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7 January 2022

Usecases for MPLS Indicators and Ancillary Data

draft-saad-mpls-miad-usecases-00

Abstract

This document presents a number of use cases that have a common need

for encoding MPLS function indicators and ancillary data inside MPLS

packets. The use cases described are not an exhaustive set, but

rather the ones that are actively discussed at the MPLS Working

Group.

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1. Introduction

This document describes important cases that require carrying

additional ancillary data within the MPLS packets, as well as the

means to indicate ancillary data is present.

These use cases have been identified by the MPLS working group design

team working on defining MPLS function indicators and ancillary data

for the MPLS data plane. The use cases described in this document

will be used to assist in identifying requirements and issues to be

considered for future resolution by the working group.

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\* ID: draft-gandhi-mpls-ioam describes the applicability of IOAM to MPLS

data plane.

\* RFC 8986 describes the network programming use case for SRv6

data plane.

\* RFC 8595 describes a solution for MPLS-based forwarding for Service

Function Chaining

1.1. Terminology

The following terminology is used in the document:

IETF Network Slice:

a well-defined composite of a set of endpoints, the connectivity

requirements between subsets of these endpoints, and associated

requirements; the term 'network slice' in this document refers to

'IETF network slice' as defined in

[I-D.ietf-teas-ietf-network-slices].

IETF Network Slice Controller (NSC):

a controller that is used to realize an IETF network slice

[I-D.ietf-teas-ietf-network-slices].

Network Resource Partition:

the collection of resources that are used to support a slice

aggregate.

Time-Sensitive Networking:

Networks that transport time-sensitive traffic.

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.

1.2. Acronyms and Abbreviations

MIAD: MPLS Label Stack Indicators for Ancillary Data

ISD: In-stack data

PSD: Post-stack data

MPLS: Multiprotocol Label Switching

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2. Use Cases

2.1. In-situ OAM

In-situ Operations, Administration, and Maintenance (IOAM) may record

operational and telemetry information within the packet while the

packet traverses a particular path in a network domain.

The term "in-situ" refers to the fact that the IOAM data fields are

added to the data packets rather than being sent within the probe

packets specifically dedicated to OAM or Performance Measurement

(PM).

IOAM can run in two modes End-to-End (E2E) and Hop-by-Hop (HbH). In

E2E mode, only the encapsulating and decapsulating nodes will process

IOAM data fields. In HbH mode, the encapsulating and decapsulating

nodes as well as intermediate IOAM-capable nodes process IOAM data fields.

The IOAM data fields are defined in [I-D.ietf-ippm-ioam-data], and

can be used for various use-cases of OAM and PM.

[I-D.gandhi-mpls-ioam-sr] defines how IOAM data fields are

transported using the MPLS data plane encapsulations, including

Segment Routing (SR) with MPLS data plane (SR-MPLS).

IOAM data may be added after the bottom of the label stack. The IOAM

data fields can be of a fixed or incremental size as defined in

[I-D.ietf-ippm-ioam-data]. [I-D.gandhi-mpls-ioam] describes

the applicability of IOAM to the MPLS data plane. The encapsulating MPLS node

needs to know if the decapsulating MPLS node can process the IOAM

data before adding it into the packet.

2.2. Network Slicing

[I-D.ietf-teas-ietf-network-slices] specifies the definition of an

IETF Network Slice . It further discusses the general

framework for requesting and operating IETF Network Slices, their

characteristics, and the necessary system components and interfaces.

Multiple network slices can be realized on top of a single shared

network.

In order to overcome scale challenges, IETF Network Slices may be

aggregated into groups according to similar characteristics. The

slice aggregate [I-D.bestbar-teas-ns-packet] is a construct that

comprises of the traffic flows of one or more IETF Network Slices of

similar characteristics.

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A router that requires forwarding of a packet that belongs to a slice

aggregate may have to decide on the forwarding action to take based

on selected next-hop(s), and the forwarding treatment (e.g.,

scheduling and drop policy) to be enforced based on the associated per-

hop behavior.

The routers in the network that forward traffic over links that are

shared by multiple slice aggregates need to identify the slice

aggregate packets in order to enforce the associated forwarding

action and treatment.

An IETF network slice MAY support the following key features:

1. A Slice Selector

2. A Network Resource Partition associated with a slice aggregate.

3. A Path selection criteria

4. Verification that per slice SLOs are being met. This may be done

by active measurements (inferred) or by using hybrid measurement methods, e.g., IOAM.

5. Additionally, there is an ongoing discussion on using Service

Functions (SFs) with network slices. This may require insertion

of an NSH.

6. For multi-domain scenarios, a packet that traverses multiple

domains may encode different identifiers within each domain.

2.2.1. Global Identifier as Slice Selector

A Global Identifier as a Slice Selector (GISS) can be encoded in the

MPLS packet as defined in [I-D.kompella-mpls-mspl4fa],

[I-D.li-mpls-enhanced-vpn-vtn-id], and

[I-D.decraene-mpls-slid-encoded-entropy-label-id]. The Global

Identifier Slice Selector can be used to associate the packets to the

slice aggregate, independent of the MPLS forwarding label that is

bound to the destination. LSRs use the MPLS forwarding label to

determine the forwarding next-hop(s), and use the Global Identifier

Slice Selector field in the packet to infer the specific forwarding

treatment that needs to be applied on the packet.

The GISS can be encoded within an MPLS label stack element that is carried in the

packet's MPLS label stack. All packets that belong to the same slice

aggregate MAY carry the same GISS in the MPLS label stack. It is

also possible to have multiple GISS's map to the same slice

aggregate. The GISS can be encoded in an MPLS label and may appear

in several positions in the MPLS label stack.

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2.2.2. Forwarding Label as a Slice Selector

[RFC3031] states in Section 2.1 that: 'Some routers analyze a

packet's network layer header not merely to choose the packet's next

hop, but also to determine a packet's "precedence" or "class of

service"'.

It is possible by assigning a unique MPLS forwarding label to each

slice aggregate (FEC) to distinguish the packets forwarded to the

same destination that belong to different slice aggregates. In

this case, LSRs can use the top forwarding label to infer both the

forwarding action and the forwarding treatment to be invoked on the

packets. A similar approach is described in

[I-D.ietf-spring-resource-aware-segments] and

[I-D.bestbar-teas-ns-packet].

2.3. Time-Sensitive Networking

The routers in a network can perform two distinct functions on

incoming packets, namely forwarding (where the packet should be sent)

and scheduling (when the packet should be sent). Time Sensitive

Networking (TSN) and Deterministic Networking provide several

mechanisms for scheduling under the assumption that routers are time-

synchronized. The most effective mechanisms for delay minimization

involve per-flow resource allocation.

Segment Routing (SR) is a forwarding paradigm that allows encoding

forwarding instructions in the packet in a stack data structure,

rather than being programmed into the routers. The SR instructions

are contained within a packet in the form of a First-in, First-out

stack dictating the forwarding decisions of successive routers.

Segment routing may be used to choose a path sufficiently short to be

capable of providing sufficiently low end-to-end latency but does

not influence the queueing of individual packets in each router along

that pat

TSN is required for networks transporting time-sensitive traffic,

that is, packets that are required to be delivered to their final

destination by a given time.

2.3.1. Stack-based Methods for Latency Control

One efficient data structure for inserting local deadlines into the

headers is a "stack", similar to that used in Segment Routing to

carry forwarding instructions. The number of deadline values in the

stack equals the number of routers the packet needs to traverse in

the network, and each deadline value corresponds to a specific

router. The Top-of-Stack (ToS) corresponds to the first router's

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deadline while the Bottom-of-Stack (BoS) refers to the last's. All

local deadlines in the stack are later or equal to the current time

(upon which all routers agree), and times closer to the ToS are

always earlier or equal to times closer to the BoS.

The ingress router inserts the deadline stack into the packet

headers; no other router needs to be aware of the requirements of the

time-sensitive flows. Hence admitting a new flow only requires

updating the information base of the ingress router.

MPLS LSRs that expose the Top of Stack (ToS) label can also inspect

the associated "deadline" carried in the packet (either in MPLS stack

or after BoS).

2.3.2. Stack Entry Format

A number of different time formats commonly used in networking

applications and can be used to encode the local deadlines.

For the forwarding sub-entry, we could adopt like SR-MPLS standard

32-bit MPLS labels (which contain a 20-bit label and BoS bit), and

thus SR-TSN stack entries could be 64-bits in size, comprising a

32-bit MPLS label and the aforementioned non-standard 32-bit

timestamp.

Alternatively, an SR-TSN stack entry could be 96 bits in length

comprising a 32-bit MPLS label and either of the standardized 64-bit

timestamps.

2.4. NSH Based Service Function Chaining

The Network Service Header (NSH) can be embedded in an Extended

Header (EH) to support the Path ID and any metadata that needs to be

carried and exchanged between Service Function Forwarders (SFFs).

A reference to the NSH SFC use case is defined in [RFC8596].

2.5. Network Programming

In SR, an ingress node steers a packet through an ordered list of

instructions, called "segments". Each one of these instructions

represents a function to be called at a specific location in the

network. A function is locally defined on the node where it is

executed and may range from simply moving forward in the segment list

to any complex user-defined behavior.

Network Programming combines Segment Routing (SR) functions to

achieve a networking objective that goes beyond mere packet routing.

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It may be desirable to encode a pointer to function and its

arguments within an MPLS packet transport header. For

example, in MPLS, we can encode the FUNC::ARGs within the label stack

or after the Bottom of Stack to support the equivalent of FUNC::ARG

in SRv6 as described in [RFC8986].

2.6. Application-Aware Networking (APN)

Application-aware Networking (APN) allows application-aware

information (i.e., APN attribute) including APN identification (ID)

and/or APN parameters (e.g., network performance requirements) to be

encapsulated at network edge devices and carried in packets

traversing an APN domain in order to facilitate service provisioning,

perform fine-granularity traffic steering and network resource

adjustment. To support APN in MPLS networks, mechanisms are needed

to hold the APN attribute.

3. Co-existence of Usecases

Two or more of the aforementioned use cases MAY co-exist in the same

packet. Some examples of such usecases are described below.

3.1. IOAM with Network Slicing

IOAM may provide key functions with network slicing to help ensure

that critical network slice SLOs are being met by the network

provider.

In such a case, IOAM is able to collect key performance measurement

parameters of network slice traffic flow as it traverses the

transport network.

This may require, in addition to carrying a specific network slice

selector (e.g., GISS), the MPLS network slice packets may have to

also carry IOAM ancillary data.

Note that the IOAM ancillary data may have to be modified, and

updated on some/all LSRs traversed by the network slice MPLS packets.

3.2. IOAM with Time-Sensitive Networking

IOAM operation may also be desirable on MPLS packets that carry time-

sensitive related data. Similarly, this may require the presence of

multiple ancillary data (whether In-stack or Post-stack ancillary

data) to be present in the same MPLS packet.

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4. IANA Considerations

This document has no IANA actions.

5. Security Considerations

This document introduces no new security considerations.

6. Acknowledgement

The authors gratefully acknowledge the input of the members of the

MPLS Open Design Team.

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