Network Service Header (NSH) Encapsulation for In Situ OAM (IOAM) Data

Abstract

   In situ Operations, Administration, and Maintenance (IOAM) is used
   for recording and collecting operational and telemetry information
   while the packet traverses a path between two points in the network.
   This document outlines how IOAM-Data-Fields are encapsulated with the
   Network Service Header (NSH).

Status of This Memo

   This is an Internet Standards Track document.

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   (IETF). It represents the consensus of the IETF community. It has
   received public review and has been approved for publication by the
   Internet Engineering Steering Group (IESG). Further information on
   Internet Standards is available in Section 2 of RFC 7841.

   Information about the current status of this document, any errata,
   and how to provide feedback on it may be obtained at
   https://www.rfc-editor.org/info/rfc9452.

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1. Introduction

IOAM, as defined in [RFC9197], is used to record and collect OAM
information while the packet traverses a particular network domain.
The term "in situ" refers to the fact that the OAM data is added to
the data packets rather than what is being sent within packets
specifically dedicated to OAM. This document defines how IOAM-Data-
Fields are transported as part of the Network Service Header (NSH)
encapsulation [RFC8300] for the Service Function Chaining (SFC)
Architecture [RFC7665]. The IOAM-Data-Fields are defined in
[RFC9197].

2. Conventions

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.

Abbreviations used in this document:

IOAM: In situ Operations, Administration, and Maintenance

MD: NSH Metadata, see [RFC7665]

NSH: Network Service Header

OAM: Operations, Administration, and Maintenance

SFC: Service Function Chaining

TLV: Type, Length, Value

3. IOAM Encapsulation with NSH

The NSH is defined in [RFC8300]. IOAM-Data-Fields are carried as NSH
payload using a Next Protocol header that follows the NSH headers.
An IOAM header containing the IOAM-Data-Fields is added. The IOAM-
Data-Fields MUST follow the definitions corresponding to IOAM Option-
Types (e.g., see Section 4 of [RFC9197] and Section 3.2 of
[RFC9326]). In an administrative domain where IOAM is used,
insertion of the IOAM header in NSH is enabled at the NSH tunnel
endpoints, which are also configured to serve as encapsulating and
decapsulating nodes for IOAM. The operator MUST ensure that SFC-
aware nodes along the Service Function Path support IOAM; otherwise,
packets might be dropped (see the last paragraph of this section as
well as Section 2.2 of [RFC8300]). The IOAM transit nodes (e.g., a
Service Function Forwarder (SFF)) MUST process all the IOAM headers
that are relevant based on its configuration. See [RFC9378] for a
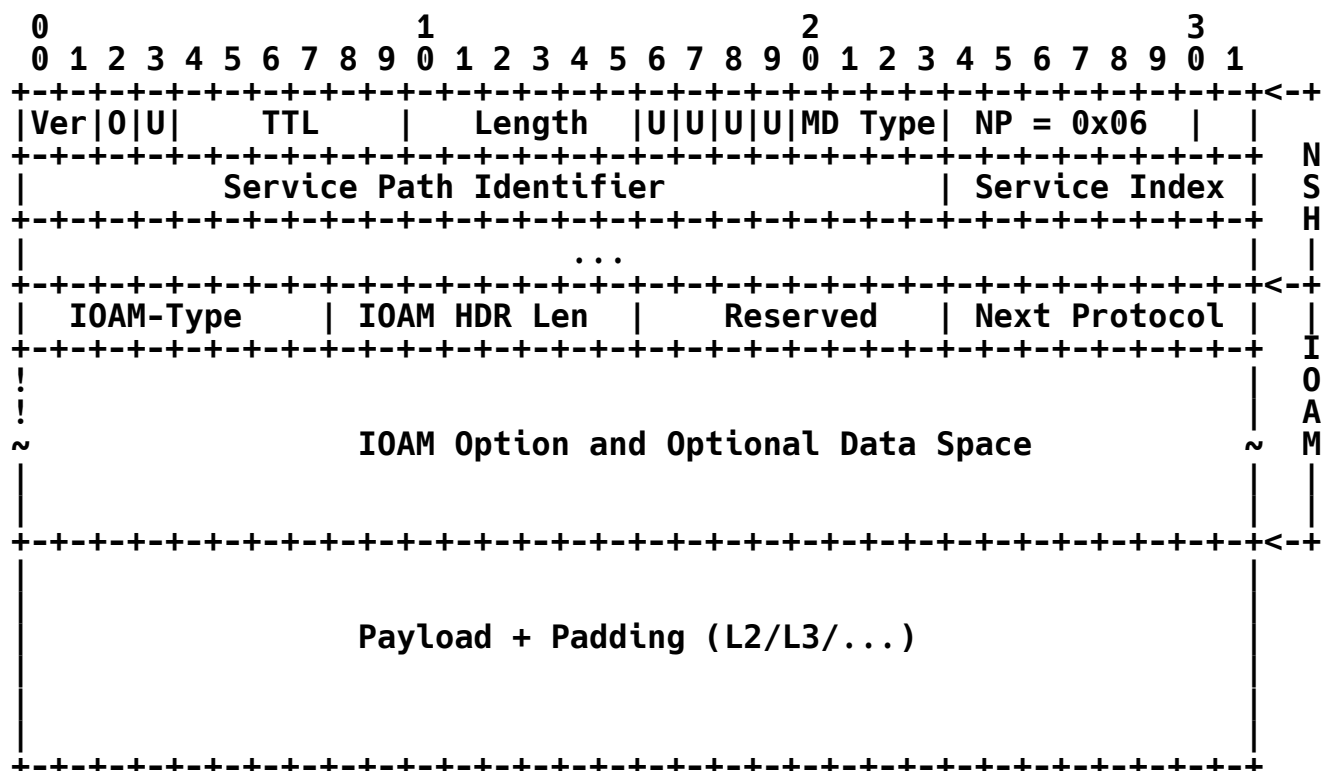discussion of deployment-related aspects of IOAM-Data-Fields.

```
    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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+<-+
   |Ver|O|U|   TTL     |   Length    |U|U|U|U|MD Type| NP = 0x06   | |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ N
   |             Service Path Identifier           | Service Index | S
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ H
   |                              ...                              | |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+<-+
   |   IOAM-Type   |  IOAM HDR Len  |    Reserved   | Next Protocol | |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ I
   !                                                               | O
   !                                                               | A
   ~            IOAM Option and Optional Data Space                ~ M
   |                                                               | |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+<-+
   |                                                               |
   |                                                               |
   |               Payload + Padding (L2/L3/...)                   |
   |                                                               |
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                                Figure 1

The NSH header and fields are defined in [RFC8300]. The O bit MUST
be handled following the rules in [RFC9451]. The "NSH Next Protocol"
value (referred to as "NP" in the diagram above) is 0x06.

The IOAM-related fields in NSH are defined as follows:

IOAM-Type:
    8-bit field defining the IOAM Option-Type, as defined in the "IOAM
    Option-Type" registry specified in [RFC9197].

IOAM HDR Len:
    8-bit field that contains the length of the IOAM header in
    multiples of 4-octets, including the "IOAM-Type" and "IOAM HDR
    Len" fields.

Reserved bits:
    Reserved bits are present for future use. The reserved bits MUST
    be set to 0x0 upon transmission and ignored upon receipt.

Next Protocol:
    8-bit unsigned integer that determines the type of header
    following IOAM. The semantics of this field are identical to the
    Next Protocol field in [RFC8300].

IOAM Option and Optional Data Space:
    IOAM-Data-Fields as specified by the IOAM-Type field. IOAM-Data-
    Fields are defined corresponding to the IOAM Option-Type (e.g.,
    see Section 4 of [RFC9197] and Section 3.2 of [RFC9326]) and are

always aligned by 4 octets. Thus, there is no padding field.

Multiple IOAM Option-Types MAY be included within the NSH encapsulation. For example, if an NSH encapsulation contains two IOAM Option-Types before a data payload, the Next Protocol field of the first IOAM option will contain the value 0x06, while the Next Protocol field of the second IOAM Option-Type will contain the "NSH Next Protocol" number indicating the type of the data payload. The applicability of the IOAM Active and Loopback flags [RFC9322] is outside the scope of this document and may be specified in the future.

In case the IOAM Incremental Trace Option-Type is used, an SFC-aware node that serves as an IOAM transit node needs to adjust the "IOAM HDR Len" field accordingly. See Section 4.4 of [RFC9197].

Per Section 2.2 of [RFC8300], packets with unsupported Next Protocol values SHOULD be silently dropped by default. Thus, when a packet with IOAM is received at an NSH-based forwarding node (such as an SFF) that does not support the IOAM header, it SHOULD drop the packet. The mechanisms to maintain and notify of such events are outside the scope of this document.

4. IANA Considerations

IANA has allocated the following code point for IOAM in the "NSH Next Protocol" registry (https://www.iana.org/assignments/nsh):

Next Protocol	Description	Reference
===============	=====================	===========
0x06	IOAM (Next Protocol is an IOAM header)	RFC 9452

Table 1

5. Security Considerations

IOAM is considered a "per domain" feature, where the operator decides how to leverage and configure IOAM according to the operator's needs. The operator needs to properly secure the IOAM domain to avoid malicious configuration and use, which could include injecting malicious IOAM packets into a domain. For additional IOAM-related security considerations, see Section 9 of [RFC9197]. For additional OAM- and NSH-related security considerations, see Section 5 of [RFC9451].

6. References

6.1. Normative References

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6.2. Informative References

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Appendix A. Discussion of the IOAM-Encapsulation Approach

This section lists several approaches considered for encapsulating
IOAM with NSH and presents the rationale for the approach chosen in
this document.

An encapsulation of IOAM-Data-Fields in NSH should be friendly to an
implementation in both hardware as well as software forwarders and
support a wide range of deployment cases, including large networks
that desire to leverage multiple IOAM-Data-Fields at the same time.

*   Hardware- and software-friendly implementation:

    Hardware forwarders benefit from an encapsulation that minimizes
    iterative lookups of fields within the packet. Any operation that
    looks up the value of a field within the packet, based on which
    another lookup is performed, consumes additional gates and time in
    an implementation, both of which should be kept to a minimum.
    This means that flat TLV structures are preferred over nested TLV
    structures. IOAM-Data-Fields are grouped into several categories,
    including trace, proof-of-transit, and edge-to-edge. Each of
    these options defines a TLV structure. A hardware-friendly
    encapsulation approach avoids grouping these three option
    categories into yet another TLV structure and would instead carry
    the options as a serial sequence.

*   Total length of the IOAM-Data-Fields:

    The total length of IOAM-Data-Fields can grow quite large if
    multiple different IOAM-Data-Fields are used and large path-
    lengths need to be considered. For example, if an operator would
    consider using the IOAM Trace Option-Type and capture node-id,
    app_data, egress and ingress interface-id, timestamp seconds, and
    timestamp nanoseconds at every hop, then a total of 20 octets
    would be added to the packet at every hop. In this case, the
    particular deployment has a maximum path length of 15 hops in the
    IOAM domain, and a maximum of 300 octets would be encapsulated in
    the packet.

Different approaches for encapsulating IOAM-Data-Fields in NSH could
be considered:

1. Encapsulation of IOAM-Data-Fields as "NSH MD Type 2" (see
    [RFC8300], Section 2.5).

    Each IOAM Option-Type (e.g., trace, proof-of-transit, and edge-
    to-edge) would be specified by a type, with the different IOAM-
    Data-Fields being TLVs within this the particular option type.
    NSH MD Type 2 offers support for variable length metadata. The
    length field is 6 bits, resulting in a maximum of 256 (2^6 x 4)
    octets.

2. Encapsulation of IOAM-Data-Fields using the "Next Protocol"
    field.

    Each IOAM Option-Type (e.g., trace, proof-of-transit, and edge-
    to-edge) would be specified by its own "next protocol".

3. Encapsulation of IOAM-Data-Fields using the "Next Protocol"
    field.

    A single NSH protocol type code point would be allocated for
    IOAM. A "sub-type" field would then specify what IOAM options
    type (trace, proof-of-transit, edge-to-edge) is carried.

The third option has been chosen here. This option avoids the
additional layer of TLV-nesting that the use of NSH MD Type 2 would

result in. In addition, this option does not constrain IOAM data to a maximum of 256 octets, thus allowing support for very large deployments.

Acknowledgments

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