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Post-Stack MPLS Network Action (MNA) Solution
draft-ietf-mpls-ps-mna-hdr-00

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 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 (PSD) specific requirements found in "Requirements for MPLS Network Actions". This document follows the architectural framework for the MPLS Network Actions (MNA) technologies specified in "MPLS Network Actions (MNA) Framework".

Status of This Memo

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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 OAM logging, for example. Ancillary Data can be used to carry additional information, such as a IOAM, Path tracing etc. Several MNA applications are described in [I-D.ietf-mpls-mna-usecases]. User-defined network actions allow new, local actions to be defined. In some cases, more Ancillary Data may required to be carried in the MPLS header, so these kind of Network Actions and its Ancillary data are encoded after the MPLS Stack. These are called as Post-Stack Data.

This document defines the syntax and semantics of Post-Stack Network Actions and their corresponding Ancillary Data based on the In-Stack MNA solution defined in [I-D.ietf-mpls-mna-hdr]. This document addresses the requirements specified in [I-D.ietf-mpls-mna-requirements]. This document follows the framework specified in [I-D.ietf-mpls-mna-fwk].

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 [I-D.ietf-mpls-mna-fwk] and [I-D.ietf-mpls-mna-requirements] are used in this document.

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

PS-MNA-OP	Post-Stack MPLS Network Action Opcode	This document
TC	Traffic Class	[RFC5462]
TTL	Time To Live	[RFC3032]

Table 1: Abbreviations

3. Overview

A Flag in the In-Stack NAS header [I-D.ietf-mpls-mna-hdr] indicates the presence of the Post-Stack MNA. The Post-Stack MNA's are encoded after the MPLS Label Stack (BoS).

The Post-Stack MNA encoding contains two main parts:

* Post-Stack Network Action Indicator

* Post-Stack Network Action Encoding

4. Post-Stack Network Action Indicator

A reserved bit (21st bit from left in LSE Format B [I-D.ietf-mpls-mna-hdr]) in the In-Stack MNA header described in [I-D.ietf-mpls-mna-hdr] is used to indicate the presence of the Post-Stack Network Action.

```
 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 Network Action Indicator

The below are the flags applicable to Post-Stack MNA encoding purposes defined in [I-D.ietf-mpls-mna-hdr].

* P (1 Bit) : Indicates the presence of the Post-Stack MNA

* IHS (2 Bit) : Indicates the combined scope of the In-Stack and the Post-Stack Network Actions. Each scope with P bit set will have its corresponding Post-Stack MNA sub-stack.

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

5. Post-Stack Network Action Encoding

The Post-Stack Network Action and its Ancillary Data are encoded after the MPLS Label Stack (BoS). The Post-Stack Network Action may carry multiple Post-Stack Network Actions and its corresponding Ancillary Data.

This consist of two main parts:

* Post-Stack Header

* Post-Stack Network Action Header

5.1. Post-Stack Header

This header is the top-level header for all the Post-Stack Network Actions that are 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|N N N N|Version|   PS-HDR-LEN  |    TYPE = POST-STACK-HDR-MNA  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 2: Post-Stack Header

* NNNN (4 bits): This first nibble identifies the start of the Post-Stack Header. A new value can be assigned by IANA (value TBA1). Generic Associated Channel (0001b) or CW (0000b) can be used instead.

* Version (4 bits): This is Post-Stack Header version. The initial version will be 0.

* PS-HDR-LEN (8 bits): Post-Stack Header Total Length in 4-octet units. This excludes the Post-Stack Header.

* TYPE (16 bits): Type is set to POST-STACK-HDR-MNA. The type value is an IANA allocated value of 1.

5.2. Post-Stack Network Action Header

This header encodes a single Post-Stack Network Action. Using this scheme, multiple Post-Stack Network Action and its 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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |  PS-MNA-OP  |R|U|  PS-NAL     |       POST-STACK DATA         |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 3: Post-Stack Network Action Header

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

* R (1 bit): Reserved bit.

* U (1 bit): Unknown Post-Stack Network Action Handling bit.

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

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

6. In-Stack Special Opcode Allocation

Some of the In-Stack MNA Opcodes are allocated to support Post-Stack Network Action. They are as follows.

6.1. Post-Stack Header Offset

Opcode: TBA2

Purpose: This opcode carries the start offset of the Post-Stack Header.

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 Post-Stack Header is encoded immediately after the MPLS BOS. A data value of 1 indicates that the Post-Stack Header starts 4 octets after the BOS.

Scope: This opcode can be used with any scope.

6.2. PS-IS-NA Ordering

Opcode: TBA3

Purpose: In cases where the ordering of network action is significant and where some of the network actions reside in Post-Stack Network Action, this opcode can be used to insert Post-Stack network actions into the order of execution. The 'P' bit and 'O' bit MUST be set in the NAS's Format B LSE [I-D.ietf-mpls-mna-hdr]) if this opcode is used.

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

Data: The data field contains one or more 7-bit Post-Stack MNA Opcode. When used with LSE Format B, only one PS MNA Opcode is carried. Two PS MNA opcodes can be carried in a Format C LSE. If Format D LSEs [I-D.ietf-mpls-mna-hdr]) are used, each may carry up to three PS MNA opcodes. The PS MNA opcodes are the stored concatenated in the most significant bits of the data field. If multiple indicators are carried, the most significant PS MNA opcode is evaluated to the least significant. PS MNA opcodes do not span LSEs. If some PS MNA opcode positions are not to be used, then the opcode should be set to value 0.

Scope: This opcode can be used with any scope.

7. Node Capability Signaling

The ingress node which is adding a Post-Stack MNA MUST make sure that the egress node is capable of MNA and removes the Post-Stack MNA.

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

* Each participating node MUST signal its Maximum Post-Stack MNA Length that could encoded.

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

8. Processing the Network Action Sub-Stack

This section defines the specific responsibilities for nodes along a MPLS path.

8.1. Encapsulating Node Responsibilities

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

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

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

8.2. Transit Node Responsibilities

A transit node MAY change the Ancillary Data in the Post-Stack MNA.

A transit node MUST respect the Unknown Action Handling value encoded in the NAS.

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

8.3. Penultimate Node Responsibilities

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

8.4. Decapsulating Node Responsibilities

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

9. Security Considerations

The security considerations in [RFC3032] also apply to this document.

In addition, MNA creates a new dimension in security concerns:

* The actions of an encapsulating node can affect any or all of the nodes along the path. In the most common and benign situations, such as a syntactically incorrect packet, this could result in packet loss or corruption.

* The semantics of a network action are unbounded and may be insecure. A network action could be defined that made arbitrary changes to the memory of the forwarding router, which could then be used by the encapsulating node to compromise every MNA capable router in the network. The IETF needs to ensure that only secure network actions are defined.

* The MNA architecture supports locally defined network actions. For such actions, there will be limited oversight to ensure that the semantics do not create security issues. Implementors and network operators will need to ensure that locally defined network actions do not compromise the security of the network.

10. IANA Considerations

10.1. Post-Stack Header First Nibble

This document requests that IANA allocate a value (TBA1) for the Post-Stack Header Nibble (NNNN) from the registry "Post-Stack First Nibble" created by [I-D.ietf-mpls-1stnibble] to indicate the start of the Post-Stack Header.

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

Table 2: Post-Stack First Nibble Registry

10.2. In-Stack Network Action Opcodes

The In-Stack Network Action Opcodes for In-Stack Network Action Opcode registry (to be created by in [[I-D.ietf-mpls-mna-hdr]])are defined in the document as follows.

Opcode	Description	Reference
TBA2	Offset of start of Post-Stack Header	This document
TBA3	PS-IS-NA Ordering	This document

Table 3: In-Stack Network Action Flags With Ancillary Data Registry

10.3. Post-Stack Header Types Registry

This document requests that IANA create a new registry with the name "Post-Stack Header Types". The registration procedure for this registry is "IETF Review". The fields are "Type" (integer), "Description" (string), and "Reference" (string). Type is an integer 0-65535.

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 4: Post-Stack Header Types Registry

The initial assignments for this registry are:

Type	Description	Reference
1	POST-STACK-HDR-MNA	This document

Table 5: Post-Stack Header Types

10.4. Post-Stack Network Action Opcodes

This document requests that IANA create a new registry with the name "Post-Stack Network Action Opcodes". The registration procedure for this registry is "IETF Review". The fields are "Opcode" (integer), "Description" (string), and "Reference" (string). Opcode is an integer 0-127.

The initial assignments for this registry are:

Opcode	Description	Reference
0	Reserved, not to be assigned	This document
1-110	IETF Review	This document
111-114	Experimental Use	This document
115-126	Private Use	This document

Table 6: Post-Stack Network Action Opcodes Registry

11. Appendix A: Examples

11.1. Post-Stack Network Action Encoding

11.1.1. NAS that only Indicates 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
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |           Label=MNA bSPL              | TC  |S|    TTL        |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |  Opcode=TBA2|    Offset = 0           |P|IHS|S|U| NASL=0|NAL=0|
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 ~                                                               ~
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                                             |1|               |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |N N N N|Version|  PS-HDR-LEN=1 |    TYPE = POST-STACK-HDR-MNA  |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |  PS-MNA-OP  |R|U|  PS-NAL=0   |       PS ANCILLARY DATA       |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 ~                                                               ~
 ~                            Payload                            ~
 ~                                                               ~
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4: NAS encoding only Post-Stack NAs

In some cases, the NAS may encode only the presence of Post-Stack NAs. The IHS field indicates the scope of the Post-Stack NAs (I2E, HBH, Select).

11.1.2. NAS with both 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Label=MNA bSPL               | TC  |0|    TTL        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Opcode=TBA2 |   Offset = 0            |P|IHS|0|U| NASL=1|NAL=0|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Opcode=1    |        Flag-Based NAIs        |S|U| NAIs  |NAL=0|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                                                               ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                             |1|               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|N N N N|Version|  PS-HDR-LEN=1 |    TYPE = POST-STACK-HDR-MNA  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  PS-MNA-OP  |R|U|  PS-NAL=0   |       POST-STACK DATA         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                                                               ~
~                            Payload                            ~
~                                                               ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5: 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 NAs. The NASL is set to "1", indicating the presence of one additional LSE. The IHS field indicates the scope of both the In-Stack and Post-Stack NAs.

11.1.3. NASes with Different ISD and PSD 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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |          Label=MNA bSPL               | TC  |0|    TTL        |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | Opcode=1 |  Flag-Baed NAIs            |P|HBH|0|U| NASL=0|NAL=0|
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |          Label=MNA bSPL               | TC  |0|    TTL        |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | Opcode=TBA2 |   Offset = 0            |P|I2E|1|U| NASL=0|NAL=0|
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |N N N N|Version|  PS-HDR-LEN=1 |    TYPE = POST-STACK-HDR-MNA  |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |  PS-MNA-OP  |R|U|  PS-NAL=0   |       POST-STACK DATA         |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    ~                                                               ~
    ~                            Payload                            ~
    ~                                                               ~
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 6: NASes with Different ISD and PSD Scope

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.

11.2. Post-Stack Network Action 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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |          Label=MNA bSPL               | TC  |0|    TTL        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Opcode=TBA2 |   Offset = 0            |P|IHS|1|U| NASL=0|NAL=0|
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |N N N N|Version| PS-HDR-LEN=3  |    TYPE = POST-STACK-HDR-MNA  |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  PS-MNA-OP=2|R|U|  PS-NAL=0   |       POST-STACK DATA         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  PS-MNA-OP=3|R|U|  PS-NAL=1   |       POST-STACK DATA         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                        POST-STACK DATA                        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                               |
   |                      Optional Payload + Padding               |
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 7: Post-Stack NA Example with two Opcodes

This is an example of Post-Stack MNA encoding, that encode two different Post-Stack Network Actions.

Details:

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

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

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

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

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

11.3. 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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |          Label=MNA bSPL               | TC  |0|    TTL        |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | Opcode=TBA2 |   Offset = 0            |P|HBH|0|U| NASL=0|NAL=0|
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |          Label=MNA bSPL               | TC  |0|    TTL        |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | Opcode=TBA2 |   Offset = 2            |P|I2E|1|U| NASL=0|NAL=0|
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |N N N N|Version| PS-HDR-LEN=1  |    TYPE = POST-STACK-HDR-MNA  |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |  PS-MNA-OP=2|R|U|  PS-NAL=0   |       POST-STACK DATA         |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |N N N N|Version| PS-HDR-LEN=2  |    TYPE = POST-STACK-HDR-MNA  |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |  PS-MNA-OP=3|R|U|  PS-NAL=1   |       POST-STACK DATA         |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                       POST-STACK DATA                         |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                                                               |
    |                     Optional Payload + Padding                |
    |                                                               |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 8: Post-Stack NA Example with two Different Scopes

This is an example of Post-Stack MNA 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 PSD data.

Details:

First Opcode:TBA2: This the offset of the Hop-By-Hop scoped PSD data. This value of this opcode is "0"

Second Opcode:TBA2: This the offset of the Ingress-To-Egress scoped PSD data. This value of this opcode is "2" (i.e) the PSD stack starts from second 4-octet unit after the MPLS Bottom Of Stack

11.4. Network Action Processing Order

The semantics of a network action can vary widely and the results of processing one network action may affect the processing of a subsequent network action.

11.4.1. Post-Stack NA Processing Order

By default, Post-Stack NAs follow the ordering of the encoding. However, the PS-IS-NA ordering opcode can be used to override the default ordering and interleave Post-Stack network actions with In-Stack network actions.

In some cases, Post-Stack NAs needs to be processed before In-Stack NAs. This section shows how to prioritize the Post-Stack NAs over In-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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Label=MNA bSPL               | TC  |0|    TTL        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Opcode=8    |      Ancillary Data     |P|IHS|0|U| NASL=3|NAL=0|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Opcode=1    |      Flag-Based NAIs          |0|U| NAIs  |NAL=0|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Opcode=TBA3 |      Post-Stack NA=6          |0|U|PS-NAI |NAL=0|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Opcode=7    |      Ancillary Data           |1|U|  AD   |NAL=0|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|N N N N|Version| PS-HDR-LEN=1  |    TYPE = POST-STACK-HDR-MNA  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| PS-MNA-OP=6 |R|U|  PS-NAL=0   |       POST-STACK DATA         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 9: Post-Stack and In-Stack NA processing order

In the above example, opcode 8 is processed first, then the Flag-Based NAIs, followed by Post-Stack NA Opcode 6, and finally opcode 7.

12. References

12.1. Normative References

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