to stop recording when too much data carried to reach the hardware limitation
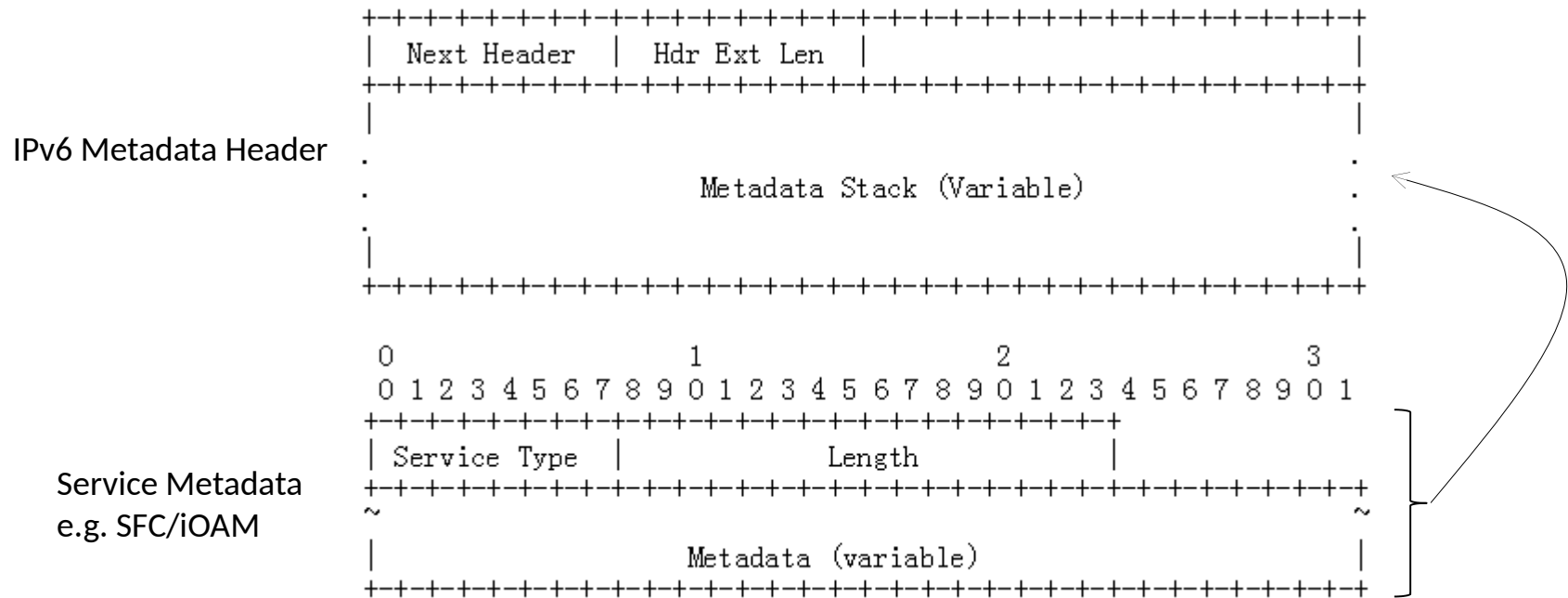
Service Options

NSH Service 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 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Ver|O|U|   TTL    |  Length  |U|U|U|U|MD Type| Next Protocol |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Service Path Identifier          | Service Index |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

iOAM Service 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 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Namespace-ID         |NodeLen | Flags | RemainingLen|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             IOAM-Trace-Type             |     Reserved     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

PBT Service 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 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Next Header  |  TIH Length  |   Reserved   |   Hop Count   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Flow ID                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Flow ID                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Sequence Number                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Data Set ID                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

IFA Service 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 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Ver=2.0|  GNS  |NextHdr = IP_xx|R|R|R|M|T|I|T|C|   Max Length  |
|       |       |               | | | |F|S| |A| |               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The places for these service options

```
IPv6 header
Hop-by-Hop Options header
Destination Options header (note 1)
Routing header  (SRH TLV)
Fragment header
Authentication header (note 2)
Encapsulating Security Payload header (note 2)
Destination Options header (note 3)
Upper-Layer header
```

IPv6 Metadata Header

- IPv6 Metadata Header is defined as a new type of IPv6 EXH
  - The metadata is the information recorded by each hop for specific path service
  - The length of the metadata is variable.

IPv6 Metadata Header

```
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Next Header   | Hdr Ext Len   |                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                              |
.                                                              .
.                  Metadata Stack (Variable)                   .
.                                                              .
|                                                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Service Metadata
e.g. SFC/iOAM

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Service Type  |             Length            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                                                              ~
|                     Metadata (variable)                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Take-away Message

- The path service encapsulations are separated into two parts
  - **Service options -** Instruction (NSH, IOAM, PBT, IFA)
    - The length is relatively fixed, recommended to place in HBH (IPv6 path), SRH (SRv6 path)
  - **IPv6 Metadata Header -** Recording
    - The length is increasing along the path, recommended to place after the RH
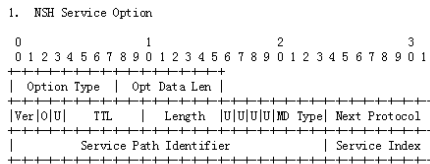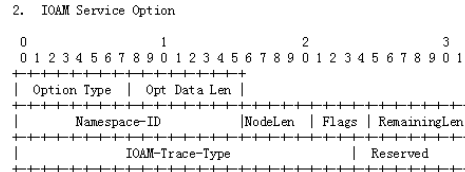

Figure 1. IPv6 Options with NSH instructions
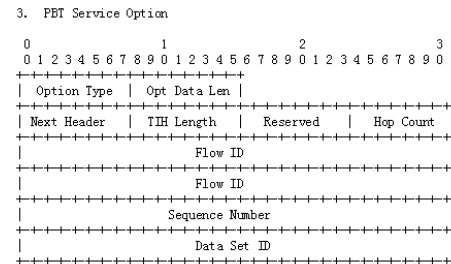
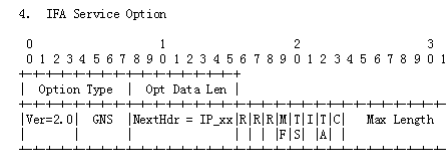Figure 2. IPv6 Options with IOAM instructions

Figure 3. IPv6 Options with PBT instructions

Figure 4. IPv6 Options with IFA instructions
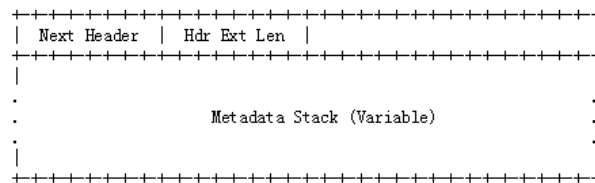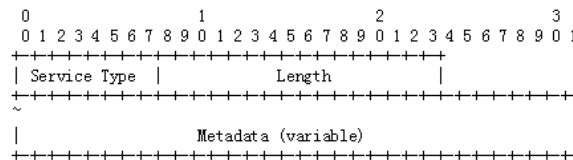
Figure 5. Metadata Header

Figure 6. Service Metadata

- Benefits
  - The path service instruction in the IPv6 extension headers can be fixed as much as possible to facilitate hardware process to keep forwarding performance
  - The SFC/IFIT metadata recording part is placed afterwards which enables to stop recording when too much recording information has to be carried to reach the limitation of hardware process

Next steps

- Questions and Comments are welcome

- Consolidate comments

- Refine drafts

Thank you!