MPLS Working Group J. Rajamanickam, Ed.
Internet-Draft R. Gandhi, Ed.
Intended status: Standards Track Cisco Systems, Inc.
Expires: 30 March 2026 R. Zigler
Broadcom
T. Li
Juniper Networks
J. Dong
Huawei Technologies
26 September 2025

Post-Stack MPLS Network Action (MNA) Solution
draft-ietf-mpls-mna-ps-hdr-02

Abstract

This document defines the Post-Stack MPLS Network Action (MNA) solution for carrying Network Actions and Ancillary Data after the MPLS label stack, based on the In-Stack MNA solution defined in "MPLS Network Action (MNA) Sub-Stack Solution." MPLS Network Actions can be used to influence packet forwarding decisions, carry additional Operations, Administration, and Maintenance (OAM) information in the MPLS packet, or perform user-defined operations. This solution document addresses the Post-Stack network action and Post-Stack data specific requirements found in "RFC 9613". This document follows the architectural framework for the MPLS Network Actions (MNA) technologies specified in "RFC 9789".

Status of This Memo

Copyright Notice

Table of Contents

1. Introduction

[RFC3032] defines the encoding of the MPLS label stack, the basic structure used to define a forwarding path. Forthcoming applications require MPLS packets to perform special network actions and carry optional Ancillary Data (AD) that can affect the packet forwarding decision or trigger Operations, Administration, and Maintenance (OAM) logging, for example. AD can be used to carry additional information, such as for In Situ OAM (IOAM) as described in [RFC9791]. User-defined network actions allow local actions to be defined. In some cases, more AD may be required than can be carried in the MPLS header, so these kinds of network actions and their AD are encoded after the Bottom of Stack (BOS). This network action with AD is called Post-Stack MNA.

This document defines the Post-Stack MPLS Network Action (MNA) solution for carrying Network Actions and Ancillary Data after the MPLS label stack. It is based on the In-Stack MNA solution defined in [I-D.ietf-mpls-mna-hdr]. This solution document addresses the Post-Stack network action and Post-Stack data specific requirements found in [RFC9613]. This document follows the architectural framework for the MPLS Network Actions (MNA) technologies specified in [RFC9789].

2. Conventions Used in This Document

2.1. 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] [RFC8174] when, and only when, they appear in all capitals, as shown here.

2.2. Abbreviations

The terminology defined in [RFC9789] and [RFC9613] are used in this document.

Abbreviation	Meaning	Reference
AD	Ancillary Data	[RFC9613]
bSPL	Base Special Purpose Label	[RFC9017]
BOS	Bottom Of Stack	[RFC3032]
HBH	Hop-By-Hop Scope	[RFC9789]
I2E	Ingress-To-Egress Scope	[RFC9789]
IHS	I2E, HBH, or Select Scope	[I-D.ietf-mpls-mna-hdr]
ISD	In-Stack Data	[RFC9613]
LSE	Label Stack Entry	[RFC3032]
MNA	MPLS Network Actions	[RFC9789]
NAI	Network Action Indicator	[RFC9613]
NAL	Network Action Length	[I-D.ietf-mpls-mna-hdr]
NAS	Network Action Sub-Stack	[RFC9789]
NASL	Network Action Sub-Stack Length	[I-D.ietf-mpls-mna-hdr]
OAM	Operations, Administration, and Maintenance	[RFC6291]
P bit	Post-Stack Header Presence Bit	This document

PSD	Post-Stack Data	[RFC9613] and [RFC9789]
PSH	Post-Stack Header	This document
TC	Traffic Class	[RFC5462]
TTL	Time To Live	[RFC3032]

Table 1: Abbreviations

3. Overview

The Post-Stack MNA solution contains two main parts:

* Post-Stack Header Presence Bit Carried in In-Stack MNA Sub-Stack

* Post-Stack Header Encoding that includes Post-Stack Header Type and Post-Stack Network Actions

3.1. Post-Stack Header Presence Bit Carried in In-Stack MNA Sub-Stack

The 21st bit from the left in LSE Format B carried in the In-Stack Network Action Sub-Stack (NAS) described in [I-D.ietf-mpls-mna-hdr] is defined as the P bit in this document to indicate the presence of the Post-Stack Header in the packet after the BOS.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Opcode    |        Data            |P|IHS|S|U|  NASL | NAL |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1: Post-Stack Header Presence Bit Carried in In-Stack MNA Sub-Stack

The following flags are carried in In-Stack NASS as defined in [I-D.ietf-mpls-mna-hdr]. These flags are also applicable to Post-Stack MNA:

* IHS (2 Bit): Indicates the combined scope of the In-Stack and the Post-Stack Network Actions. In-Stack NASS for each scope with P bit set will have its corresponding Post-Stack Header.

* U (1 Bit): Indicates the combined Unknown Action Handling of the In-Stack and the Post-Stack Network Actions.

3.2. Post-Stack Header Encoding

The Post-Stack Header is encoded after the Bottom of the MPLS Label Stack (BOS), either immediately after the BOS (i.e., start offset of 0) or after any other Post-Stack headers that follow the BOS (i.e., start offset of non-zero), as described in Section 4.

The Post-Stack Header carries one or more Post-Stack Network Actions and their Ancillary Data.

The PSH consist of two main parts:

* Post-Stack Header (PSH) Type

* Post-Stack Network Action Encoding

3.2.1. Post-Stack Header Type

The Post-Stack Header type is the top-header for all the Post-Stack Network Actions that are encoded in the PSH for each scope.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| TBA1  |Version| PS-HDR-LEN    | TYPE = MNA-POST-STACK-HDR = 1 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 2: Post-Stack Header Type

* TBA1 (4 bits): This first nibble [RFC9790] identifies the start of the PSH. A new value (value TBA1) is to be assigned by IANA for PSH.

* Version (4 bits): This is PSH version. The initial version is set to 0.

* PS-HDR-LEN (8 bits): PSH Total Length in 4-octet units that includes Post-Stack Network Actions. This excludes the PSH type header.

* TYPE (16 bits): Type is set to 1 to indicate Post-Stack Header Type For MNA. See Section 8.2.

3.2.2. Post-Stack Network Action Encoding

The format shown in Figure 3, encodes a single Post-Stack Network Action. By repeating this format, multiple Post-Stack Network Actions and their corresponding Ancillary data can be encoded.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  MNA-PS-OP  |R|R|  PS-NAL     |       POST-STACK DATA         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    CONTINUED POST-STACK DATA                  ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 3: Post-Stack Network Action Encoding

* MNA-PS-OP (7 bits): Post-Stack Network Action Opcode. Opcode "0" is reserved and other opcodes will be assigned by IANA accordingly.

* R (2 bits): Reserved bits.

* PS-NAL (7 bits): Post-Stack Network Action Length in 4-octet units. This excludes the first 4-octets starting MNA-PS-OP.

* POST-STACK DATA (16 bits): Post-Stack Data associated with the Post-Stack Network Action.

* CONTINUED POST-STACK DATA: Further Post-Stack Data associated with the Post-Stack Network Action, as indicated by the value of PS-NAL. The padding rules for Post-Stack Data that does not fill a multiple of 32 bit units is described in the document that defines the NA indicated by the MNA-PS-OP value.

4. In-Stack Network Action Special Opcodes

4.1. In-Stack Network Action Opcode for PSH Start Offset

Opcode: TBA2

Purpose: This opcode carries the start offset of the PSH from BOS.

LSE Format: B or C (defined in [I-D.ietf-mpls-mna-hdr])

Data: The data value of the LSE contains the offset from the MPLS BOS in units of 4 octets. This allows the Generic Control Word (0000b) [RFC4385] and G-ACh (0001b) [RFC5586] fields to be placed immediately after the BOS. In the absence of this opcode, the PSH is encoded immediately after the MPLS BOS. A data value of 1 indicates that the PSH starts 4 octets after the BOS.

Scope: This opcode can be used with any scope.

4.2. In-Stack Network Action Opcode for Offset of End of Post-Stack Header

Opcode: TBA3

Purpose: This opcode carries the offset of end of the Post-Stack Header from BOS.

LSE Format: B or C (defined in [I-D.ietf-mpls-mna-hdr])

Data: The data value of the LSE contains the offset from the MPLS BOS in units of 4 octets. A data value of 5 indicates that the Post-Stack Header ends 20 octets after the BOS.

Scope: This opcode can be used with any scope.

5. Procedure

5.1. Processing Rules for P Bit

The P bit MUST be set to 1 in In-Stack Network Action Sub-Stack when corresponding Post-Stack Header is added in the packet.

By default, the PSH starts immediately after the BOS. The offset of the PSH that does not start immediately after the BOS is indicated using the PSH Start Offset Opcode TBA2.

The P bit MUST be set to 1 when the network action with opcode TBA2 is added to the In-Stack Network Action Sub-Stack. The node that recognizes the network action with Opcode TBA2 MUST process the packet according to the U flag if the P bit is not set.

The P bit MUST be set to 1 when the network action with opcode TBA3 is added to the In-Stack Network Action Sub-Stack. The node that recognizes the network action with Opcode TBA3 MUST process the packet according to the U flag if the P bit is not set.

The node that supports the P bit, processes the Post-Stack Network Actions in the Post-Stack Header as defined in this document. Conversely, the node that does not support the P bit, will skip processing the Post-Stack Header altogether.

5.2. Network Action Processing Order

The Post-Stack Network Actions are processed in the same order they are encoded after the BOS. By default, they are processed after the In-Stack Network Actions in the Network Action Sub-Stack. However, Post-Stack Network Action Opcodes for applications (such as IOAM as described in [RFC9791]) can be added in the In-Stack Network Action Sub-Stack to process Post-Stack Network Actions in a certain order with respect to the Opcodes in the In-Stack Network Action Sub-Stack.

5.3. Node Capability Signaling

The ingress node that is adding a Post-Stack Header MUST ensure that the egress node is capable of Post-Stack MNA and can remove the PSH from the packet.

* Each participating node MUST signal the network actions that it supports.

* Each participating node MUST signal its "Readable Label Depth including Post-Stack Header" that can be encoded.

The above capability signaling will be added in appropriate protocols. Signaling details are outside the scope of this document.

6. Node Responsibilities

This section defines the specific responsibilities for nodes along an MPLS path for processing a Post-Stack Header.

6.1. Encapsulating Node Responsibilities

The encapsulating node MAY add Post-Stack Header to the packet in accordance with its policies, the placement restrictions, and the limitations.

The encapsulating node MUST NOT add a Post-Stack Header to the packet if the decapsulation node does not support Post-Stack Header.

If the encapsulating node is also a transit node, then it MUST also respect transit node responsibilities.

6.2. Transit Node Responsibilities

A transit node MAY modify the Ancillary Data in the Post-Stack Header.

A transit node MUST respect the Unknown Action Handling flag encoded in the corresponding NAS when processing the PSH.

A node that removes the last copy of a NAS that has the P bit set MUST remove all Post-Stack Headers.

6.3. Penultimate Node Responsibilities

In addition to the transit node responsibilities above, the penultimate node MUST NOT remove the last copy of an HBH or I2E NAS and associated PSH when the NAS is exposed after removing the forwarding (transport) label. This allows the egress node to process the NAS and associated PSH.

6.4. Decapsulating Node Responsibilities

The decapsulating node MUST remove any Post-Stack Header it receives.

7. Security Considerations

The security considerations in [RFC3032], [RFC9789], and [I-D.ietf-mpls-mna-hdr] also apply to this document.

System designers must be aware that information included in Post-Stack Ancillary Data may be transmitted "in the clear." Network actions that require the exchange of sensitive data, must be defined in such a way that the data is encrypted in transit.

8. IANA Considerations

8.1. First Nibble for Post-Stack Header

This document requests that IANA allocate a value (TBA1) for the First Nibble (value TBA1) for Post-Stack Header from the registry "Post-Stack First Nibble" created by [RFC9790] to indicate the start of the PSH after BOS.

Value	Description	Reference
TBA1	First Nibble for Post-Stack Header	This document

Table 2: First Nibble for Post-Stack Header

8.2. Post-Stack Header Types Registry

This document requests that IANA create a new registry with the name "Post-Stack Header Types" as follows. The registration procedure for this registry is "IETF Review", "Experimental Use" and "Private Use". The fields are "Type" (integer), "Description" (string), and "Reference" (string).

The assignments for this registry are:

Type	Description	Reference
0	Reserved, not to be assigned	This document
1-65520	IETF Review	This document
65521-65524	Experimental Use	This document
65525-65535	Private Use	This document

Table 3: Post-Stack Header Types Registry

The initial assignment for this registry is:

Type	Description	Reference
1	Post-Stack Header Type For MNA	This document

Table 4: Post-Stack Header Type For MNA

8.3. In-Stack Network Action Opcodes

The opcodes for In-Stack Network Action to be allocated by IANA from the "In-Stack Network Action Opcodes registry" to be created by [[I-D.ietf-mpls-mna-hdr]], as defined in this document as follows.

Opcode	Description	Reference
TBA2	Offset of Start of Post-Stack Header	This document
TBA3	Offset of End of Post-Stack Header	This document

Table 5: In-Stack Network Action Opcodes

8.4. Post-Stack Network Action Opcodes

This document requests that IANA create a new registry with the name "Post-Stack Network Action Opcodes" that belongs to the "MPLS Network Actions Parameters" registry to be created by [[I-D.ietf-mpls-mna-hdr]]. The registration procedure for this registry is "IETF Review", "Experimental Use" and "Private Use". The fields are "Opcode" (integer), "Description" (string), and "Reference" (string). Opcode is an integer 0-127.

The assignments for this registry are:

Opcode	Description	Reference
1-110	IETF Review	This document
111-114	Experimental Use	This document
115-126	Private Use	This document
127	IETF Review	This document

Table 6: Post-Stack Network Action Opcodes Registry

IANA has allocated values for the following Post-Stack Network Action Opcodes from this registry.

Opcode	Description	Reference
0	Reserved, not to be assigned	This document
127	Opcode Range Extension Beyond 127	This document

Table 7: Post-Stack Network Action Opcodes

9. Appendix A: Examples

9.1. Examples of Post-Stack Header Encoding

9.1.1. NAS that only Indicates Post-Stack Header

```
    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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |           MNA Label                   | TC  |0|    TTL        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |Opcode=2=NOOP|    0                    |1|IHS|0|U| NASL=0|NAL=0|
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   ~                                             [0|               ~
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                             |1|               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | TBA1  |Version| PS-HDR-LEN=1  | TYPE = MNA-POST-STACK-HDR = 1 |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  MNA-PS-OP  |R|R|  PS-NAL=0   |       POST-STACK DATA         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   ~                                                               ~
   ~                            Payload                            ~
   ~                                                               ~
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4: NAS that only indicates Post-Stack Header

In some cases, the NAS may encode only the presence of Post-Stack Header. The Post-Stack Header starts immediately after the BOS.

9.1.2. NAS that Indicates Post-Stack Header Start Offset

```
    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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |           MNA Label                   | TC  |0|    TTL        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Opcode=TBA2 |  Post-Stack Offset = 2  |1|IHS|0|U| NASL=0|NAL=0|
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   ~                                            [0|                ~
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                            |1|                |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                               |
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | TBA1  |Version| PS-HDR-LEN=1  | TYPE = MNA-POST-STACK-HDR = 1 |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  MNA-PS-OP  |R|R|  PS-NAL=0   |       POST-STACK DATA         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   ~                                                               ~
   ~                            Payload                            ~
   ~                                                               ~
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5: NAS Indicates Post-Stack Header Start Offset

The NAS may encode the start offset of the Post-Stack Header with a non-zero value, for example, when it is after other header such as GACH or CW header. In this example, the PSH starts at offset of 8 bytes after the BoS.

9.1.3. Post-Stack Network Actions with Two Opcodes

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          MNA Label                    | TC  |0|    TTL        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Opcode=2=NOOP|    0                    |1|IHS|1|U| NASL=0|NAL=0|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| TBA1  |Version| PS-HDR-LEN=3  | TYPE = MNA-POST-STACK-HDR = 1 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  MNA-PS-OP=2|R|R|  PS-NAL=0   |       POST-STACK DATA         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  MNA-PS-OP=3|R|R|  PS-NAL=1   |       POST-STACK DATA         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       POST-STACK DATA                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
|                     Optional Payload + Padding                |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 6: Post-Stack NA with Two Opcodes

This is an example, Post-Stack Header encodes two different Post-Stack Network Actions.

Details:

PS-HDR-LEN=3: This is the Total Length of Post-Stack Header.

MNA-PS-OP=2: Post-Stack NA Opcode 2.

PS-NAL=0: Post-Stack Network Action does not contain any additional data.

MNA-PS-OP=3: Post-Stack NA Opcode 3.

PS-NAL=1: Post-Stack Network Action contains 1 additional 4-octet Ancillary data.

9.1.4. Post-Stack Network Action with two Different Scopes

```
    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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |          MNA Label                    | TC  |0|    TTL        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |Opcode=2=NOOP|    0                    |1|HBH|0|U| NASL=0|NAL=0|
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |          MNA Label                    | TC  |0|    TTL        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Opcode=TBA2 |  Post-Stack Offset = 2  |1|I2E|1|U| NASL=0|NAL=0|
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | TBA1  |Version| PS-HDR-LEN=1  | TYPE = MNA-POST-STACK-HDR = 1 |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  MNA-PS-OP=2|R|R|  PS-NAL=0   |       POST-STACK DATA         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | TBA1  |Version| PS-HDR-LEN=2  | TYPE = MNA-POST-STACK-HDR = 1 |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  MNA-PS-OP=3|R|R|  PS-NAL=1   |       POST-STACK DATA         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                       POST-STACK DATA                         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                               |
   |                     Optional Payload + Padding                |
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 7: Post-Stack NA with two Different Scopes

This is an example of Post-Stack Header encoding, that encode two different different scoped Post-Stack Network Actions. The first scope is Hop-By-Hop and the second scope is Ingress-To-Egress scoped Post-Stack Network Action.

Details:

The offset of the Hop-By-Hop scoped Post-Stack Network Action 0.

Opcode TBA2 carries the offset of the Ingress-To-Egress scoped Post-Stack Network Action. The data is 2, i.e., the Post-Stack Header starts 8 bytes after the MPLS Bottom of Stack.

9.2. In-Stack and Post-Stack Network Actions

9.2.1. NAS with In-Stack and Post-Stack NAs

```
    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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |          MNA Label                    | TC  |0|    TTL        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Opcode=1    |   Flag-Based NAIs       |1|IHS|0|U| NASL=0|NAL=0|
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   ~                                             [0|               ~
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                             |1|               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | TBA1  |Version| PS-HDR-LEN=1  | TYPE = MNA-POST-STACK-HDR = 1 |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  MNA-PS-OP  |R|R|  PS-NAL=0   |       POST-STACK DATA         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   ~                                                               ~
   ~                           Payload                             ~
   ~                                                               ~
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 8: NAS with In-Stack and Post-Stack NAs

In some cases, the NAS may encode In-Stack NAs and indicate the presence of Post-Stack Header. The IHS field indicates the scope of both the In-Stack and Post-Stack NAs.

9.2.2. NASes with Different In-Stack and Post-Stack Scopes

```
    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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |          MNA Label                    | TC  |0|    TTL        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Opcode=1    |   Flag-Based NAIs       |0|HBH|0|U| NASL=0|NAL=0|
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |          MNA Label                    | TC  |0|    TTL        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |Opcode=2=NOOP|    0                    |1|I2E|1|U| NASL=0|NAL=0|
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | TBA1  |Version| PS-HDR-LEN=1  | TYPE = MNA-POST-STACK-HDR = 1 |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  MNA-PS-OP  |R|R|  PS-NAL=0   |       POST-STACK DATA         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   ~                                                               ~
   ~                           Payload                             ~
   ~                                                               ~
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 9: NASes with Different In-Stack and Post-Stack Scopes

In some cases the label stack may need to carry In-Stack NAs with Hop-By-Hop scope and Post-Stack NAs with I2E scope. In this case, there will be two NASes in the label stack. In this case, the first NAS will encode the In-Stack NA with the Hop-By-Hop scope and the second NAS will encode the presence of I2E scoped Post-Stack NAs.

10. References

10.1. Normative References

[I-D.ietf-mpls-mna-hdr]
Rajamanickam, J., Gandhi, R., Zigler, R., Song, H., and K. Kompella, "MPLS Network Action (MNA) Sub-Stack Solution", Work in Progress, Internet-Draft, draft-ietf-mpls-mna-hdr-15, 5 September 2025, <https://datatracker.ietf.org/doc/html/draft-ietf-mpls-mna-hdr-15>.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC3032] Rosen, E., Tappan, D., Fedorkow, G., Rekhter, Y., Farinacci, D., Li, T., and A. Conta, "MPLS Label Stack Encoding", RFC 3032, DOI 10.17487/RFC3032, January 2001, <https://www.rfc-editor.org/info/rfc3032>.

[RFC4385] Bryant, S., Swallow, G., Martini, L., and D. McPherson, "Pseudowire Emulation Edge-to-Edge (PWE3) Control Word for Use over an MPLS PSN", RFC 4385, DOI 10.17487/RFC4385, February 2006, <https://www.rfc-editor.org/info/rfc4385>.

[RFC5462] Andersson, L. and R. Asati, "Multiprotocol Label Switching (MPLS) Label Stack Entry: "EXP" Field Renamed to "Traffic Class" Field", RFC 5462, DOI 10.17487/RFC5462, February 2009, <https://www.rfc-editor.org/info/rfc5462>.

[RFC5586] Bocci, M., Ed., Vigoureux, M., Ed., and S. Bryant, Ed., "MPLS Generic Associated Channel", RFC 5586, DOI 10.17487/RFC5586, June 2009, <https://www.rfc-editor.org/info/rfc5586>.

[RFC6291] Andersson, L., van Helvoort, H., Bonica, R., Romascanu, D., and S. Mansfield, "Guidelines for the Use of the "OAM" Acronym in the IETF", BCP 161, RFC 6291, DOI 10.17487/RFC6291, June 2011, <https://www.rfc-editor.org/info/rfc6291>.

[RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <https://www.rfc-editor.org/info/rfc8174>.

[RFC9017] Andersson, L., Kompella, K., and A. Farrel, "Special-Purpose Label Terminology", RFC 9017, DOI 10.17487/RFC9017, April 2021, <https://www.rfc-editor.org/info/rfc9017>.

[RFC9613] Bocci, M., Ed., Bryant, S., and J. Drake, "Requirements for Solutions that Support MPLS Network Actions (MNAs)", RFC 9613, DOI 10.17487/RFC9613, August 2024, <https://www.rfc-editor.org/info/rfc9613>.

[RFC9789] Andersson, L., Bryant, S., Bocci, M., and T. Li, "MPLS Network Actions (MNAs) Framework", RFC 9789, DOI 10.17487/RFC9789, July 2025, <https://www.rfc-editor.org/info/rfc9789>.

[RFC9790] Kompella, K., Bryant, S., Bocci, M., Mirsky, G., Ed., Andersson, L., and J. Dong, "IANA Registry and Processing Recommendations for the First Nibble Following a Label Stack", RFC 9790, DOI 10.17487/RFC9790, July 2025, <https://www.rfc-editor.org/info/rfc9790>.

10.2. Informative References

[RFC9791] Saad, T., Makhijani, K., Song, H., and G. Mirsky, "Use Cases for MPLS Network Action Indicators and Ancillary Data", RFC 9791, DOI 10.17487/RFC9791, July 2025, <https://www.rfc-editor.org/info/rfc9791>.

Acknowledgments

The authors would like to thank the authors and contributors of the draft-ietf-mpls-mna-hdr as this document borrows some text from the earlier version of that document. The authors would like to thank Greg Mirsky, Loa Andersson, Haoyu Song, Adrian Farrel, and Joel Halpern for reviewing this document and providing many useful comments.

Contributors

The following people have substantially contributed to this document:

Jisu Bhattacharya
Cisco Systems, Inc.
Email: jisu@cisco.com

John Drake
Juniper Networks
United States
Email: jdrake@juniper.net

Authors' Addresses

Jaganbabu Rajamanickam (editor)
Cisco Systems, Inc.
Canada
Email: jrajaman@cisco.com

Rakesh Gandhi (editor)
Cisco Systems, Inc.
Canada
Email: rgandhi@cisco.com

Royi Zigler
Broadcom
Email: royi.zigler@broadcom.com

Tony Li
Juniper Networks
Email: tony.li@tony.li

Jie Dong
Huawei Technologies
Beijing
China
Email: jie.dong@huawei.com