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MPLS Network Actions Framework

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Abstract

This document specifies an architectural framework for the MPLS

Network Actions (MNA) technologies. MNA technologies are used to

indicate actions for Label Switched Paths (LSPs) and/or packets and

to transfer data needed for these actions.

The document describes a common set of protocol actions and

information elements supporting additional operational models and

capabilities of MPLS networks. Some of these actions are defined in

existing MPLS specifications, while others require extensions to

existing specifications to meet the requirements found in

"Requirements for MPLS Label Stack Indicators and Ancillary Data".

This document is the result of work started in MPLS Open Desgign

Team, with participation by the MPLS, PALS and DETNET working groups.

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1. Introduction

This document specifies an architectural framework for the MPLS

Network Actions (MNA) technologies. MNA technologies are used to

indicate actions for LSPs and/or packets and to transfer data needed

for these actions.

The document describes a common set of protocol actions and

information elements supporting additional operational models and

capabilities of MPLS networks. Some of these actions are defined in

existing MPLS specifications, while others require extensions to

existing specifications to meet the requirements found in

[I-D.bocci-mpls-miad-adi-requirements]. [Ed.: In a future draft, the

language in the requirements draft will be changed to align with the

terminology found here.]

Forwarding actions are instructions to MPLS routers to apply

additional actions when forwarding a packet. These might include

load-balancing a packet given its entropy, whether or not to perform

fast reroute on a failure, and whether or not a packet has metadata

relevant to the forwarding decisions along the path.

This document generalizes the concept of "forwarding actions" into

"network actions" to include any action that an MPLS router is

requested to take on the packet. That includes any forwarding

action, but may include other operations (such as security functions,

OAM procedures, etc.) that are not directly related to forwarding of

the packet.

This document is the result of work started in MPLS Open Desgign

Team, with participation by the MPLS, PALS and DETNET working groups.

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1.1. Requirement Language

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

BCP14 [RFC2119] [RFC8174] when, and only when, they appear in all

capitals, as shown here.

1.2. Terminology

1.2.1. Normative Definitions

\* Ancillary Data (AD): Data relating to the MPLS packet that may be

used to affect the forwarding or other processing of that packet,

either at an Label Edge Router (LER) [RFC4221] or Label Switching

Router (LSR). This data may be encoded within a network action

sub-stack (see below) (in-stack data), and/or after the bottom of

the label stack (post-stack data).

\* Network Action: An operation to be performed on a packet. A

network action may affect router state, packet forwarding, or it

may affect the packet in some other way. A network action is said

to be present if there is an indicator in the packet that invokes

the action.

\* Network Action Indication (NAI): An indication in the packet that

a certain network action is to be perfomed. There may be

associated ancillary data in the packet.

\* Network Action Sub-Stack (NAS): A set of related, contiguous Label

Stack Entries (LSEs). The first LSE is the Network Action Sub-

stack Indicator. The TC and TTL values in the sub-stack may be

redefined. The label field in the second and following LSE may be

redefined. Solutions MUST NOT redefine the S bit. See

Section 3.1 through Section 3.5.

\* Network Action Sub-Stack Indicator (NSI): An LSE that contains a

special label that indicates the start of a Network Action Sub-

stack.

\* Scope: The set of nodes that should perform a given action.

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1.2.2. Abbreviations

+==============+===========+========================================+

| Abbreviation |Meaning | Reference |

+==============+===========+========================================+

| AD |Ancillary | [I-D.bocci-mpls-miad-adi-requirements] |

| |Data | |

+--------------+-----------+----------------------------------------+

| bSPL |Base | [RFC9017] |

| |Special | |

| |Purpose | |

| |Label | |

+--------------+-----------+----------------------------------------+

| ECMP |Equal Cost | |

| |Multipath | |

+--------------+-----------+----------------------------------------+

| eSPL |Extended | [RFC9017] |

| |Special | |

| |Purpose | |

| |Label | |

+--------------+-----------+----------------------------------------+

| HBH |Hop by hop | In the MNA context, this document. |

+--------------+-----------+----------------------------------------+

| I2E |Ingress to | In the MNA context, this document. |

| |Egress | |

+--------------+-----------+----------------------------------------+

| ISD |In stack | [I-D.bocci-mpls-miad-adi-requirements] |

| |data | |

+--------------+-----------+----------------------------------------+

| LSE |Label Stack| [RFC3032] |

| |Entry | |

+--------------+-----------+----------------------------------------+

| MNA |MPLS | This documnent |

| |Network | |

| |Actions | |

+--------------+-----------+----------------------------------------+

| NAI |Network | [I-D.bocci-mpls-miad-adi-requirements] |

| |Action | |

| |Indicator | |

+--------------+-----------+----------------------------------------+

| NAS |Network | This document |

| |Action Sub-| |

| |Stack | |

+--------------+-----------+----------------------------------------+

| PSD |Post stack | [I-D.bocci-mpls-miad-adi-requirements] |

| |data | and Section 3.6 |

+--------------+-----------+----------------------------------------+

| SPL |Special | [RFC9017] |

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| |Purpose | |

| |Label | |

+--------------+-----------+----------------------------------------+

Table 1: Abbreviations

2. Structure

An MNA solution is envisioned as a set of network action sub-stacks

that indicate the network actions being invoked, plus possible post-

stack data. A solution must specify where in the label stack the

network actions sub-stacks occur, if and how frequently they should

be replicated, and how network action sub-stack and post-stack data

are encoded.

A network action sub-stack contains:

\* Label: A special label is used to indicate the start of a network

action sub-stack.

\* Indicators: A set of indicators that describes the set of network

actions.

\* In-Stack Data: A set of zero or more LSEs that carry ancillary

data for the present network actions.

Each network action present in the network action sub-stack may have

zero or more LSEs of in-stack data. The ordering of the in-stack

data LSEs corresponds to the ordering of the network action

indicators. The encoding of the in-stack data, if any, for a network

action must be specified in the document that defines the network

action.

Certain network actions may also specify that data is carried after

the label stack. This is called post-stack data. The encoding of

the post-stack data, if any, for a network action must be specified

in the document that defines the network action. If multiple network

actions are present and have post-stack data, the ordering of their

post-stack data corresponds to the ordering of the network action

indicators.

A solution must specify the order that network actions are to be

applied to the packet.

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2.1. Scopes

A network action may need to be processed by every node along the

path, or some subset of the nodes along its path. Some of the scopes

that an action may have are:

\* Hop-by-hop (HBH): Every node along the path will perform the

action.

\* Ingress-to-Egress (I2E): Only the last node on the path will

perform the action.

\* Select: Only specific nodes along the path will perform the

action.

If a solution supports the select scope, it must describe how it

specifies the set of nodes to perform the actions.

2.2. Partial Processing

Legacy devices that do not recognize the MNA label will discard the

packet as described in [RFC3031].

Devices that do recognize the MNA label may not implement all of the

present network actions. A solution must specify how unrecognized

present network actions should be handled.

One alternative is that an implementation should stop processing

network actions when it encounters an unrecognized network action.

Subsequent present network actions would not be applied. The result

is dependent on the solution's order of operations.

Another alternative is that an implementation should drop any packet

that contains any unrecognized present network actions.

A third alternative is that an implementation should perform all

recognized present network actions, but ignore all unrecognized

present network actions.

Other alternatives may also be possible and should be specified by

the solution.

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2.3. Signaling

A node that wishes to make use of MNA and apply network actions to a

packet must understand the nodes that the packet will transit and

whether or not the nodes support MNA and the network actions that are

to be invoked. These capabilities are presumed to be signaled by

protocols that are out-of-scope for this document and are presumed to

have per-network action granularity. If a solution requires

alternate signaling, it must specify so explicitly.

A node that pushes a NAS onto the label stack is responsible for

determining that all nodes that should process the NAS will have the

NAS within its Readable Label Depth (RLD). A node should use

signaling (e.g., [RFC9088]) to determine this.

2.4. Positioning

A network action sub-stack should never occur at the top of the MPLS

label stack. A node that is responsible for popping a forwarding

label immediately above a network action sub-stack must also pop any

network action sub-stacks that immediately follow.

2.5. State

A network action can affect state in the network. This implies that

a packet may affect how subsequent packets are handled.

3. Encoding

Several possibilities to carry NAI's have been discussed in MNA

drafts and in the MPLS Open DT. In this section, we enumerate the

possibilities and some considerations for the various alternatives.

All types of network actions are represented in the MPLS label stack

by a set of LSEs termed a network action sub-stack (NAS). An NAS

consists of a special label, followed by LSEs that specify which

network actions are to be performed on the packet, and the in-stack

ancillary data for each indicated network action.

[I-D.bocci-mpls-miad-adi-requirements] requires that a solution not

add unnecessary LSEs to the sub-stack (Section 3.1, requirement 5).

Accordingly, solutions should also make efficient use of the bits

within the sub-stack, as inefficient use of the bits will result in

the addition of unnecessary LSEs.

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3.1. The MNA Label

The first LSE in a network action sub-stack contains a special label

that indicates a network action sub-stack. A solution has several

choices for this special label.

3.1.1. Existing Base SPL

A solution may reuse an existing Base SPL (bSPL). If it elects to do

so, it must explain how the usage is backwards compatible, including

in the case where there is ISD.

3.1.2. New Base SPL

A solution may select a new bSPL.

3.1.3. New Extended SPL

A solution may select a new eSPL. If it elects to do so, it must

address the requirement for the minimal number of LSEs.

3.1.4. User-Defined Label

A solution may allow the network operator to define the label that

indicates the network action sub-stack. This creates management

overhead for the network operator to coordinate the use of this label

across all nodes on the path using management or signaling protocols.

If a solution elects to use a user-defined label, the solution should

justify this overhead.

3.2. TC and TTL

In the first LSE of the network action sub-stack, only the 20 bits of

Label Value and the Bottom of Stack bit are significant, the TC field

(3 bits) and the TTL (8 bits) are not used. This leaves 11 bits that

could be used for other purposes.

3.2.1. TC and TTL retained

If the solution elects to retain the TC and TTL field, then the first

LSE of the network action sub-stack would appear as:

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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 | TC |S| TTL |

+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

Label: Label value, 20 bits

TC: Traffic Class, 3 bits

S: Bottom of Stack, 1 bit

TTL: Time To Live

Further LSEs would be needed to encode NAIs. If a solution elects to

retain these fields, it must address the requirement for the minimal

number of LSEs.

3.2.2. TC and TTL Repurposed

If the solution elects to reuse the TC and TTL field, then the first

LSE of the network action sub-stack would appear as:

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 |x x x|S|x x x x x x x x|

+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

Label: Label value, 20 bits

x: Bit available for solution definition

S: Bottom of Stack, 1 bit

The solution may use more LSEs to contain NAIs.

3.3. Length of the NAS

A solution must have a mechanism to indicate the length of the NAS.

This must be easily processed even by implementations that do not

understand the full contents of the NAS. Two options are described

below, other solutions may be possible.

3.3.1. Last/Continuation Bits

A solution may use a bit per LSE to indicate whether the NAS

continues into the next LSE or not. The bit may indicate

continuation by being set or by being clear. The overhead of this

approach is one bit per LSE and has the advantage that it can

effectively encode an arbitrarily sized NAS. This approach is

efficient if the NAS is small.

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3.3.2. Length Field

A solution may opt to have a fixed size length field at a fixed

location within the NAS. The fixed size of the length field may not

be large enough to support all possible NAS contents. This approach

may be more efficient if the NAS is longer, but not longer than can

be described by the length field.

Advice from hardware designers advocates a length field as this

minimizes branching in the logic.

3.4. Encoding of Scopes

A solution may choose to explicitly encode the scope of the actions

contained in a network action sub-stack. A solution may also choose

to have the scope encoded implicitly, based on the actions present in

the network action sub-stack. This choice may have performance

implications as an implementation might have to parse the network

actions that are present in a network action sub-stack only to

discover that there are no actions for it to perform.

Solutions need to consider the order of scoped NAIs and their

associated AD within individual sub-stacks and the order of per-scope

sub-stacks in order that network actions and the AD can be most

readily found and not need to processed by nodes that are not

required to handle those actions.

3.5. Encoding a Network Action

Two options for encoding NAIs are described below, other solutions

may be possible. Any solution should allow encoding of an arbitrary

number of NAIs.

3.5.1. Bit Catalogs

A solution may opt to encode the set of network actions as a list of

bits, sometimes known as a catalog. The solution must provide a

mechanism to determine how many LSEs are devoted to the catalog. A

set bit in the catalog would indicate that the corresponding network

action is present.

Catalogs are efficient if the number of present network actions is

relatively high and if the size of the necessary catalog is small.

For example, if the first 16 actions are all present, a catalog can

encode this in 16 bits. However, if the number of possible actions

is large, then a catalog can become inefficient. Selecting only one

action that is the 256th action would require a catalog of 256 bits,

which would require more than one LSE.

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3.5.2. Operation Codes

A solution may opt to encode the set of present network actions as a

list of operation codes (opcodes). Each opcode is a fixed number of

bits. The size of the opcode bounds the number of network actions

that the solution can support.

Opcodes are efficient if there are only one or two active network

actions. For example, if an opcode is 8 bits, then two active

network actions could be encoded in in 16 bits. However, if there

are 16 actions required, then opcodes would consume 128 bits.

Opcodes are efficient at encoding a large number of possible actions.

If only the 256th action is to be selected, that still requires 8

bits.

3.6. Encoding of Post-Stack Data

If there are multiple instances of post-stack data, they should occur

in the same order as their relevant network action sub-stacks and

then in the same order as their relevant network functions occur

within the network action sub-stacks.

3.6.1. First Nibble Considerations

The first nibble after the label stack has been used to convey

information in certain cases.

For example, in [RFC4928] this nibble is investigated to find out if

it has the value "4" or "6", if it is not, it is assumed that the

packet payload is not IPv4 or IPv6 and Equal Cost Multipath (ECMP) is

not performed.

It should be noted that this is an inexact method, for example an

Ethernet Pseudowire without a control word might have "4" or "6" in

the first nibble and thus will be ECMP'ed.

Nevertheless, the method is implemented and deployed, it is used

today and will be for the foreseeable future.

The use of the first nibble for BIER is specified in [RFC8296]. Bier

sets the first nibble to 5. The same is true for BIER payload, as

for any use of the first nibble, it is not possible from the first

nibble itself being set to 5, conclude that the payload is BIER.

However, it achieves the design goal of [RFC8296], to exclude that

the payload is IPv4, IPv6 or a pseudowire.

There are possibly more examples, they will be added if we find that

they further highlight the issue with using the first nibble.

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[Ed. Outstanding comments from Adrian:

Shouldn't we include RFC4385 for 0b0000 for the PW control word and

0b0001 for the PW ACH?

This section is all very well, but it doesn't give any direction to

the solution developer for what they should do with the first nibble

in the post stack data.

Is it also relevant to note that there may be other post-stack

information that comes before the payload (such as the PW control

word, and that the solution must consider the location of the post-

stack data in relaiton to that (e.g., immeidately after the LSE with

the S bit set) etc.]

4. Definition of a Network Action

Network actions should be defined in a document and must contain:

\* Name: The name of the network action.

\* Network Action Indicator: The bit position or opcode that

indicates that the network action is active.

\* Scope: The document should specify which nodes should perform the

network action. The action may apply to each transit node (HBH),

only the egress node that pops the final label off of the label

stack, or specific nodes along the label switched path.

\* State: The document should specify if the network action can

modify state in the network, and if so, the state that may be

modified and its side-effects.

\* Required/Optional: The document should specify whether a node is

required to perform the network action.

\* In-Stack Data: The number of LSEs of in-stack data. If this is of

a variable length, then the solution must specify how an

implementation can determine this length without implementing the

network action.

\* Post-Stack Data: The encoding of post-stack data, if any. If this

is of a variable length, then the solution must specify how an

implementation can determine this length without implementing the

network action.

A solution should create an IANA registry for network actions.

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5. Management Considerations

Network operators will need to be cognizant of which network actions

are supported by which nodes and will need to ensure that this is

signalled appropriately. Some solutions may require network-wide

configuration to synchronize the use of the labels that indicate the

start of an NAS. Solution documents must make clear what management

considerations apply to the solutions they are describing. Solutions

documents must describe mechanisms for performing network diagnostics

in the presence of MNAs.

6. Security Considerations

The forwarding plane is insecure. If an adversary can affect the

forwarding plane, then they can inject data, remove data, corrupt

data, or modify data. MNA additionally allows an adversary to make

packets perform arbitrary network actions.

Link-level security mechanisms can help mitigate some on-link

attacks, but does nothing to preclude hostile nodes.

End-to-end encryption of an LSP can help provide security, but would

make it impossible to process post-stack data.

7. IANA Considerations

This document does not make any allocations of code points from IANA

registries.

As long as the "does not make any allocations ..." from IANA is true,

this pragraph shoukd be removed by the RFC-Editor. If it turns out

that we will need to do IANA allocation, a proper IANA section will

be added.

8. Acknowledgements

The authors would like to thank Adrian Farrel for his contributions

and to John Drake for his comments.

9. Editorial attic

This section contains old material that will be discarded before

publication, assuming we don't find it useful between now and then.

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9.1. Process Note on E2E

There has been some discussion on the of the E2E abbreviation. 1. In

a mail to the MPLS Working group mailing list Joel Halpern pointed

out that the abbreviation E2E has been used in several different

meanings. Joel suggested to use another abbreviation.

1. Some variants has been proposed, for example.

\* Ingress to Egress (I2E); alernative abbreviation (i2e)

\* Egress

\* LSP Ingress to LSP Egress (LI2LE)

\* Egress (because the Ingress has already done its thing)

\* Ultimate Hop

\* Destination

\* Start-to-End

\* Last-LSR

\* Head to Tail

In a few days (counting from the publication date of this document)

the working group chairs will take an initiative to poll the working

groups for consensus on this.

9.2. Concepts used in this Framework

+=============+====================+===========+======+

| Concept | Meaning | Reference | Note |

+=============+====================+===========+======+

| E2E concept | E2E in MNA context | this | - |

| | is defined in... | document | |

+-------------+--------------------+-----------+------+

| concept | free text | this | - |

| | | document | |

+-------------+--------------------+-----------+------+

Table 2: Concepts

Not complete, help appreciated. [Ed. This section is planned for

removal as it seems unhelpful so far.]

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9.3. LSE

An individual LSE has the following format [RFC3032]:

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 | TC |S| TTL |

+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

Label: Label Value, 20 bits

TC: Traffic Class, 3 bits

S: Bottom of Stack, 1 bit

TTL: Time to Live, 8 bits

Figure 1: A Label Stack Entry (LSE)

9.4. MPLS Forwarding model

This is section here to basically to have a place holder where to

discuss the development of the MPLS forwrding model. It might be

removed. [Ed. So far, it adds no value. Wave bye-bye.]

9.4.1. Orginal Model

+-----------------------------------------------------------------+

| |

| +---------------------+ |

| | +------------+ | |

| | | MPLS Label | LSE | |

| | +---|--------+ | |

| +-----|---------------+ |

| | |

| | +----------------------+ |

| | | FIB | |

| | | | |

| | | +------------+ | +----------------------+ |

| +------->|FIB Entry |-----+-->|Forwarding Code | |

| | +------------+ | | +----------------------+ |

| +----------------------| | |

| | | +----------------------+ |

| +-->|Forwarding Parameters | |

| +----------------------+ |

| |

| |

| LSE = Label Stack Entry (what many people call a label) |

| FIB = Forwarding Information (date)Base |

+-----------------------------------------------------------------+

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Figure 2: MPLS Original Forwarding Model

10. References

10.1. Normative References

[I-D.bocci-mpls-miad-adi-requirements]

Bocci, M. and S. Bryant, "Requirements for MPLS Network

Action Indicators and MPLS Ancillary Data", Work in

Progress, Internet-Draft, draft-bocci-mpls-miad-adi-

requirements-04, 11 April 2022,

<https://www.ietf.org/archive/id/draft-bocci-mpls-miad-

adi-requirements-04.txt>.

[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>.

[RFC3031] Rosen, E., Viswanathan, A., and R. Callon, "Multiprotocol

Label Switching Architecture", RFC 3031,

DOI 10.17487/RFC3031, January 2001,

<https://www.rfc-editor.org/info/rfc3031>.

[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>.

[RFC4221] Nadeau, T., Srinivasan, C., and A. Farrel, "Multiprotocol

Label Switching (MPLS) Management Overview", RFC 4221,

DOI 10.17487/RFC4221, November 2005,

<https://www.rfc-editor.org/info/rfc4221>.

[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>.

[RFC9088] Xu, X., Kini, S., Psenak, P., Filsfils, C., Litkowski, S.,

and M. Bocci, "Signaling Entropy Label Capability and

Entropy Readable Label Depth Using IS-IS", RFC 9088,

DOI 10.17487/RFC9088, August 2021,

<https://www.rfc-editor.org/info/rfc9088>.

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10.2. Informative References

[RFC4928] Swallow, G., Bryant, S., and L. Andersson, "Avoiding Equal

Cost Multipath Treatment in MPLS Networks", BCP 128,

RFC 4928, DOI 10.17487/RFC4928, June 2007,

<https://www.rfc-editor.org/info/rfc4928>.

[RFC8296] Wijnands, IJ., Ed., Rosen, E., Ed., Dolganow, A.,

Tantsura, J., Aldrin, S., and I. Meilik, "Encapsulation

for Bit Index Explicit Replication (BIER) in MPLS and Non-

MPLS Networks", RFC 8296, DOI 10.17487/RFC8296, January

2018, <https://www.rfc-editor.org/info/rfc8296>.

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